

## BIOSTRATIGRAPHY OF THE MIDDLE EOCENE KOHAT FORMATION, SHEKHAN NALA KOHAT BASIN, NORTHERN PAKISTAN

BY

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**Abstract:** *The Kohat Formation from Shekhan Nala, Kohat Basin, northern Pakistan has been measured and closely sampled to undertake detailed stratigraphical and micropalaeontological studies to determine the age and environmental style of the formation. Ninety seven (97) samples were collected to cover all the lithological and facies variations from bottom to top. More than one hundred thin sections were made. A number of foraminiferal species belonging to the genera Nummulites, Assilina, Operculina, Discocyclusina, Alveolina and Dictyoconoides have been recorded. These foraminiferal species are age diagnostic and are excellent indicators of the paleoenvironments prevailing during the deposition of the Kohat Formation.*

### INTRODUCTION

The Kohat Basin is an important geological entity of the Northern Pakistan. The importance of area lies in its enormous hydrocarbon potential, which is a burning topic in today's oil industry. A number of successful discoveries of oil and gas have increased its importance manifold.

The Eocene sequence of the Kohat Basin shows a variety of environments during this period in the Kohat Basin. The stratigraphical nomenclature according to the Stratigraphic Committee of Pakistan (Fatmi, 1973) is as follows (Fig. 1)

The Kohat formation is an integral part of the Eocene sequence of the Kohat Basin and is quite well exposed throughout the Basin. In fact the Kohat Formation marks the end of Eocene period in the area followed by an unconformity. This unconformity which is marked by the Fateh Jang member of the overlying Murree Formation represents the absence of upper Eocene time throughout the Kohat Basin. The Kohat Basin can be divided into two parts on the basis of its structural and depositional systems. The northern part of the basin represents imbricate structures and normal marine shallow shelf environments of deposition (Panoba Shale and Shekhan

Formation). Whereas, the southern part of the basin represents normal marine to restricted lagoonal environments during the Eocene period (Bahadur Khel Salt and Jatta Gypsum Fig. 1).

The Kohat Formation is one of the most widely exposed stratigraphic units present in the entire Kohat Basin. The formation is only exposed in the Kohat, Northern Potwar and Kala Chitta areas. The formation is traditionally divided into three members. These members in the order of superposition are:

- Habib Rahi Limestone Member (Kohat Limestone and Sirki Shales of Eames 1952)
- Sadkal Shale Member (Nummulitic Shales of Pinfold 1918)
- Kaladhand Member (Kohat Shales of Davies 1926)

This threefold division of the Kohat Formation is well represented in the Shekhan Nala. At this locality the lower Kaladhand member is composed of well developed, hard, thin to medium bedded, sometimes massive light to medium grey limestone. The limestone also contains

some thin beds of shale in the lower part. This member is consistent in lithology and appearance throughout its extension in the Kohat Basin. The middle and upper parts of the member are richly fossiliferous. The Sadkal member is mainly composed of khaki to light brown color shale. The member is so richly fossiliferous that the rock appears to be almost entirely composed of fossils. The member also has fine layers of marl and limestone which are also full of fossils. This part of the formation is so rich in micro fauna that it can be called biolithite. In other parts of the basin the percentage of limestone becomes more dominant and the member appears to be a part of the lower Kaladhand member. That's why at most of the places in Kohat Basin it is difficult to mark the boundary between the Kaladhand and Sadkal members and these units appear to be mixed with each other.

The Habib Rahi Limestone Member marks the upper part of the formation and contains well bedded to slightly nodular cream colored limestone. This unit is also richly fossiliferous. But the abundance of fossils and their size decrease in the upper part of the member. The upper most part of the member i.e about 5-10 m is shattered, fractured and nodular with scarcity of fossils. The solution holes and the karren structure also dominant in the upper most part of the member. The Habib Rahi Limestone Member has quite uniform appearance and lithology throughout its extent (Fig. 2).

The lower contact of the Kohat Formation is conformable and sharp with the Mami Khel Clay (Kuldana Formation), whereas the upper contact with the Murree Formation is unconformable throughout the area, which is marked by Fatehjang member (of Murree Formation) containing foraminifera from underlying units.

The Kohat Formation is almost entirely composed of larger benthic foraminifera belonging to the genera *Nummulites*, *Assilina* and *Alveolina*. The forams are age diagnostic and some excellent age diagnostic larger foraminiferal species of *Nummulitids*, *Assilinids* and *Alveolinids* have been found namely *Nummulites mamillatus*, *N. atacicus*, *N.globulus*, *N. subirregularis*, *Operculina patalensis*, *Operculina sp.*, *Assilina exponens*, *A. granulosa*, *A. spinosa*, *A. subspinosa*, *A. laminosa*, *A. dandotica*, *Assilina sp.*, *Discocyclina dispansa*, *Dictyoconoides sp.*, *Alveolina elliptica* and *Alveolina stercusmuris*.

