PALYNOSTRATIGRAPHY OF THE SEDIMENTARY FORMATIONS OF THE ARUNACHAL PRADESH, 2. PALYNOLOGY OF THE SIWALIK EQUIVALENT ROCKS OF KAMENG DISTRICT

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ABSTRACT

Based on apparent stratigraphical similarity, the upper Tertiary rocks of the eastern Himalayas were considered as the continuation of the western Himalayas and have been regarded as Siwalik. The present work suggests that these rocks are possibly a continuation of the Tertiary sequence of the Brahmaputra Valley. The sediments show maximum thickness in the Kameng District and become thinner in the south easterly direction. The palynological assemblage shows mixed type of flora having Tertiary elements mixed with Permian, indicating recycled deposition. The Permian sediments were brought down to the sub-Himalayan ranges from the north, i.e. Tibetan Section. The indigenous palynotaxa suggests a Middle Miocene age for these sediments.

INTRODUCTION

The eastern Himalayas which lie between longitudes 91° 40′ and 97° 11′, or in other words, between the eastern boundary of the land of the Twang and the Khampa Bhutias, Lohit on the West having Assam on its south and Tibet on its north constitute Arunachal Pradesh. The area under discussion forms the westernmost part of the Kameng District, Arunachal Pradesh, bordering the state of Bhutan.

Physiographically, the district can be divided into three broad divisions : 1. The Upper Tertiary (Siwalik?) sub-Himalayan tract with hill ranges trending EW to ENE-WSW and rising to an altitude of 1,500 metres. This forms the 15-20 km wide foot hills and lies to the south. 2. The Lesser Himalayan Ranges represent the middle division. 3. The northern most part is represented by Great Himalayan ranges with such well known peaks as Kangte (7,048 m) and Gorichen (6,500 m).

The Kameng Valley exhibits low but steep hills of Tertiary rocks (Siwalik?) which are densely forested and dissected by several streams flowing E-W in the strike direction. Kameng is the main river flowing south across the hilly terrain. In the Upper Tertiary Zone its course is along N-S gorges. The western tributaries are the Tenga and the Bischen and eastern tributaries are the Paper and Pasar. On the north-western corner of the district across the Sela Pass (4242 m) is the Twang Valley draining west into Bhutan.

Previous work—The first geological traverse in the area was carried out by La Touche in the year 1885. The Geological Survey of India has started detailed geological mapping since 1962 but unfortunately the results of these surveys have not been published so far except a well compiled report in 1974 (Mis. Publ. No. 30). In the same year JAIN *et al.* (1974) published an informative and comprehensive paper on the stratigraphy and structure of the Siang District. In 1976, RAMACHANDRAN AND MALLIK of Geological Survey of India reviewed the geology of the Kameng District. KARUNAKARAN AND RANGA RAO (1976) of Oil and Natural Gas Commission have dealt with the geology of the Himalayas in great detail.

BANERJEE (1968) reported Siwalik mioflora from the Punjab Himalayas. DUTTA AND SINGH (in press) have studied the palynology of the 'Siwalik' rocks of the sub-Himalayan tract of the area around Bhalukpung of Kameng District. On the basis of this study they could identify four different groups of rock. Their palynological study of the 'Siwalik' sediments from the Kameng District shows that the contained palynomorph assemblages are of mixed nature. Indigenous elements in the Siwalik assemblage point out to Miocene age whereas the recycled elements point to source areas of the Lower Gondwana rocks to the north.

NOMENCLATURE

Before entering into details of the geology of the area, a little discussion on its nomenclature is important. The Upper Tertiary rocks of the Aurnachal Pradesh are described by different authors under different names. RAMACHANDRAN AND MALLIK (1976) have described them from bottom upwards as Tipam, Namsang and Dihing sediments as they are found in the Brahmaputra Valley to the south. The workers of Burma Oil Company and Wadia Institute of Himalayan Geology have described them as Siwaliks. According to KARUNAKARAN AND RANGA RAO (1976) the Siwalik Group comprises the Dafla, the Subansiri and the Kimin Formations. Recently, DUTTA AND SINGH (*loc. cit.*) have described them as Siwaliks and correlated them with the Surma, Tipam, Namsang and Dihing/Dhekiajuli Formations of the Brahmaputra Valley. For geologists working on the Upper Tertiary Stratigraphy of this part of the country the use of different nomenclature is rather confusing.

