

# Foraminiferal studies of eocen shekhan formation panoba section kohat northern Pakistan: implication for biostratigraphy and paleoenvironments

## Abstract

The present research is comprised of detail foraminiferal based biostratigraphy and paleoenvironmental understandings of Shekhan Formation (Early-Middle Eocene) Panoba section Pakistan. The foraminiferal studies exhibited detail for biostratigraphy which resulted in the interpretations of three planktonic-foraminiferal-biozones. Identified planktonic-foraminiferal-biozones include; (i) Nummulites globules (lower Eocene), (ii) Nummulites perforatus Biozone (middle Eocene), and (iii) Nummulites aturicus (middle Eocene). Furthermore, correlation of planktonic-foraminiferal-biozones with standard planktonic zonations have been done. In conclusion, various larger benthonic and smaller foraminifers of Lower-Middle Eocene interval have been identified. With the help of planktonic-benthonic ratio, the total foraminiferal abundance and their diversification/preservation shallow to neritic inner shelf environmental setting has been interpreted for Early-Middle Eocene Shekhan Formation.

**Keywords:** paleoenvironmental setting, eocene shekhan formation, panoba section.

Volume 3 Issue 5 - 2019

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**Received:** August 05, 2019 | **Published:** October 11, 2019

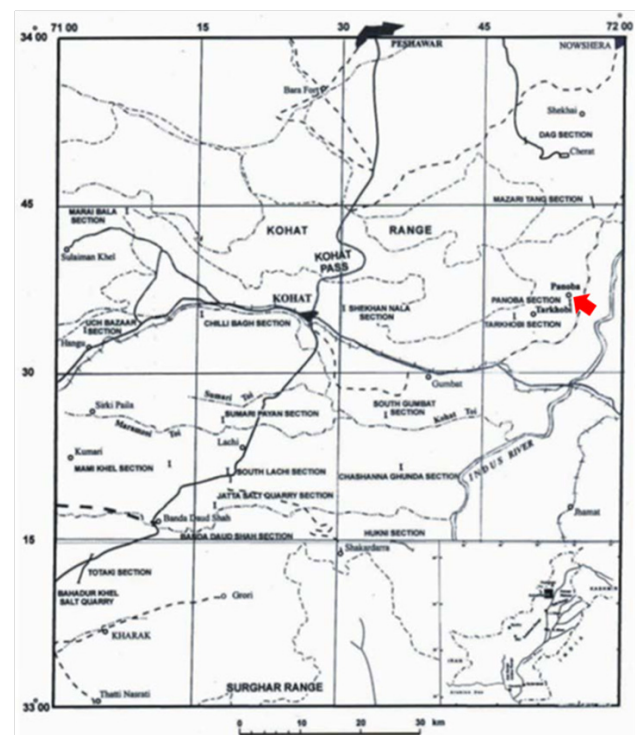
## Introduction

The studied section is situated in the North-Eastern side of the Kohat Plateau on Kohat Nizampur Road near Panoba Village (Figure 1). The Kohat Plateau forms the western margin of the Himalayan foreland folds and thrust belt. The sedimentary record of the Himalayan orogenic belt in North-Western Pakistan is well preserved in the Kohat foreland folds and thrust belt.<sup>1</sup> The Kohat Plateau is linked to the North by Main Boundary Thrust (MBT) and to the south by Surghar Range Thrust (SRT). The eastern continuation of the Surghar Range Thrust is called the Salt Range Thrust, which is offset by right lateral movement along Kalabagh fault. On the eastern side, Indus River separates Kohat Plateau from Potwar Plateau. On the western side, the Kohat plateau is constrained by the Kurram fault. Total measured thickness of Panoba Section is 345m and is comprised of sedimentary rocks of Paleocene-Miocene Figures 2&3.<sup>2</sup> Shekhan Limestone was studied in detail at Panoba section. Shekhan formation is part of the Eocene sequence of the Kohat Plateau.<sup>2,3</sup> The formation consists of limestone sequence in the lower part and alternating beds of limestone and shale in the upper part.<sup>2</sup> The non-clastic facies of the Shekhan formation in the Northern part of the Kohat Basin, laterally changes to clastic facies of the Chashmai Formation<sup>4</sup> in the west and to evaporites of the Bahadar Khel Salt and Jatta Gypsum in central and southern part of the basin. Furthermore, Shekhan formation rests conformably on the Panoba Shale and is composed of Yellowish grey, medium to thick bedded, nodular, highly bioturbated Limestone with shale partings.<sup>2</sup> The formation contains abundant Eocene fossils. The Shekhan Formation is also exposed at Shekhan Nala South-East of Panoba Village and near the Tarkhobi village in Kohat. The main purpose of the present study is;

