

## PALEOGENE BIOSTRATIGRAPHY OF KOHAT AREA, NORTHERN PAKISTAN.

BY

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**Abstract:-** *The Kohat area of north Pakistan has a thick sequence of Paleogene strata. As a part of this study, four stratigraphic sections were measured and sampled for biostratigraphic studies. At present, the established stratigraphic sequence of Kohat area is after Shah, 1977, for the first time, the age of the units is established on the basis of Alveolinids Shallow Benthic Biozones commonly referred as SB zones.*

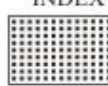
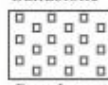
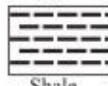
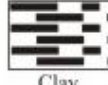

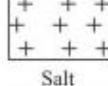
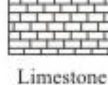











|                         |  |
|-------------------------|--|
| <i>Eocene</i>           | <i>Kohat Formation (SB-13-14)<br/>Kuldana/Mamikhel (SB-10-12) based on its position<br/>Shekhan Formation/Jatta Gypsum (SB-8-10)<br/>Panoba Shale/Bahadurkhel Salt &amp; Gypsum (SB-6-8)</i> |
| <i>Paleocene-Eocene</i> | <i>Patala Formation (SB-4-6)</i>   |
| <i>Paleocene</i>        | <i>Lockhart Limestone (SB-3)<br/>Hangu Formation (SB-3)</i>  |

*The data presented in this study will provide a basis for global correlation, sequence stratigraphy and paleobathymetry, important tools for surface and sub-surface hydrocarbon exploration.*

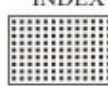
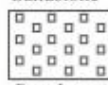
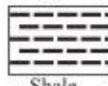
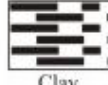

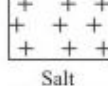
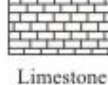

### INTRODUCTION

The Kohat basin is the most complex tectonic area of northern Pakistan. It is a tilted plateau with a moderate to steeper dips and asymmetrical structures formed by a large number of thrust/normal faults. It has been interpreted as formed by transgressional tectonics based on salt affected or basement involved thrust/reverse faulting (Paracha, 2001). The exposed stratigraphic sequence comprised of clastic, carbonate and evaporite strata ranging in age from Jurassic to Quaternary constitute a thickness in excess of 4 km (Table.1)

The earlier literature on the geology of Kohat and adjacent area is mainly focused on the salt deposits (Brunes, 1832; Fleming, 1853; Oldham and Thomas, 1864. Later work on the stratigraphy and structure include that of Eames (1952) Rashid et. al, (1965) Khan (1967) Meissner et. al (1968; Meissner, et. al. (1974). Gardezi, et al., (1976) discussed the geology of the Darra Adam Khel, District Kohat with the observations on the facies changes and their tectonic implications. Tanoli, et. al. (1993) has done a detailed study of the Eocene sedimentary sequence in Kohat Basin.

| Era      | Period     | Epoch              | Group            | Unit Thickness  | Formation      | Log   |   |   |
|----------|------------|--------------------|------------------|---|----------------|---|---|---|
| Cenozoic | Quaternary | Pleistocene        |                  | 170m  | Soan Fm        |  |   |   |
|          |            | Tertiary           | Pliocene         | Siwalik Group   | 1666m          | Dhok Pathan Fm  |    |   |
|          | Miocene    |                    |                  |   | 2651m          | Nagri Fm  |    |   |
|          |            |                    |                  |   | 934m           | Chinji Fm   |    |   |
|          | Eocene     |                    | Rawalpindi Group |   | 565m           | Kamlial Fm  |    |   |
|          |            |                    |                  |   | 101m           | Murree Fm   |    |   |
|          |            |                    | Cherat Group     |   | 173m           | Kohat Fm  |   |   |
|          |            |                    |                  |   | 70m            | Mami Khel Clay  |  |   |
|          |            |                    |                  |   | 95m            | Jatta Gypsum  |  |   |
|          |            |                    | Paleocene        |   | Makarwal Group | 227m  | Shekhan Fm<br>Bahadur Khel Salt<br>Panoba Shale                                       |  |
|          |            |                    |                  |   |                | 127m  | Patala Fm   |  |
|          | 103m       | Lockhart Limestone |                  |  |                |   |   |   |
|          | Mesozoic   | Cretaceous         |                  |   | 121m           | Hangu Fm  |  |   |
|          |            |                    |                  |   | 91m            | Kawagarh Fm   |  |   |
|          |            |                    |                  |   | 115m           | Lumshiwai Fm  |  |   |
|          |            | Jurassic           |                  |   | 15m            | Chichali Fm   |  |   |
|          |            |                    |                  |   | 153m           | Samana suk Fm   |  |   |
|          |            |                    |                  |   | 357m           | Datta Fm  |  |   |