In this paper an attempt has been made to suggest their relationship with the Upper Tertiary Formations observed in Upper Assam lying to the south bank of the Brahmaputra.

GEOLOGY

The rock formations observed in the area under discussion are only the Lower Gondwana coal bearing sediments of Permian and the Upper Tertiaries.

Gondwanas—The Gondwana sediments are well exposed on the road sections about 16 km north of Bhalukpung, extending east west with northerly dips. Here workable coal seams have been observed on the road side. They vary in thickness from a few centimeters to about 6 metres. A recent map published by the Geological Survey of India (1974) shows that this coal extends up to the Siang District. On the west they continue up to Bhutan. More recent work reveals that there is no coal seam in the Siang District from where coal seams had been reported earlier.

The sediments consist of gritty sandstone, variegated shales, khaki green shale, micaceous sandstone and grey and carbonaceous shales. The base of the Gondwana sediments is represented by a green micaceous crumpled shale (JAIN *et al.*, *loc. cit.*) and is well exposed at Km 40/0 on Likabali-Along road in the district of Siang. However, in the present area the base of the Gondwana has not been observed.

DUTTA AND SINGH (*loc. cit.*) attempted to study the palynology of the Gondwana coal and shale exposed on the Bhalukpung-Bomdila road. But unfortunately no sample yielded any palynotaxa. It is presumed that the coal and shale of that area were subjected to severe metamorphism and as a result no palynoforms could be survived.

Recently, SRIVASTAVA AND DUTTA (1977) have, however, studied the palynology of the Gondwana sediments exposed along Garu-Gensi road, for a distance of about 18 km in the district of Siang, Arunachal Pradesh. Here the Gondwana sediments form a long

strip comprising of khaki green shale, black shale, carbonaceous phyllite, calcareous and greenish grey micaceous sandstone, mudstone and siltstone.

Siwalik—The Upper Tertiary rocks are well observed on the Bhalukpung-Bomdila road (Table 1). In the present area (Misamari road section) they are thin and not divisible into the four units as has been done in the central portion of the Kameng District (DUTTA & SINGH, *loc. cit.*). In the area under discussion they are represented by micaceous sandstone, hard, poorly-bedded ferruginous sandstone, with bluish grey clay and siltstone. Possibly these rock types represent the bottom unit of the 'Siwalik'.

Since the entire thickness of the Upper Tertiaries is not represented in the area of study and does not have good exposures, systematic sedimentological study could not be made. However, preliminary sedimentological study on samples around Bhalukpung shows close resemblance of these rock types with the Upper Tertiary rock types encountered in oil-wells at Dibrugarh and Sibsagar Districts. An attempt has been made to suggest the relationship (Table 1) of the different units of 'Siwalik' of Kameng District with the Upper Tertiary rock types of the Brahmaputra Valley of Upper Assam.

Palynology—The occurrence of palynotaxa from the 'Siwalik' of the Kameng District was first reported by DUTTA AND SINGH (*loc. cit.*). They have studied the section along Bhalukpung-Bomdila road. The study reveals the presence of a mixed type of flora consisting of Permian, Eocene and Miocene palynotaxa. Amongst Permian, the following taxa are quite common : *Cuneatisporites* sp., *Scheuringipollenites* sp., *Veliasaccites* sp., *Densipollenites* sp., *Parasaccites* sp., *Striapollenites* sp., etc. Based on the palynological data the 'Siwalik' sediments have been subdivide into three zones. The characteristic palynotaxa recorded here are listed below :

