## MICROFACIES ANALYSIS OF THE MIDDLE EOCENE KOHAT FORMATION, SHEKHAN NALA, KOHAT BASIN, PAKISTAN

BY

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**Abstract:** The Kohat Formation from the Shekhan Nala was sampled and measured for detailed stratigraphical and micropalentological studies to determine the age and environment of the formation. The Kohat Formation contains abundant varieties of larger foraminifera belonging to the genera Nummulites, Assilina and Alveolina. On the basis of larger foraminifera Middle Eocene age of the formation has been confirmed The microfacies studies identified the bioclastic wackestone, bioclastic packstone and bioclastic grainstone where the bioclasts are larger foraminiferal species, Nummulites beaumonti, Nummulites mamillatus, Assilina exponens and Alveolina elliptica. The Kohat Formation on the basis of larger foraminifera and micro facies analysis draws attention to the fact that it was deposited in shallow marine environments. The Kohat Formation has been identified into four lithofacies, which are from base to top, TS-1:- Calcareous shale interbedded with fossiliferous limestone. TS 2:- Nummulitic shale and limestone. TS-3:-Highly fossiliferous limestone. TS-4: Massive nodular limestone.

#### **INTRODUCTION:**

The Kohat area is underlain by sedimentary sequence ranging in age from Jurassic to Pliocene. In the northeastern and northwestern corners of the Survey of Pakistan Toposheet no 38 0/6 and 380/10 between longitude 71°30'15" E and 71°31'40" E and 30°35'20" N and 30°36'50" N. (Fig. 1) The rocks are tightly folded and faulted. The northern and southern flanks are in faulted contact with younger rocks (Meissner et. al. 1974).

The Eocene and Miocene sequences lie to the south of Kohat in a belt which is 16 to 25 miles wide from north to south. The Eocene sequence consists of limestone, clay, silt and gypsum with a total exposed stratigraphic thickness of about 548 m. (Meissner et. al. 1974).

The Middle Eocene Kohat Formation is distinguished into three members. (Meissner et. al. 1974). The Kaladhand Member is composed of interbedded limestone and shale. The limestone is soft and flaggy from medium to hard and highly fossiliferous (Davies 1926). The Sadkal Member is composed of bank bed facies. The colour is light brown and limestone is soft and argillaceous. This part is almost entirely composed of larger foraminifera (the Nummulitic Shales of Pinfold 1918). The Habib Rahi Member is composed of very fine grained micritic limestone.

The Miocene sequence is composed of sandstone, siltstone, shale and clay with a Stratigraphic thickness of about 710m. (Meissner et.al. 1974). South of Eocene and Miocene expose the area underlain by Pliocene strata, which mainly consist of interbedded, sandstone, siltstone and clay which contain conglomerate lenses. The objective of the detailed study of the Kohat Formation 16 Yaseen et al

exposed in Shekhan Nala is to identify the sedimentary facies, fossil contents and the environment of deposition. The present contribution is the outcome of first author's M.Sc. Field work (Yaseen, 2004).

#### PREVIOUS WORK

Eames (1952) described the stratigraphy of the region in greater detail and proposed various nomenclature for rock units exposed in the Kohat Quadrangle.

The first systematic geological work of the Kohat area was carried out by Meissner et. al. (1974) who prepared a geological map on a scale of 1:250,000 with the help of aerial photographs and gave a comprehensive account of the stratigraphy and structure of the area. Sameeni and Butt (1998) identified *Alveolina elliptica* (Sowerby) and *Alveolina stercusmuris* Mayer – Eymar from the Kohat Formation at Kundao Check Post, Kalabagh to Kohat Road.

#### MATERIAL AND METHODS

The oriented rocks specimens were collected for petrographic studies and hundred thin sections were prepared for microfacies analysis. However there were certain levels from where the free specimens of large foraminifera could be collected for systematic study.

#### STRATIGRAPHY OF THE SHEKHAN NALA

The stratigraphic section in the Shekhan Nala is as follows:

Miocene		Murree Formation
Eocene	Middle	Kohat Formation
		Kuldana Formation
	Lower	Shekhan Formation
		Panoba Shale
Paleocene		Patala Formation

#### **KOHAT FORMATION**

The Stratigaphic Committee of Pakistan (Fatmi, 1973) formalized the name Kohat Formation for the Kohat Shale and Kohat Limestone of Davies (1926, 1940) and for the Upper Chharat, Lower Chharat and the Kohat Limestone of Eames (1952). This also includes the Nummulitic Shales of Pinfold (1918).