On the basis of this faunal assemblage a late early Eocene to early Middle Eocene age of the formation has been confirmed.

Bioclastic wackestone, packstone and grainstone microfacies have been identified (Fig.2). The bioclasts are mainly larger forams. On the basis of observed fauna and lithologic assemblage it has been established that the

formation was deposited under shallowshelf open marine environments representing both inner neritic facies and bank bed facies.

### Systematic Paleontology

#### Genus: *Nummulites* Lamarck, 1801

*Nummulites mamillatus* (Fichtel & Moll)

(Plate 1, Figs. 1, 2)

*Nautilus mamilla*, sp.nov. ; Fichtel and Moll, 1798. 'Testacea Microscopia', pp. 53-54; Pl. 6, figs. a-d.

#### Remarks:

This species is very common and abundant throughout the formation. It is characterized by having a biconvex shell with thick umbilical pillars in the middle part. Marginal cord is present. but comparatively thin as compared to the other species of *Nummulites*.

*Nummulites atacicus*, Leymerie

(Plate 1, Figs. 3, 4)

*Nummulites atacicus* Leymerie, A., (1846), Mem. Sur le Terrain a Nummulites des Corbieres, etc., Mem. Soc. Geol. France, (2), V. I: 337-373.

#### Remarks:

This species is not so common in the Kohat Formation. Only found in the middle part of the formation. Mostly the megalospheric forms are present with larger proloculus. The pillars are not so well developed. The marginal cord is well preserved and quite prominent.

*Nummulites globulus*, Leymerie

(Plate 1, Figs. 5, 6)

*Nummulites globulus* Leymerie, A., (1846), Mem. Sur le Terrain a Nummulites des Corbieres, etc., Mem. Soc. Geol. France, (2), V. I: 337-373.

#### Remarks:

This species has few representatives in the Kohat Formation. It is characterized by having a strongly biconvex shell which is more globular in appearance. The umbilical pillars are well developed and very prominent. The wall of the shell is usually very thick.

AGE		NORTHERN KOHAT		SOUTHERN KOHAT		
MIOCENE		MURREE FORMATION		KAMLIAL FORMATION		
		FATEH JANG MEMBER				
OLIGOCENE						
EOCENE	UPPER	PRIABONIAN				
	MIDDLE	LUTETIAN	KOHAT FORMATION	Habib Rahi Limestone Member	KOHAT FORMATION	Habib Rahi Limestone Member
				Sadkal Member		Kaladhand Member
				Kaladhand Member		Kaladhand Member
	LOWER	YPRESIAN	KULDANA FORMATION (MAMI KHEL CLAY)		MAMI KHEL CLAY	
			SHEKHAN FORMATION		JATTA GYPSUM	
PANOBA SHALE			BAHADUR KHEL SALT			
PALEOCENE	UPPER	THANETIAN	PATALA FORMATION		PATALA FORMATION	
			LOCKHART LIMESTONE		LOCKHART LIMESTONE	
	LOWER	DANIAN	HANGU FORMATION		HANGU FORMATION	

Fig. 1: Stratigraphic Succession of the Paleocene-Eocene rocks of the Kohat Basin, Northern Pakistan

