JOURNAL OF THE PALAEONTOLOGICAL SOCIETY OF INDIA
VOL. 25, 1981, pp. 42—52 (*For* 1980)

A STUDY OF THE SURMA-TIPAM GROUPS OF UPPER ASSAM VALLEY, SOUTH OF BRAHMAPUTRA

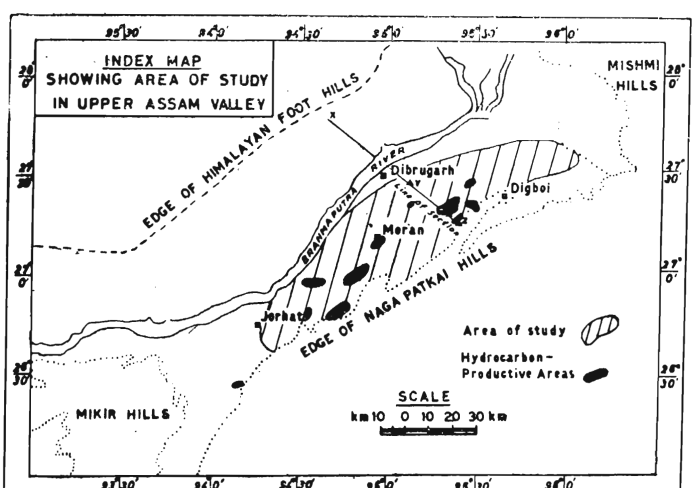
G. K. HANDIQUE[1] AND S. K. DUTTA[2]

ABSTRACT

This paper deals with the stratigraphical nomenclature, structure, lithofacies variation and palynology of the Surma-Tipam Groups of the Upper Assam Valley based mainly on subsurface data. The thickness of these groups generally increases in a southerly direction. The palynological assemblages of Surma-Tipam of Lower-Upper Miocene age show mixed type while Girujan of Uppermost Miocene contains only indigenous elements. All these sediments were deposited under fluviatile and swampy, humid and warm conditions in the area under discussion. The source rocks of these sediments were in the Eastern Himalayas.

INTRODUCTION

The sedimentary basin of the Upper Assam Valley forms the north-eastern corner of the Indian sub-continent. It is bounded on the north-west by the Eastern Himalayas, in the north-east by the Mishmi Hills, in the south-east by Naga Patkai Hills and in the south-west by the Mikir Hills. The area under study is mainly confined to the south bank of the Brahmaputra river and extends from near Jorhat in the west to the Kumchai in Arunachal Pradesh in the east (Index Map). Extensive drilling operations have been carried out in this area by Oil India Limited and Oil & Natural Gas Commission for oil exploration.



Outcrops of Tertiary rocks all along the Naga-Patkai Hills, separated from the Upper Assam alluvial plain by the major Naga and Margherita thrusts, provide a geological succession to study the Upper Tertiary sediments of the region. The outcrops of these rocks and the presence of oil seepages associated with them led to the discovery of Digboi oilfield as far back as 1889, the first pioneering step in the history of the Indian oil industry. There is today much scope to make detailed study of the stratigraphy of the alluvium-covered Upper Assam Valley of north-east India in the light of subsurface data obtained by drilling about 700 wells in the region. Though only a few wells have penetrated the full Tertiary succession down to the basement, almost all wells have encountered the Surma-Tipam Groups.

The main purpose of the work is confined mainly to study the lithological characteristics, lithofacies variation, electrolog characteristics, distribution of the formations in time and space, palynology and depositional environment of these groups. An attempt has also been made to clarify certain confusions that have arisen out of the new nomenclatures especially for Surma-Tipam Groups proposed by various workers in the recent past.

PREVIOUS WORK

Mallet (1876) was the first to attempt a preliminary classification of the Tertiary sediments of the Assam Valley. Later, the detailed classification of the Tertiary sequence of Assam including the hills bordering Assam Valley, central Assam ranges and the Surma Valley was done by Evans (1932, 1959), which is accepted till today as the basic classification. Recently, some authors have attempted to study the subsurface stratigraphy of the Upper Assam Valley. Bhandari *et al.* (1973) have introduced a few new names for the Upper Tertiary rocks of the Upper Assam Valley. Shrivastava *et al.* (1974) also put forward another classification for the same rock

[1]Geological Department, Oil India Limited, Duliajan, Assam.
[2]Applied Geology Department, Dibrugarh University, Dibrugarh, Assam.
[3]The paper was presented in the Third Geophytological Conference held in Lucknow, 8-10 December, 1979.
The views expressed herein are those of the authors only and not necessarily of the organisations for which they are working.

groups. For ready reference, the different names introduced for the same rock groups by different authors are given in Table 1.

From Table 1 it is clear that the use of the same names for different lithologic units and also the placement of an individual rock unit in different stratigraphic positions may mislead and confuse.

Baruah *et al.* (1975) have also attempted to study the Tipam Sandstone Formation based mainly on the electrolog evidence obtained from drilled wells in Nahorkatiya and neighbouring areas. On the basis of their study, Tipam Sandstone Formation has been subdivided into : Lower, Middle and Upper Tipam ranges. They have tried to correlate the stratigraphic units within the

Table 1. Comparative Stratigraphic Successions of Neogene Sediments in Upper Assam (Suggested by different Authors)

MATHUR & EVANS (1964)			BHANDARI et al. (1973)				SRIVASTAVA et al. (1974)		
Age (Approx.)	Group	Formation	Age (Approx.)	Super Group	Group	Formations	Group	Formation	Member
Recent—Pleistocene		Alluvium	Pre-Holocene—Holocene		Alluvium				
Unconformity									
Pliocene	DIHING	Dhekiajuli Beds	Late Pliocene—Pleistocene	BRAHMAPUTRA	MORAN	Dhekiauli			
Unconformity									
Pliocene—Miocene	DUPITILA	Namsang Beds	Late Miocene—Mid Pliocene			Namsang		Namsang	
Unconformity					Unconformity		Unconformity		
Miocene	TIPAM	Girujan Clay			TIPAM	Nazira Sandstone	TIPAM	Girujan Clay	Upper Clay Unit
						Girujan Clay			Teok Sandstone
									Lower Clay Unit
		Tipam Sandstone	Middle Miocene			Lakwa Sandstone		Nazira Sandstone	
								Lawka Clay	
	SURMA	Not sub-divided	Early Miocene		SURMA	Geleki Sandstone*		Geleki Sandstone	Geleki Sandstone
									Safrai Sandstone
Unconformity			Unconformity				Unconformity		
Oligocene	BARAIL		Oligocene		BARAIL		BARAIL		

(1) It is difficult to distinguish between the Alluvium and Dhekiajuli Formation from sub-surface evidence. From regional geological considerations, an unconformity may be inferred, separating the two rock units.

(2) Development of the Surma Group, which is extensive in the type area of the Surma Valley is doubtful in the Upper Assam Shelf area.

*The Geleki Sandstone is considered equivalent to the Surma Series of the type area in Surma Valley.