(i) To present detail study of existing foraminiferal species of Early-Middle Eocene Shekhan Formation;

(ii) To identify foraminiferal based biostratigraphic zonations, and

(iii) Based on studied foraminiferal species to present paleoenvironment of the formation.



**Figure 1** Location of study area. Red arrow showing location of studied section.

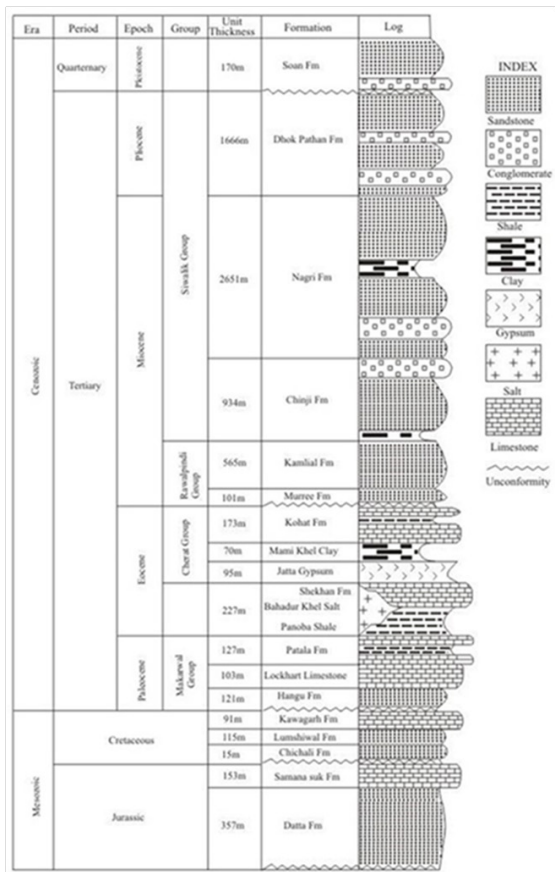


Figure 2 Stratigraphy of Kohat Plateau (modified after Kadri et al., 1995; Meissner et al., 1974).