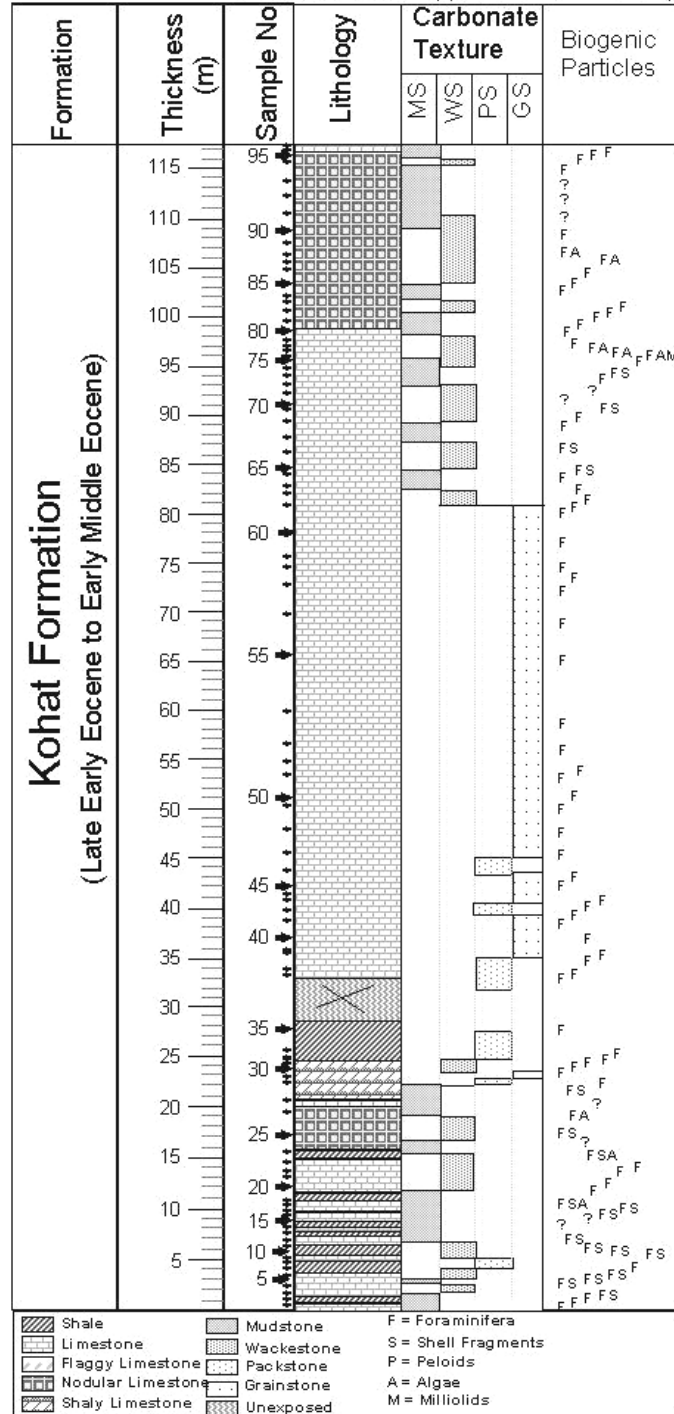


Fig. II Depositional Log of the Kohat formation, Shekhan Nala

Fig. 2: Depositional Log of the Kohat Formation, Shekhan Nala.

*Nummulites subirregularis* De la Harpe  
(Plate 2, Fig. 1)

*Nummulites subirregularis* Harpe, De la (1883) Mem.Soc. pal. suisse, Vol. X, pp. 158-159; Pl. V, figs. 3-14a.

**Remarks:**

There are only few specimens of this species found in the Kohat Formation. It is first time being reported from this formation in northern Pakistan. It is characterized by having comparatively thin shell with thin walls.

**Genus: Operculina, d'Orbigny 1826.**

*Operculina patalensis* Davies and Pinfold

(Plate 2, Figs. 2, 3)

*Operculina patalensis* Davies, L. M. and Pinfold, E. S., (1937), The Eocene beds of the Punjab Salt Range. Geol. Surv. Mem., Paleont. Indica, New series, V. 24 (1), p. 79.

**Remarks:**

There are few specimens of this species recorded from the middle part of the formation. It is found in association with different species of *Assilina*. But it is differentiated by having a rapid loosening of the spire (operculinoidal growth). The shell is elongated with thin walls and smooth surface in the longitudinal section.

*Operculina sp.*

(Plate 2, Figs. 4, 5)

**Remarks:**

This species is also found in association with *Operculina patalensis* in the middle part of the formation. It is differentiated from above on the basis of having very prominent pustules throughout its extent on both sides of the shell.

**Genus Assilina, d'Orbigny 1826.**

*Assilina exponens*, Sowerby  
(Plate 2 Fig. 6; Plate 3, Fig. 1)

*Assilina exponens* Sowerby, J. De C., (1840), Systematic description of organic remains of Cutch., Trans. Geol. Soc. London, (2), V. V.: 327-329.

**Remarks:**

This species is quite abundant in the middle part of the formation. This species is distinguished on the basis of its rounded shape and very thin structure. It also has thick ribs throughout its extent.

*Assilina granulosa*, d'Archiac

(Plate 3, Figs. 2, 3)

*Assilina granulosa* Archiac, E.J.A.D (1847) Mem.sur les Fossiles des couches a Nummulites des environs de Bayonne et de Dax, Bull. Soc. geol. France, (2), Vol. IV, pp. 1006-1010.

**Remarks:**

This species is quite frequent in the Kohat Formation and is found mainly in the middle part of the formation which is shale bearing (Sadkal Member). The shell is generally flat with sharp margins. There are frequent granules on the surface of the shell. These granules are sometimes very clear.

*Assilina spinosa* Davies and Pinfold  
(Plate 3, Fig. 4)

*Assilina spinosa* Davies, L. M. and Pinfold, E. S., (1937), The Eocene beds of the Punjab Salt Range. Geol. Surv. Mem., Paleont. Indica, New series, V. 24 (1), p. 79.

**Remarks:**

There are few representatives found in the middle shaly part of the formation. This species is relatively stouter than the *Assilina granulosa*. The wall is relatively thick and the granules or spines are more strong and prominent throughout the shell. There is always a central depression which separates it from *Assilina subspinosa*.