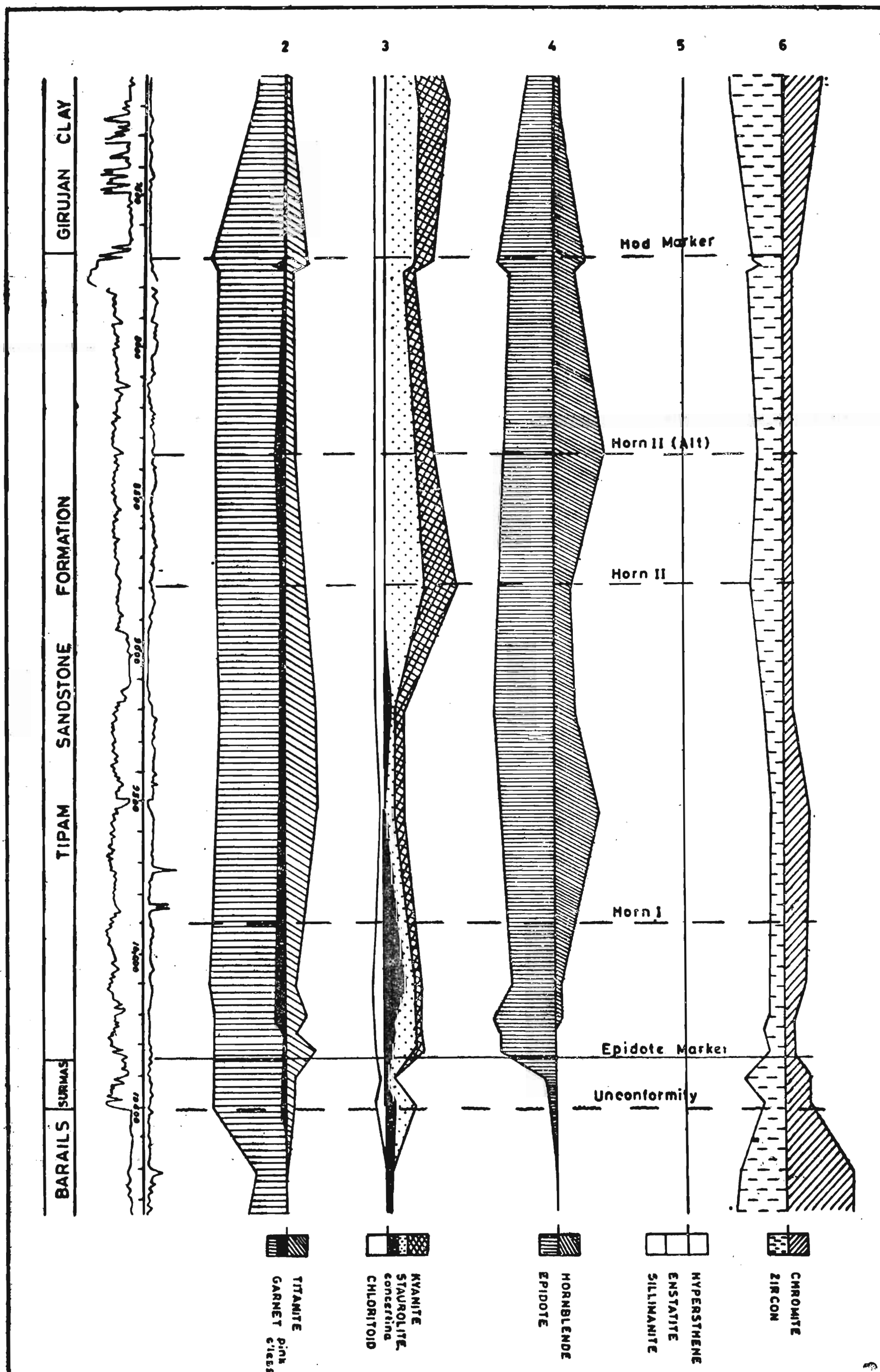

2
3
4
5
6
GIRUJAN CLAY
TIPAM SANDSTONE FORMATION
SURMAS
BARAILS
Hod Marker
Horn II (Alt)
Horn II
Horn I
Epidote Marker
Unconformity
TITANITE
GARNET pink
cless
KYANITE
STAUROLITE
CHLORITOID
HORNBLENDE
EPIDOTE
HYPERSTHENE
ENSTATITE
SILLIMANITE
CHROMITE
ZIRCON

Fig. 1

Tipam Sandstone Formation with those of the south-western part of the Upper Asasm Valley adopting the classification suggested by Shrivastava *et al.* (1974). As per this regional correlation, the Girujan Clay Formation encountered in Eastern Nahorkatiya and neighbouring areas has been shown to be equivalent of Girujan Clay, Nazira Sandstone and Lakwa Clay encountered in the western part of the valley in the time-stratigraphic scale.

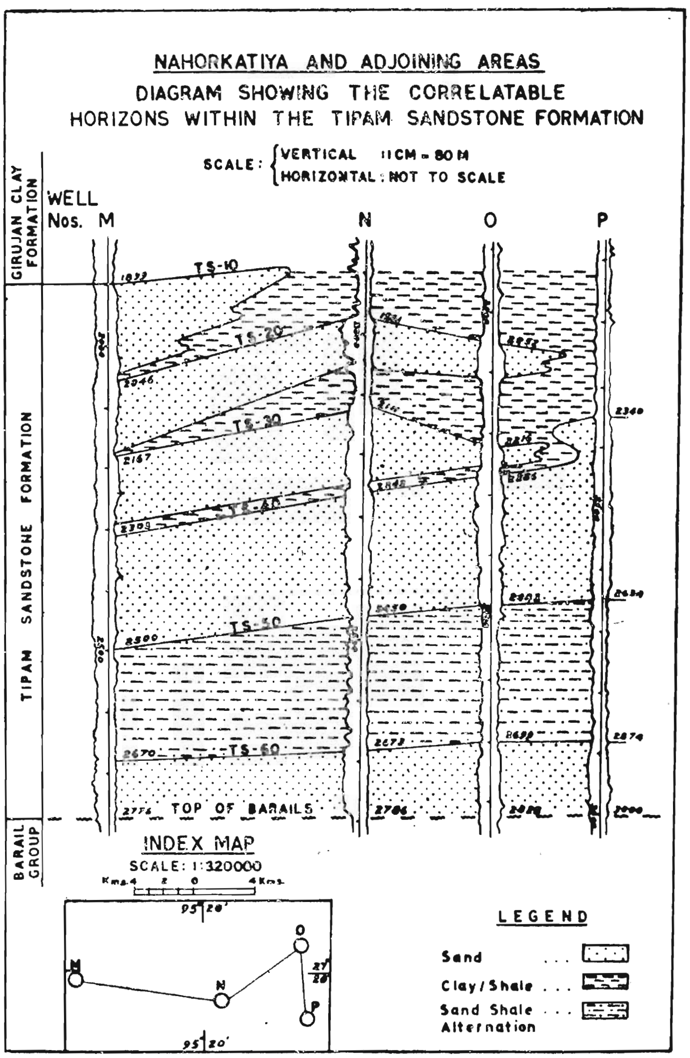


Fig. 2

These classifications may help only in detailed local correlation provided uniformity in naming the different formations and members is properly maintained. Hence, to avoid further confusion and for easy understanding, the present workers have adopted the classification of Mathur and Evans (1964).

GEOLOGY AND PALYNOLOGY

The Tipam Group of the Tertiary Succession of the Upper Assam Valley comprises Tipam Sandstone and the Girujan Clay Formations. Since the Surma Group has a doubtful development in the eastern part of the areas, viz. in Moran, Nahorkatiya, Jorajan oilfields, and this group of rocks has not been definitely identified in the wells, the succession immediately above the post-Barail unconformity will be considered as part of the Tipam Group in the present study. For the purpose of regional correlation and in preparing the isopach map of Tipam Sandstone Formation, the Surma type rocks are not differentiated.

The Surma Group of rocks (Surma Series by Evans 1932) has attained a thickness of about 3500 m of shale, sandy shale, mudstone and thin gritty sandstone with pebbles above the post-Barail unconformity in the type area of Surma Valley.

In the Upper Assam Valley, a number of wells have penetrated a thin stratigraphic section having more or less similar lithological characters immediately overlying the Barail unconformity. The stratigraphic position, similar lithological characteristics and consistent occurrence of this rock unit throughout the area under study are suggestive of equivalence to the rock units having Surma affinity.

The Tipam Sandstone Formation is a predominantly arenaceous succession with a number of intervening clay and shale bands. A number of rock fragments or smaller pebbles have been observed in the drill-cuttings, mostly as constituent grains of the rocks. This arenaceous formation can be easily distinguished from the overlying predominantly argillaceous Girujan Clay Formation. There is a marked regularity in the lateral variation of the lithofacies. From north-west to south-east, the uppermost part of the arenaceous formation is gradually replaced by clay/claystones resulting the interfingering of the Tipam Sandstone and Girujan Clay Formations and thus shifting the upper boundary of Tipam Sandstone to successively lower stratigraphic level (Figs. 2 & 5).

