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PROOF FOR THE SYNSEDIMENTARY BIOTA IN PRE-CAMBRIAN SHALES

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ABSTRACT

Three optical techniques are described to differentiate synsedimentary biota from contaminants and artifacts in Pre-Cambrian shales. These techniques are (a) study of polished rock surface in dark field in incident light illumination and with heating on stage microscope in fluorescence light, (b) study of thin sections in interference contrast, and (c) examination of macerated and isolated specimens in Zernike phase-contrast and in interference contrast. Two young Pre-Cambrian shales, one from Vindhyan Supergroup of India and the other from the Bushimay Group of Zäire have been examined by these techniques. The results demonstrate that both the shale samples contain biota of the synsedimentary deposits.

Key-words — Optical techniques, Synsedimentary biota, Pre-Cambrian shales, India.

सारांश

पूर्व-कैम्ब्रियन शैलों में सहअवसादीय जीवजात के लिए प्रमाण – प्रभात कुमार माइती एवं एच०डी० फ़्लूग्

पूर्व-कैम्ब्रियन शैलों में विद्यमान सहअवसादीय जीवजात को संदूषकों एवं अश्मोपकरणों से विभेदनार्थ तीन प्रकाशीय-प्रविधियाँ अर्थात् (अ) अदीप्त क्षेत्र में चरण-सूक्ष्मदर्शी पर प्रतिदीप्ति प्रकाश में गर्म की गई पॉलिस युक्त चट्टान की सतह का आपतित-प्रकाश प्रदीप्ति में अध्ययन, (ब) व्यतिकरण-विपयसि में पतली काटों का अध्ययन, तथा (स) जनद्रिक प्रावस्था-विपयसि एवं व्यतिकरण-विपयसि में पृथक्कृत तथा मसृणित प्रादर्शों की परीक्षा वर्णित की गई है। इन प्रविधियों द्वारा दो नव पूर्व-कैम्ब्रियन शैल-समूहों की परीक्षा की गई है जिनमें से एक भारत के विंध्ययन महासमूह से तथा दूसरा ज़ायर के बुशिमेय समूह से है। उपलब्ध परिणाम व्यक्त करते हैं कि दोनों शैल-नमूनों में सहअवसादीय निक्षेपों के जीवजात विद्यमान हैं।

INTRODUCTION

THE micropalaeontological investigation of the Pre-Cambrian poses a number of problems. The traditional Russian school and other similar workers have investigated commonly the clay or shale material for microbiota. The preparations were done by maceration method, i.e. the digestion of shale samples by acid treatment. On the other, the American school studied the chert material by thin section method. It is noteworthy that in both the methods several types of microbiota were identified with morphological distinctiveness. However, the biota observed in one method does not agree qualitatively with that of other method. Therefore, the basic problem is why the recorded biota are preserved differently in different methods of studies.

Authenticity of biota recorded by maceration methods from the Pre-Cambrian rocks has also been questioned. People have opined that they are contaminants or biota of younger sediments. They have leached to the older rocks through rock perforations. Cloud (1976) has considered many of these records to be the contaminants or artifacts. Due to these doubts the study of Pre-Cambrian biota by maceration technique has become unreliable. On the contrary, the

study by thin section method is considered to be more reliable because one observes the microbiota in *in situ*. The possibility of contamination in chert is less, because the probability of leaching of biota from younger sediments is also remote.

In view of these doubts, the recorded biota from Pre-Cambrian shales poses problems for study. However, the study of biota in thin sections of rocks gives little information about the surface morphology. Commonly, in thin sections, two types of biota are identifiable — the 'spherical' and the 'filamentous' types. The morphological differentiation in each type is not well pronounced due to interference of rock matrix in optical study. Moreover the recorded biota in rock section showing different organisation is presumed to be the developmental stages of the same biota (Knoll & Barghoorn, 1975).

The forms recorded with poor morphological differentiation have little importance for stratigraphy. Moreover, the algal records have insignificant role in stratigraphy as they resemble modern Cyanophyceae and remained unchanged during the entire period of geological history. On the other hand the microbiota found in shales show significant role in biostratigraphy due to diversified biota. This is well documented from the work of Vidal (1976) and Timofeev *et al.* (1976) on Late Pre-Cambrian. Therefore, to tackle future problems of Precambrian biostratigraphy the investigations for shales seem to be extremely important since it gives more information on the morphology of biota.