INDEX

|   |              |
|---|--------------|
|    | Sandstone    |
|    | Conglomerate |
|    | Shale        |
|    | Clay         |
|    | Gypsum       |
|    | Salt         |
|   | Limestone    |
|  | Unconformity |

**Table 1.** Generalized stratigraphy of the Kohat Plateau (Based on data from Meissner et. al,1974,Kadri et.al,1995).

## REGIONAL STRATIGRAPHY:

The study area mostly lies in the eastern side of Kohat city (Fig.1) i.e. Shekhan Nala section, Tarkhobi section and Panoba section while only one section under study is the Uch Bazar section which is in the west of Kohat town.

The nomenclature of the stratigraphic units exposed in the area, adopted by the Stratigraphic Committee of Pakistan (Fatmi, 1973) are as follows.

| Age               | Old Names  | Present Names   |
|-------------------|--|---|
| Eocene            | Kohat Limestone & Sirki Shales<br>Kuldana Series/Lr. Chharat Series<br>Shekhan Lst./Jatta Gypsum<br>Green Shales/Kohat Saline Series | Kohat Formation<br>Kuldana Formation/Mamikhel Clay<br>Shekhan Lst./Jatta Gypsum<br>Panoba Shale/Bahadur Khel Salt |
| Paleocene- Eocene | Tarkhobi Shales  | Patala Formation  |
| Paleocene         | Tarkhobi Limestone<br>Hangu Shale & Sst  | Lockhart Limestone<br>Hangu Formation   |

### Hangu Formation

The name “Hangu Shale” and “Hangu Sandstone” was first used by Davies in 1930 which was laterally formulized by the Stratigraphic Committee of Pakistan (Fatmi,1973) as “Hangu Formation”.

The formation consists of light gray to reddish brown, weathers dark rusty brown, fine to coarse- grained sandstone, medium to thick-bedded with gray shale intercalations in the upper part.The thickness of the formation in the Uch Bazar section is 71 meters(Fig.2).

### Lockhart Limestone

Davies in 1930 introduced the name “Lockhart Limestone” for a Paleocene Limestone unit for the Tarkhobi Limestone of Eames (1952) in Kohat area which was later on formulized by the Stratigraphic Committee of Pakistan (Fatmi,1973). In the study area, the formation consists of light gray to dark gray, medium to thick-bedded and massive limestone. In the Tarkhobi area, the limestone contains shale interbeds in its lower part and is nodular in its upper part having a thickness of around 150 meters while it is only 48 meters thick in the Uch Bazar section (Fig. 2).

### Patala Formation

The name “Patala Shale” was introduced by Davies and Pinfold (1937) for Paleocene shales of the Salt Range area. Later, the Stratigraphic Committee of Pakistan (Fatmi, 1973) formulized it as “Patala Formation” and extended this name to the “Tarkhobi Shales” of Eames (1952) in the Kohat area.The formation consists of gray, splintery shale

with beds of silty shale and argillaceous limestone with Eocene forams in the upper limestone. The formation is exposed in all the measured stratigraphic sections carried out during this study. A thickness of 45 meters (Panoba section), 188 meters (Tarkhobi section), 20 meters (Shekhan Nala section) and 32 meters was recorded in the study area (Fig.2).

### Panoba Shales

Eames (1952) introduced the name Panoba Shale for the previously named Green Shales of Parson (1926). The name was later on adopted by the Stratigraphic Committee of Pakistan (Fatmi, 1973). The formation consists of greenish grey to light grey shale, slightly silty and calcareous at the base with flaggy limestone interbeds at some places. A thickness of 110 meters at Panoba section, 68 meters at Tarkhobi section, 60 meters at Shekhan Nala section and 172 meters at Uch Bazar section is recorded during present study.The Bahadur Khel Salt is the lateral facies of the Panoba Shale exposed in the southern side of the Kohat area.

### Shekhan Formation

The name Shekhan Limestone was introduced by Davies in 1930 which was later formulized by the Stratigraphic Committee of Pakistan (Fatmi, 1973) as Shekhan Formation.

