FIRST REPORT OF WELL-PRESERVED PRECAMBRIAN MICROFOSSILS IN BRAZIL (PARAOPEBA FORMATION, BAMBUÍ GROUP, NEAR BRASÍLIA)

THOMAS R. FAIRCHILD

(Professor Visitante, Departamento de Paleontologia e Estratigrafia)

MARCEL A. DARDENNE

(Departamento de Geociências, Universidade de Brasília)

INTRODUCTION

Thin sections of black chert from two localities at the base of the upper Precambrian Paraopeba Formation (Bambuí Group) near Brasília in south-central Brazil contain abundant microfossils. Although supposed Precambrian microfossils have been recorded previously from Precambrian rocks (summarized in FAIRCHILD and DARDENNE, in prep.), the following preliminary study marks the first time that well-preserved, morphologically diverse microfossils have been reported from indisputably Precambrian rocks in Brazil. These microfossils occur in silicified, branched, columnar stromatolites from 30-40 km north of Unaí, Minas Gerais, and about 100 km to the northwest in silicified, flat-laminated dolostone 30 km west-southwest of São Gabriel, Goiás. Solitary and colonial forms predominate at both localities, with the São Gabriel assemblege being the better preserved, more diverse, and more abundant assemblage. These discoveries are important because (1) They provide a standard of comparison for past and future microfossil finds in the Brazilian Precambrian; (2) They may further elucidate the relationships between biological content and columnar stromatolite morphology, thereby facilitating insight into the possible reasons for the apparent "evolution" of stromatolites; (3) Together with stromatolite data (see FAIRCHILD and DARDENNE, in prep.), they may help us to better date and correlate the Bambuí Group and make better paleoenvironmental and paleogeographical interpretations of these strata. On a broader scale, the Unaí and São Gabriel microfloras represent additional valuable evidence for deciphering the early evolution of the algae and for testing Precambrian biostratigraphic schemes (see SCHOPF, 1977).

GEOLOGIC SETTING AND AGE

Both the São Gabriel and Unaí localities are located near the western margin of the ancient São Francisco basin in which the Bambuí Group was deposited. As elsewhere in the region, the Bambuí Group near São Gabriel is divided into three formations (DARDENNE et al., 1976), the lowest of which is the 4000 to 5000 m-thick, predominantly sandy and pelitic Paranoá Formation. Apparently conformably upon this lies the Paraopeba Formation, which is at least several hundred meters thick. This formation begins with reddish pelites containing abundant chert nodules and layers, then gives way upwards to calcareous pelites having limestone and dolostone lenses. Throughout this sequence, numerous fine to microconglomeratic sandstones are intercalated. The Três Marias Formation, consisting of pelites and very fine arkoses, normally occurs above the Para-

opeba Formation but near São Gabriel has been overridden by the thrust-faulted Paranoá Formation. The São Gabriel microflora is found in chert from near the base of the Paraopeba Formation within the zone of transition with the underlying Paranoá Formation. Near Unaí, the silicified, microfossiliferous, columnar stromatolites are concentrated in lenticular dolostones within carbonate-rich mudstones at essentially the same stratigraphic position in the Paraopeba Formation. Silicified, unbranched, columnar stromatolites also occur in a similar stratigraphic position near Formosa, Goiás, about half-way between Unaí and São Gabriel, but these have yet to yield microfossils.

The Bambuí Group is not well dated but is probably younger than 1350 Ma (10^6 years), the metamorphic age of underlying rocks, and older than 620 Ma, the late diagenetic age of Bambuí shales near Januária, Minas Gerais (BONHOMME, 1976). In the São Gabriel area, DARDENNE et al. (1976) have found *Conophyton metula* in the Paraopeba Formation; this stromatolite typically occurs in rocks 1350 to 1000 Ma old on other continents (PREISS, 1976). However, near Brasília the Bambuí Group also contains the stromatolite *Linella avis* (identified by J. Bertrand-Sarfati, pers. comm. to M. A. D., 1976), a form known elsewhere only in rocks less than 850 Ma old (PREISS, 1976). *Conophyton* also crops out near Unaí, but, like the microfossiliferous columnar stromatolite from the same area, it has not been classified to a biostratigraphically significant taxonomic level. Thus, at present we can conclude only that the Bambuí microfloras reported here are between 620 and 1350 Ma old.

