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Reworked Permian palynofossils from Bhuban Formation (Early Miocene) of Tripura, India

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ABSTRACT

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Palynological investigations were carried out from the sediments of Bhuban Formation, Amarpur area, located on the southern part of Tripura. The assemblage consists of a large number of marker pollen/spores of Miocene age, comprising pteridophytic spores, angiosperm and gymnosperm pollen and fungal remains. Besides these, an abundance of reworked Permian palynomorphs of Gondwanan affinity have been recorded which include *Acanthotriletes, Jayantisporites, Barakarites, Parasaccites, Plicatipollenites, Densipollenites, Scheuringipollenites, Faunipollenites, Alisporites, Primuspollenites, Klausipollenites,* etc. The recovered palynoassemblage is dominated by *Parasaccites* and subdominated by *Plicatipollenites*. From bottom to top, the monosaccates appear to decline and the striate and non–striate disaccates become dominant. The Gondwana sediments were eroded, transported and redeposited within the Miocene sediments in a shallow sea adjacent to a densely vegetated land mass. The implications of the reworked Permian palynofossils in the Miocene sediments of Tripura has been discussed.

Key–words—Permian palynofossils, Miocene sediments, Reworking, Tripura, India.

त्रिपुरा, भारत के भुबन शैलसमूह (प्रारंभिक मध्यनूतन) से पुनःरचित पर्मियन परागाणुजीवाश्म

बी.डी. मंडावकर एवं रतन कर

सारांश

त्रिपुरा के दक्षिणी भाग में स्थित भुबन शैलसमूह, अमरपुर क्षेत्र के अवसादों से प्राप्त परागाणविक अन्वेषण किए गए। समुच्चय में टेरिडोफाइटी बीजाणुओं, आवृतबीजी एवं अनावृतबीजी पराग एवं कवक अवशेष समाविष्ट मध्यनूतन काल के चिह्नक पराग/बीजाणुओं की विशाल संख्या समावेशित है। इनके अलावा, गोंडवाना वंश–सादृश्य के पुनः रचित पर्मियन परागाणुसंरूपों की प्रचुरता अभिलिखित की गई है जिसमें *एकेन्थोट्रिलेटीज, जयंतीस्पोराइटिस, बराकराइटिस, पैरासेक्काइटिस, प्लिकेटीपॉल्लेनाटिस, डेन्सीपॉल्लेनाइटिस, स्युरिंगीपॉल्लेनाइटिस, फॉनीपॉल्लेनाइटिस, अलीस्पोराइटिस, प्रिमसपॉल्लेनाइटिस, क्लॉसीपॉल्लेनाइटिस* इत्यादि सम्मिलित हैं। पुनः प्राप्त परागाणुसमुच्चय *पैरासेक्काइटिस* से प्रभावित एवं *प्लिकेटीपॉल्लेनाइटिस* से सह–प्रभावित है। तल से शिखर तक एकलसपुटों का पतन तथा रेखित व गैर–रेखित द्विसपुट प्रभावी हैं। गोंडवाना अवसाद सघन वनस्पति–आवृत भू–खंड से सन्निकट उथले समुद्र में मध्यनूतन अवसादों में अपरदित, वाहित एवं पुनःनिक्षेपित हो गए थे। त्रिपुरा के मध्यनूतन अवसादों में पुनःरचित पर्मियन परागाणुजीवाश्मों से निहितार्थ पर चर्चा की गई है।

सूचक शब्द—पर्मियन परागाणुजीवाश्म, मध्यनूतन अवसाद, पुनर्रचित, त्रिपुरा, भारत।

INTRODUCTION

THE Tripura State lies in the eastern part of India and is bordered by Bangladesh to the west, south and north; by Assam in the northeast and by Mizoram in the east. It is bounded by latitudes 22º56' N and 24º32' N and longitudes 91º10' E and 92º21' E (Fig. 1). The geomorphology of the region is typified by a succession of low hill ranges (200–500 m high) and valleys. The hill ranges mainly comprise relatively compact and resistant older rock units exposed in the anticlinal crests, whereas the valleys are composed of younger and softer formations exposed in the synclinal troughs (GSI, 1974).