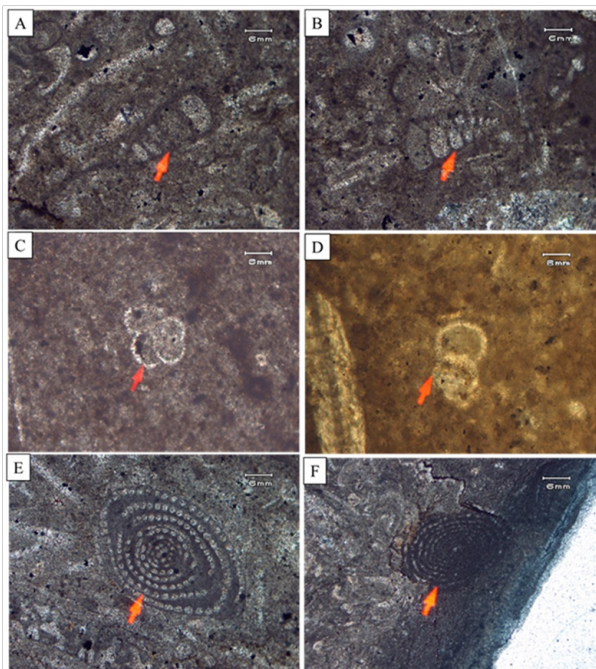


Figure 3 Identified species of foraminifera in Shekhan Formation Panoba section are: (A) specie: Chilogumbelina aff. martini (Martini); side view, P (x10), sample# 7 (B) specie: Chilogumbelina victoriana (Beckmann, 1957); equatorial view, P (x10), sample# 7 (C) specie: Globogerina taroubaensis (Bronnimann, 1952); umbilical view, P (x20), sample# 19 (D) specie: Subbotina lozanoi prolata (Bolli); P (x20), sample# 16 (E) specie: Alveolina ludwingi (Reichel, 1936); P (x4), sample# 7 (F) specie: Alveolina periloculinoides (Silvestri, 1939); P (x4), sample# 7.

### Stratigraphy of panoba section

The Panoba section lies in the north eastern part of Kohat. The Kohat area is underlain by a thick sedimentary sequence of more than 61m ranging in age from Jurassic to Pliocene. Due to severe tectonism, the rocks are highly folded and faulted.<sup>5,6</sup> In the study area the rocks range in age from Paleocene to Miocene. In the study area due to tectonic activity rocks are folded and is existed in the form of east-west Panoba anticline. The Paleocene rocks constitute the core of the Anticline whereas the Miocene rocks lies on its flanks. The southern limb of this Anticline is faulted along which the Kohat Formation is thrust over the Murree Formation in the Footwall. The fault surface is characterized by Slickenside, fault breccias and the beds are steeply dipping in the hanging wall and footwall of the fault. The rocks exposed in Panoba section ranges in age from Paleocene to Miocene (Table 1).

Table 1 General Stratigraphy of Panoba section, Kohat Northern Pakistan

S. No	Formations	Geological age	Lithology
1	Kamlail Formation	Miocene	Sandstone
2	Murree Formation	Miocene	Siltstone, fossiliferous, Monotonous sequence of clay
3	Kohat Formation	Eocene	Interbeds of limestone & shale
4	Kuldana Formations	Eocene	Shale, Marl
5	Shekhan Formation	Eocene	Shale, limestone
6	Panoba Shale	Eocene	Shale
7	Patala Formation	Paleocene	Shale & marl, limestone
8	Lockhart Limestone	Paleocene	Limestone, trans, fossiliferous

### Results

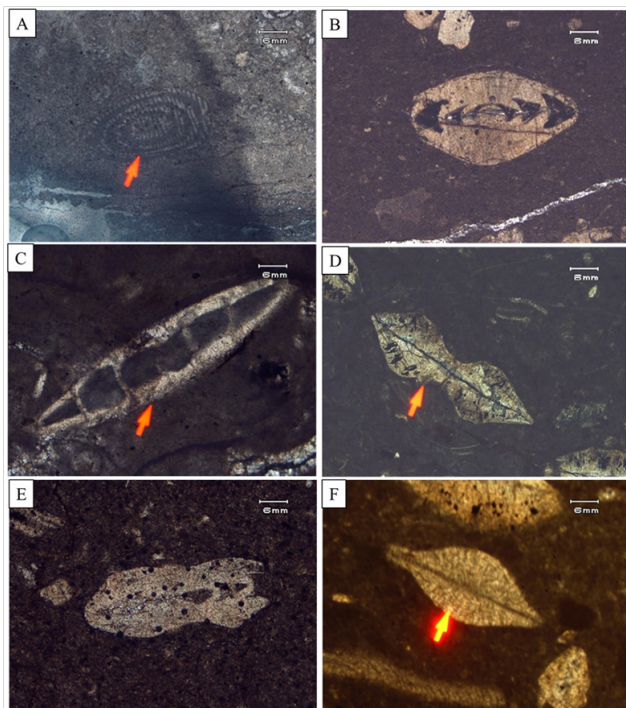
Biostratigraphic results are based on identification of foraminiferal species which include twenty seven Larger Benthics, eight Smaller Benthic and four Planktonic Forams, from the outcrop samples of Shekhan Formation at Panoba section, Northern Kohat Plateau. Foraminiferal range distribution chart and biozonation is established using larger benthic Foraminifera which include mostly Nummulites. Larger Benthic foraminifera can be used for correlation of shelf sequences where Planktonic Foraminifera are absent or in low abundance. Schaub, recognized four separate and partly overlapping boson sequences in Paleocene rocks of the Mediterranean based on Nummulites and Assilina (Table 2). Similarly Hottinger,<sup>7-9</sup> also established Paleogene Alveolinids Biozonation (Figure 3). The Biozonation interval recognized on the basis of larger foraminifera provides a finer stratigraphic resolution than the circum globally recognized Planktonic foraminifera and calcareous nano Planktonic zones. In present study we have recognized thirty nine foraminifera species recognized after<sup>10</sup> which include Assilina dandotica (Figure 4B), A. pustulosa (Figure 4D), A. exponents (Figure 4C), A. pustulosa, A. subspinosa (Figure 4E), Discocyclina dispensa (Figure 4F), D. forsi (Figure 5A), D. roberti (Figure 5B), D. scalaris (Figure 5C), D. sella (Figure 5D), D. undulata (Figure 5E), Lepidocyclina bikinensis (Figure 5E), Lockhartia pustulosa (Figure 6A), Miscellanea miscella (Figure 6B), Nummulites aturicus (Figure 6C), N. discorbina (Figure 6D), N. distans (Figure 6E), N. globulus (Figure 6F), N. mamillatus (Figure 7A), N. perforatus (Figure 7B), N. stellatus (Figure 7C), N. striatus (Figure 7D), Operculina canalifera (Figure 7E), Bigenerina