*Assilina subspinosa* Davies and Pinfold  
(Plate 3, Fig. 5)

*Assilina subspinosa* Davies, L. M. and Pinfold, E. S., (1937), The Eocene beds of the Punjab Salt Range. Geol. Surv. Mem., Paleont. Indica, New series, V. 24 (1), p. 79.

**Remarks:**

Few specimens of this species are also found in the middle part of the formation. The species is characterized by having large and very prominent spines closely distributed on the surface of the shell. These spines are relatively more concentrated in the middle part of the shell. Unlike *Assilina spinosa* there is no central depression in the middle part of the shell.

*Assilina laminosa* Gill  
(Plate 3, Fig. 6)

*Assilina laminosa* Gill, W. D., (1953), the genus *Assilina* in Laki Series (Lower Eocene) of the Kohat Potowar basin, north-west Pakistan. Contr. Cushman Found. For. Res. V. 4: 76-84.

**Remarks:**

There are few specimens of this species found in the middle part of the formation. The species is characterized by having thick wall and thick margins, in cross section the walls showing quite prominent laminations.

*Assilina dandotica* Davies and Pinfold  
(Plate 4, Fig. 1)

*Assilina dandotica* Davies, L. M. and Pinfold, E. S., (1937), The Eocene beds of the Punjab Salt Range. Geol. Surv. Mem., Paleont. Indica, New series, V. 24 (1), p. 79.

**Remarks:**

There are only very few specimens of this species found in the Kohat Formation. The form is discoid, thick from the centre, with sharp periphery. The surface of the shell is sometimes covered with granules which are not so prominent as in the other forms of *Assilina*. The shell is stouter than the *Assilina granulosa* or *Assilina subspinosa*.

*Assilina sp.*  
(Plate 4, Fig. 4)

**Remarks:**

There are only few specimens of this species found in the middle part of the formation. The form has a unique appearance especially in the middle part where it is strongly biconvex. The margins are sharp. The author has not found any species comparable to this in the available literature.

**Genus: Discocyclina, Gumbel, 1868.**

*Discocyclina dispansa* Sowerby  
(Plate 4, Fig. 2)

*Discocyclina dispansa* Sowerby, J. De C., (1840), Systematic description of organic remains of Cutch. Trans. Geol. Soc. London, (2), V. V.,: 327-329.

**Remarks:**

Only two specimens of this form are found in the middle part of the formation in association with rich assemblage of *Assilina*. It is characteristically a biconvex form with thin edges. Numerous chamberlets which are a characteristic of this form are also visible in the cross section.

*Discocyclina ranikotensis* Davies  
(Plate 4, Fig. 5)

*Discocyclina ranikotensis* Davies, L. M. (1927) The Ranikot Beds at Thal. Quart. Journ. Geol. Soc. Lond., Vol. LXXXIII, pp. 260-290; Pls. XVIII- XXII.

**Remarks:**

There are only few specimens of this form present in the middle shaly part of the formation. This species is characterized by having a thin and elongated shell unlike *Discocyclina dispansa* which is strongly biconvex. Numerous chamberlets are also visible and prominent.

**Genus: Dictyoconoides, Nuttal**

*Dictyoconoides sp.*  
(Plate 4, Fig. 3)

*Dictyoconoides* Nuttal, W. L. F., (1925). The Stratigraphy of Laki Series, Quart. J. Geol. Soc. London, V. LXXXI: 417-453.

**Remarks:**

This species is also rare in the section. There are only few specimens observed in association with *Assilina* in the middle part of the formation. It is differentiated by having a trochospiral shell. The dorsal side is more convex than the ventral side.

**Genus: Alveolina, d'Orbigny 1826.**

*Alveolina elliptica* Sowerby  
(Plate 4, Fig. 6)

*Alveolina elliptica* Sowerby, J. De C., (1840), Systematic description of organic remains of Cutch., Trans. Geol. Soc. London, (2), V. V.,: 327-329.

**Remarks:**

This species is characterized by having flosculinization in its early stage then regular whorls.

*Alveolina stercusmeris* Mayer-Eymar,  
(Plate 4, Fig. 7)

*Alveolina stercusmeris* Mayer-Eymar K., 1886, table 1.

*Alveolina stercusmeris* Mayer-Eymar, Hottinger L., 1960, p.147, (no figure)

**Remarks:**

The flosculinization in the early stage which is a characteristic of *Alveolina elliptica* is lacking in this form and the whorls are quite closely spaced.