PRESERVATION OF THE MICROFOSSILS

In both assemblages, the microfossils consist of brown organic matter, are structurally well preserved, and occur in cryptocrystalline chert with a dull to waxy luster and a subconchoidal to conchoidal fracture (Figs. 1, 5). Spheroidal microfossils are more faithfully preserved than filamentous forms and may contain degraded intracellular organic matter (Figs. 15-20, 22). The Unaí assemblage is not as well preserved, as abundant, nor as diversified as the São Gabriel assemblage. This may partly have resulted from the apparently early diagenetic or synsedimentary growth of radial-fibrous carbonate? or anhydrite? crystals (now silicified; see fig. 4) within the organic-rich algal mats prior to silicification of the stromatolites. Both assemblages probably were preserved originally in organic-rich carbonate that was subsequently replaced by non-disruptive, early diagenetic silica permineralization.

METHOD OF STUDY

The two microfloras have been studied and measured in thicker-than-normal petrographic thin sections using transmitted light microscopy. Given the low number of measurements, the statistical data presented here represent preliminary values, and interpretations based on them are subject to future modifications.

THE UNAÍ MICROFLORA

In the cherty, branched, columnar stromatolites (Fig. 1) from near Unaí, simple spheroidal microfossils ranging from 3 to 81 μm in diameter (Fig. 2) predominate over very narrow (less than 2 μm) cellular filaments (Fig. 3). Of 62 measured spheroids, all but three lie between 3 and 24 μm. Within this range, peaks are evident at 6 μm (5 of 62 individuals), 9-14 μm (27/62), and 17-20 μm (11/62) that may indicate the modal sizes of different microbiological species. Only nine of the measured spheroids are surrounded by a sheath and/or contain intracellular organic matter, though more recent study has shown that cells with internal organic matter are locally commoner than first believed. Many spheroidal unicells occur in loose clusters that parallel the poorly defined stromatolitic lamination; compact colonies are rare. Filaments

(Fig. 3) are poorly preserved, being relatively abundant only locally where they appear to have formed thin stromatolitic laminae.

For the most part, the Unaí microflora represents the remains of an autochthonous, stromatolite building, microbiological community. Most of the microfossils are similar in size and morphology to blue-green algae, although the filaments and the smallest unicells also fall within the size range of bacteria. On the other hand, the largest microfossil (Fig. 2) is larger than modern cyanophytic unicells and thus may have been eucaryotic (see SCHOPF, 1977). The inter-relationships between the microflora and the stromatolite's morphology require additional study, but note that the most prominent microstructural feature of the stromatolitic laminae – the submillimetric, radial-fibrous mineral clusters (Fig. 4) – is not directly biogenic in origin.