MATERIAL AND METHODS

Two shale samples were investigated: 1. Material no. 109; Suket Shale, Vindhyan Supergroup, Ramapura, Madhya Pradesh (for locality map see Maithy & Shukla, 1977). The material was collected from surface of river bed exposures. This horizon has been radiometrically considered to be 1100 ± 60 m.y. by Vinogradov *et al.* (1964). From these shales megascopic structure, *Fermoria* Chapman, and microbiota comprising algae and acritarch remains have earlier been recorded (Maithy, 1968; Maithy & Shukla, 1977). 2. Material No. 32-322: Bushimay Supergroup, Kansi, Zaire (for map see Maithy, 1975). It is a drill core material from group B IIC of Bushimay Supergroup. The rock has been radiometrically dated between 1050-1100 m.y. (Cahen, 1973). Maithy (1975) has described microbiota containing algae and acritarchs from this sample.

To study the microbiota by maceration method the drill core samples are more reliable, as the possibilities of surface contamination or weathering is far less in them. The surface samples are always influenced by natural weathering. Therefore, the possibilities of contamination is far greater than the drill core samples.

The distoration in the morphology of biota during fossilization is also equally important. The morphology, wall structure, sculpture, and other morphological features may get corroded due to rolling or crushing of biota during fossilization.

The following sources of errors should also be taken into consideration:

1. Geological contamination possibly by atmosphere or water.
2. Laboratory contamination during transport, storage or during the course of other processes before digestion of rocks.
3. Association of mineral crystals, glass crystals and gas bubbles.
4. Artifacts produced during preparation; new crystals are formed due to coagulation and corrosion.
5. Problem of age determination.

Geological Contamination — Possibilities of contamination in Pre-Cambrian rocks of recent micro-organisms or microfossils of younger sediments lying above the older rocks are through pores, cracks or other decomposed places. The bore core material is from subsurface area, therefore, the chance of such contamination is less. On the other hand, the surface material remains exposed to water in river beds and also to atmosphere. Hence, it has the possibility of contamination of modern microbiota. Keller (1959) and Krylov (1968) have opined that most of the publication in USSR done before 1969 claiming to be the Pre-Cambrian biota are from Palaeozoic or younger sediments. These microbiota have percolated from younger sediments to Pre-Cambrian rocks through rock cracks. Only rock sections and thin sections of rock can throw important light on this problem that the microbiota is synsedimentary or preserved later. Synsedimentary microbiota in optical

study will demonstrate occupying a position in between the rock texture.

Laboratory Contamination — It is possible only when rocks are stored in wet condition. On the rock surface modern biota may grow due to moist condition. Therefore, before maceration one should take all precautions to remove them by repeated washing of rock under running water and subsequently burning it after immersing in alcohol. Moreover, there is possibility that modern atmospheric dust precipitates on rock surface which may also come in maceration. In the study of rock sections and thin sections possibilities of such contaminations are remote.

Pseudofossils like mineral corners, mineral concretions, glass particles, granules and bubbles can come or get formed in preparation of rock sections and thin sections. These are also acid resistant. Therefore, they are also present in maceration preparations.

Formation of Artifacts — In maceration preparation the fine rock structures and other spherical bodies like microfossils can be formed due to chemical reactions. They also look similar to biological bodies. But in rock section and thin section such things are not seen.

Problem of Age Determination — Radiometric dating is the best method for age determination. Special care is to be taken especially for stromatolites and oncolites which are also formed by algae in recent and subrecent sediments. The microbiota in these stromatolites are spheroid or filamentous cyanophyceacous remains. These modern sedimentary structures may create confusion with the Pre-Cambrian stromatolites resulting into a wrong age determination. Therefore, special precaution has to be taken while considering these organo-sedimentary structures for age determination.