sp. (Figure 7F), *Articulina sagra* (Figure 8A), *Hauerina bradyi* (Figure 8B), *Quinqueloculina vulgaris* (Figure 8C), *Nodosaria nammalensis* (Figure 8D), *Nonionella* sp. (Figure 8E), *Pseudoglandulina caudigera* (Figure 8F), *Texularia* sp. (Figure 8G), *Chiloguembelina* aff. *Martini* (Figure 3A), *Chiloguembelina Victoriana* (Figure 3B), *Globigerina*

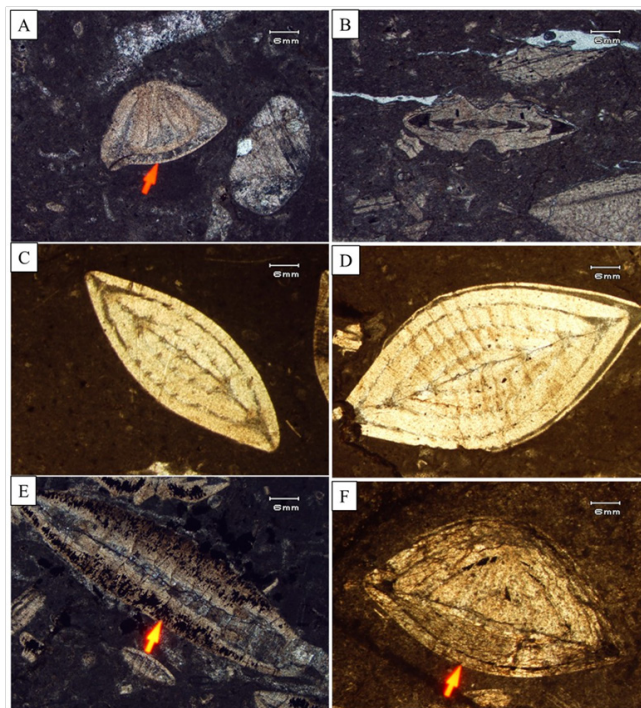
*taroubaensis* (Figure 3C), *Subbotina lozanoi prolata* (Figure 3D), *Alveolina ludwingi* (Figure 5E), *Alveolina periloculinoides* (Figure 3F) are as shown in the range distribution chart (Figure 2). Following the scheme of Schaub, (Table 2), three Nummulitic Biozones are established which include:

**Table 2** Schaub's multiple biozonation charts for the Palaeogene based on Nummulites and Assilina compared with the Alveolina zones of Hottinger (1960) and the nannoplankton zones of Kapellos and Schaub (1975) and Cavalier (1975) (modified after Schaub, 1981).