## PLATE 1

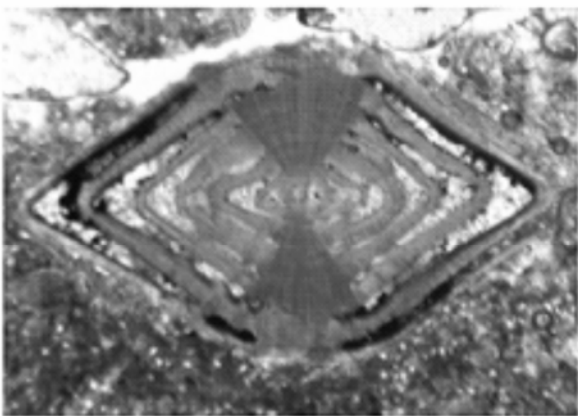


Fig. 1

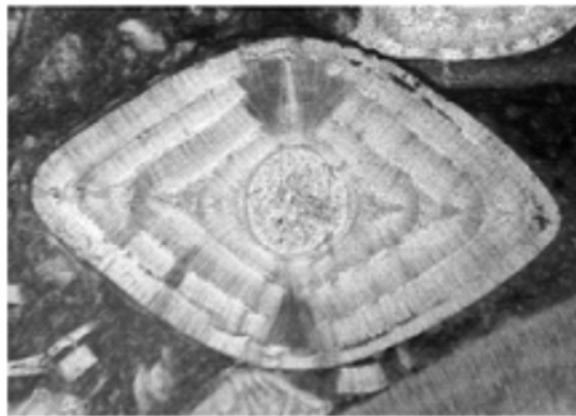


Fig. 2

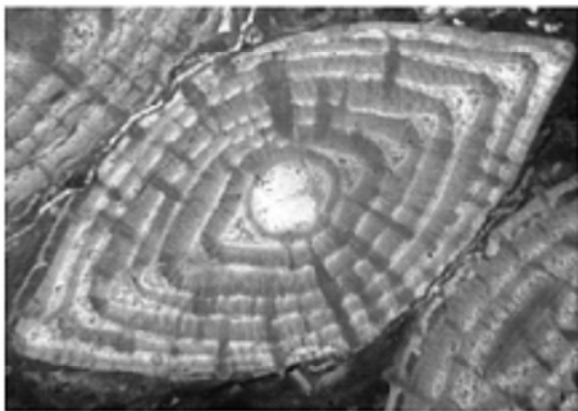
Figs. 1-2 *Nummulites mamillatus* (Fichtel & Moll)

Fig. 3

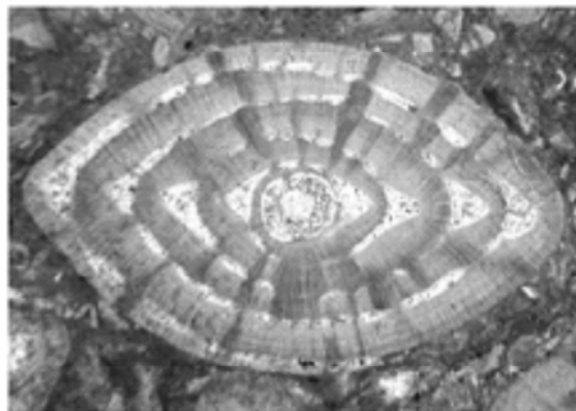


Fig. 4

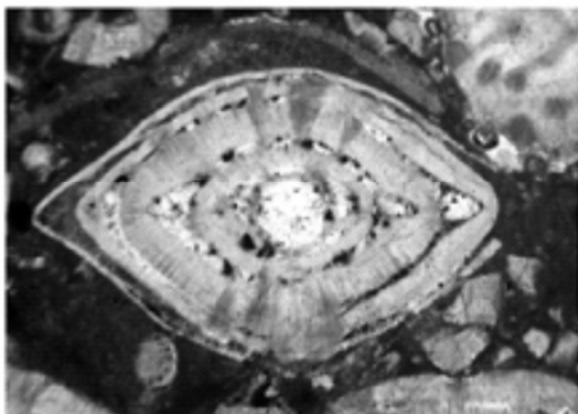
Figs. 3-4 *Nummulites atacicus* Leymerie