THE SÃO GABRIEL MICROFLORA

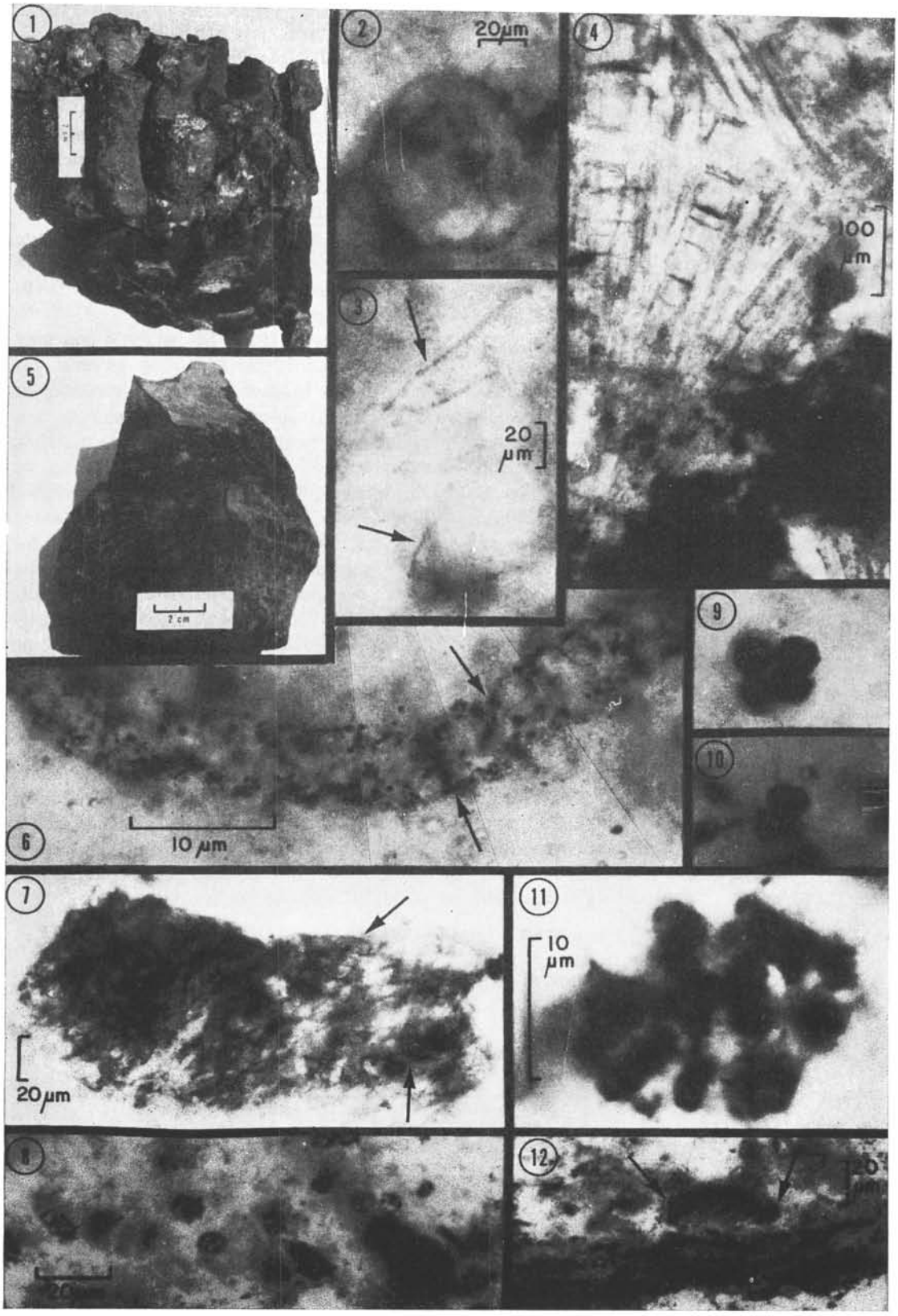
Even more than in the Unaí assemblage, unicellular and colonial microfossils predominate in the São Gabriel microflora. Measurements of 82 spheroidal cells revealed a range of diameters between 1,4 and 13,5 um with but one cell exceeding 24 μm. Five modal size groupings are evident within this range at 2-3 μm (9 of 82 individuals), 6-8 μm (17/82), 10-11 μm (11/82), 14-16 μm (12/82), and possibly 18-21 μm (13/82). About half (43) of the spheroids are empty, unsheathed forms (Figs. 9-14); about one-fourth (22) have intracellular remains but lack sheaths (Fig. 22); ten have both sheaths and intracellular remains (Figs. 17, 18); and only seven are empty, sheathed cells. Most of the spheroids occur in loose clusters (Figs. 8-10), in more or less compact colonies (Figs. 11, 13-16), or in commonly ensheathed groups of four or more cells frequently exhibiting intracellular organic material (Figs. 17-20). Among the unicells are forms with apparent folds (Fig. 21) or pores (Fig. 22) and a rare compressed form with possible surface ornamentation (Fig. 12).

The rare filaments in the assemblage range from about 7 to 10 μm in diameter and include a cellular variety (Fig. 6) and a rarer, tubular variety (possibly cylindrical sheaths) that is best seen in small detrital fragments of algal mats (Fig. 7). The cellular filaments are typically more than several hundred microns long and oriented perpendicular to bedding. They vary from 7.6 to 10.0 μm, (n = 11), and have poorly preserved cells apparently about 4 to 7 μm long (n = 6). Neither filamentous form appears to be branched or associated with proven reproductive structures.