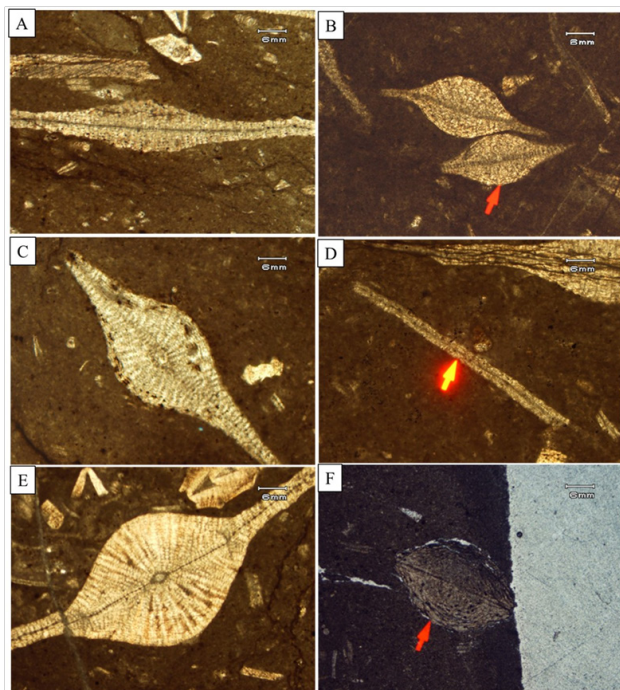
EPOCH	Stage	Biozones					
		Nummulites			Assilina	Alveolina	Nanoplankton
		Group of N bronogratis	Group of N Pertoratus	Others			
Oligocene	Lower			fichteli			Er. subdisticha
UPPER	PRIABONIAN			Fabiani		Neo Alveolina	I.Pseudoraduan I.recurvus
	BIARRITZIAN	brongniarti	perforatus	ptutiari		elongata	Ch.Oamaruensis
MIDDLE	UPPER	herbi	aturicus	bulstus	gigantea		
	MIDDLE 2	scrdensis	crasus		planospra	prorecta	Disc. tari nodifer
	MIDDLE 1	gratus	beneharnesis		spira spira	murieri	
	LOWER 2	laevigatus	obesus		spira abrard	stipes	Chiphr.alatus
LOWER			gallensis				
	UPPER	manfred	campesinus	lormosus	major	violae	Disc.sublodoensi
	MIDDLE	praelaevigatus	burd. cantabrich	nitous	laxispira	daineli	
	LOWER 1						Disc.ladoersis
	LOWER 2	planulatus	buragalensis	aff.larus	plana	obionga	
	UPPER	involutus		laxus	adrianensis	trepina	Marth trbrachiatus
UPPER	MIDDLE 2	exilis	perrotus		leymeriei	corbarira	Disc.binodosus
	MIDDLE 1	robustiformis		globulus zarcasonensis	aff.Arenesis	-noussoulens	
	LOWER 2					ellpsoidais cucumtorms	Marth contartus
	LOWER 1	fraasi	soatarus	minervensis deserti	arenensis prisca		Disc mutradiatus
UPPER	UPPER				yvettae	levis	
	LOWER					primaeva	Hel rededi Disc gemmeus Hel Herpeli Fasc lympanformis El macelius Chiasm dancus Crupl terius Martial mersus
LOWER	DANIAN						