Fig. 5

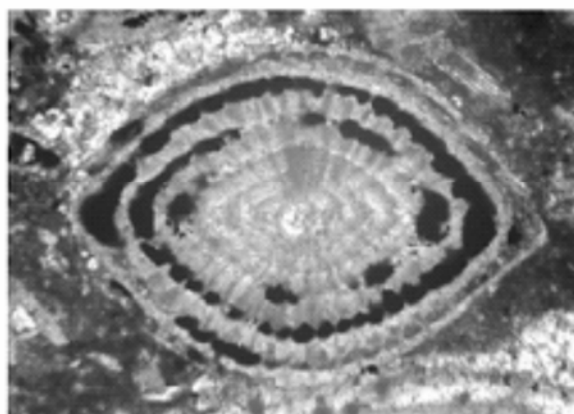


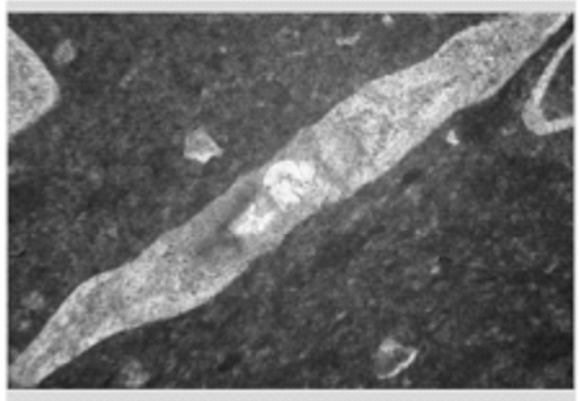
Fig. 6

Figs. 5 - 6 *Nummulites globulus* Leymerie

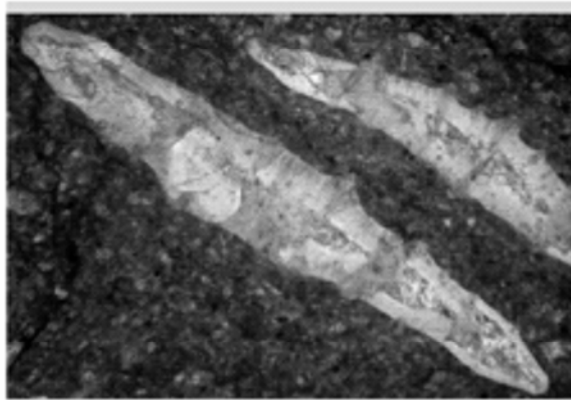
PLATE 2



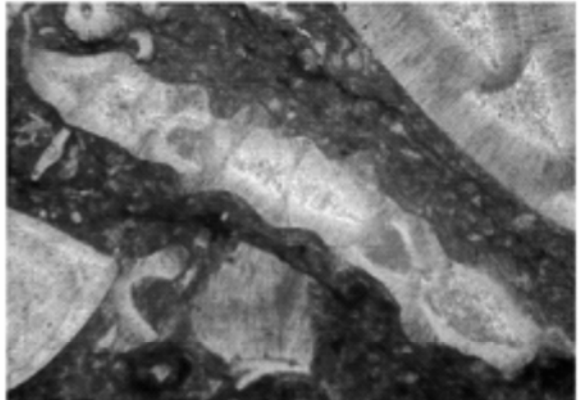
Fig. 1 *Nummulites subirregularis* De la Harpe



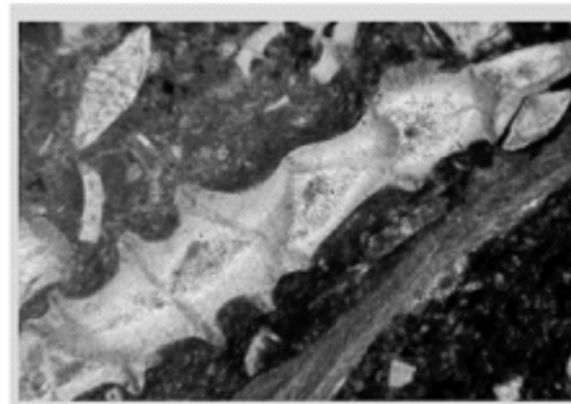
Figs. 2 *Operculina patalensis* Davies and Pinfold



Figs. 3 *Operculina patalensis* Davies and Pinfold



Figs. 4 *Operculina* sp.



Figs. 5 *Operculina* sp.