Polypodiaceoisporites sp., *Striatriletes susannae* van der Hammen 1956, *Leptolepidites assamicus* sp. nov., *Punctatisporites gretensis* Balme & Henn. 1956, *Laevigatosporites colliensis* (Balme & Henn.) Venkat. & Kar 1968, *Tiwariasporis gondwanensis* (Tiw.) Maheshw. & Kar 1967, *Cannanoropollis obscurus* (Lele) Bose & Maheshwari 1968, *Platysaccus papilionis* Pot. & Kl. 1954, *P. densus* Kar 1968, *Striatites ornatus* Venkat. & Kar, 1968, *Lahirites raniganjensis* Bharad. 1962, *Strotersporites decorus* (Bharad. & Sal.) Venkat. & Kar 1964, *S. magnificus* (Bharad. & Sal.) Venkat. & Kar 1964, *Scheuringipollenites maximus* (Hart.) Tiw. 1973, Microplankton type- 1, Microplankton type-2. Out of these-*Leptolepidites assamicus* sp. nov. and Microplankton types 1 and 2 have been described in detail while the rest are illustrated in Plates 1 and 2.

Infraturma	APICULATI (Bennie & Kidston) Potonié, 1956
Genus	**Leptolepidites** Couper, 1953
Type species	*Leptolepidites verrucatus* Couper, 1953

Leptolepidites assamicus sp. nov.

Pl. 1, Fig. 16 ; Pl. 2, Figs. 18-20

Holotype—Pl. 2, Fig. 19., Size 47 μm

Diagnosis—Spores subcircular, 35-52 μm. Trilete generally not observed. Exine heavily verrucose at equatorial region, proximally laevigate, verrucae also present on distal side.

Comparison—*Leptolepidites* sp. A and B. reported by SAH AND KAR (1969) from the Eocene sediments of Kutch are comparable to the present species in shape but are much larger in size range. Moreover, the specimens described by SAH AND KAR (1969) have

verrucae of same size whereas in the present ones, the equatorial verrucae are much larger in size than the rest.

Incertae sedis

Microplankton type-1

Pl. 1, Fig. 13; Pl. 2, Figs. 25, 32

Description—Microplankton subcircular-oval in shape, 54-96 μm. Wall up to 2 μm thick, psilate, irregularly folded. A circular operculum mostly observed.

Microplankton type-2

Pl. 1, Fig. 12

Description—Microplankton subcircular, 38 μm. Wall about 1.5 μm thick, sculptured with grana. A big operculum present in central region.

DISCUSSION

The Lower Gondwana sediments in the sub Himalayan ranges of the N. E. Region are thrust to the south over the younger Tertiaries. The contact between the Gondwanas and younger Tertiaries (Siwalik) is elsewhere described as the Main Boundary Fault. In Arunachal, JAIN *et al.* (1974) have named this thrust as the 'Garu Thrust'.

Although no palynoforms could be recovered from the Gondwanas of Kameng, the presence of Permian mioflora in the Upper Tertiary sediments does indicate the existence of such flora in the area. It has already been mentioned earlier (SRIVASTAVA & DUTTA, 1977) that the Gondwanas of Siang District show quite rich miofloral assemblages.

No discrete signs of glaciation are observed anywhere in the present area. The presence of calcareous sandstone within the formation suggests marine environment while semi-anthracite, micaceous sandstone and carbonaceous phyllite suggest various degrees of metamorphism.

BANERJEE (1968), who studied the palynology of the Lower and Middle Siwalik sediments of the Bhakra-Nangal area, Punjab, opined that palynologically the rocks are very poor. He mentioned that it is difficult to demarcate the boundaries of these sediments on the basis of qualitative analysis. However, a quantitative method was found satisfactory. No mioflora older than Tertiaries have been observed in these rocks.

In the area under discussion, the younger Tertiary rocks show recycled floral elements. It is interesting to note that the Surma and Tipam Formations of Upper Assam which are correlated with the Lower-Middle rock types of the Siwalik Group of the Eastern Himalayas also contain recycled elements, viz. Permian and Lower-Middle Tertiary.