The term "Girujan Clay Stage" was introduced by Evans (1932) for a thick mottled clay formation exposed in the Girujan stream near Digboi. The Girujan Clay Formation comprises mainly of mottled clay with intercalations of sand bands and occasional coal streaks. This formation is overlain unconformably by Dhekiajulis in the Nahorkatiya area, where Namsang Beds have not been recognised. In the areas to the east of Nahorkatiya, a thin section of Namsangs has been recognised, while in the west (in Moran area and further west) thick Namsang Beds are present over a regional unconformity. The Girujan Clay is easily identified from overlying Namsang Beds or Dheikiajulis over a regional unconformity and from underlying Tipam Sandstone, on the electric logs by increase in the thickness of the clay beds. Due to presence of regional unconformity at the top of Girujan Clay resulting in a sharp contrast in lithology, prominent seismic reflections are also obtained.

Table 2 A. Details of the Formation Characteristics of Surma-Tipam Groups in Upper Assam

GROUP	FORMATION	Lithological Characteristics	Heavy Mineral Assemblage	Resistivity Characteristics/ Salinity (NaCl)	Thickness of formations (metres)	Remarks
TIPAM	GIRUJAN CLAY (G.C.)	Mainly mottled clay with intercalations of sand bands and occasional coal streaks. Clays are characteristically mottled in different shades of grey, brown, brick red, light yellow etc. and are soft and sticky when wet. The sandstones are light grey, fine to medium grained, soft to medium hard.	Sudden increase in staurolite, kyanite, zircon and chromite and decrease in hornblende, epidote, garnet and enstatite-silliminite-andelusite(ESA) suite in the junction with Dhekiajulis, where Namsang Beds intervene between Dhekiajulis and Girujans, it is difficult to define the Namsang/Girujan boundary on the heavy mineral assemblage (Fig. 1)·	The resistivity against the clay is about 5 ohms m^2/m and against the water-bearing sand-stone bands is 15-20 ohms m^2/m. Salinity about 1000-3000 ppm.	0—above 2000. Thickness gradually decreases towards north and west to the extent that it is totally absent in Disangmukh, Dikhomukh and north of Tengakhat, while towards south and east it increases considerably (Fig. 4).	Decrease in thickness towards north and north-west is due to gradual reduction in sedimentary thickness and gradual replacement of clays by Tipam sand stones, and in some areas, due to deep erosion at the end of Tipam.
TIPAM	TIPAM SANDSTONE (T.S.)	Predominantly arenaceous succession with number of intervening clay bands. Sands tones are light grey, fine to medium-grained, moderately to poorly shorted rock, sub-angular to sub-rounded and soft with argillaceous matrix. Clay and shales are of various shades of dirty grey, blusih grey, brown, red, variegated and soft. Shale content gradulay increases downwards within the formaton·	Hornblende, epidote and garnet which persist in fair abundance in the Girujans, show a sudden enrichment in Tipam Sandstone. Also characterised by absence of ESA suite and the restricted occurrence of staurolite kyanite and chloritoid (Fig. 1)	About 5 ohms m^8/m against the clay and 15-20 ohms $m/^2 m$ against the upper Tipam and 5-10 ohms m^2/m against the lower Tipam water bearing sandstone ranges. Salinity about 1500-6000 ppm.	Combined thickness of TS+?S shows a general trend of increase from NW to SE and varies from 600m near Disangmukn and 1100 m at Geleki. However, this general trend is not maintained in and around Nahorkatiya (650-750 m). Overall thickness of Tipam+? Surma groups shows a regular increase in keeping with the general trend of thickening of the sedimentary sequence towards the Naga- Patkai range (Figs. 3, 4 & 5)	Excepting minor variations in grain size, sorting and colour, the lithology of most sandstone beds within the formation is the same. The heavy mineral characters also do not differ much.
?SURMA (?S)	NOT DIFFERENTIATED	Mainly light grey to grey, fine to medium grained, moderately hard sandstone with subordinate bluish-grey shale and clay, hard gritty calcareous sandstone with pebbles of quartzites and glassy volcanic rocks immediately overlying the Barail unconformity.	The epidote content abruptly decreases in comparison to the overlying Tipam Sandstone Formation below the epidote marker (Fig. 1) This is more or less a characteristic features observed through out the area and this marker can be considered as the boundary between Surma type of rocks and Tipams.	Electrolog characteristics against this section however, do not show any marked dfference from overlying lower Tipam Sandstone except for the presence of a number of thin high resistivity bands. Salinity about 1500-6000 ppm.	The thickness between the interval of the epidote marker and Barail unconformity varies from 15 to 130 m at Nahorkatiya and about 50 m at Moran areas.	

Table 2B. Distribution of Palynoforms in Surma-Tipam Groups in Upper Assam

? SURMA GROUP	TIPAM GROUP: TIPAM SANDSTONE	TIPAM GROUP: GIRUJAN CLAY
Recycled Lower Gondwana playnoforms : *Divarisaccus, Cuneatisporites, Parasaccites, Vesicaspora, Alisporitis, Cannanoropollis, Potonieisporites, Faunipollenites* etc.	Recycled Lower Gondwana playnoforms : *Strotersporites, Cannaroropollis, Divarisaccus Platysaccus Alisporites, Cuneatisporites, Parasaccites, Faunipollenites, Scheuringipollenites, Rhizomaspora* are quite frequent.	No recycled palynoforms is so far recorded.
Indigenous Tertiary palynoforms : *Striatriletes, sussane, Cyathidites australis, Crassoretitriletes vanraadshooveni, Podocarpidites classicus, Polypodiaceaesporties mawkmaensis, Nyssapollenites barrooahii, Palmaepollanites kutchenais, P nadhamunii Foveosporites.*	Indigenous Tertiary palynoforms : *Stereisporites assamensis, Rhoipites nitidus, Padocarpidites microreticuloidatus, P. classicus, Striatriletes susanne, Polygonacidites frequens, corrugatisporites terminalis, Ilexopollenitse ornus, Nyssapollenites, boroahii, Lakiasporites triangulus, Phragmothyrites eocaenica.*	The important Tertiary palynoforms : *Lycopodiumsporites austroclavatidites, Retipilonapites cenozoicus, Polygonacidites frequens, Cyathidites minor, Nyssapollenites borooahii, Polyporina excellens.*

Remarks :

1. Floral assemblages of sub-crop and outcrop sampies are more or less identical.
2. Surma is generally poor in fossil content. Tipam formation is dominated by recycled forms. Both the groups contain mixed type of flora. Girujan contains only indigenous forms and many fresh water algae. So far no marine element has been reported from Surma-Tipam Groups of Upper Assam.
3. The Upper Bhuban of Surma at Nichuguard in Nagaland shows identical mixed type of assemblage.

Details of the lithological characteristics, heavy mineral assemblage, resistivity characteristics, thickness and its variations etc. of the individual group/formation are given in Table 2A and the palynological findings of the subcrop samples from Surma-Tipam Groups of Moran and Nahorkatiya oilfields and also of the outcrop samples from the neighbouring areas, i.e. Jaipur anticline and Tipangpani areas are given in Table 2B.

DISCUSSION ON GENERAL GEOLOGICAL SETTING AND DEPOSITIONAL HISTORY

In order to understand the geological setting of the Surma-Tipam Group of rocks in the Upper Assam Valley, a NW-SE profile has been constructed (Fig. 5). Except for a few wells in the areas north-west of Nahorkatiya which have encocuntered the basement, the other wells have not penetrated the entire sedimentary succession. Since there is limited information on the thickness of the Barail and pre-Barail Formations, factors like (i) general trend of thickness variation of the individual formation and (ii) approximate depth to the basement have been considered on the basis of the seismic and gravity data while drawing this geological section (Sharma & Handique).