The formation consists of yellowish gray to gray, thick bedded to massive and nodular limestone with interbeds of shale, which is gypsiferous at places. At Panoba , a thin bed of gypsum is also present (Fig.2). The formation is not exposed in the Uch Bazar section where

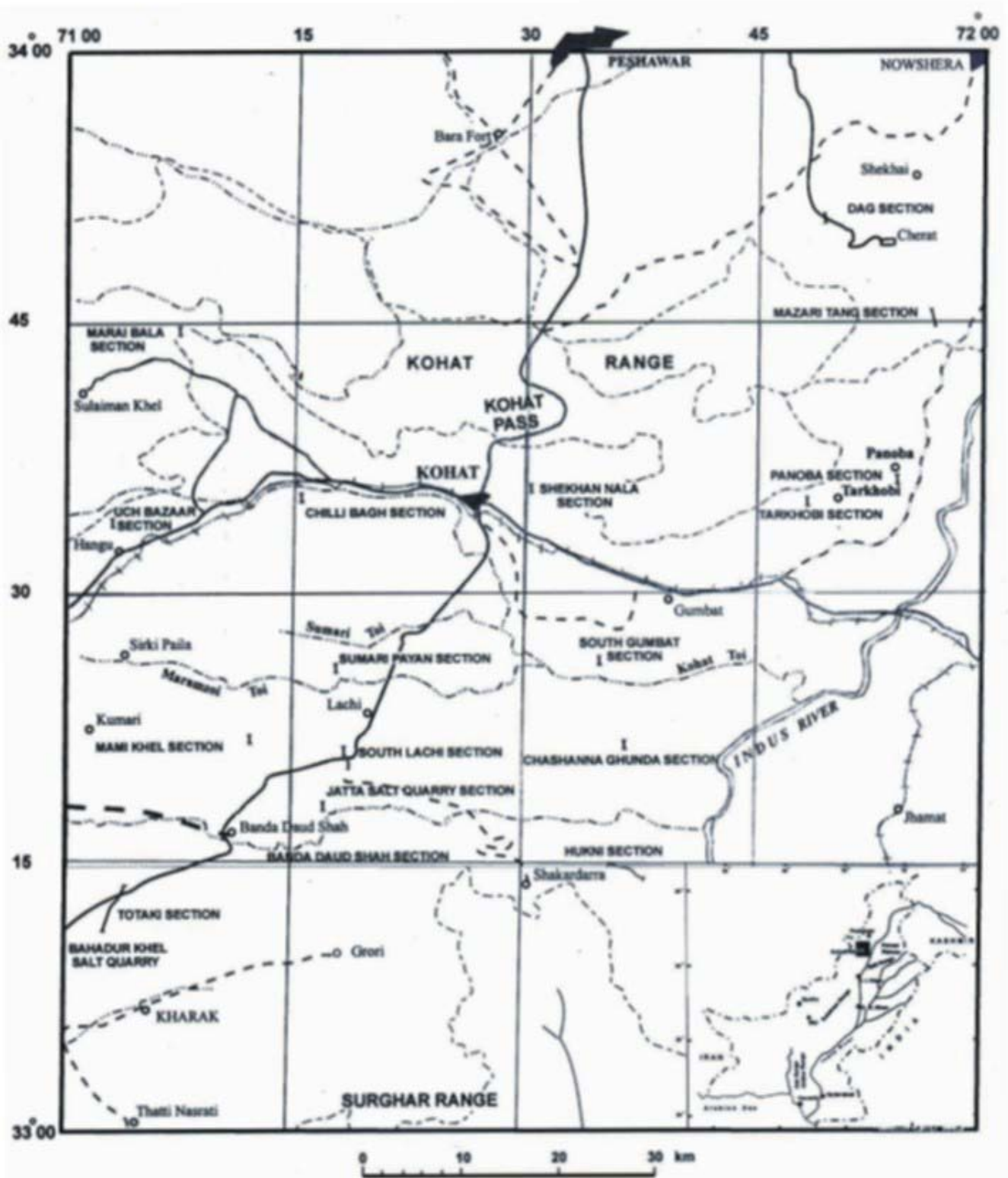


Fig. 1. Location map (after Meissner et al 1974)

the Kohat Formation has a disconformable upper contact with the Panoba Shales. A thickness of 74 meters at Panoba section, 65 meters at Tarkhobi section and 52 meters at Shekhan Nala section were observed. The Jatta Gypsum is the lateral facies of Shekhan Formation in the southern side of Kohat.

### Kuldana Formation

The name Kuldana Formation was first used by Latif (1970) to the Kuldana Series of Middlemiss (1896) and later on the name was formalized by the Stratigraphic Committee of Pakistan (Fatmi, 1973). The same name was extended to "Lower Chharat Series" of Eames (1952) in the Kohat area. The formation is comprised of brownish red to red shale which is calcareous and silty with thin beds of sandstone. The Kuldana Formation records the southward progression of a fluvial/deltaic system that introduced red shales, sandstones and local conglomerates in the basin. It has a continental fluvial origin and was deposited in a semi-arid basin at the end of a marine regression by rapidly flowing streams (Abbassi & McEalory, 1991). The formation is only exposed in the Panoba section and the Shekhan Nala section. Its thickness is 21 meter at Panoba and 120 meters at Shekhan Nala. The Mamikhel Clay is regarded as its lateral facies equivalent in other parts of the Kohat area.