BANERJEE *et al.* (1973) have reported the presence of Miocene and Mio-Pliocene forms along with some recycled palynotaxa of Permian from the different oil-wells of Sibsagar District, Assam. The characteristic Permian palynotaxa are *Scheuringipollenites* sp., *Verticipollenites* sp., *Striatites* sp., *Alisporites* sp., etc.

Recently DUTTA (1978) has recorded *Vesicaspora* sp., *Platysaccus* sp., *Striapollenites* sp., *Parasaccites* sp., from the Upper part of the Bhuban Formation at Nichuguard, Nagaland and *Vesicaspora* sp., *Alisporites* sp., *Striatopodocarpites* sp. from the Surma Formation of Miocene age from the Tipangpani area, Dibrugarh District, Assam.

The Siwalik sediments of North-Western Himalayas are prolific in vertebrate fossils whereas in the Arunachal Pradesh except for an isolated occurrence of mamalian fossil

Table 1—Correlation Chart of Upper Tertiary lithostratigraphic units of Arunachal Pradesh with Upper Assam Valley (After S. K. Dutta and H. P. Singh (in press).)

	ONGC (Burai River)			B.O.C. (Subansiri River)			Jain *et al.* (Siang District)			Dutta & Singh (Kameng-Along Bomdila road)			
Probable Age	*Formation*	*Lithological Description*	*Thickness* m	*Formation*	*Lithological Description*	*Thickness* m	*Formation*	*Lithological characters*	*Thickness* m	*Formation*		*Lithological characters*	Suggested correlation with Upper Assam Stratigraphy
Pleistocene	Kimin	Alterations of soft massive sandstone, silty clays and gravel beds.	3,000	Group A (Upper Siwaliks)	Soft, massive, coarse-grained, bluish-grey sandstone with many pebble bands.	1,560	Unit A	Grey, massive to bedded, siltstone, nodular silty shale and clay shale; conglomerate stringers & lenses.	2,000	Unit A	SIWALIK GROUP	Soft massive sandstone grey green laminated siltstone, clay and pebble bands.	Dihing/Dhekiajuli
	Upper Subansiri	Predominantly soft sandstone alternating with silty clay bands.	800	Group B (Upper Siwaliks)	Mainly massive type coarse bluish-grey sandstone with occasionally poorly bedded sandstone.	458	Unit B	Conglomerate with sandstone interbeds; roller and bladed shape clasts of quartzite.	200	Unit B		Massive, soft coarse grained dirty white to blue grey sandstone with silty clay bands	Lwang (Namsang ?)
Pliocene to Upper Miocene	Lower Subansiri	Monotonous sandstone, soft and massive.	1,830		Soft, medium to coarse-grained sandstone with bands of lignite.	258				Unit C		Soft medium to coarse grained poorly bedded sandstone with lenses and stringers of coal	Tipam Sandstone
Miocene	Dafla	Alternations of hard sandstone and shale.	2,400	Group C	Massive, poorly-bedded, hard fairly coarse, blue grey, ferruginous sandstone, micaceous in parts; frequently jointed and fractured.	1,340	Unit C	FAULT Grey, hard, micaceous sandstone, siltstone and shale	2,500	Unit D		Micaceous sandstone, hard poorly bedded, ferruginous sandstone with bluish grey clay	Surma

Table 1—Correlation Chart of Upper

ONGC (Burai River)

Probable Age	*Formation*	*Lithological Description*	*Thickness* m
Pleistocene	Kimin	Alterations of soft massive sandstone, silty clays and gravel beds.	3,000
	Upper Subansiri	Predominantly soft sandstone alternating with silty clay bands.	800
Pliocene to Upper Miocene	Lower Subansiri	Monotonous sandstone, soft and massive.	1,830
Miocene	Dafla	Alternations of hard sandstone and shale.	2,400

per Tertiary lithostratigraphic units of Arunachal Pradesh with Upper Assam Valley (After S. K. Dutta and H. P. Singh (in press).)