It is apparent from the seismic sections that detection of all basement faults and their throws is not always possible. Faults identified at Tipam and Barail levels are, therefore, considered to be extended down to the basement. The geological section shown in Fig. 5 has been extended to the foothills of eastern Himalayas in the north representing a regional geological section across the entire Upper Assam Valley. The northern part of the section has been constructed almost entirely from two-dimensional gravity model studies in the absence of well and seismic data. Available evidence from aeromagnetic survey has also been taken into account in making this section. The regional geological section shows only the general stratigraphy and structure. From the available evidence in the south-eastern part of the section, it is expected that north-western part of the section (north of Well A) might also be affected by numerous faults.

The oilfields so far discovered are mainly on the southern sides of the more or less hidden basement ridge (Figs. 5 & 6) which is the continuation of the Mikir Hills. Although no oilfield has so far been discovered on the northern side, i.e. along the foothills of the Eastern Himalayas, there is the possibility of encountering similar favourable geological conditions suitable for oil accumulation.

From the study of isopach maps and geological sections, the following salient features are observed :

(i) The Tipam Formation including the Surmas shows general increase in thickness from north-west to south-east (Fig. 3).

(ii) The Girujans thicken towards south and south-east, while towards north and west it thins out and is totally absent north of Tengakhat, Disangmukh, Dikhowmukh and near Mikir Hills Maximum thickness of about 2000 m has been observed near Kumchai area in the east (Fig. 4).

(iii) Towards south-east, the thickness of the youngest formation Alluvium/Dhekiajulis decreases,

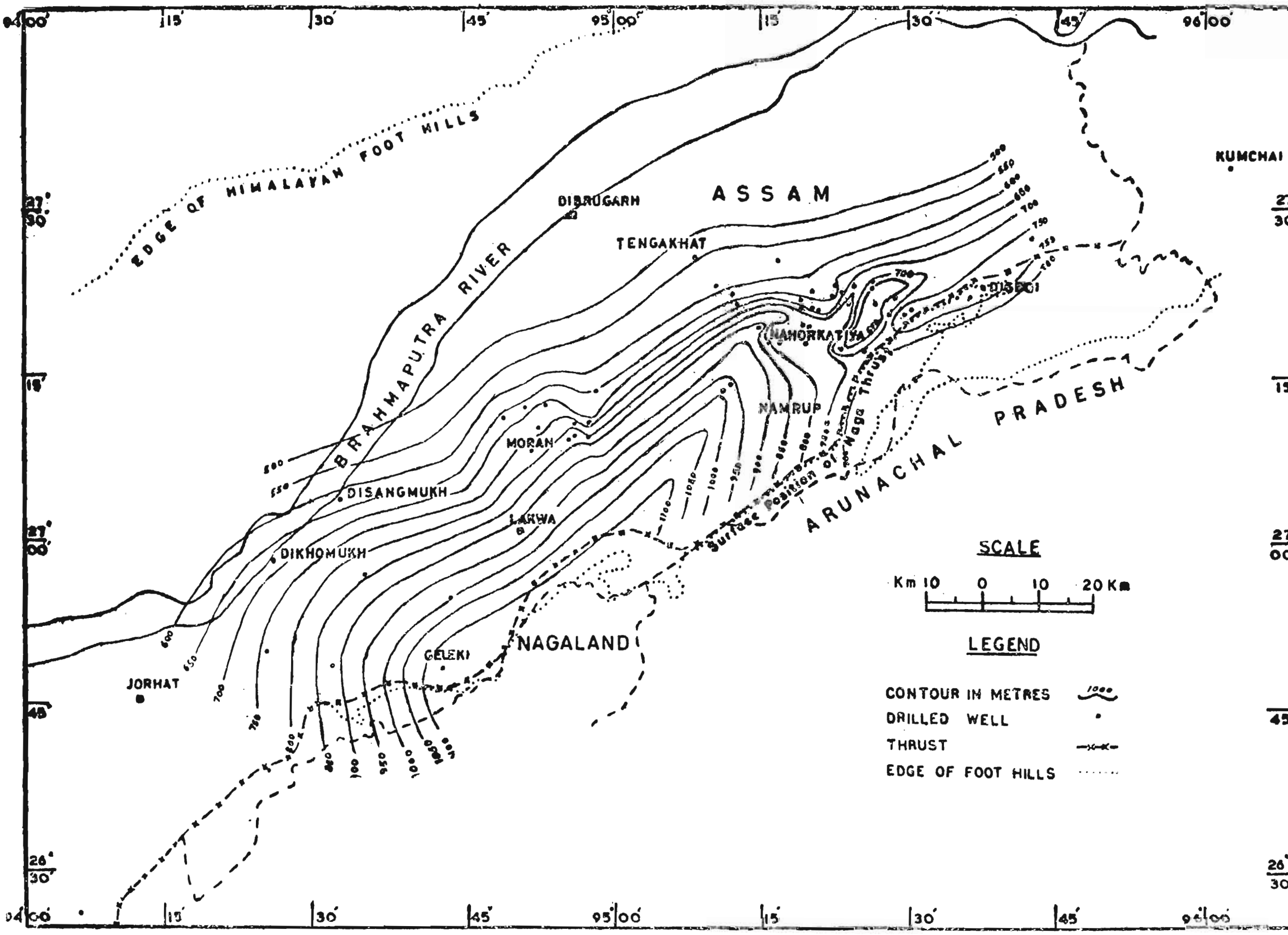


Fig. 3

while the Girujan-Tipam-Surma-Barail and pre-Barail Formations appear to become thicker in this direction (Figs. 5 & 6).

(iv) The basement surface forms a major high in the area near well location A and slopes down towards north-west and south-east; the estimated basement depths are about 6 km and 5 km in the foothills of Himalayas and close to the Naga thrust respectively (Fig. 6).

During Palaeogene, the Assam Valley was the platform shelf of the Naga-Lushai mobile belt which was converted into an intermontane continental basin in Neogene times as the East Himalayan geotectonic cycle was superposed on the Naga-Lushai geotectonic cycle. The Palaeogene platform deposits thus are succeeded by intermontane Neogene molasse. In Upper Assam, the Surma period is marked by regional uplift of both geosynclinal and platform areas whereby part of the Barail was eroded. The Surma were deposited in some structural lows on the pericraton attaining a thickness of up to 600 m, while the thickness in the local depressions is up to 200 m (Raju 1968).

So far no animal fossil has been recorded from Surma-Tipams-Girujans of the areas under study. Banerjee *et al.* (1973) published a detailed palynological report on the Tertiary subcrops of Sibsagar district. Sah and Dutta (1967) studied various outcrop as well as subcrop samples from the different formations and members of the Tertiary Era of Assam and Meghalaya. Recycled Lower Gondwana elements have been recorded by Sah & Dutta (1967) and Banerjee *et al.* (1973) from Surmas and Tipams.

The palynological assemblage compose of fungal bodies, pteridophytic spores, gymnospremous and angiospremic pollen grains. The fungal bodies are represented by Phragmothyrites. Amongst the pteridophytes *Cyathidites*, *Lycopodiumsporites*, *Lygodiumsporites*, *Foveosporites*, *Crassoretitriletes*, *Striatriletes*, *Lakiasporites*, *Polypodiaceaesporites*, *Polypodiisporites* and *Laevigatesporites* are common. The gymnospremous pollen grains find their representation in *Podocapridites*. Angiospermic pollen grains are *Palmaepollenites*, *Tricolpites*, *Rhoipites*, *Bombacacidites*, *Nyssapollenites*, *Polyporina*, *Ilexpollenites*, *Polygonacidites* and *Tetracolporites*.