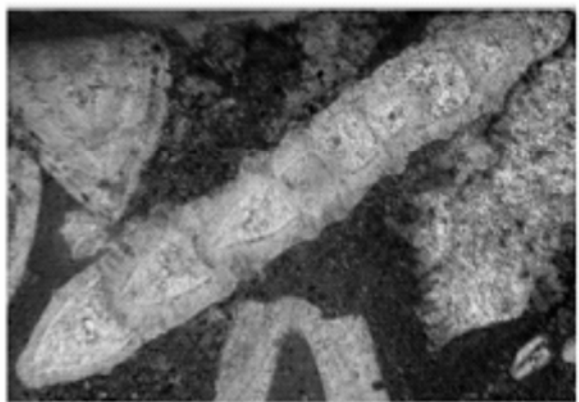


Fig. 6 *Assilina exponens* Sowerby



## PLATE 3

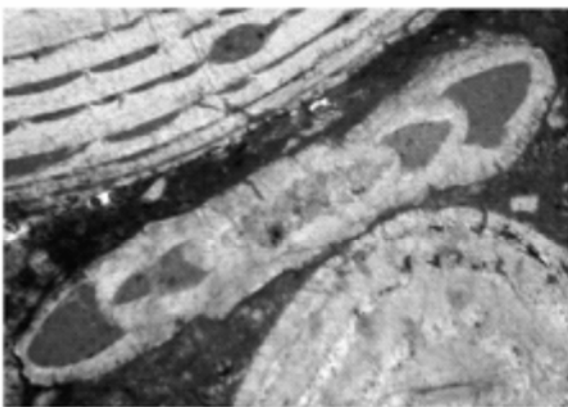
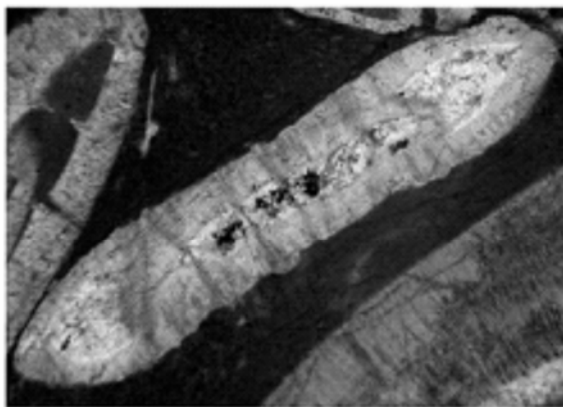
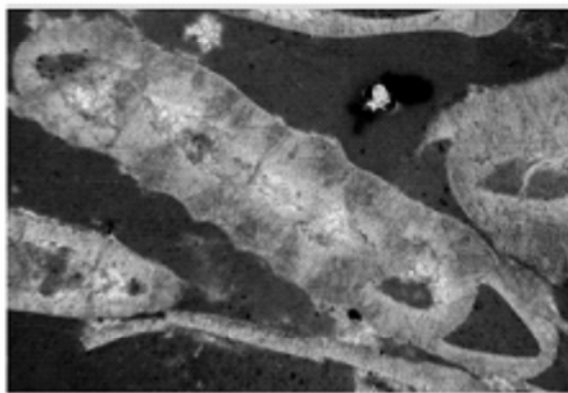