Like the Unaí microfossils, the elements of the São Gabriel assemblage mostly fall within the size range of modern procaryotes, and principally within the range of the range of the cyanophytes. However, the smallest spheroids (Figs. 9-11) possibly represent bacteria, while certain cells with intracellular organic granules associated with degraded membranous structures (Figs. 17,20) could prove to be eucaryotic (see SCHOPF and OEHLER, 1976, OEHLER, 1977). The relatively large, compressed, thick-walled cell in Fig. 12 exhibits an apparently ornamented surface, a feature unusual in blue-green algae; hence, it could possibly represent the crushed dead cell (or abandoned cyst?) of a eucaryotic planktic alga. Thus, the São Gabriel assemblage includes microfossils that were probably deposited as sedimentary

PLATE 1, FIGS. 1-12

Photomicrographs of microfossils and microstructure in petrographic thin sections of black chert from the Upper Precambrian Paraopeba Formation, Bambuí Group, near Brasília. Fig. 6 is a photomontage. Scale in Fig. 11 also serves Figs. 9, 10. Thin sections are deposited in the Paleontology Collections, IG/USP. Fig. 1: Silicified, branched, columnar stromatolites from north of Unaí, Minas Gerais; Figs. 2-4 show, respectively, a large spheroidal microfossil, narrow filaments (arrows), and radial-fibrous microstructure that occur within these stromatolites. Fig. 5: Silicified, flat-laminated dolostone from west-southwest of São Gabriel, Goiás. Its microflora includes filaments with poorly preserved cross-walls (arrows, Fig. 6); tubular filaments (arrows) in a small algal mat fragment (Fig. 7); small, loosely grouped cells (Fig. 8); very small cells (Figs. 9-11), some of which are paired (Figs. 9, 10); and a compressed, relatively thick-walled, possibly phytoplanktic spheroid with apparent surface ornamentation (arrows, Fig. 12).


1
2
20µm
4
100 µm
3
20 µm
5
2 cm
9
10
6
10 µm
7
20µm
11
10 µm
8
12
20 µm

particles (e. g. Figs. 12, 21) as well as colonies (Figs. 8-11, 15-16) and filaments (Fig. 6) that grew within or at the surface of the sediments.

CONCLUSIONS

Despite their similar stratigraphic positions, the Unaí and São Gabriel microfloras exhibit more differences than similarities. Most of the spheroidal cells in both assemblages lie between 3 and 24 μm in diameter, and several of their modal size groupings nearly coincide (e.g. at 6μm, 10-11μm, and 18-20μm). However, the total size range of spheroidal cells, diversity, abundance, preservational state, and filamentous elements are different for each microflora. But the most significant difference between them is in their origins: the Unaí microfossils represent the vestiges of a stromatolitic microflora, whereas the São Gabriel assemblage contains both allochthonous and autochthonous elements.