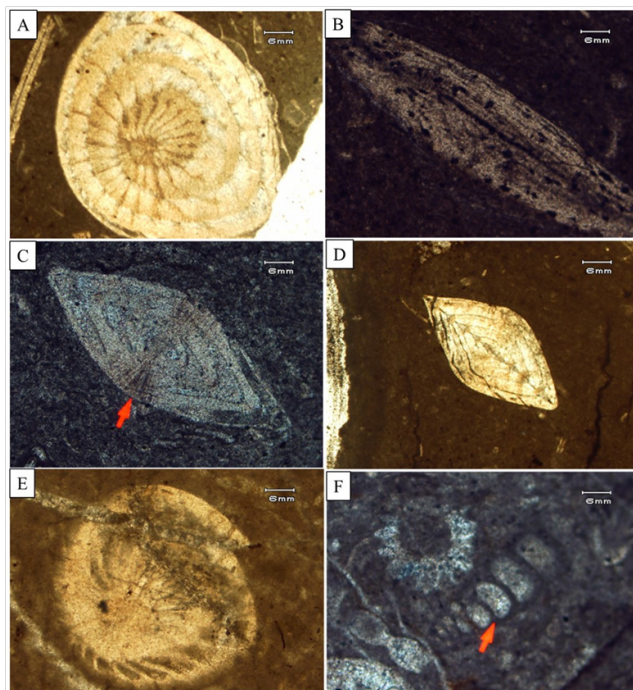
**Figure 4** Identified species of foraminifera in Shekhan Formation Panoba section are; (A) specie: *Alveolina terebrata* (Silvestri, 1939) P (x4), sample # 7 (B) Specie: *Assilina dandotica* (Davies, 1937) P (x4), sample # 4, 11, 4 (C) specie: *Assilina exponens* (Sowerby, 1840) P (x4), sample # 4, 14, 16 (D) specie: *Assilina pustulosa* (Doncieux, 1926) P (x4), sample # 4 (E) specie: *Assilina subspinoso* (Davies and Pinfold, 1937) P (x10), sample # 11 (F) specie: *Discocyclusina dispensa* (Sowerby, 1926) P(x4), sample # 11, 14–16, 18.



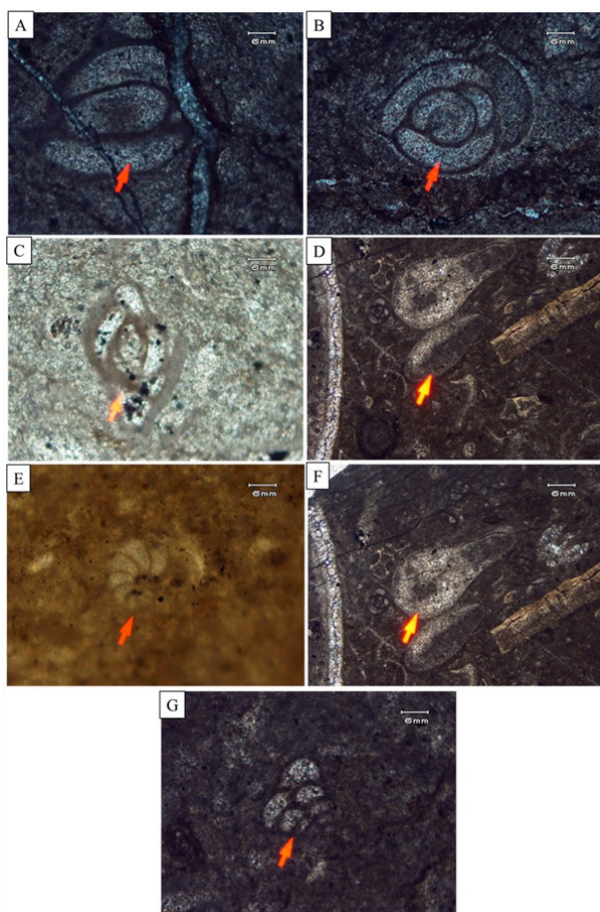
**Figure 6** Identified species of foraminifera in Shekhan Formation Panoba section are; (A) specie: *Lockhartia pustulosa* (Smout, 1954) P (x4), sample # 7, 19 (B) specie: *Miscellanea miscella* (d'Archaic and Haime, 1854) P (x4), sample # 11, 14, 17 (C) specie: *Nummulites aturicus* (Joly and Leymerie, 1962) P (x10), sample # 5, 14 (D) specie: *Nummulites discorbina* (d'Archaic and Haime, 1853) P (x4), sample # 6, 12, 14 (E) specie: *Nummulites distans* (Deshayes, 1959) P (x10), Sample # 4, 11, 14, 15 (F) specie: *Nummulites globulus* (Leymerie, 1846) P (x4), Sample # 4, 18.