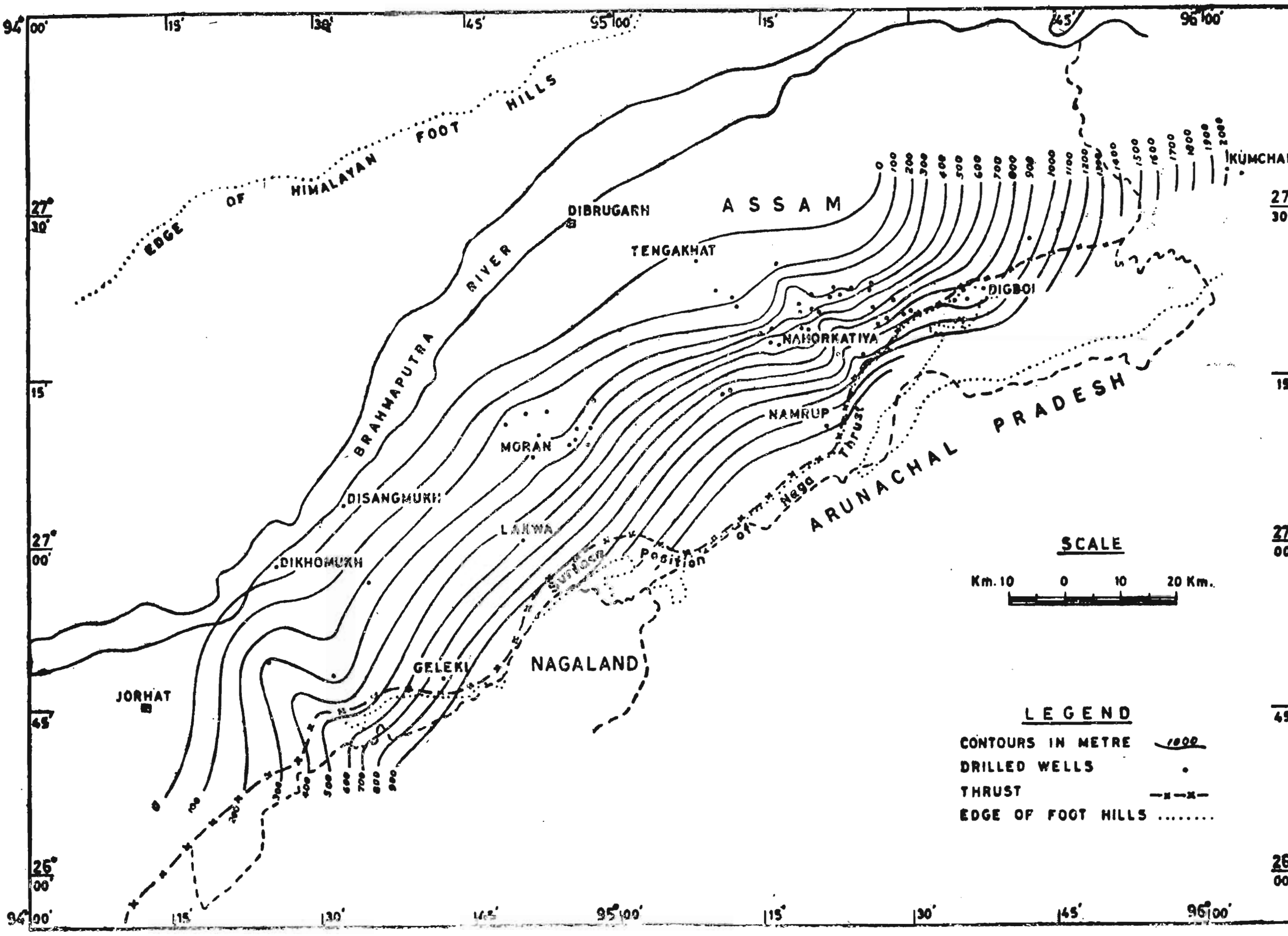

ASSAM
DIBRUGARH
TENGAKHAT
DIGBOI
NAHORKATIYA
NAMRUP
MORAN
DISANGMUKH
LAKWA
DIKHOMUKH
GELEKI
NAGALAND
JORHAT
KUMCHAI
ARUNACHAL PRADESH
EDGE OF HIMALAYAN FOOT HILLS
BRAHMAPUTRA RIVER
Position of Naga Thrust
SCALE
Km. 10 0 10 20 Km.
LEGEND
CONTOURS IN METRE
DRILLED WELLS
THRUST
EDGE OF FOOT HILLS

Fig. 4

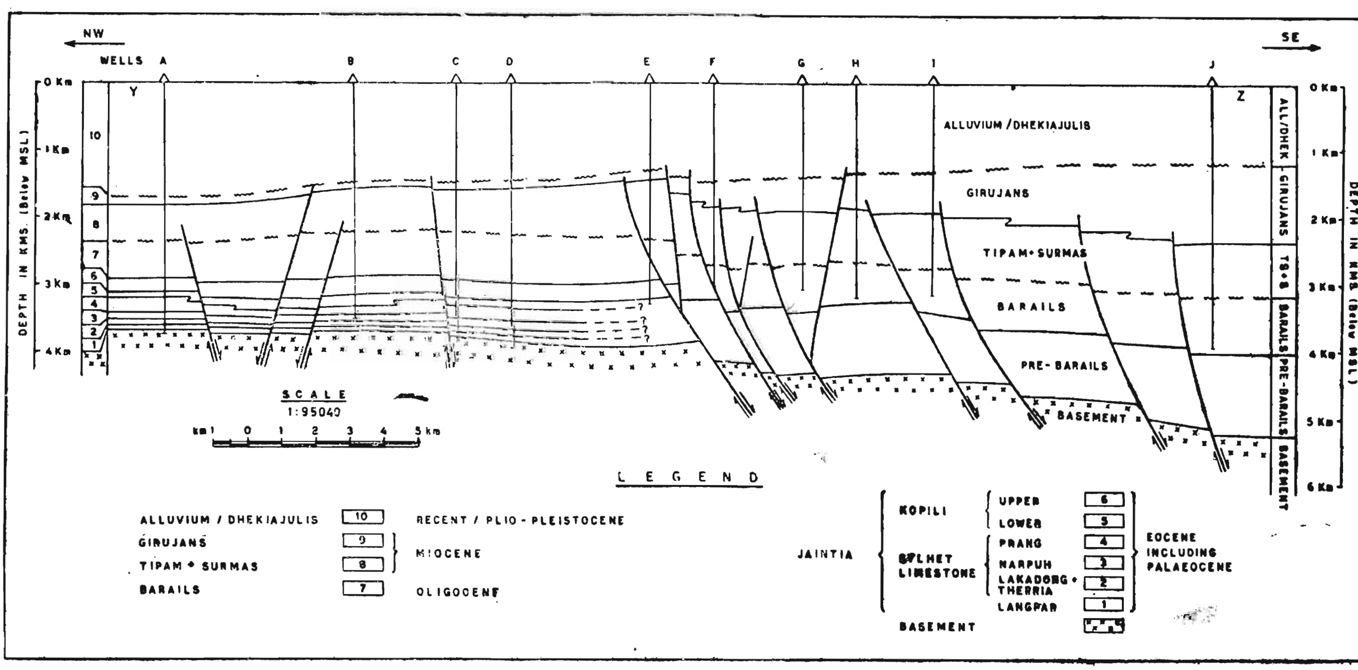

NW
SE
WELLS A B C D E F G H I J
Y
Z
DEPTH IN KMS. (Below MSL)
ALLUVIUM / DHEKIAJULIS
GIRUJANS
TIPAM+SURMAS
BARAILS
PRE-BARAILS
BASEMENT
ALL/DHEK
GIRUJANS
TS+S
BARAILS
PRE-BARAILS
BASEMENT
SCALE
1:95040
km 1 0 1 2 3 4 5 km
LEGEND
ALLUVIUM / DHEKIAJULIS 10 RECENT / PLIO-PLEISTOCENE
GIRUJANS 9
TIPAM + SURMAS 8 MIOCENE
BARAILS 7 OLIGOCENE
JAINTIA
KOPILI UPPER 6
LOWER 5
SYLHET LIMESTONE PRANG 4
NARPUH 3
LAKADONG + THERRIA 2
LANGPAR 1
EOCENE INCLUDING PALAEOCENE
BASEMENT