INVESTIGATIONS

The possibilities of contaminations in Pre-Cambrian rocks can be overruled by studying the samples by combination of techniques. The mode of study for Pre-Cambrian shales is detailed below:

Examination of polished rock surface — Rocks are cut to a thickness of $2 \pm 2{\cdot}5$ mm wide along the parallel line of bedding and then polished finely. The polished surface is immersed in water or oil-emulsion and examined under direct incident light. The biota, if present in rock, gives a three dimensional view. Distinction in between synsedimentary biota and other ingredients can be easily made. Moreover, one can observe the rock and its contents layerwise by gradual grinding or etching. It is possible to distinguish easily the organic elements and the mineral elements which are clumped together in rock surface. The mineral elements show a bright lusture on surface.

Thin section — Thin sections of shales of 30 μm thick are good enough and transparent for microscopic study. However, the biota with thick body gets damaged during preparation. Therefore, their identification becomes difficult (Pl. 1, fig. 3). In this method of study, the problem is that the small individuals are closely placed together, hence they show little morphological distinctiveness due to lack of transparency and rock interference. However, this study is important because it has the possibility to analyse rock ingredients and minerals in polarized light. In Pl. 1, figs 1-6, one can observe that the fossil remains are preserved along the layers of shale. This layer is composed of primary sedimentary matrix and the biota. The biota is surrounded by rock matrix from all sides. Occasionally cell crystals (m) are seen sticked to the walls of fossil body (Pl. 1, fig. 4). From this one can infer that the organisms belong to the sediment and they have not reached to the older rocks from younger sediments.

Maceration method — By treating the samples with acid and alkali, the mineral portions are dissolved and the resistant organic residues are left over. The maceration process gives better morphological picture of the organic bodies since they are free from rock matrix. Moreover, by maceration process one can also concentrate the organic residue. The disadvantage of maceration method lies due to possible chances of contamination. The contamination problem can be easily over-ruled by studying the material with the help of phase-contrast and interference-contrast microscopy. By enlarging the organic objects one can see the crystal matrix of the rocks preserved on their walls. In addition to this the biota resembles to that observed in thin

section. With this one can safely conclude that the biota observed in maceration are the same as observed in thin section.

Electron microscopy investigations — The electron microscopy study in recent years has been applied for different Pre-Cambrian microbiota. However, the same investigation has not yet been applied to the material of shale samples. The preparations and study of microbiota in rock section is very difficult. However, it is easy to handle the macerated biota. There are certain problems in this method because it is difficult to judge, if one is examining the original structure of biota or the artifacts formed on wall due to rolling or formed during fossilization. In principle it is presumed that the scanning study will give more surface details, however, a false image will emerge if the surface structure gets distorted by secondary folds or rolling. Therefore, for such material one should take into consideration the results of optical studies (Pflug, 1976). It is also clear that the electron microscopic study of thin section will not be very useful as the surface of biota may have rock particles.

CONCLUSIONS

Organic microfossils of the Pre-Cambrian shales have been critically studied. Earlier workers remarked that several reports of microbiota from Pre-Cambrian shales are either contamination or artifact. This has been specially said for the material studied by maceration methods. However, for the study of shale material the maceration method seems to be extremely important. The investigation done by the authors demonstrates how one can differentiate between the fossils and pseudofossils in maceration preparations by following the procedures mentioned below:

1. Investigation of rock sections and thin sections in polariod microscope.

2. The study of thin section and macerated material in polarized light in Zernike-phase contrast and in interference-contrast.

These combination of studies show that the recorded biota is synsedimentary or a contamination.

Two shale samples from the late Pre-Cambrians of India and Africa have been investigated. Both the samples were previously studied in maceration preparations. The investigation leads to the following conclusions:

1. The rock section and thin section studied have shown that the microbiota is associated with the original rock matrix. This is supported by the presence of mineral crystal sticked to the walls of microbiota.

2. On heating the microbiota in fluorescence light up to 300°C the organic body starts loosing its structure; up to 400°C the outline remains and at 700°C the organic remain is lost. This behaviour is the characteristic for organic fossil substance and indicates that the biota cannot be a mineral or pseudofossil.

3. In maceration preparations the same microbiota is observed as seen in thin section (compare Pl. 1 with Pl. 2). In interference contrast one observes the rock particles still sticked to the walls of microbiota. The crystals compare well with the rock crystals in which the microbiota is preserved. This mode of preservation of microbiota is not possible if the biota gets entry into rocks by pores or cracks. By such characteristic corrosion on the wall of microbiota one can distinguish the synsedimentary microfossil from contaminants.