	B.O.C. (Subansiri River)			Jain *et al.* (Siang District)			Dutta & Singh (Kameng-Along Bomdila road)		
s	*Formation*	*Lithological Description*	*Thickness* m	*Formation*	*Lithological characters*	*Thickness* m	*Formation*	*Lithological characters*	Suggested correlation with Upper Assam Stratigraphy
	Group A (Upper Siwaliks)	Soft, massive, coarse-grained, bluish-grey sandstone with many pebble bands.	1,560	Unit A	Grey, massive to bedded, siltstone, nodular silty shale and clay shale ; conglomerate stringers & lenses.	2,000	Unit A	Soft massive sandstone grey green laminated siltstone, clay and pebble bands.	Dihing/Dhekiajuli
	Group B (Upper Siwaliks)	Mainly massive type coarse bluish-grey sandstone with occasionally poorly bedded sandstone.	458	Unit B	Conglomerate with sandstone interbeds; roller and bladed shape clasts of quartzite.	200	Unit B	Massive, soft coarse grained dirty white to blue grey sandstone with silty clay bands	Lwang (Namsang ?)
		Soft, medium to coarse-grained sandstone with bands of lignite.	258				Unit C	Soft medium to coarse grained poorly bedded sandstone with lenses and stringers of coal	Tipam Sandstone
	Group C	Massive, poorly-bedded, hard fairly coarse, blue grey, ferruginous sandstone, micaceous in parts ; frequently jointed and fractured.	1,340	Unit C	FAULT Grey, hard, micaceous sandstone, siltstone and shale	2,500	Unit D	Micaceous sandstone, hard poorly bedded, ferruginous sandstone with bluish grey clay	Surma

SIWALIK GROUP

viz. *Bos* in the Burai river section about 1.5 Km upstream of Ramghat, the Siwaliks are barren. There is also much difference in lithology between the Siwaliks of Western and Eastern Himalayas. The characterstic red clays of North Western Siwaliks are entirely missing in the Eastern Himalayas and are replaced by dark grey carbonaceous or green clays (KARUNAKARAN & RAO, 1976). RANGA RAO (1974) has reported that recent studies in the eastern Himalaya-Bhutan, Arunachal areas, indicate that the Siwalik basin was not a continuous depression as postulated earlier, i.e. extending from Jammu to the Brahmaputra. It is terminated somewhere in the region of the Manas river in Central Bhutan.

The configuration of the deposits of the Upper Tertiary rocks of the Arunachal Pradesh suggests that the sediments are thinning out from west to east, indicating transportation from north-west to south-east. The presence of coal in the Kameng District, and lacking in eastern part is also confirming this impression. As regards the depositional environment, the concept that the whole of the Siwaliks on the foot-hills of the Himalaya are due to the Indo-Brahm river as postulated by PASCOE (1919) and PILGRIM (1919) was subsequently refuted by KRISHNAN AND AIYANGER (1940) who instead advocated deposition by glacial streams flowing from the north and debouching their load of sediments into the lakes and basins or lagoons left by the Eocene sea. The palynological assemblages described from the Tertiaries of the Kameng area contain Permian miospores along with typical Tertiary ones. In fact, Permian miospores are more abundant in some of the samples collected (S/K/1) than Tertiary miospores. The Permian spores and pollens obtained here include *Punctatisporites*, *Laevigatosporis*, *Tiwariasporis*, *Cannanorpollis*, *Platysaccus*, *Striatites*, *Lahirites*, *Strotersporites*, *Striatopiceites* and *Scheuringipollenites*. All these genera have been recorded from strata in the Lower Gondwana coalfields of Bengal and Bihar. Although most of the genera found in the Surma and Tipam Formations of Upper Assam both on the surface and sub-surface are not identical with those obtained in the Siang area, nevertheless, they are of Permian age.