Fig. 5

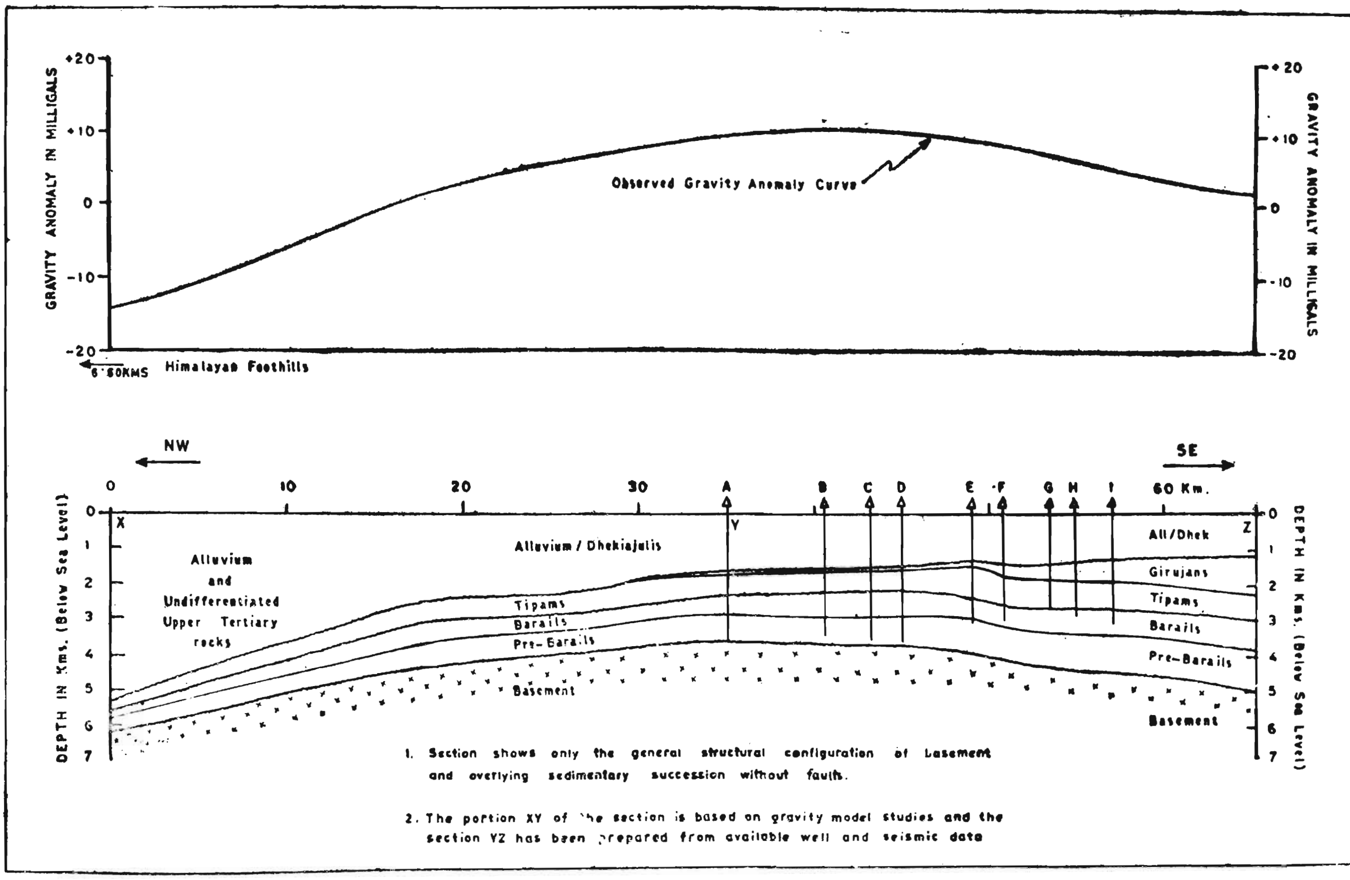


Fig. 6

An interesting finding of these assemblages is the presence of typical Lower .Gondwana palynoforms in Surma Group and Tipam Formation. Sometimes they even overshadow the indigenous forms. Most of the Permian forms are generally eroded and often found in fragments. Their colour is also quite different from those of the indigeonus elements. In Girujans, however, a conspicuous feature is the complete absence of Lower Gondwana elements. This provides an easy identification to distinguish these formations from the overlying and underlying formations. However, Surmas and Tipams cannot be differentiated since the assemblages are more or less identical. The Girujans assemblage also contains some algal bodies of fresh water origin.

It is apparent that the geological history of Upper Assam in late Tertiary is different from that of the Surma Valley and Tripura as Upper Assam was involved in the East Himalayan orogeny during this period. It is interesting to note that mineral assemblages of Surma Valley and Tripura are distinctly different from those of Nagaland and Upper Assam.

Within the heavy mineral suites, there is some indication of source of the sediments. The rich chromite-zircon suite of the Barail is repeated to some extent in the Lower Tipams, the Girujans (Namsang beds in Moran and adjacent areas) indicating that these may have derived their materials in part from the Barails or from the same source of the Barails. Chromite is associated with ultrabasic rocks and its occurrence in the Himalayas is known.

It is observed that the Tipam Group of rocks are more arenaceous towards Himalayas in the north-west and Mikir Hills in the south-west with the Girujan Clay being gradually replaced by Tipam Sandstone (Figs. 5 & 6). Similar features are also observed in the underlying Barails. The argillaceous upper part of Brarails is also thinning out in the same direction. These observations indicate that the sediments were carried away from the Eastern Himalayas.

The Neogene sediments of Arunachal Pradesh, Upper Assam and Nagaland are recycled as is evident by the presence of mixed type of floral assemblage, i.e. Permian, Eocene and Miocene, The source of the Permian palynoforms in the Neogene sediments must be the Lower Gondwana rocks, now exposed in the foothills of Bhutan and Arunachal or in earlier sediments which were derived from these areas and later became themselves source for the Surma and Tipam sediments.

Absence of typical marine plankton in the sediments i.e. in Surmas, Tipams and Girujans suggests that they were deposited in a fresh water environment which is also supported by the estimated values of low formation salinity ranging from 1000—6000 ppm (equivalent sodium chloride salinity). The assemblages, especially because of the good representation of occurrences of *Striatriletes* indicate prevalence of swampy, humid and warm conditions during the deposition of these sediments. Coniferous pollen grains represented by *Podocarpidites* signify high altitude in surrounding areas.

The cylindrical shape of the resistivity log curves against the Surma/Tipam sand ranges represents deposited by braided rivers. The predominant red silty clay of the Girujan Formation is a thick deposit with a large aerial extent and uniform character. The red clay beds associated with fluviatile deposits are considered indicative of heavy rainfall followed by hot dry seasons (Van Houten, 1961). The red colour of the clay is due to the oxidation of the disseminated iron in sediments under these conditions to ferric oxide which causes staining of the sediments.

So far no Gondwana element has been recorded from the Barail sediments. Although the Barail sediments were brought down from the northern side, it is possible that durng Oligocene times the Himalayas were not sufficiently uplifted to become the main source for the Barail sediments.

From the observations of formation characteristics as shown in Table 2A it is apparent that except minor variations in grain size, sorting and colour, lithology of most sandstone beds within the Surma-Tipam sandstones is same. Palynologically also they do not differ much (Table 2B). From well evidence in the Nahorkatiya and neighbouring areas of eastern region it is seen that number of shale bands are present within Surma-Tipams ; some of them have significant lateral extent while others, even having considerable thickness are either pinching out or are represented by thin shale breaks within a short distance. Similar features have been observed in the western part of the area too. Regional correlation of these shale breaks connecting Nahorkatiya-Moran oilfields and Lakwa-Rudrasagar-Geleki oilfields is, therefore, not very much straightforward.