**Figure 5** Identified species of foraminifera in Shekhan Formation Panoba section are; (A) specie: *Discocyclusina fortis* (d'Archaic, 1958) P (x4), sample # 11, 14–15 (B) specie: *Discocyclusina roberti* (Douville, 1958) P (x4), sample # 15, 18 (C) specie: *Discocyclusina scalaris* (Schlumberger, 1958) P (x4), sample # 11, 14–15 (D) specie: *Discocyclusina sella* (d'Archaic, 1958) P (x4), sample # 15 (E) specie: *Discocyclusina undulata* (Nuttall, 1926) P (x4), sample # 14 (F) specie: *Lepidocyclusina bikinensis* (Cole, 1954) P (x4), sample # 11.



**Figure 7** Identified species of foraminifera in Shekhan Formation Panoba section are; (A) Specie: *Nummulites mamillatus* (Fichtel Moll) P (x4), sample# 4, 18 (B) specie: *Nummulites perforatus* (de Montfort, 1808) P (x10), sample# 11 (C) specie: *Nummulites stellatus* (Roveda, 1961) P (x10), sample# 4, 12 (D) specie: *Nummulites striatus* (Bruguiere, 1792) P (x4), sample# 14 (E) specie: *Operculina canalifera* (d'Archaic and Haime, 1853) P (x20), sample# 17 (F) specie: *Bigenerina* sp. (d'Orbigny, 1826) P (x10), sample# 7



**Figure 8** Identified species of foraminifera in Shekhan Formation Panoba section are; (A) species: *Articulina sagra* (d'Orbigny, 1826) P (x20), sample# 12 (B) Species: *Hauerina bradyi* (Cushman, 1946) P (x20), Sample # 12 (C) Species: *Quinqueloculina vulgaris* (d'Orbigny, 1826) P (x20), sample# 7, 12 (D) species: *Nodosaria nammalensis* (Haque, 1956) P (x4), sample# 7 (E) species: *Nonionella* sp. (Haque, 1956) P (x10), sample# 16, 17 (F) species: *Pseudoglandulina caudigera* (Schwager, 1883) P (x4), sample# 7 (G) species: *Textularia* sp. (Haque, 1956) P (x20), Sample# 7.

### Nummulites globulus Biozone

*Nummulites globulus* specie is recognized in sample Sf 4 (Figure 6F). The base of this zone is marked by first occurrence of *Nummulites globulus*, *Assilina dandotica* and *Nummulites stellatus*. Associated fauna includes *Discocyclina dispensa*, *D. roberti*, *Assilina exponens*, *A. dandotica*, *A. pustulosa*, *Miscellanea miscella*, *Nummulites distans*, *N. carteri*, *N. stellatus*, *N. vredenburgi* and *Lockhartia pustulosa*. *Nummulites globulus* Biozone marks the deposition of Limestone in Lower Eocene (Ilerdian stage).

### Nummulites aturicus Biozone

*Nummulites aturicus* is recognized by Schaub and Racey<sup>10</sup> as an important Nummulitid. The base of *N. aturicus* Biozone is taken at the first occurrence of *Nummulites aturicus* in sample Sf 5 (Figure 6C). In our present study and it extends up to Sf 14. In Shekhan Formation *Nummulites aturicus* is often associated with *Discocyclina dispensa*, *D. forsi*, *D. scalaris*, *D. undulata*, *Assilina exponens*, *A. dandotica*, *Miscellanea miscella*, *Nummulites distans*, *N. discorbina*, *N. mamillatus* and *N. striatus*. The range of *Nummulites aturicus* is Lutetian to Early Biarrizian.