Fig. 1 *Assilina exponens* Sowerby



Figs.2 *Assilina granulosa* d'Archiac



Figs. 3 *Assilina granulosa* d'Archiac

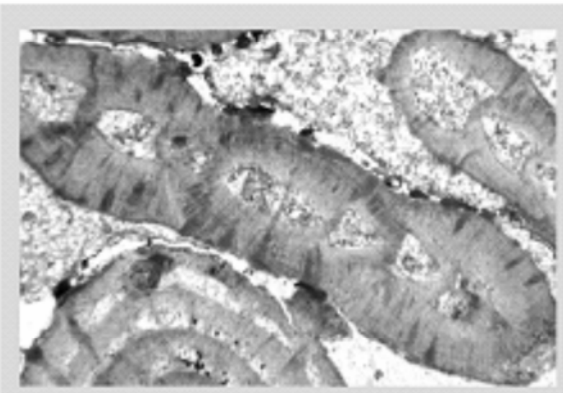


Fig. 4 *Assilina spinosa* Davies and Pinfold

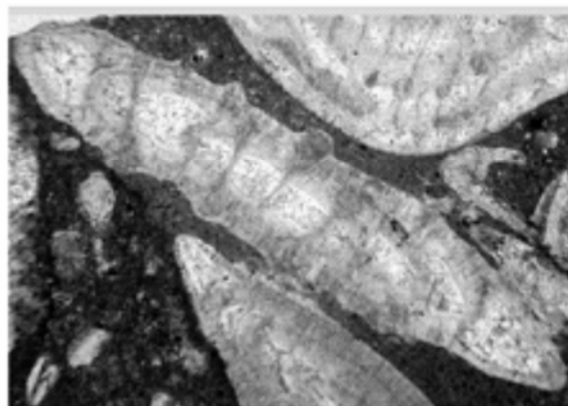


Fig. 5 *Assilina subspinosa* Davies and Pinfold



Fig. 6 *Assilina laminosa* Gill

PLATE 4

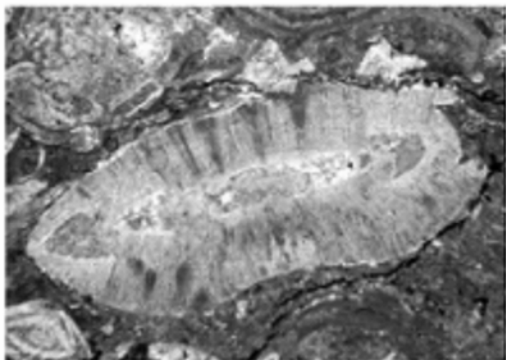


Fig. 1 *Assilina dandotica*, Davies and Pinfold

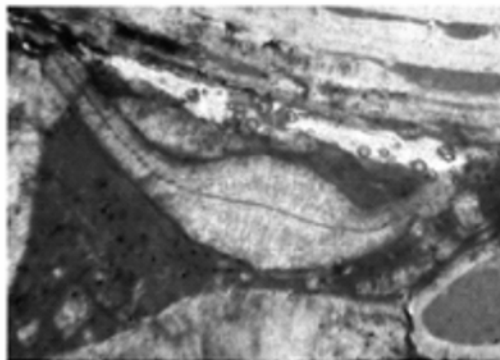


Fig. 2 *Discocyclina dispansa* Sowerby

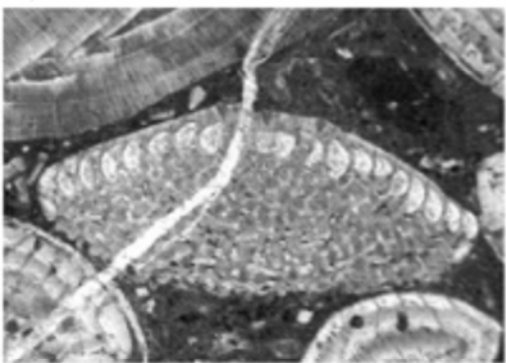


Fig. 3 *Dictyoconoides* sp.

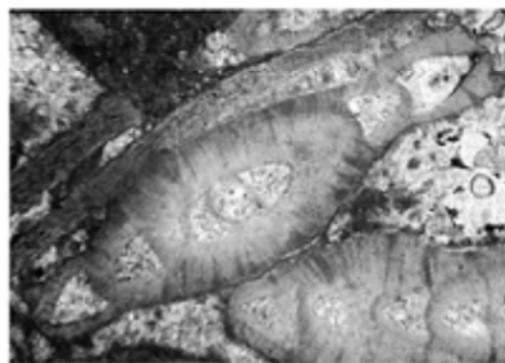


Fig. 4 *Assilina* sp.

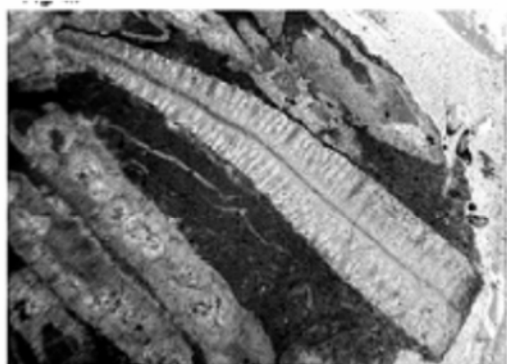


Fig. 5 *Discocyclina ranikotensis* Davies

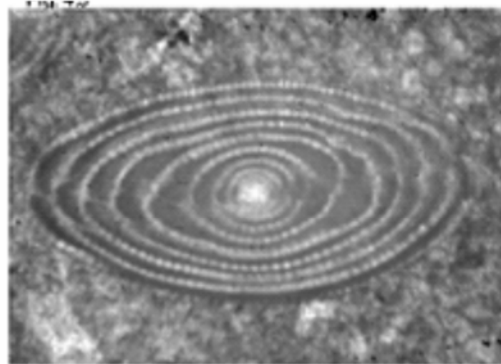


Fig. 6 *Alveolina elliptica* (Sowerby)

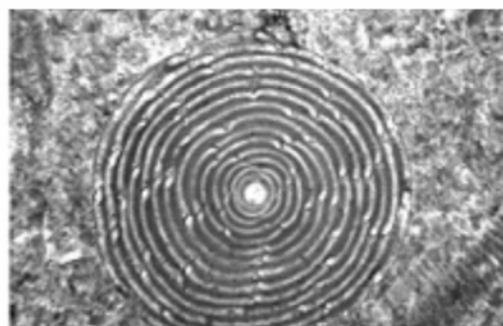


Fig. 7 *Alveolina stercusmeris* Mayer-Eymar

**Conclusion:**

The middle Eocene period is characterized by having abundant fauna and making bank bed deposits throughout the world. The Kohat Formation being an integral part of the Eocene Biostratigraphy of the Northern Pakistan is also characterized by having bank bed facies. This type of

facies is more common in the middle part of the formation which is shale bearing (Sadkal Member).

On the basis of observed fauna in the formation it can be concluded that the formation was deposited in open marine, shallow shelf environments. The observed fauna also confirms the middle Eocene age of the formation.

**REFERENCES**

- Davies, L. M., 1926, Notes on the geology of Kohat, with reference to the homotexial Position of the salt marl at Bahadur Khel. *Asiatic Soc. Bengal Jour. Proc., New Series*, **20**: 207-224.
- Eames, F. E., 1952, A contribution to the study of the Eocene in western Pakistan and Western India, Part a., The geology of the standard sections in the western Punjab and in the Kohat District. *Geol. Soc. London. Quart. Jour.*, **107**: 159-172.
- Fatmi, A.N. 1973 Lithostratigraphic units of Kohat-Potwar Province, Indus Basin. *Mem. Geol. Surv. Pakistan*, **10**, 1-89.
- Pinfold, E. S., 1918, Notes on structure and stratigraphy in the north-west Punjab. *Geol. Surv., Recs. India*: 137-160.