All these facts suggest that use of the classifications of Tipam Group proposed by Bhandari *et al.* and Shrivastava *et al.* will be difficult in application in a regional scale. However, the classifications suggested by different authors may be useful for detailed local correlation provided uniformity in naming the different formations and members are properly maintained. The broad classification given by Mathur and Evans is more acceptable for regional correlation.

The recent discovery of vertebrate fossils in the Bokabil in Tripura (Trivedi, 1966) throws interesting light on the age and depositional condition of Surma and Tipam Formations. Amongst the mammalian fossils was a *Dorcathorium* which has been reported only from the Nagri beds of Siwalik and the Nagri Stage and is of Pontian age. The Baghmara and Dalu marine fossils from Garo Hills of Meghalaya give a Burdigalian age. Thus the Bokabil which started in Burdigalian as marine sediments ended as estuarine in Pontian. Thus the Tipams, even if they come as a lateral variation of Bokabils, must be of Pontian age. This only confirms what Sale and Evans (1940) had stated that "Palaeontological opinion is inclined to assign a Pliocene to the fossil horizon ——in the Tipams of Arakan coast". The Tipam subcrops of Upper Assam are of Upper Miocene. Therefore, it is possible that the age of the Tipams ranges from Upper Miocene in the Assam Valley to Pliocene in the Surma Valley and Arakan Coast.

Based on apparent stratigraphical similarity, the Upper Tertiary rocks of Eastern Himalayas were considered as the continuation of the Western Himalayas and have been regarded as 'Siwalik'. It has been observed (Dutta ; Dutta and Singh) that the Upper Tertiary sediments of Arunachal Pradesh show mixed type of floral assemblage, i.e. Permian, Eocene and Miocene. No microflora older than the Tertiaries has been recorded in the Western Himalayas (Banerjee, 1968). A comparative palynological study of the Siwaliks of North-West India, Upper Tertiaries of Arunachal, Upper Assam and Nagaland suggests that the Upper Tertiary sediments of Arunachal Pradesh correlate better with those of Upper Assam and Nagaland.

ACKNOWLEDGEMENT

We express our gratefulness to the authorities of Oil India Limited for the permission to incorporate freely the various data and figures and to publish this paper. We wish to express our sincere gratitude to senior officers of Oil India Limited for critically going through the manuscript. Our thanks are also due to Shri P. K. Chandra, Chief Geologist, Oil & Natural Gas Commission, Sibsagar for giving some well data to one of the authors (SKD).

REFERENCES

Banerjee, D. 1968. Siwalik microflora from Punjab (India). *Rev. Palaeobotan Palynol.*. **6** : 171-176.

Banerjeee, D., Misra, C. M. and Koshal, V. N. 1973. Palynology of the Tertiary subcrops of Upper Assam. *Palaeobotanist.* **20** (1) : 1-6.

Bhandari, L. L., Fuloria, R. C. and Sastri, V. V. 1973. Stratigraphy of Assam Valley, India.. *Bull. Amer. Assoc. Pet. Geol.* **57** (4) April : 642-654.

Baruah, J.M.B., Mukhopadhyay, A. and Baishya, N. 1975. Lithofacies variation and palaeostructural evolution of Tipam Sandstone Formation in part of Upper Assam Valley. *Sym. Sed. Sedimentation & Sedimentary Env.*

DUTTA, S. K. (MS) Palynostratigraphy of the sedimentary formations of Arunachal Pradesh : 2. Palynology of Siwalik equivalent rocks of Kameng District. *Geophytology*. **10** (2) 1980.

DUTTA, S. K. AND SINGH, H. P. (MS) 1. Palynology of the Siwalik rocks of the Lesser Himalayas, Kameng District *Proc. 4th Int. Pal. Conf.* (In press).

EVANS, P. 1932. Tertiary succession in Assam. *Trans. Min. Geol. Inst. India.* **27** : 155.

EVANS, P. 1959. Stratigraphy and tectonics of the Assam Oilfield Region. *E. C. A. F. E. Symposium*, 1958, *New Delhi* : 170 (United Nations, Bangkok).

MALLET, F. R. 1876. Coalfields of Naga Hills. *Mem. Geol. Surv. Ind.* **2** (2).

MATHUR, L. P. AND EVANS, P. 1964. Oil in India. *Int. Geol. Cong., 22nd Session, India.*.

RAJU, A. T. R. 1968. Geological evolution of Assam and Cambay Tertiary Basins of India. *Bull. Am. Assoc. Pet. Geol.* **52** (12) : 2422-2437.

SAH, S. C. D. AND DUTTA, S. K. 1968. Palynostratigraphy of the sedimentary formations of Assam : 2. Stratigraphic significance of spores and pollen in the Tertiary succession of Assam. *Palaeobotanist*. **16** (2) : 177-195.

SHARMA, B. AND HANDIQUE, G. K. A study of a Regional Geological section across the Upper Assam Valley—from Jaipur up to the foothills of the Himalayas. (Internal publication, Oil India).

SHRIVASTAVA, P. K., GANESHAN, S. AND RAY, D. 1974. Tipam Group in the subsurface of Upper Assam Valley, south of Brahmaputra. *Jour. Geol. Soc. Ind.* **15** (2) : 165-181.

SALE, H. M. AND EVANS, P. 1940. Geology of the Assam Arakan Oil region. *Geol. Mag.* **77** (5) : 337-362.

TRIVEDI, A. N. 1966. A note on the finding of vertebrate fauna in the Surma Series of Tripura and its bearing on the stratigraphy of the area. *Curr. Sci.*. 35 : (3) Feb.

VON HOUTEN, F. B. 1961. *Climatic significance of red beds in Descriptive Palaeoclimatology*. Interscience, Wiley.

EXPLANATION OF PLATES

(All photomicrographs are enlarged Ca $\times$500 except otherwise mentioned)