The presence of older palynological fossils in comparatively younger sediments has commonly been recorded in India. As data on the dispersed spores of the various formations of India accumulated over the years, reworked palynomorphs were recognised from various horizons. Redeposited Permian pollen in the Miocene sediments of Tripura has not been reported earlier. However, reworked Gondwana pollen have been recorded from other Cenozoic deposits of northeast India. Banerjee *et al.* (1973) have reported the occurrence of *Scheuringipollenites* sp., *Verticipollenites* sp., *Alisporites* sp. from the Bokabil and Tipam formations, respectively of Miocene and Mio–Pliocene age from different oil wells, in Sibsagar District, Assam. Sah and Singh (1977) worked on the Tertiary sediments of Gumaghat Formation, Assam and pointed out that the palynological assemblage is characterized by the dominance of *Ariadnaesporites*. This spore has been recorded from the Deccan Intertrappean sediments and is considered an index of Maastrichtian age worldwide. Dutta (1979) observed recycled Permian pollen in the upper Cretaceous rocks of Jaintia Hills, Meghalaya. Dutta (1980) further recorded Permian palynofossils from the Siwalik sequence of Arunachal Pradesh and Dutta and Singh (1980) reported Permian and Eocene palynofossils from the Siwalik equivalents of Arunachal Pradesh. Trivedi (1990) cited Permian and late Mesozoic palynofossils from the late Eocene sediments of Meghalaya. Singh *et al.* (1990) recorded the presence of Permian and Cretaceous palynofossils from the Oligocene sediments of Meghalaya and Assam. From the other Tertiary deposits of India, Kar (1980) reported Permian palynofossils in the Khari Nadi Formation (Miocene) of Kutch, Gujarat. Saxena (1979) recorded typical Mesozoic palynomorphs from the Matanomadh Formation (Palaeocene) of Kutch along with characteristic Palaeocene palynofossils.

A large number of fossil palm peduncles of *Palmostroboxylon deotamuraensis,* belonging to cocoid group of family Arecaceae have been described from the Tipam Sandstone (Middle Miocene) of Deotamura, Amarpur District, Tripura (Mandaokar & Ambwani, 2013). Studies on the fungal remains from Bhuban Sub–Group (early Miocene) of Maharanicherra, Tripura have also been carried out (Mandaokar & Saxena, 2014). These studies provide an insight into the palaeoclimatic trends in different sedimentary basins during the Miocene from the region.