It is significant that no recycled Gondwana polospores have been detected in the Barail Formation of Assam of Oligocene age. Further detailed mapping has shown that the Upper Barails (Oligocene) of both the Nakorkatiya and Moran oil fields are made up of a number of sandbodies each of which was deposited by river channels following approximately from northwest to southeast (BUZARBARUA *et al.*, 1975). There is a widespread pronounced unconformity at the end of the Barail Formation in Assam. Thus, upto the end of the Oligocene the Gondwanas of the present area did not come within the reach of the rivers flowing south into the Assam Sea. The orogenic uplift after the Oligocene brought these Gondwana-bearing areas within the source area of the then drainage system.

The presence of *Striatrilites* in the material is important in as much as this genus has not been recorded in any Palaeozoic or Mesozoic rocks. It is known to occur only in Upper Eocene and continues to grow in the region to the present time. Besides the presence of *Inaperturosporites* and *Leptolepidites* also proivde additional support for its Tertiary origin. So far the age of these material is concerned, it may belong to the Middle Miocene.

The above discussion suggests that the Upper Tertiary rocks of the Arunachal Himalayas are more closely correlatable to the Upper Tertiary sediments observed in the Upper Assam valley lying to the south bank of the Brahmaputra river. These rocks may be the time equivalent of the Siwalik of N. W. Himalaya rather than their actual extensions. The results of the aero-magnetic survey (OIL, personal communication) have also suggested that the transportation of the Upper Tertiary sediments were from north to south, i.e. from Himalayan side to the Assam valley.

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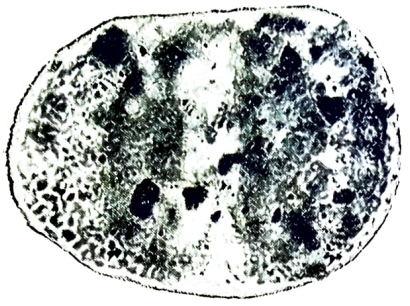

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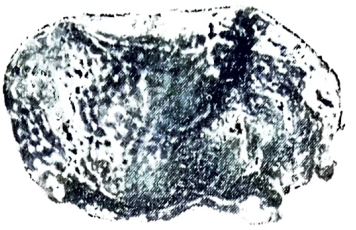

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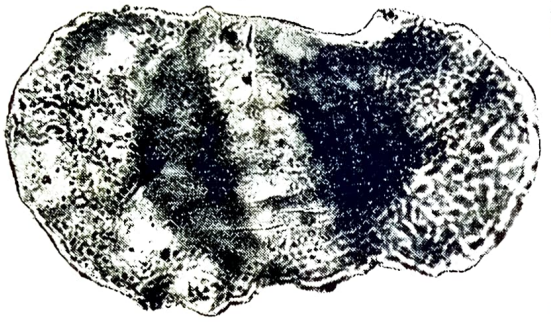

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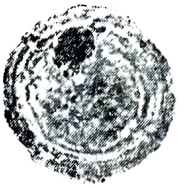

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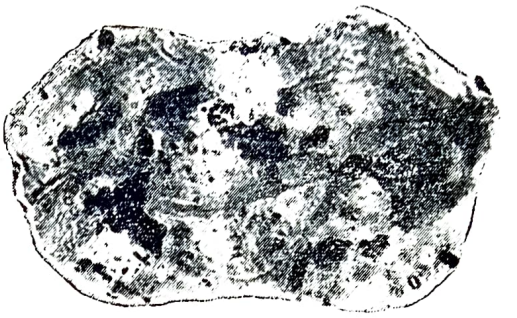

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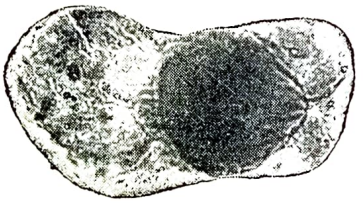

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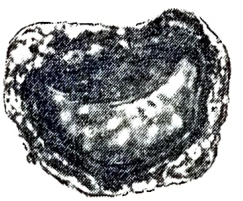