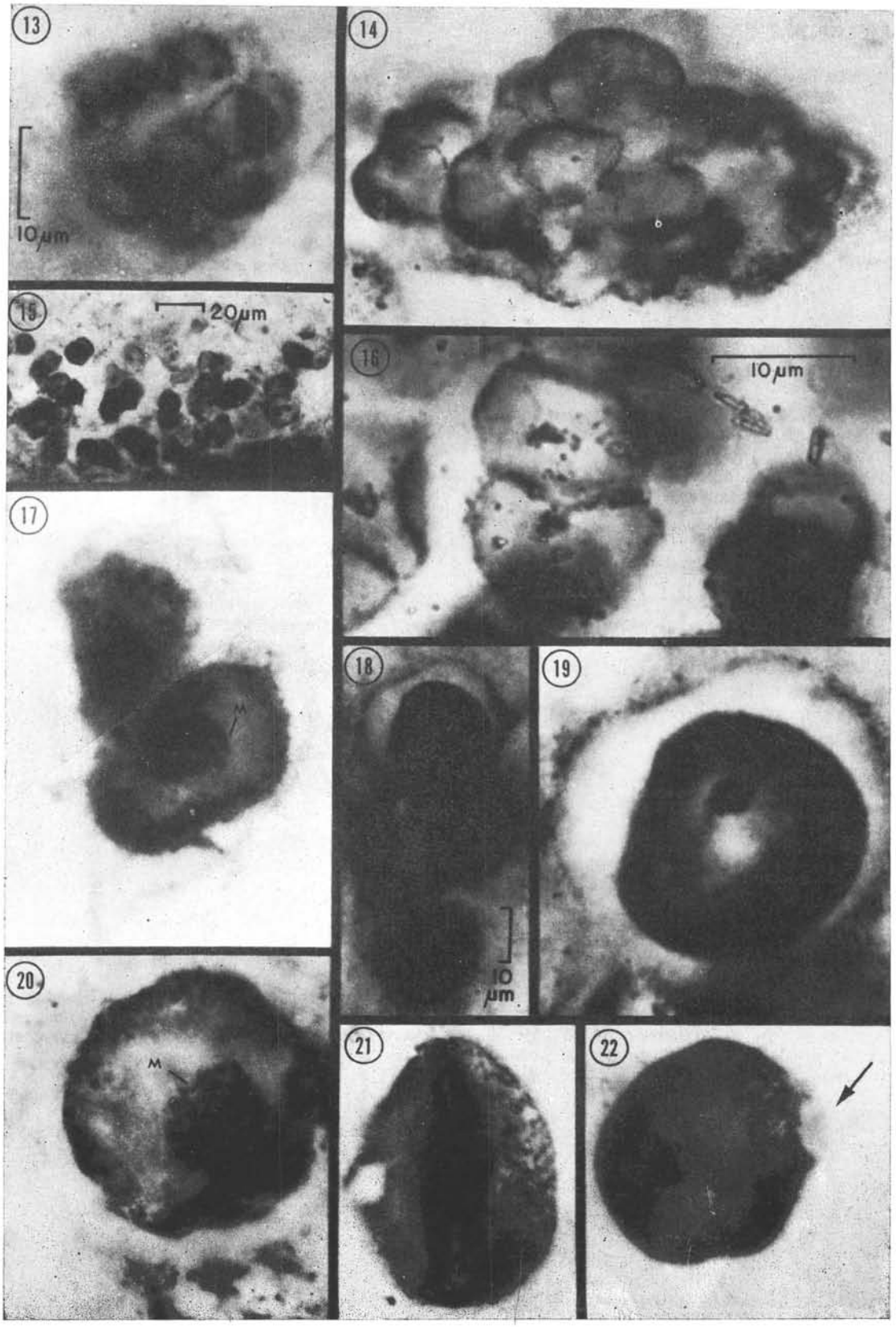
It is too soon to attempt close comparisons between these microfloras and those from the Precambrian on other continents. Eventually, however, the São Gabriel microflora should be compared with the similary preserved and deposited Bitter Springs microflora from the upper Proterozoic of central Australia (SCHOPF, 1968, SCHOPF and BLACIC, 1971), and the Unaí microflora should be compared with microfloras in other biostratigraphically significant stromatolites (see SCHOPF, 1977). In fact, preliminary comparison with the microflora of the ca. 650 Ma-old *Conophyton gaubitza* of the Soviet Union (SCHOPF and SOVIETOV, 1976) reveals generally smaller-sized taxa within the Unaí assemblage. We should also note here that problematical microfossils previously described from the Bambuí Group by CASSEDANNE (1965) and SOMMER (1971) are much larger than all but the rare, very largest elements of the two silicified Bambuí microfloras (see FAIRCHILD and DARDENNE, in prep.).

SCHOPF (1977) has recently presented a preliminary biostratigraphic scheme for Precambrian sediments based on size analyses of spheroidal unicells, cellular filaments, and cylindrical sheaths in silicified stromatolitic microbiotas. When analyzed according to this scheme, the preliminary size data presented here appear to confirm the less than 1400 Ma age that has previously been suggested for the Unaí and São Gabriel microfloras on the basis of geochronologic and stromatolitic evidence. More thorough statistical and morphological studies of the microfossils of these assemblages may lead one day to greater precision in the dating and correlation of the Bambuí Group.

Acknowledgments: We would like to thank Dr. J. Bertrand-Sarfati for her identification of *Linella avis* and Prof. A. C. Rocha-Campos for financial support to T. R. F. through a grant from the Fundação de Amparo à Pesquisa do Estado de São Paulo.