### Kohat Formation

The name Kohat Shales and Kohat Limestone is used by Eames (1952) and has been formalized by the Stratigraphic Committee of Pakistan (Fatmi, 1973) as Kohat Formation. Meissner *et. al.* (1968) divided the formation into three members as Kaladand Member as lower one, Sadkal Member as upper one while the third one Habib Rahi Member is the lower member of the Kirthar Formation of the Sulaiman Province, exposed here in Kohat area. The formation is composed of limestone and shale interbeds. The Kaladand Member is mainly composed of light gray, thin-bedded limestone with intercalations of shale in its lower part while the upper Sadkal Member is composed of calcareous, greenish gray shale and gray limestone. The formation is not exposed in the Tarkhobi area. A thickness of 61 meters in Panoba section, 95 meters in Shekhan Nala section and 191 meters in Uch Bazar section were measured.

### Kirthar Formation

The Habib Rahi Member of the Kirthar Formation is exposed in the studied sections and is composed of pale gray to brownish limestone. In the Shekhan Nala section, it is overlain by the Murree Formation. Its thickness varies from 47 m in Panoba section, 38m in Shekhan Nala section and 41m in the Uch Bazar section.

## Methodology

As a part of this study, four, previously known (Meissner, *et al* 1974), stratigraphic sections of the Paleogene succession were selected in Kohat area. Three of these sections, Panoba, Tarkhobi and Shekhan Nala are located in the east while the Uch Bazar section lies in the west of Kohat city (Fig.1). Paleocene and Eocene succession was logged and about 100 samples were collected from these rocks for the preparation of thin sections. Loose specimens of larger foraminifers were also collected for detailed study and identification of age diagnostic foraminiferal species.

## OBSERVATIONS

After detailed study of thin sections and loose specimens, the following age diagnostic species of larger foraminifers are recorded.

- Alveolina elliptica* (SOWERBY), 1840
- Alveolina stercusmeris* MAYER-EYMAR, 1886
- Alveolina frumentiformis* SCHWAGER, 1883
- Alveolina aff. canavarii* HOTTINGER, 1974
- Alveolina pasticillata* SCHWAGER, 1883
- Alveolina indicatrix* HOTTINGER, 1960
- Nummulites mamillatus* (FICHEL and MOLL)
- Nummulites atacicus* LEYMERIE
- Nummulites globulus* LEYMERIE
- Nummulites pengaroensis* VERBEEK
- Discocyclina dispansa* (SOWERBY)
- Assilina laminosa* GILL

## SYSTEMATIC PALEONTOLOGY

### Genus *Alveolina* D'Orbigny, 1826

- Alveolina elliptica* (SOWERBY) 1840  
(Plate-II, Figs-a-c)

- Fasciolites elliptica* SOWERBY W., 1840, pl. 24. fig. 17.
- Alveolina javana* VERBEEK R., 1891, p. 111, pl. 1, figs. 4-7.
- A. (Flosculina) pillai* CHECCHIA-RISPOLI G., 1909, p. 69, pl. 3, fig. 12, text fig. 8.
- Fasciolites elliptica* SOWERBY. BAKX L. A., 1932, p. 229, pl. 3, figs. 15-17.
- Fasciolites javana* VERBEEK. BAKX L.A., 1932, p. 231, pl. 4, figs. 21-25.
- Alveolina (Fasciolites) subpryenaica* var. *flosculina* SILVESTRI A., 1939, p.30, pl. 7, figs. 4-5.
- A. elliptica nuttalli* DAVIES L., 1940, p. 219,221, pl. 12, figs. 1-4.
- A. elliptica* (SOWERBY) var. *flosculina* SILVESTRI. SMOUT A. H., 1954, p. 82, pl. 14, figs. 8-12.
- Alveolina elliptica* (SOWERBY). HOTTINGER L., 1960, p. 146, pl. 12, figs. 1-3.

