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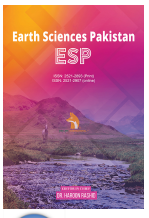

RESEARCH ARTICLE

PALEONTOLOGY, PALEOENVIRONMENT AND PALEOGEOGRAPHY OF THE EARLY PALEOGENE PAKISTANIAN BENTHIC FORAMINIFERAL SPECIES OF HAQUE - SUBORDER ROTALIINA

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ABSTRACT

Eighty-five Early Paleogene Pakistanian smaller Rotaliid benthic foraminiferal species belong to thirty-nine genera from the Ranikot, Nammal and Laki Formations of the Nammal Gorge, Salt and Sor Ranges of Pakistan have been studied. The modern taxonomic consideration and systematic description of the species is based on the diagnostic morphology, list of synonyms, short remarks about morphological features, and annotations about taxa with problematic generic status. Most of the recorded species are, so far, an endemic to Pakistan, except 19 species of them were recorded in other localities in the Southern Tethys (India, Qatar, United Arab Emirates, Saudi Arabia, Egypt, Nigeria) and also in Northern Tethys (France, Spain, Slovenia). The high abundance of pelagic Pakistanian foraminiferal assemblage indicate open connection to the Tethys, which represents middle-outer neritic environment (100-200 m depth) and shows an affinity with Midway-Type Fauna 'MTF'.

KEYWORDS

Benthic foraminifera, Pakistan, Haque, Tethys.

1. INTRODUCTION

This study is a part of a series studying the eighty-five Early Paleogene Pakistanian smaller Rotaliid benthic foraminiferal species from Ranikot, Laki, Patala and Nammal Formations of the Nammal Gorge, Salt and Sor Ranges of Pakistan have been studied and systematically listed (Figure 1). Most of these Pakistanian species of Haque are, so far, an endemic to Pakistan, except nineteen species were recorded in some other localities in Southern and Northern Tethys (Figure 2). Five out of these species are believed to be new: *Bolivina pakistanica*, *Loxostomum pakistanica*, *Eponides pakistanica*, *Rosalina haquei* and *Pararotalia pakistanica.* Based on the stratigraphic distribution of the planktonic, larger foraminifera and calcareous nannoplankton assemblages of the Ranikot, Nammal and Laki Formations of the Nammal Gorge, Salt and Sor Ranges of Pakistan which recovered by many authors (Haque, 1956; 1960; 1962; Dorreen, 1974; Nomura and Brohi, 1995; Afzal, 1996; Gibson, 2007; Bybell and Self-Trail, 2007; Naz et al., 2011; Özcan et al., 2015; Ahmad et al., 2016; Khawaj et al., 2018; Anan, 2020b, 2021a,b). the intent of this study is fourfold: 1) to present an additional information about the modern taxonomic consideration and systematic description of the recorded species, 2) to throw light on the five new erected benthic species from Pakistan, 3) its paleogeographic distribution outside Pakistan in the Northern and Southern Tethys, 4) an additional prove of the connection of the ancestral Tethys with the ancestral Indian Ocean in the Paleogene time.

Figure 1: Location map of study area Salt Range, Northern Pakistan (after Gibson, 2007).

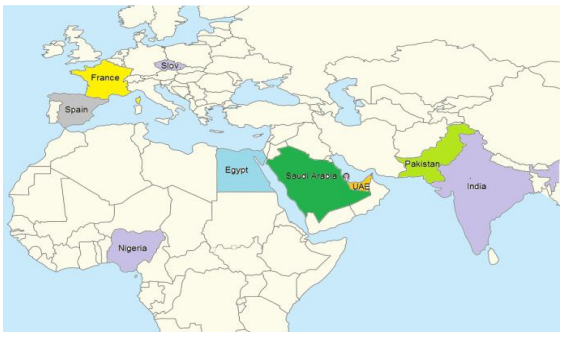

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Figure 2: Geographic map of the recorded Pakistanian foraminiferal Rotaliid species in different localities in Northern Tethys (Spain, France, Slovenia) and Southern Tethys (Nigeria, Egypt, Saudi Arabia, Qatar, United Arab Emirates, Pakistan, India).