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EXPLANATION OF PLATES

PLATE 1

1. Thin section parallel to sedimentary deposit. In the centre a microfossil is marked out from the rock matrix in Interference-contrast, Nicolas+.

2,4. The microfossil referable to *Kildinella* Timofeev in Pl. 1, fig. 1 is observed in slightly polarized reflected light (Pl. 1, fig. 2) and in Interference-contrast (Pl. 1, fig. 4) (m-Mineral individual sticked to the wall of fossils).

3. Microfossil non-identifiable due to surface distortion.

5,6. aff. *Kildinella*. Timofeev sp. Thin section observed in normal reflected light (Pl. 1, fig. 5) and in Interference-contrast (Pl. 1, fig. 6). (All specimens photographed from sample 109, Suket Shales).

PLATE 2

Microfossil in maceration preparation in Interference-contrast. A mineral crystal (m) sticked to the wall of microfossils. A protuberance in Pl. 2, fig. 12 has been indicated as (b).

7,8,11. cf. *Gunflintia* Barghoorn.

9,10. *Protosphaeridium* Timofeev.

12,13. *Trachysphaeridium* Timofeev.

(Pl. 2, figs 7, 8, 11 from material no. 32, 422. Bushimay Supergroup, Zaire and Pl. 2, figs 9, 10, 12, 13 from sample 109, Suket shale, Vindhyan Supergroup, India).