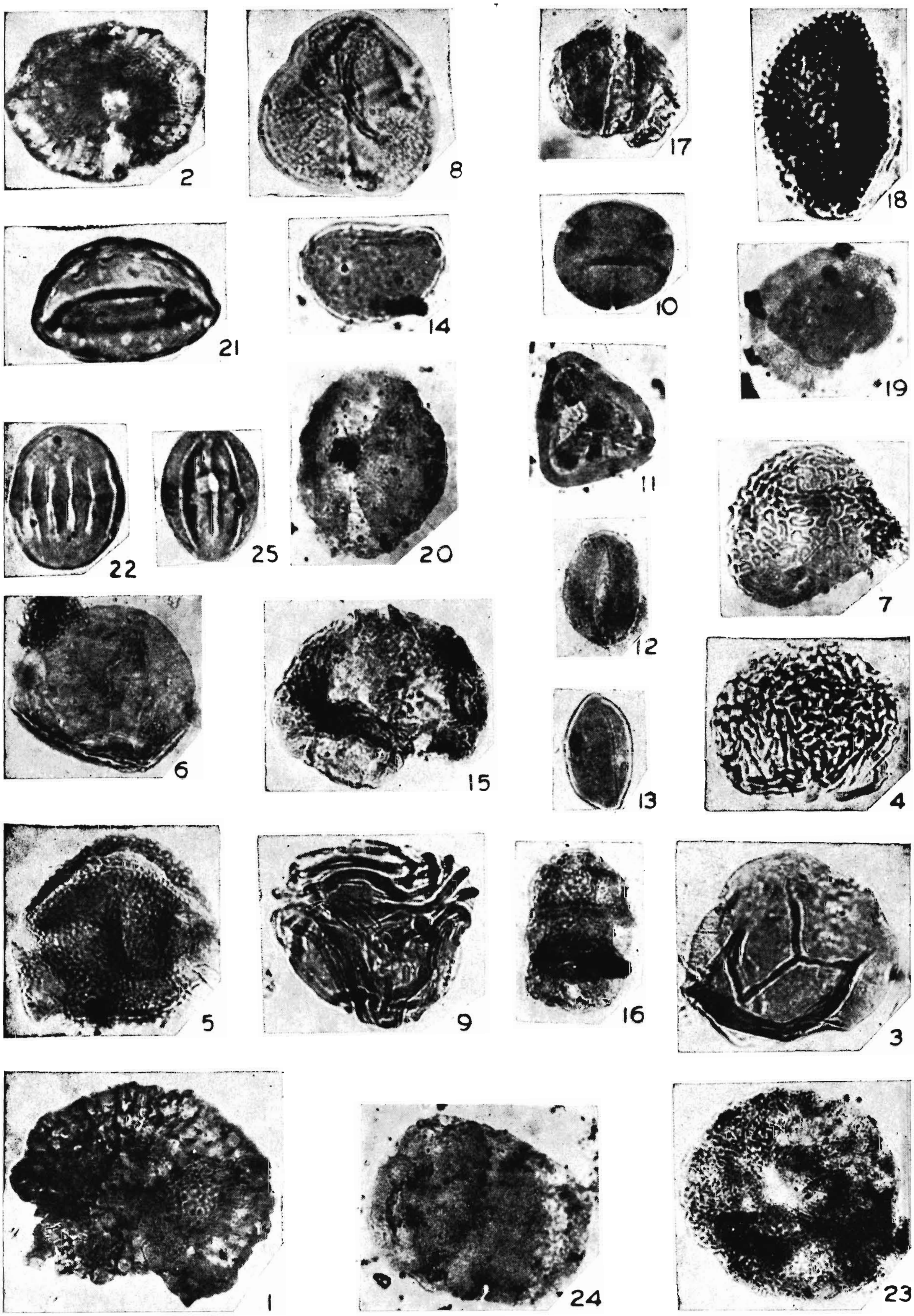
PLATE I

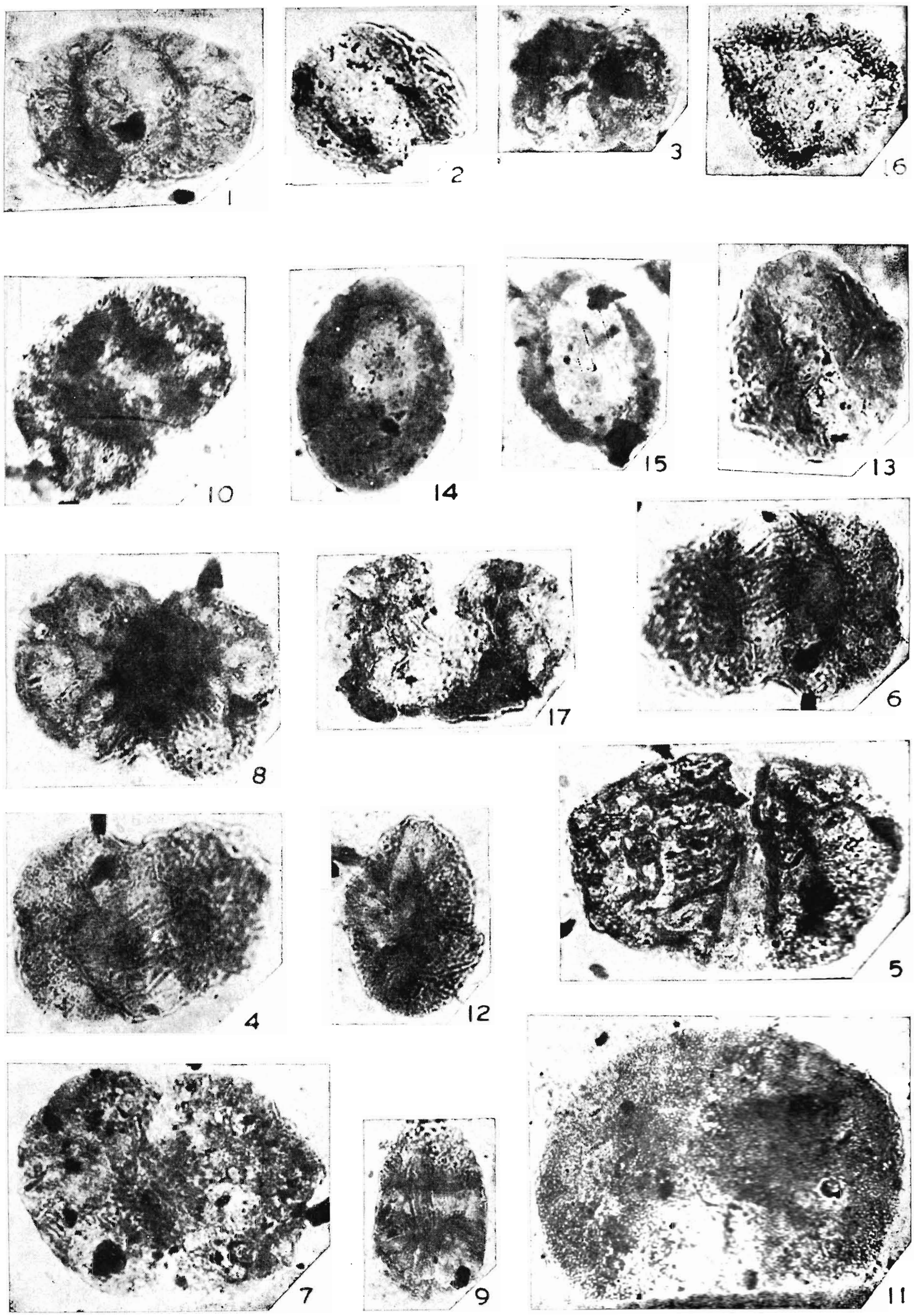
1. *Phargmothyrites eocaenica* (Edward) Kar and Saxena
2. *Phragmothyrites eocaenica* (Edward) Kar and Sexana
3. *Cyathidites australis* Couper
4. *Crassoretitriletes vanraddshooveni* Germeraad, Hopping and Muller.
5. *Foveosporites* sp.
6. *Lycoppodiumsporities austroclavatidites* (Cookson) Potonie
7. *Lycopodiumsporites austroclavatidites* (Cookson) Potonie
8. *Bombacacidites assamicus* Sah & Dutta
9. *Striatriletes sussane* (van der Hammen) Kar
10. *Nyssapollenites barooahii* Sah and Dutta
11. *Lakiasporites triangulus* Sah & Kar
12. *Palmaepollenities kutchenis* Venkatachala & Kar
13. *Palmaepollepites nadhamunii* Venkatachala & Kar
14. *Polypodiaceaesporites mawkmaensis* Dutta & Sah
15. *Podocarpidites clasoicus* Salujha, Kindra and Rehman
16. *Podocarpidites* sp.
17. *Podocarpidites* sp.
18. *Illexpollenites ornus* Sah & Dutta
19. *Potonieisporites* sp.
20. *Divarisaccus lelei* Venkatachala & Kar
21. *Polyporina excellens* Sah & Dutta
22. *Polygonacidites clarus* Sah and Dutta
23. *Cannanoropollis* sp.
24. *Cuneatisporites* sp.
25. *Rhoipities nitidus* Sah & Dutta

PLATE II

1. *Cuneatisporites* sp.
2. *Podocarpidites* sp.
3. *Strotersporites* sp.
4. *Strotersporites* sp.
5. *Strotersporites* sp.
6. *Strotersporites* sp.
7. *Rhizomaspora* sp.
8. *Platyscaccus papillionis* Potonie and Kalus
9. *Faunipollenites* sp.
10. *Cuneatisporites* sp.
11. *Scheuringipollenites* sp.
12. *Divarisaccus lelei* Venkatachala & Kar
13. *Divarisaccus lelei* Venkatachala & Kar
14. *Parasaccites* sp.
15. *Parasaccites* sp.
16. *Cannanoropollis* sp.
17. *Podocarpidites classicus* Salujha, Kindra & Rehman

PLATE I





HANDIQUE & DUTTA