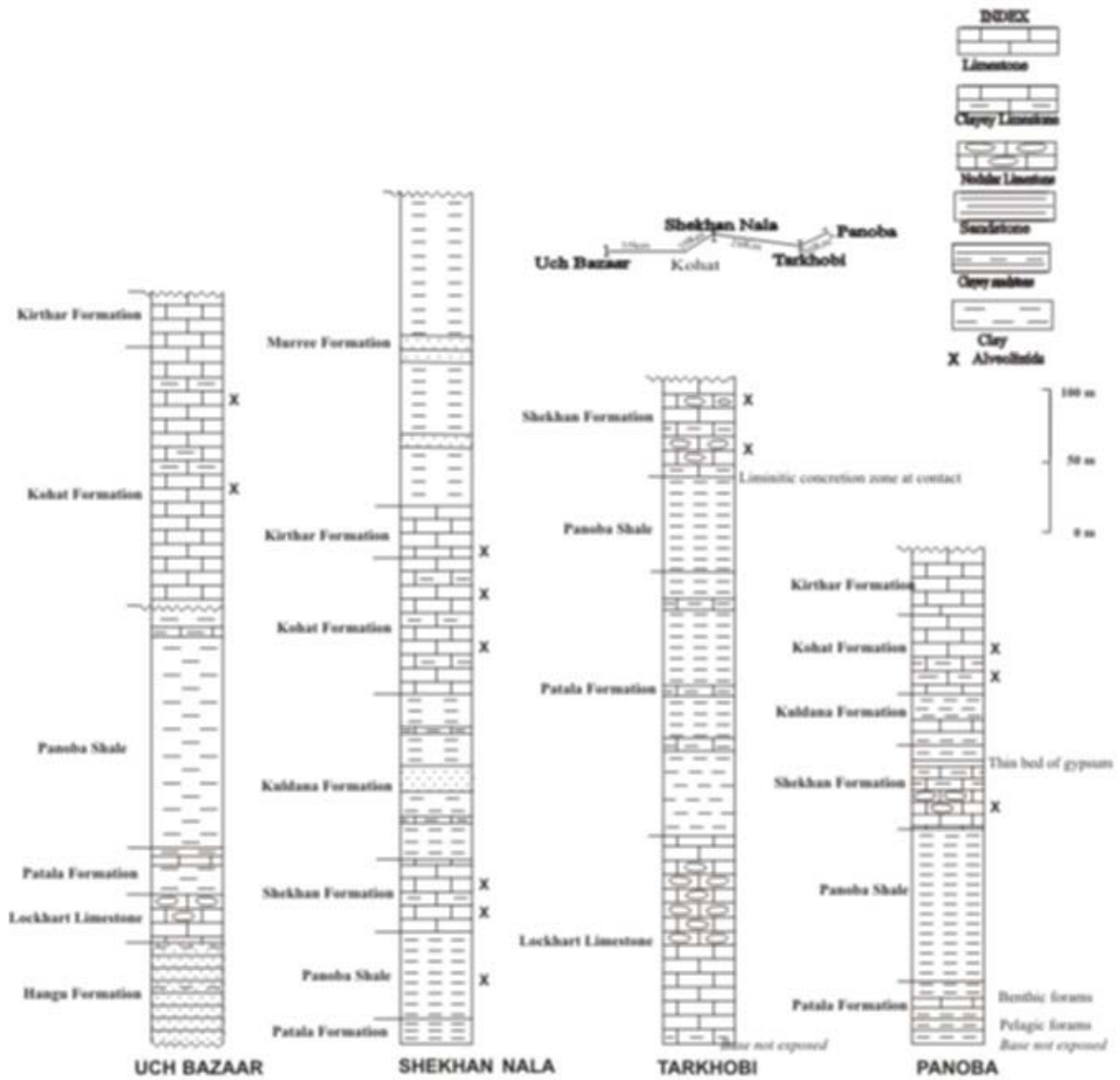


Fig.2. Stratigraphic columns of the measured sections Paleogene succession in Kohat area.

*A. elliptica nuttalli* DAVIES. HOTTINGER L., 1960, p. 146, pl. 12, fig. 4.

REMARKS:- This species is recorded from middle and upper part of the Kohat Formation from Panoba, Shekhan Nala and Uch Bazar sections. It is also recorded from the Habib Rahi Member of the Kirthar Formation in the Shekhan Nala section. The stratigraphic range of the species is *A. stipes* zone to *A. prorrecta* zone (Fig. 3).

-*Alveolina stercusmeris* MAYER-EYMAR, 1886.  
(Plate-II, Fig-e)

*Alveolina stercusmeris* MAYER-EYMAR K., 1886, table 1.

*Alveolina stercusmeris* MAYER-EYMAR. HOTTINGER L., 1960, p. 147, (no figure)

REMARKS: Oval shape, medium sized with rounded to slightly truncated poles, can be separated from *Alveolina elliptica* in lack of flosculinization. This species is recorded from the Kohat Formation of the Shekhan Nala section. The stratigraphic range of this species is *A. stipes* zone (Fig. 3).

-*Alveolina frumentiformis* SCHWAGER, 1883  
(Plate-II, Fig-d)

*Alveolina frumentiformis* SCHWAGER C., 1883, p. 100, pl. 2, fig. 4.

*Alveolina frumentiformis* SHWAGER. HOTTINGER L., 1960, p. 152, pl. 10, figs. 15-18, text fig. 82.

REMARKS: This species is recorded from the middle and upper part of the Kohat Formation from Panoba and Shekhan Nala sections. The stratigraphic range of this species is *A. stipes* zone (Fig. 3).