The lower part of the Kohat Formation named as the "Kaladhand Member" is composed of interbedded limestone and shale. The colour of the limestone is light grey to medium grey, while the shale is of off white to medium grey colour.

The middle part of the Kohat Formation is called the "Sadkal Member" which is composed of bank bed facies due to the presence of abundant larger foraminifera. The colour of the limestone is light brown and the rock is soft and argillaceous. This corresponds to the Nummulitic Shals of Pinfold (1918).

The upper part of the Kohat Fomation is called the "Habib Rahi Member" which is medium hard to hard and is of light grey to medium grey in colour. This part is fossiliferous. The upper most part of the formation is micritic limestone. This member is also nodular.

It is interesing to note that all these three members are not exposed in a single section.

#### MICROFACIES

The thin section study identified three types of larger foraminifera (*Nummulites, Assilina* and *Alveolina*). Three main types of microfacies namely, Bioclastic Wackestone. (Plate 1, Figs. 1-3), Bioclastic Packstone (Plate 1, Figs. 4-5; Plate 3, Fig 1), and Bioclastic Grainstone (Plate 2, Figs. 1-2; Plate 3, Fig. 2) are identified.

The following species of larger foraminifera have been encountered during the detailed thin section study.

- 1. Nummulites beaumonti d'Archiac & Haime
- 2. Nummulites mamillatus (Fichtel & Moll)
- 3. Assilina exponens (Sowerby)
- 4. Alveolina elliptica (Sowerby)

*Nummulites beaumonti* d' Archiac & Haime (Plate 2, Figs. 3-5)

*Nummulites beaumonti* d' Archiac & Haime has originally been described and illustrated by d' Archiac & Haime (1859) from the Lower Tertiary of Egypt and Indian subcontinent.

Our material from the Kohat Formation represents microspheric individuals. The outline of the species is

lenticular with rounded margin. The wall is reasonably thick and shape of the chambers in the equatorial view is squarish in outline.

*Nummulites mamillatus* (Fichtel & Moll) (Plate 3, Figs. 1-2)

*Nummulites mamillatus* (Fichtel & Moll) is characterized by the thick wall, narrowly spaced chambers and the presence of umbonal pillars as seen in the vertical view. The specimen is strongly biconvex.

Assilina exponens (Sowerby) (Plate 3, Figs. 1-3)

Assilina exponens (Sowerby) has originally been described and illustrated from the "Nummulitic Series" of the Indian sub continent. The free specimens are of the size of coin and discoidal. The surface is provided by raised ridges. The specimens in our material are microspheric and the wall is thick. Assilina exponens (Sowerby) is abundantly found in the Kohat Formation.

# *Alveolina elliptica* (Sowerby) (Plate 3, Figs. 4-6)

*Alveolina elliptica* (Sowerby) has been described and illustrated by Hottinger (1960) from the Middle Eocene Kirthar Formation, Pakistan. Our illustrated material from the Kohat Formation closely compares with his figures. The initial portion of this species shows loose coiling and the later portion is closely spaced.

#### LITHOFACIES OF THE KOHAT FORMATION

For the environmental interpretation the Kohat Formation is divided into four facies in the project area on the basis of this detailed thin section study. (Fig.2)

#### 1- TSI (Tertiary at Shekhan Nala Section-I)

This is the unit present in the base of Kohat Formation. It is composed of calcareous shale and laminated, grey, hard, fossiliferous limestone.

The petrographic studies suggest that it contains micrite as major constituent, with larger foraminifera, crinoids and echinoids. It is bioclastic wackestone.

## Interpretation:

The depositional conditions represent shallow marine environments after the deposition of the Kuldana Fomation indicated by the presence of the association of *Nummulites*, *Assilina* and a1gae in a high energy environment.

#### 2- TS2 (Tertiary at Shekhan Nala Section-2)

This unit is composed of bluish grey, fine-grained, thinly bedded, nodular and richly fossiliferous limestone with interbedded argillaceous Nummulitic shale.