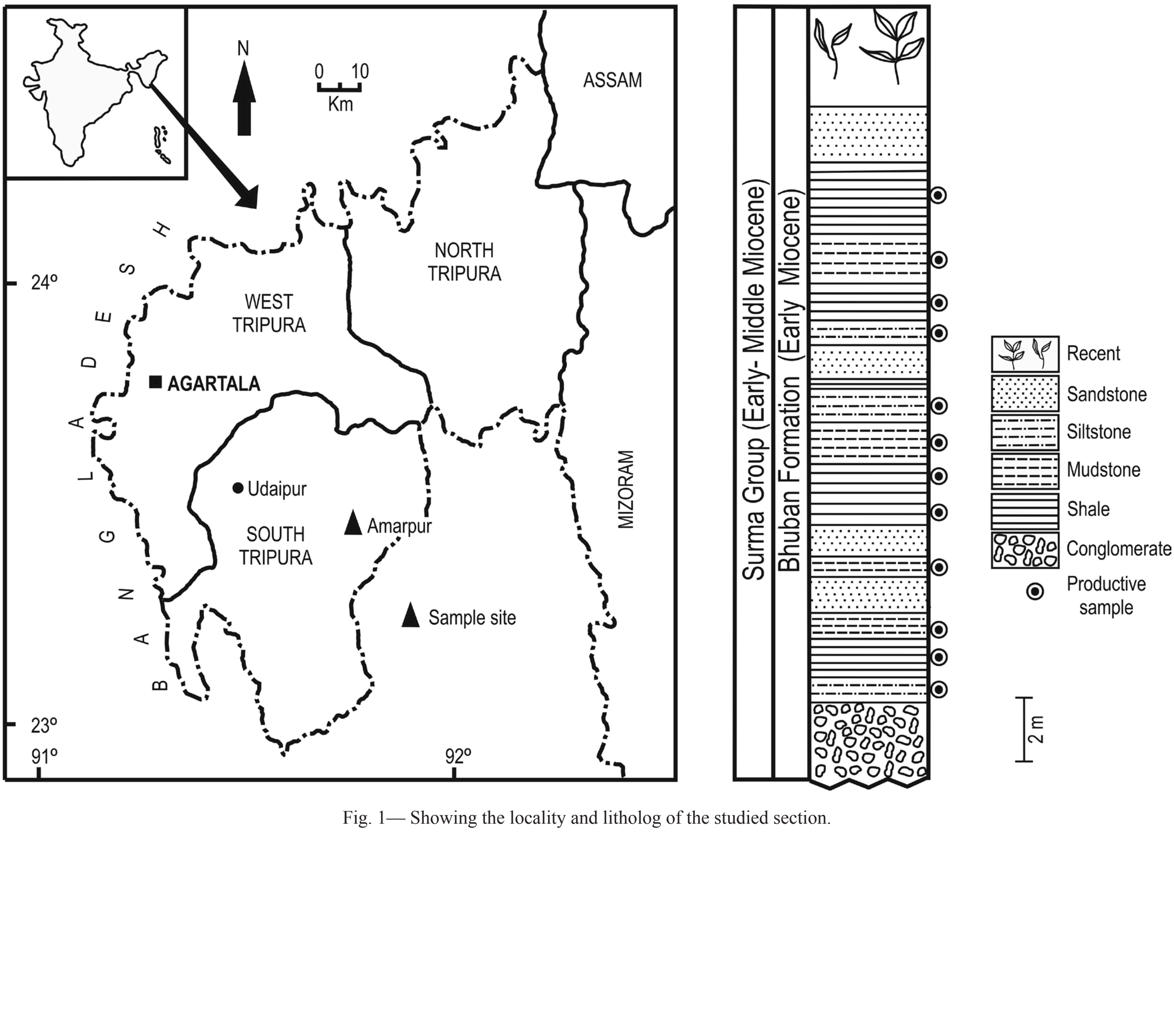

Fig. 1— Showing the locality and litholog of the studied section.

Palynofloristic records of the Miocene sediments from Amarpur area of Tripura are not yet known. Hence the study of this sequence was undertaken to determine the age of the sediments and bring out their relationship with other parts of the Tripura Basin. The main objective of this study is to establish a pollen–spores zonation for the Tripura Basin, on the basis of qualitative as well as quantitative changes in the composition of palynoassemblages. Besides, to study the botanical affinities of the pollen–spore species, and palaeoclimate and palaeoenvironment reconstruction. However, the present communication focuses only on the reworked palynoassemblage. The location of the study area and the litholog of the section are shown in Fig. 1.

GEOLOGICAL SETTING

The sedimentary rocks in Tripura comprise of Surma Group, which can be further divided into Bhuban (Early Miocene) and Bokabil (Middle Miocene) formations. The Bokabil is easily identified from the underlying Bhuban sediments by the absence of well–bedded argillaceous sandstones. The older rocks of this subgroup occupy the anticlinal crests, whereas the younger rocks are exposed along the flanks. The Surma Group is conformably overlain by the Tipam Group (Middle Miocene). The latter is differentiated from the former by its common occurrence of arenaceous sediments. The Tipam Group is divided into a lower part (Tipam Sandstone) comprising mainly coarse–grained massive sandstone and an upper part (Girujan Clay) consisting of mottled clays with subordinate argillaceous sandstone. Dupitila Group (Upper Miocene) lies unconformably above the Girujan Clay and consists of coarse–grained, poorly consolidated ferruginous sandstones, intercalated with brown mottled clays. This Group is unconformably overlain by the Dihing Group (Upper Pliocene–Lower Pleistocene), which consists essentially of conglomerates with thin bands of sandstones and clays. Dihing Group is unconformably overlain by alluvial sands and pebble beds of Middle Pleistocene to Recent age. The generalized geological succession is depicted in Table 1 (GSI, 1974).