-*Alveolina* aff. *canavarii* HOTTINGER, 1974  
(Plate-III, Fig-a)

*Alveolina* sp. aff. *Alveolina canavarii*, n. sp. 2, HOTTINGER L., 1974, p. 51, pl. 58, Figs. 1-3.

REMARKS: This species is recorded from the middle and upper part of Shekhan Formation from Tarkhobi and Shekhan Nala sections. The stratigraphic range of this species is *A. trempina* zone (SB-9) to the lower part of the *A. oblonga* zone (SB-10) Fig. 3.

-*Alveolina pasticillata* SHWAGER, 1883  
(Plate-III, Fig-b)

*Alveolina pasticillata* SCHWAGER C., 1883, p. 104, pl. 26, fig. 2.

*Alveolina pasticillata* SCHWAGER. HOTTINGER L. 1958, figs. 7d, e.

*Alveolina pasticillata* SHWAGER. HOTTINGER L., 1960, p. 88, pl. 4, figs. 26-33, Text figs. 44-45.

REMARKS: This species is recorded from Panoba Shale of the Shekhan Nala area. The stratigraphic range of this species is from *A. ellipsoidalis* zone (SB-6) to the lower part of *A. carbrica* zone (SB-8) Fig. 3.

-*Alveolina indicatrix* HOTTINGER, 1960.  
(Plate-IV, Fig-a)

*Alveolina indicatrix* HOTTINGER L., 1960, p.100, pl. 5, figs. 1-2, text figs. 51a,b,52.

REMARKS: This species is recorded from the upper part of the Shekhan Formation from Tarkhobi and Shekhan Nala sections. The stratigraphic range of this species is from the upper part of *A. trempina* zone (SB-9) to *A. oblonga* zone (SB-10) Fig. 3.

### Genus *Nummulites* Lamarck, 1801

*Nummulites globulus* LEYMERIE  
(Plate-IV, Fig-b)

*Nummulites globulus* LEYMERIE, 1846. p.359, pl. XIII, figs. 14a,14d.

REMARKS:-This species is recorded from the Shekhan Formation and the Kohat Formation from Tarkhobi and Shekhan Nala sections. The stratigraphic range of this species is from lower to middle Eocene.

-*Nummulites mamillatus* (FICHTEL & MOLL)  
(Plate-III, Fig.c)

*Nummulites mamilla* (FICHTEL & MOLL), NUTTAL, 1925,p. 445, pl. 27, figs. 1-3.

REMARKS: This species is recorded from the uppermost part of the Patala Formation in the Panoba section. The stratigraphic range of this species is from lower to middle Eocene.

-*Nummulites atacicus* LEYMERIE  
(Plate-III, Fig-f)

*Nummulites atacicus* LEYMERIE, 1846, p.p. 358, pl. 13, fig. 13.

REMARKS: This species is recorded from the lower part of the Shekhan Formation of the Shekhan Nala section. The stratigraphic range of this species is from lower to middle Eocene.

-*Nummulites pengaroensis* VERBEEK  
(Plate-IV, Fig-c)

*Nummulites pengaroensis* VERBEEK. NAGAPPA, 1951, p. 181, pl. 10, figs. 3-5.

REMARK:-This species is recorded from the Kohat Formation and the Habib Rahi Member of the Kirthar Formation of Shekhan Nala section. The stratigraphic range of this species is from middle to upper Eocene.

### Genus *Discocyclina* Gumbel, 1870

-*Discocyclina dispansa* (SOWERBY)  
(Plate-IV, Fig.d)

| Age                |                          | Shallow Benthic Biozones (SB) | Alveolinids Zones | elliptica Group |                 | vredenburgi Group | canavarii Group   | pasticillata Group               |                  |
|--------------------|--------------------------|-------------------------------|-------------------|-----------------|-----------------|-------------------|-------------------|----------------------------------|------------------|
|                    |                          |                               |                   | A. elliptica    | A. stercusmeris | A. frumentiformis | A. aff. canavarii | A. pasticillata<br>A. indicatrix |                  |
| <b>E o c e n e</b> | <b>Lutetian</b>          | SB-15                         | A. prorecta       |                 |                 |                   |                   |                                  |                  |
|                    |                          | SB-14                         | A. munieri        |                 |                 |                   |                   |                                  |                  |
|                    |                          | SB-13                         | A. stipes         |                 |                 |                   |                   |                                  |                  |
|                    | <b>Ypresian</b>          | <b>Cusian</b>                 | SB-12             |                 |                 |                   |                   |                                  | A. voilae        |
|                    |                          |                               | SB-11             |                 |                 |                   |                   |                                  | A. dainelli      |
|                    |                          |                               | SB-10             |                 |                 |                   |                   |                                  | A. oblonga       |
|                    |                          | <b>Herdian</b>                | SB-9              |                 |                 |                   |                   |                                  | A. trempina      |
|                    |                          |                               | SB-8              |                 |                 |                   |                   |                                  | A. carbica       |
|                    |                          |                               | SB-7              |                 |                 |                   |                   |                                  | A. moussoulensis |
|                    | SB-6                     | A. ellipsoidalis              |                   |                 |                 |                   |                   |                                  |                  |
|                    | SB-5                     | A. vredenburgi                |                   |                 |                 |                   |                   |                                  |                  |
|                    | <b>P a l e o c e n e</b> | <b>Danian</b>                 | SB-4              |                 |                 |                   |                   |                                  | A. (G.) levis    |
|                    |                          |                               | SB-3              |                 |                 |                   |                   |                                  | A. (G.) primaeva |
|                    |                          | SB-2                          |                   |                 |                 |                   |                   |                                  |                  |
|                    |                          | <b>Thanetian</b>              | SB-1              |                 |                 |                   |                   |                                  |                  |