### Nummulites perforatus Biozone

Racey<sup>10</sup> recognized *Nummulites perforatus* in Eocene rocks of Oman and gave Biarrizian age to this particular biozone. The base of this biozone is taken at the first occurrence of *Nummulites perforatus* in Shekhan formation sample Sf 11 (Figure 7B). The associated fauna in Shekhan Formation includes *Discocyclina dispensa*, *D. forsi*, *D. scalaris*, *Assilina dandotica*, *A. subspinosa*, *Miscellanea miscella*, *Nummulites distans* and *Lepidocyclina bikinensis*. The Biozonation shows that deposition of outcrop of Shekhan Formation in Panoba Section, Northern Kohat Plateau started in Lower Eocene (Ilerdian) and ended in Middle Eocene (Biarrizian).

### Discussions

Paleo-environmental identification is generally based on the qualitative and quantitative analysis of planktonic, smaller benthic and larger benthic foraminifers.<sup>11,12</sup> The quantitative approach is based on the carefully assigned frequency classes mentioned in the distribution chart with their respective ranges. The fauna gradually changes with water depth mainly in term of relative abundance rather than generic or species composition of the assemblage. The larger benthic foraminifers are the most common constituents of the late Paleocene-early Eocene carbonate platforms<sup>13</sup> and they are of tropic in nature, lived within the shallow photic zone in symbiosis with algae. Thus the integrated analysis of the quantitative distribution of the larger benthic, smaller benthic and planktonic foraminifers allowed us to reconstruct paleoenvironmental history for the Shekhan Formation at Panoba Section as follow. The over-all formation shows very high ratio (sample wise) of larger benthic, smaller benthic and very low ratio of planktonic foraminifers, which suggests shallow neritic inner shelf environment for the deposition of Shekhan formation in Panoba section Kohat.<sup>14-19</sup>

### Conclusion

- i. The Panoba section of Kohat, NWFP Pakistan has an excellent exposure of Lower to Middle Eocene carbonate sequence of Shekhan formation.
- ii. The measured section is lithologically composed of medium to thin bedded gray to yellowish gray limestone interbedded with shale.
- iii. Formation has yielded rich assemblages of foraminifers, which lead to the identification of four planktonic, eight smaller and twenty seven larger benthonic species, which include *Assilina dandotica*, *A. pustulosa*, *A. exponens*, *A. pustulosa*, *A. subspinosa*, *Discocyclina dispensa*, *D. forsi*, *D. roberti*, *D. scalaris*, *D. sella*, *D. undulata*, *Lepidocyclina bikinensis*, *Lockhartia pustulosa*, *Miscellanea miscella*, *Nummulites aturicus*, *N. discorbina*, *N. distans*, *N. globulus*, *N. perforatus*, *N. stellatus*, *N. striatus*, *N. mamillatus*, *Operculina canalifera*, *Bigenerina* sp., *Articulina sagra*, *Hauerina bradyi*, *Quinqueloculina vulgaris*, *Nodosaria nammalensis*, *Nonionella* sp., *Pseudoglandulina caudigera*, *Textularia* sp., *Chiloguembelina* aff. *martini*, *Chiloguembelina victoriana*, *Globigerina taroubaensis* and *Subbotina lozanoi prolata* as shown in the range distribution chart.
- iv. Among recorded foraminifers smaller benthic are long range and are less significant for Stratigraphic determinations except few species, while larger benthic are abundant and have lead to the establishment of three biozones i.e. (*Nummulites aturicus*, *N. perforatus*, *N. globulus*). Planktonic foraminifers were found stratigraphically not significant.

- v. Lower to Middle Eocene age has assigned to the Shekhan formation on the basis of present research on the recorded foraminifers.<sup>10</sup>
- vi. Paleo-environmental interpretations based on the distribution of studied foraminifers have yielded shallow neritic inner shelf environment for the deposition of Shekhan formation at Panoba Section Kohat.

## Acknowledgments

None.

## Conflict of interest

The authors declare that there is no conflict of interest.

## Funding

None.

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