Table 1—Generalised stratigraphic succession in Tripura (After GSI, 1974).

Group	Formation	Lithology
Recent	Recent	Alluvium represented by unconsolidated pale to dirty grey silt, sand, clay, silty clay, sandy clay, sometime with decomposed vegetable matters and yellowish brown coarse river sand, gravels and concretions.
		Unconformity
Dupitila (Upper Miocene)	Dupitila	Earthy–brown to buff sandy clays with greyish brown to reddish–brown sandy loam, mottled sandy clays, clayey sandstone, coarse to gritty ferruginous sandstone including lenticular bands, pockets of bluish to grey plastic clays, white silica sand and laterites.
		Unconformity
Tipam (Middle Miocene)	Champanagar	Massive medium to coarse, friable, sub–arkosic sandstone with occasional laminae of sandy–shale and abundant lumps of silicified fossil woods.
		Contact gradational
	Manu Bazar	Fairly bedded, fine to medium, subarkosic sandstone, including laminated layers and thick lenticular bands of sandy–shale, siltstone and sandy mudstone.
		Contact transitional
Surma (Early–Middle Miocene)	Bokabil (Middle Miocene)	Thinly laminated and thinly bedded repetition of sandstone, siltstone/ shale alternation, shales, mudstone and ferruginous sandstone with irregular partings of fine to coarse sand and interstratified thick, occasionally lenticular horizon of medium to coarse, micaceous sandstone with mudstone.
		Contact gradational to transitional
	Bhuban (Early Miocene)	Indurated hard, compact, both massive and well bedded sandstone, dark to olive shale, sandy shale and siltstone repeatedly occurring in space.
		Base not seen

MATERIAL AND METHODS

The samples for the present study were collected from the Amarpur–Maharanichera cliff road section exposed at Amarpur. The base is marked by a conglomerate bed and thereafter the section comprises of alternating shale, mudstone, siltstone and sandstone beds. The basal part consists of bluish–grey units occasionally yielding fragmentary leaf impressions; while the upper part comprises red, yellow variegated beds. Depending on the change in sediment type, twelve samples were collected from the mudstone–siltstone–shale beds (Fig. 1). The sandstone beds were not sampled as they do not yield palynomorphs.

Approximately 50 gm of each sample were carefully cleaned and disaggregated prior to the removal of carbonates by immersion in cold hydrochloric acid. Silicates were then dissolved with hydrofluoric acid, and fluorides and any remaining carbonates were eliminated by further immersion in hydrochloric acid. The organic residue so obtained was oxidized with nitric acid and then washed with potassium hydroxide solution. Following frequent washing and neutralization with distilled water, the palynomorphs were concentrated using a 400 mesh and mounted in Canada Balsam with the help of polyvinyl alcohol. Specimens were photographed under Olympus BH2 microscope in bright field illumination.

PALYNOLOGY

The palynoflora consists of a rich assemblage of marker pollen–spores of Miocene age, comprising fungi, pteridophytes, gymnosperms and angiosperms. Some stratigraphically important forms are *Striatriletes susannae, Pteridacidites vermiverrucatus, Pilamonoletes moderatus, Malvacearumpollis bakonyensis, Compositoipollenites conicus, Bombacacidites bambaxoides, Trisyncolpites ramanujamii, Polyadopollenites miocenicus,* etc. Besides the Miocene taxa, a diverse spectrum of reworked Permian palynomorphs of Gondwanan affinity have been recovered, which are listed in Table 2. Some important reworked pollen–spores are shown in Pl. 1.

Table 2—Showing the list of the reworked palynomorphs.