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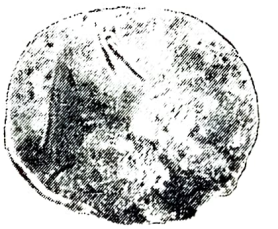

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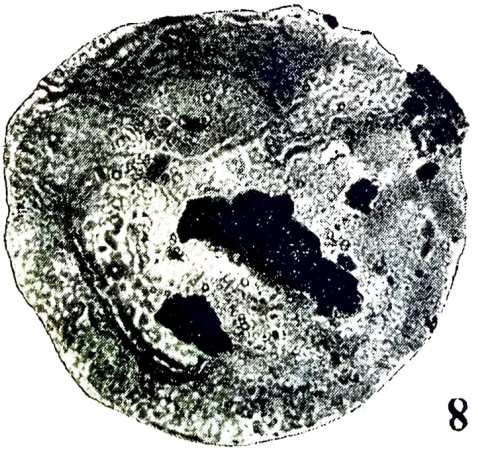

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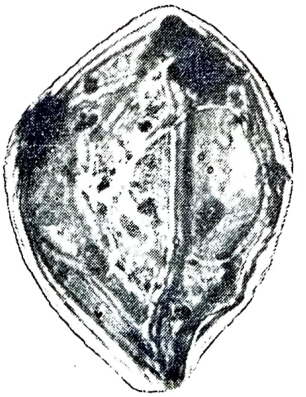

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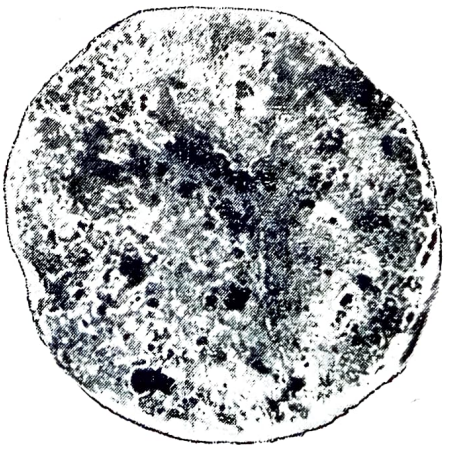

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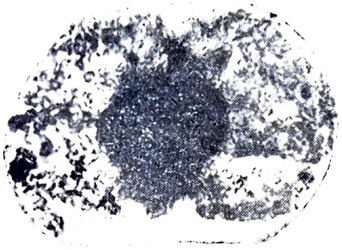

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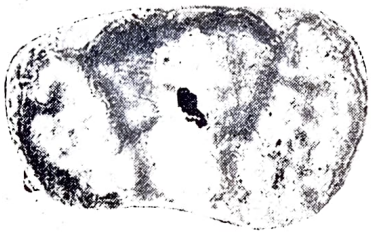

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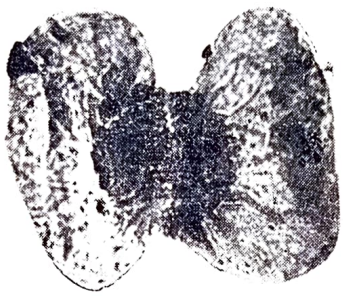

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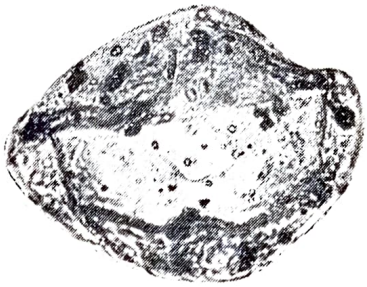

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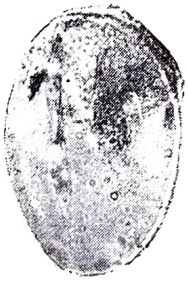

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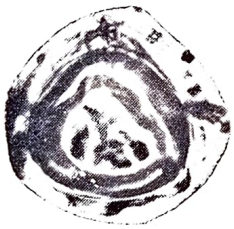