The petrographic studies suggest bioclastic wackestone to bioclastic packstone Major constituents are larger benthic foraminifera and shell fragments.

#### Interpretation:

This depositional phase shows a stabilized condition of transgression. The bioclastic packstone indicates a relatively high energy environment and shows a shoal sequence within the shallowing upward sequence.

#### 3- TS3 (Tertiary at Shekhan Nala Section-3)

It is an argillaceous limestone facies rich in larger benthic foraminifera having the tests of *Assilina* and *Nummulites*.

The petrographic studies show bioclastic wackestone with *Assilina* and *Nummulites* as bioclasts. Interpretation:

#### Interpretation:

The facies of this depositional phase show a low energy environment.

#### 4- TS4 (Tertiary at Shekhan Nala Section-4)

This unit consists of limestone. The topmost unit of this facies consists of brownish grey massive nodular limestone, which is in contact with the overlying Murree Formation, a molasse deposit of Miocene age. The petrographic study shows that the limestone is foraminiferal packstone to foraminiferal grainstone.

#### Interpretation:

The basal part of the facies shows, deposition in alternating low and high energy conditions. The top unit of the facies shows high energy conditions and the dominant microfacies are the bioclastic grainstones composed of foraminiferal bioclasts. The depositional phase of this facies carried out when the agitated water conditions prevailed.

#### CONCLUSIONS

The Kohat Formation is a carbonate sequence containing diagnostic larger foraminifera that confirm the Middle Eocene age of the formation.

The Kohat Formation represents shallow shelf deposits because of the presence of larger foraminifera and at certain stratigraphic level the calcareous shale containing abundant Nummulitic foraminifera represent bank bed facies.

The prominent microfacies are the bioclastic wackestone, the bioclastic packstone and the bioclastic grainstone. The bioclasts are larger foraminifera identified as *Nummulites beaumonti* d' Archiac & Haime, *Nummulites mamillatus* (Fichtel & Moll), *Assilina exponens* (Sowerby) and *Alveolina elliptica* (Sowerby).

The Kohat Formation has been distinguished into the following four lithofacies.

TS-I:- Calcareous shale interbedded with fossiliferous limestone.

TS-2:- Nummulitic shale and limestone.

TS-3:- Highly fossiliferous limestone.

TS-4:- Massive nodular limestone.

The entire study has demonstrated that the Kohat formation has been deposited in shallow marine environments.

### PLATE-1



Fig. 1 Bioclastic Wackestone. Nummulites beaumonti d' Archiac & Haime is the prominent bioclast



Fig, 2 Bioclastic Wackestone. Nummulites beaumonti d' Archiac & Haime is the prominent bioclast



Fig. 3 Bioclastic Wackestone. Nummulites and Assilina are the prominent bioclasts



Fig. 4 Bioclastic Packstone. Assilina exponens (Sowerby) and Nummulites beaumonti d' Archiac & Haime are the dominant bioclasts



Fig. 5 Bioclastic Packstone. Assilina exponens (Sowerby) and Nummulites beaumonti d' Archiac & Haime are the dominant bioclasts

## PLATE-2



Fig. 1 Bioclastic Grainstone. Nummulites beaumonti d' Archiac & Haime and Assilina exponens (Sowerby) are the prominent bioclasts



Fig. 2 Bioclastic Grainstone. Assilina sp being the dominant bioclast



Fig. 3 Equatorial view of Nummulites beaumonti d'Archiac & Haime



Fig. 4 Axial view of the microspheric Nummulites beaumonti d' Archiac & Haime



Fig. 5 Axial view of the microspheric Nummulites beaumonti d' Archiac & Haime



Fig. 1 Bioclastic Packstone Assilina exponens (Sowerby) and Nummulites mamillatus (Fichtel & Moll) are the prominent bioclasts



Fig. 2 Bioclastic Grainstone Assilina exponens (Sowerby) and Nummulites mamillatus (Fichtel & Moll) are the prominent bioclasts



Fig. 3 Axial view of Assilina exponens (Sowerby)



Fig. 5 Axial view of Alveolina elliptica (Sowerby)



Fig. 4 Equatorial view of Alveolina elliptica (Sowerby)



Fig. 6 Axial view of Alveolina elliptica (Sowerby)

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