Jayantisporites pseudozonatus
Anapiculatisporites sp.
Acanthotriletes ciliates
Barakarites implicates
Indotriradites korbaensis
Cyclogranisporites minutes
Laevigatosporites colliensis
Rhizomaspora radiata
Rhizomaspora triassica
Parasaccites korbaensis
Parasaccites diffuses
Plicatipollenites gondwanensis
Virkkipollenites orientalis
Densipollenites indicus
Divarisaccus lelei
Scheuringipollenites tentulus
Alisporites sp.
Aurangapollenites sp.
Cf. *Hamiapollenites* sp.
Faunipollenites varius
Striatopodocarpites diffuses
Verticipollenites gibbosus
Crescentipollenites fuscus
Falcisporites stabilis
Klausipollenites schaubergeri
Primuspollenites sp.
Gingkocycadophytes cymbatus
Guttulapollenites hannonicus

Palynological study of Amarpur–Maharatrichera cliff road cutting section has yielded quite a diverse Permian palynoassemblage of Gondwanan affinity. This assemblage has an essential unity manifested by the uniform presence of trilete spores, radial monosaccates, non–striate and striate disaccate pollen. The triletes mainly include *Jayantisporites pseudozonatus, Anapiculatisporites* sp., *Acanthotriletes ciliates* and *Barakarites implicatus*. The monolete spores include *Laevigatosporites colliensis*. The monosaccate pollen are represented by *Parasaccates korbaensis, P. diffuses, Plicatipollenites gondwanensis, Virkkipollenites orientalis*

PLATE 1

→

1. *Parasaccites korbaensis* BSIP Slide No. 15546.
2. *Parasaccites diffuses* BSIP Slide No. 15546.
3. *Parasaccites* sp. BSIP Slide No. 15547.
4. *Parasaccites* sp. BSIP Slide No. 15546.
5. *Plicatipollenites gondwanensis* BSIP Slide No. 15545.
6. *Virkkipollenites orientalis* BSIP Slide No. 15546.
7. *Divarisaccus lelei* BSIP Slide No. 15545.
8. *Rhizomaspora triassica* BSIP Slide No. 15547.
9. *Rhizomaspora radiata* BSIP Slide No. 15547.
10. *Jayantisporites pseudozonatus* BSIP Slide No. 15545.
11. *Barakarites implicates* BSIP Slide No. 15545.
12. *Scheuringipollenites tentulus* BSIP Slide No. 15546.
13. *Aurangapollenites* sp. BSIP Slide No. 15547.
14. *Primuspollenites dicavus* BSIP Slide No. 15546.
15. *Faunipollenites varius* BSIP Slide No. 15547.
16. Cf. *Hamiapollenites* sp. BSIP Slide No. 15546.
17. *Falcisporites stabilis* BSIP Slide No. 15545.
18. *Chordasporites* sp. BSIP Slide No. 15546.
19. *Guttulapollenites hannonicus* BSIP Slide No. 15545.
20. *Lygodiumsporites lakiensis* (Miocene) BSIP Slide No. 15546.