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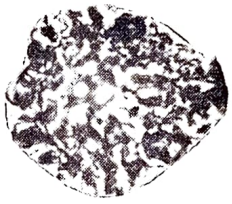

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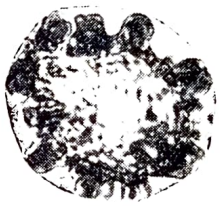

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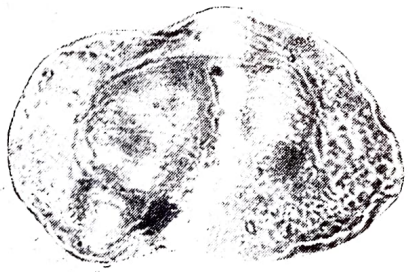

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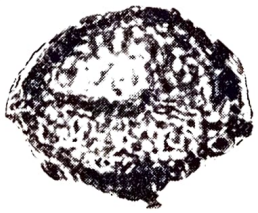

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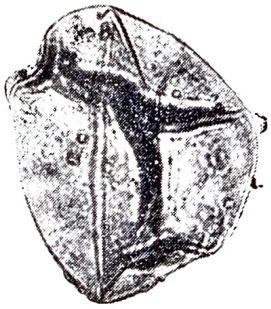

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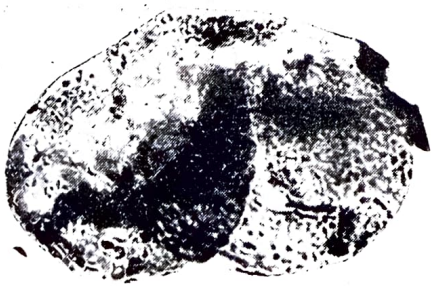

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Dutta—Plate 2

SRIVASTAVA, S. C. & DUTTA, S. K. (1977). A note on the Palynology of the Gondwanas of Siang District, Arunachal Pradesh. *Geophytology*. **7**(2) : 281-283.

TIWARI, R. S. (1973). *Scheuringipollenites*, a new name for the Gondwana sporomorphs so far assigned to "*Sulcatisporites* Leschik, 1955". *Senck. leth.* **54** : 105-117.

EXPLANATION OF PLATES

(All microphotographs enlarged *ca* × 500 unless otherwise mentioned)

PLATE 1

1. *Strotersporites magnificus* (Bharadwaj & Saluja) Venkatachala & Kar.
2. *Platysaccus densus* Kar.
3. *Striatites ornatus* Venkatachala & Kar.
4-5. *Strotersporites decorus* (Bharadwaj & Saluja) Venkatachala & Kar.
6. *Tiwariasporis gondwanensis* (Tiwari) Maheshwari & Kar.
7. *Lahirites raniganjensis* Bharadwaj.
8. *Cannanoropollis obscurus* (Lele) Bose & Maheshwari.
9. *Scheuringipollenites maximus* (Hart) Tiwari.
10-11. *Inaperturosporites kedvesii* Elsik.
12. Microplankton type 2.
13. Microplankton type 1.
14. *Lahirities raniganjensis* Bharadwaj.
15. *Punctatisporites gretensis* Balme & Hennelly.
16. *Leptolepidites assamicus* sp. nov.

PLATE 2

17. *Punctatisporites gretersis* Balme & Hennelly.
18-20. *Leptolepidites assamicus* sp. nov.
21. *Laevigatosporites colliensis* (Balme & Hennelly) Venkatachala & Kar.
22. ?Tetrad of *Punctatisporites* sp.
23-24. *Striatriletes sussannae* van der Hammen.
25. Microplankton type 1.
26. *Polypodiaceoisporites* sp.
27. *Platysaccus papilionsis* Potonié and Klaus.
28. *Strotersporites decorus* (Bharadwaj and Saluja) Venkatachala & Kar.
29-30. *Striatopiceites* sp.
31. *Lahirites raniganjensis* Bharadwaj.
32. Microplankton type 1.