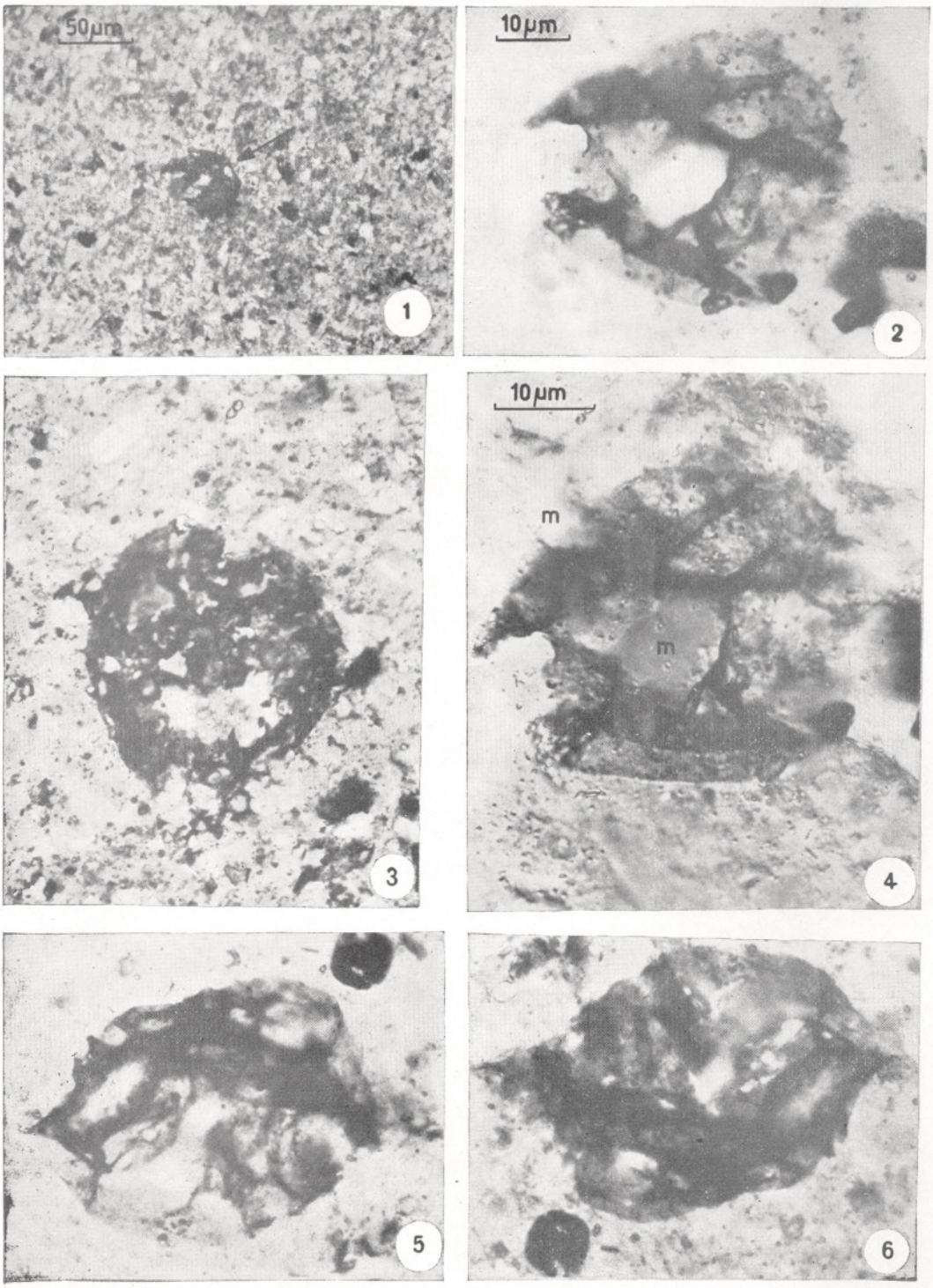
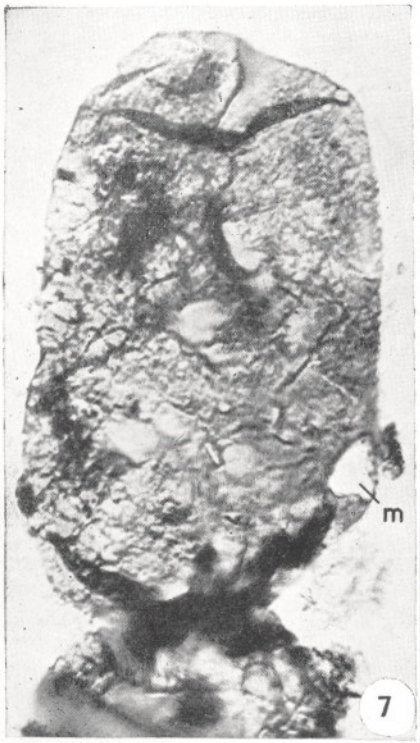
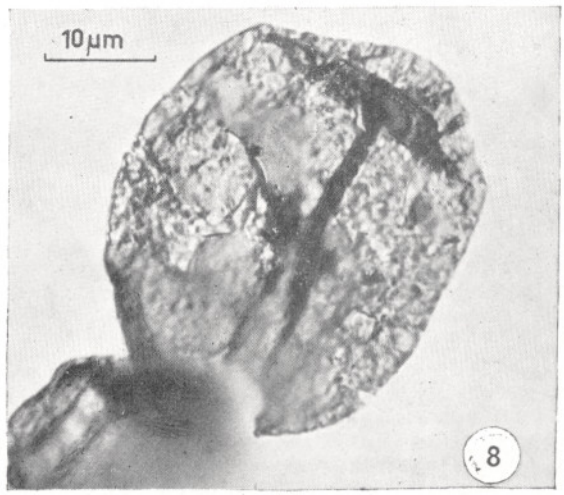
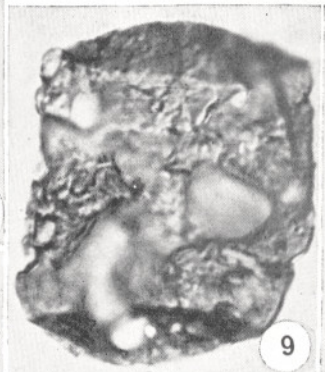


PLATE 1







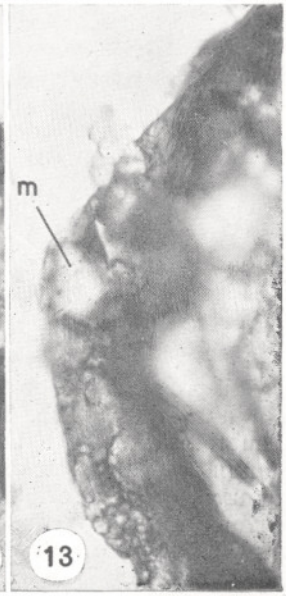


PLATE 2