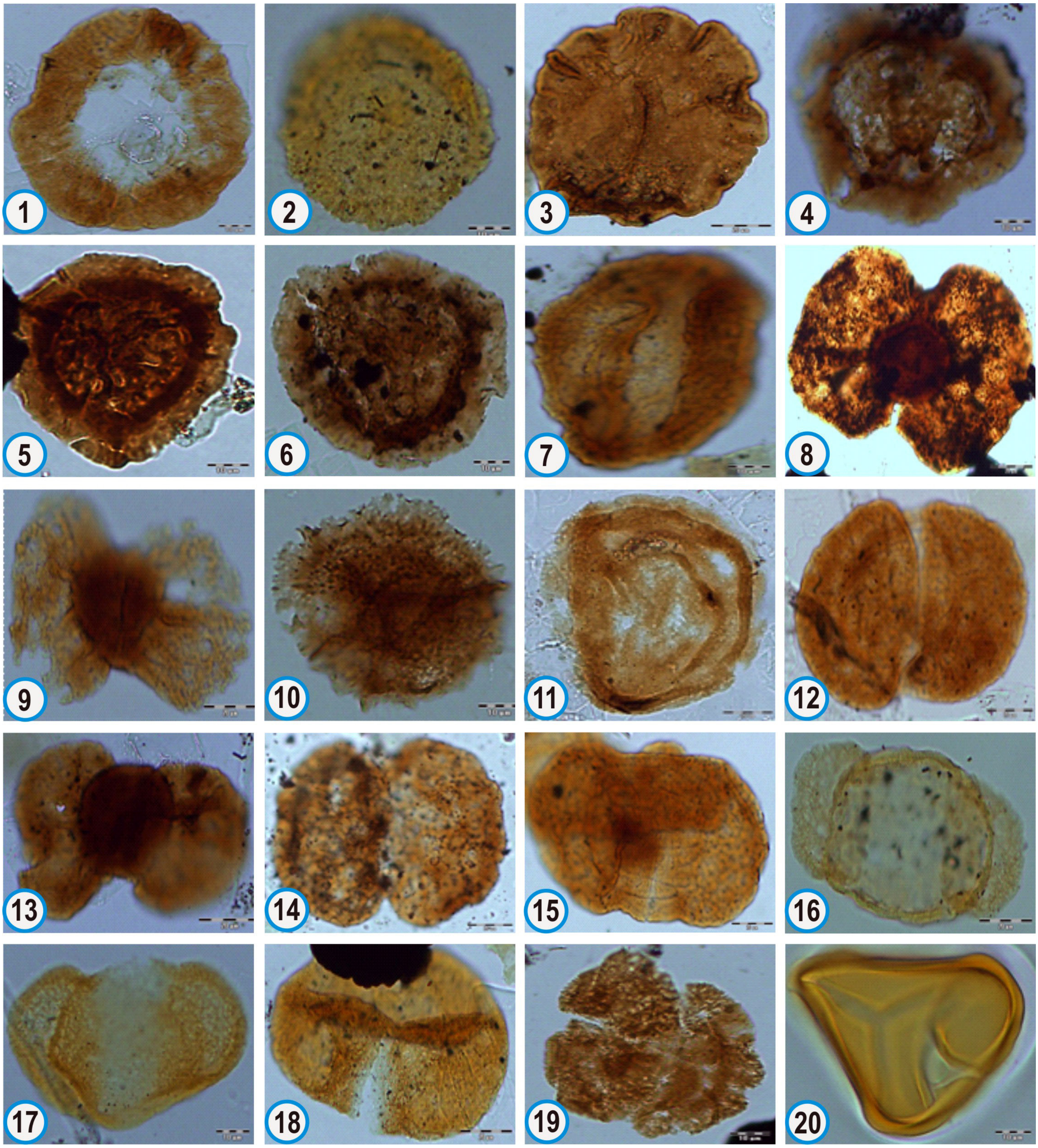

PLATE 1

and *Densipollenites indicus.* Non–striate disaccate pollen are also important components of the assemblage and include *Alisporites* sp., *Scheuringipollenites tentulus, Falcisporites stabilis, Klausipollenites schaubergeri* and *Primuspollenites* sp. Amongst the striate disaccate pollen, most common and consistantly occurring forms are *Faunipollenites varius, Crescentipollenites fuscus, Striatopodocarpites diffuses* and *Verticipollenites gibbosus.* Other important forms recorded are *Rhizomaspora radiata, Ginkgocycadophytes cymbatus* and *Guttulapollenites hannonicus.*

The monosaccates, mainly *Parasaccites* and *Plicatipollenites,* along with striate and non–striate pollen and other Gondwanan forms constitute between 70 and 80 percent of the total assemblage. Individual species belonging to these groups range throughout the sequence, and seldom marked fluctuations in abundance, from sample to sample, are observed. The palynological evidence strongly points to the presence of stable floral elements across the Permian. Some sporadic early Triassic forms have also been recovered. However, the majority of reworked forms are of early Permian age as evidenced by the dominance of radial monosaccates. Similar assemblages have been commonly recorded from across the different Gondwana coalfields of peninsular India (Tiwari & Tripathi, 1992).