PLATE 2, FIGS. 13-22

Additional photomicrographs of microfossils in petrographic thin sections of silicified, flat-laminated dolostone of the Upper Precambrian Paraopeba Formation, Bambuí Group, west-southwest of São Gabriel, Goiás. Fig. 17 is a photomontage, and Figs. 16 and 19 are details of Figs. 15 and 18, respectively. Scale in Fig. 13 also serves Fig. 14; scale in Fig. 16 also serves Figs. 17, 19-22. Thin sections are deposited in the Paleontology Collections, IG/USP. Figs. 13-20 show colonial forms; Figs. 21, 22 show solitary spheroidal microfossils. Note the intracellular organic bodies in Figs. 15-20, 21, some of which have associated membrane-like structures (M) (Figs. 17, 20). Also note folded specimen in Fig. 21 and pore-like opening (arrow) in specimen in Fig. 22.


13
10 µm
14
15
20 µm
16
10 µm
17
M
18
10 µm
19
20
M
21
22

BIBLIOGRAPHY

BONHOMME, M. G. – 1976 – *Mineralogie des fractions fines et datations rubidium-strontium dans le Groupe Bambuí, MG, Brésil.* Revista Bras. Geociênc. 6 : 211-222.

CASSEDANNE, J. – 1965 – *Decouverte d'algue dans le calcaire Bambuí (Etat de Minas Gerais, Brésil).* An. Acad. Bras. Ciênc. 37 : 79-81.

DARDENNE, M. A., FARIA, A. and ANDRADE, G. F. – 1976 – *Occurrence de stromatolites columnaires dans le Groupe Bambuí (Goiás, Brésil).* An. Acad. Bras. Ciênc. 48 : 555-566.

FAIRCHILD, T. R. and DARDENNE, M. A. – in prep. – *Present status of Precambrian paleobiological research in Brazil.*

OEHLER, D. Z. – 1977 – *Pyrenoid-like structures in Late Precambrian algae from the Bitter Springs Formation of Australia.* Jour. Paleont. 51 : 885-901.

PREISS, W. V. – 1976 – *Intercontinental correlations.* In Stromatolites. M. R. Walter (ed.). Elsevier Scientific Publishing Co., Amsterdam: 359-370.

SCHOPF, J. W. – 1968 – *Microflora of the Bitter Springs Formation, Late Precambrian, central Australia.* Jour. Paleont. 42 : 651-688.

SCHOPF, J. W. – 1977 – *Biostratigraphical usefulness of stromatolitic Precambrian microbiotas: a preliminary analysis.* Precambrian Research. 5 : 143-173.

SCHOPF, J. W. and BLACIC, J. M. – 1971 – *New microorganisms from the Bitter Springs Formation (Late Precambrian) of the north-central Amadeus Basin, Australia.* Jour. Paleont. 45 : 925-961.

SCHOPF, J. W. and OEHLER, D. Z. – 1976 – *How old are the eucaryotes?* Science. 193 : 47-49.

SCHOPF, J. W. and SOVIETOV, Yu. K. – 1976 – *Microfossils in* Conophyton *from the Soviet Union and their bearing on Precambrian biostratigraphy.* Science. 193 : 143-146.

SOMMER, F. W. – 1971 – *Microfósseis do calcário Bambuí, de Pedro Leopoldo, Estado de Minas Gerais.* An. Acad. Bras. Ciênc. 43 : 135-139.

APPENDIX – MATERIAL STUDIED

Material illustrated in this paper is deposited in the Paleontology Collections of the Instituto de Geociências, Universidade de São Paulo, under the following numbers: hand sample GP/3T-555 (Fig. 1) and its thin sections GP/L-3T-35 (Fig. 2), GP/L-3T-36 (Figs. 3, 4); hand sample GP/3T-556 and its thin sections GP/L-3T-37 (Figs. 18,19), GP/L-3T-38 (Figs. 12, 17, 22); hand sample GP/3T-557 (not illustrated) and its thin sections GP/L-3T-39 (Fig. 7), GP/L-3T-40 (Figs. 6-11, 13-16, 20), GP/L-3T-41 (Fig. 21).