Fig. 3. Stratigraphic range of Alveolinids recorded.



| Age              |                  | Shallow Benthic Biozones (SB) | Alveolinids Zones                     | Formation                                |                   |
|------------------|------------------|-------------------------------|---------------------------------------|--|-------------------|
| <b>Eocene</b>    | <b>Lutetian</b>  | SB-15                         | <i>A. prorecta</i>                    | Kirthar Formation<br>(Habib Rahi member) |                   |
|                  |                  | SB-14                         | <i>A. munieri</i>                     |  |                   |
|                  |                  | SB-13                         | <i>A. stipes</i>                      | Kohat Formation                          |                   |
|                  | <b>Ypresian</b>  | <b>Cusian</b>                 | SB-12                                 | <i>A. voilae</i>                         | Kuldana Formation |
|                  |                  |                               | SB-11                                 | <i>A. dainelli</i>                       |                   |
|                  |                  |                               | SB-10                                 | <i>A. oblonga</i>                        |                   |
|                  |                  | <b>Herdian</b>                | SB-9                                  | <i>A. trempina</i>                       | Shekhan Formation |
|                  |                  |                               | SB-8                                  | <i>A. carbrica</i>                       | Panoba Shale      |
|                  |                  |                               | SB-7                                  | <i>A. moussoulensis</i>                  |                   |
|                  | <b>Paleocene</b> | <b>Danian</b>                 | SB-6                                  | <i>A. ellipsoidalis</i>                  | Patala Formation  |
|                  |                  |                               | SB-5                                  | <i>A. vredenburgi</i>                    |                   |
|                  |                  |                               | SB-4                                  | <i>A. (G) levis</i>                      |                   |
| SB-3             |                  |                               | <i>A. (G) primaeva</i>                |  |                   |
| SB-2             |                  |                               |                                       |  |                   |
| <b>Thanetian</b> | SB-1             |                               | Lockhart Limestone<br>Hangu Formation |  |                   |

Fig. 4. Chronostratigraphy of Paleogene succession of Kohat area on the basis of Alveolinids

## DISCRIPTION OF PLATES

### PLATE-I

*Alveolina elliptica* group, from Kohat Formation.