The occurrence of reworked Permian palynofossils in the Miocene sediments is significant as it is of help in deciphering the environment of deposition of the sediments of Bhuban Formation in the Amarpur area. The Permo–Triassic sediments along with the pollen–spores, were carried from the adjoining hinterland by streams and deposited in the mouth of the delta during the early–middle Miocene times. Besides, since the Gondwanan palynomorphs are in dominance and tend to overwhelm the Miocene elements, care has to be taken while studying the stratigraphy of the area.

DISCUSSIONS

The recycled palynomorphs are mostly poorly preserved than those of indigenous assemblage; however, some possibly transported from short distances are comparatively better preserved. Presently the older sediments occur as a small patch of lower Gondwana deposits at Singrimari in Garo Hills. The present study also records the occurrence of early Triassic palynomorphs like *Klausipollenites,* which indicates that these sediments were exposed for long durations, across the Permian and encompassing the Permo–Triassic transition. Reworked palynofossils of Permian age have so far been recorded from the Tertiary sediments of Assam, Meghalaya and Bangladesh (Datta & Banerjee, 1979). Sharma *et al.* (1986) recorded both Permian and early Cretaceous palynofossils from Barpathar Well No. 1 of Upper Assam.

The occurrence of recycled palynomorphs indicates that bulk of the material for the Tripura Basin was derived from the pre–existing Permian and Cretaceous sediments. This poses an important question as to wherefrom these palynofossils came? The Gondwana sediments are not exposed in the vicinity of the area of study and such sediments in Meghalaya are known only from isolated outcrops at Singrimari in Garo Hills (Fox, 1935; De & Boral, 1982). Besides, lower Gondwana sediments are also developed in the Himalayan foothills of Bhutan and Arunachal Pradesh, which are relatively far off. The Cretaceous sediments on other hand are exposed very near to the area of study and possibly might have contributed to the early Miocene sedimentation.

The source of Permian palynofossils is however debatable. Although, the possibility of these forms being transported directly from the Himalayan foothills or Singrimari cannot be ruled out, it also appears likely that there might be extensive development of Permian sediments in Khasi and Jaintia Hills, which in due course had been eroded and possibly redeposited in the Cretaceous sediments. The Cretaceous sediments containing the reworked Permian palynoflora acted as a source for the sedimentation during Miocene times. Probably, when the deposition of Bhuban sediments was taking place the then existing drainage channels eroded the older formations in the region, particularly wherever these were exposed in the faulted blocks, and washed down the Permian sediments into the basin during their course of transportation (Evans, 1932). Occurrence of trap wash in many of the studied sections in the region below the pre existing formations is also quite common. The recycling of the Permian palynofossils in the Cretaceous sediments has already been reported by Jain *et al*. (1975) and Dutta (1979), which supports the above contention

The recycling of the Gondwana palynofossils in the present context may also be related with the orogeny of Himalayas. According to Valdiya (1984) the second upheaval of deformation in the evolution of Himalayas took place during Late Eocene–Oligocene. The Gondwana sediments also probably underwent deformation during the evolution of Himalayas and were then subjected to various degrees of erosion to get deposited again with the Tertiary sediments.

CONCLUSIONS

- The sediments of the Bhuban Formation (early Miocene) were deposited under deltaic environment. This is evidenced by the presence of dinoflagellate cysts and *Spinizonocolpites* referable to *Nypa*, which indicate near shore environment of deposition.
- The occurrence of reworked Permian palynofossils in the present assemblage has significant implications for palaeoenvironment and stratigraphy of the region.
- Since the reworked Permian palynofossils are more abundant than the Miocene taxa, care should be taken while interpreting the stratigraphy of the region.

- The source for the Permian palynomorphs could be former extensive Gondwana exposures in the region, reworked Cretaceous sediments or the Himalayan foothills.

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