### PLATE-II

**Fig. a,b,c :** *Alveolina elliptica* (Sowerby), 1840, from Kohat Formation.

**Fig. e:** *Alveolina stercumeris* (Mayer-Eymar), 1886, from Kohat Formation.

**Fig. d:** *Alveolina frumentiformis* Schwager, 1883, from Kohat Formation.

### PLATE-III

**Fig. a:** *Alveolina* aff. *canavarii* Hottinger, 1974, from Shekhan Formation.

**Fig. b:** *Alveolina pasticillata* Schwager, 1883, from Panoba Shale.

**Fig. c:** *Nummulites mamillatus* (Fichtel & Moll), from Patala Formation.

**Fig. d:** *Nummulites ataticus* Leymerie, from Patala Formation.

**Fig. e:** *Assilina laminosa* Gill, from Panoba Shale.

### Plate-IV

**Fig. a:** *Alveolina indicatrix* Hottinger, 1960, from Shekhan Formation.

**Fig. b:** *Nummulites globulus* Leymerie, from Kohat Formation.

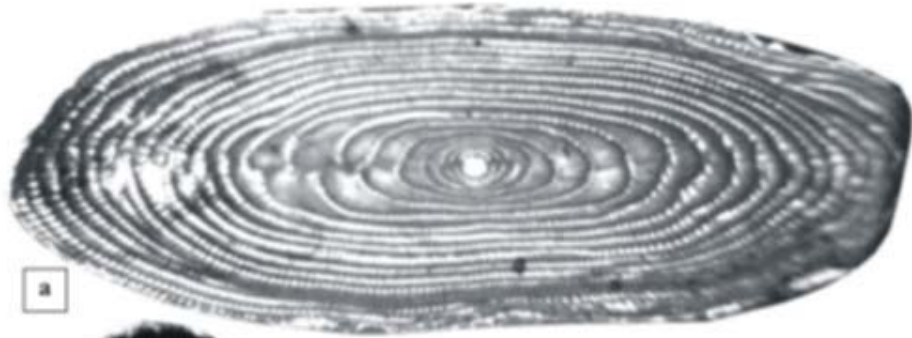
**Fig. c:** *Nummulites pengaroensis* Verbeek, frm Kohat Formation.

**Fig.d:** *Discocyclina dispansa* (Sowerby), from Panoba Shale

Plate-I



Plate-II



a



b



c

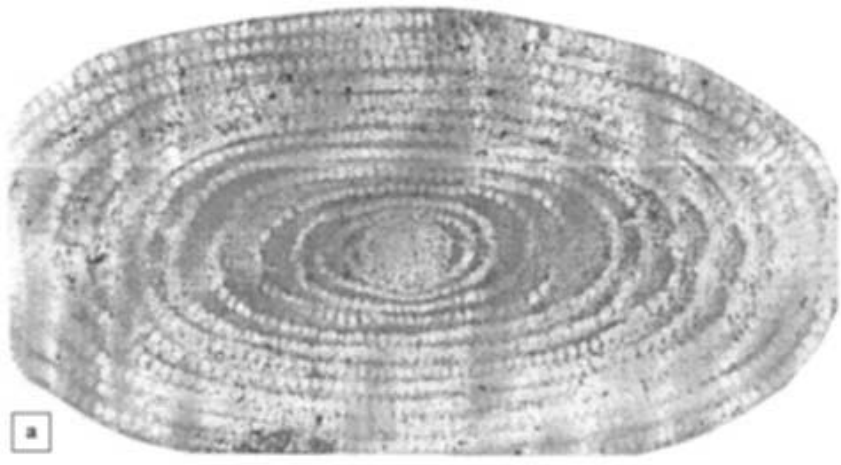


d



e

Plate-III



a



b



c



d



e

Plate-IV



*Discocyclina dispansa* (SOWERBY), NUTTAL, 1926, p. 157, pl. 7, figs. 1-3,5.

REMARKS: This species is recorded from the Panoba Shale of Shekhan Nala section. The stratigraphic range of this species is from lower to middle Eocene.

### Genus *Assilina* D'orbigny, 1826

-*Assilina laminosa* GILL

(Plate-III, Fig-e)

*Assilina laminosa* GILL, 1953, p. 83, pl. 13, figs. 14-17.

REMARKS: This species is recorded from Panoba Shale of the Shekhan Nala section. The stratigraphic range of this species is lower Eocene.

### CONCLUSIONS

Chronostratigraphy of the Paleogene rocks of Kohat area is established according to the modern Shallow Benthic Biozones (SB zones) on the basis of Alveolinids (Fig. 4). The Hangu Formation and Lockhart Limestone are upper Paleocene rocks as they contain upper Paleocene fauna. The Lockhart Limestone belongs to *A. (G.) primaeva* zone (SB-3) due to the presence of *Alveolina (Glomalveolina) dachelensis*. The base of the Patala

Formation is not exposed in Panoba section, the lower part in this area contains planktons of P-5 zone which is equivalent to *Alveolina vredenburgi* zone (SB-5) and the upper part of the Patala Formation in this area contains *Nummulites mamillatus* which belongs to lower Eocene i.e. *Alveolina ellipsoidalis* zone (SB-6). Due to the presence of *Alveolina pasticillata* in the Panoba Shale, this Formation ranges from *Alveolina ellipsoidalis* zone to *Alveolina carbrica* zone (SB-6 to SB-8). *Alveolina aff. canavarii* and *Alveolina indicatrix* are recorded from the Shekhan Formation, so this formation ranges from *Alveolina carbrica* zone to *Alveolina oblonga* zone (SB-8 to SB-10). *Alveolina elliptica*, *Alveolina stercusmeris* and *Alveolina frumentiformis* are recorded from middle and upper part of Kohat Formation which show the range of Kohat Formation from *Alveolina stipes* zone to *Alveolina munieri* zone (Fig. 4). *Alveolina elliptica* is also present in the HabibRahi member of Kithar Formation so the boundary between the Kohat Formation and the Kirthar Formation is in between *Alveolina munieri* zone. The Kuldana Formation is lacking Alveolinids so because of its position, it ranges from *Alveolina oblonga* zone to *Alveolina voilae* zone (SB-10 to SB-12).

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