2. Stratigraphy

The age strata of the study area indicate the Late Paleocene-Early Eocene. The Patala Formation is very Late Paleocene and the Nammal Formation, which overlies it, is of Early Eocene in age (Figure 3). The earliest Eocene strata are missing due the disconformity at the Paleocene-Eocene boundary. On the other hand, noted that the Ranikot beds of Pakistan may be correlated to the Esna Shale (Paleocene-Early Eocene) of Egypt, and many foraminiferal forms which were recorded from Europe and America, are also recorded in the Laki Formation of Pakistan (Haque, 1956).

3. Taxonomy

Some modern references have been added to complete description, and taxonomic considerations. The generic concept of the eighty-four identified Rotaliid species in this study are adapted according to the taxonomic classification of Loeblich & Tappan and presented in Plates 1, 4 (Loeblich and Tappan, 1988).

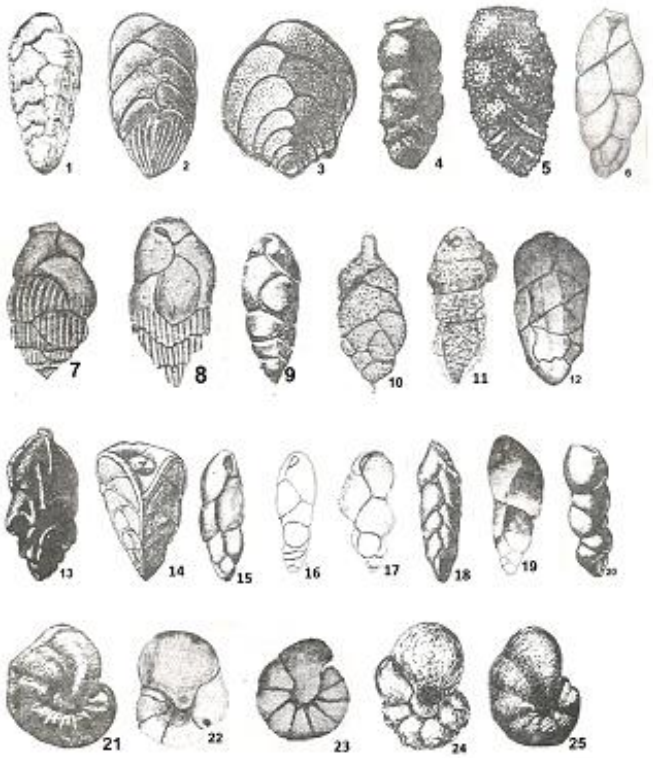

Plate 1. Figure 1: *Bolivina pakistanica* x 70, **2**: *B. sorangensis* x 95, **3:** *B. soriensis* x 100, **4:** *Loxostomum pakistanica* x 70, **5:** *L. rugosum* x 73, **6:** *Hopkinsina haquei* x 30, **7:** *Rectuvigerina lakiensis* 165, **8:** *Bulimina nammalensis* 170, **9:** *B. pseudoquadrata* x 20, **10:** *Euuvigerina subproboscidea* x 100, **11:** *Uvigerina sori* x 30, **12:** *Angulogerina laevigata* x 85, **13:** *A. dubia* x 30, **14:** *Reussella johnstoni* x 50, **15:** *Coryphostoma pseudoacuta* x 30, **16:** *Fursenkoina dubia* x 60, **17**: *F. nagappai* x 60, **18:** *F. nammalensis* x 70, **19:** *F. robusta* x 70, **20:** *Pleurostomella haquei* x 60, **21:** *Sakhiella nammalensis* x70, **22:** *Valvulineria hillsi* x60, **23:** *V. nammalensis* x60, **24:** *V. patalaensis* x45, **25:** *V. ranikotensis* x40.

Suborder Rotaliina Delage & Hérouard, 1896
Superfamily Bolivinacea Glaessner, 1937
Family Bolivinidae Glaessner, 1937
Genus *Bolivina* d'Orbigny, 1839
Type species *Bolivina plicata* d'Orbigny, 1839

***Bolivina pakistanica* Anan, n. sp. - (Pl. 1, figure 1)**

1960 *Bolivina* sp., Haque, p. 27, pl. 5, fig. 2. ●{illustrated species}

Holotype: Illustrated specimen in Pl. 1, fig. 1 x 70.
Dimension: Length 50 mm, width 14 mm in the top part of the test.
Etymology: After the Islamic Republic of Pakistan.
Type locality: Sor Range, Quetta District, West Pakistan, sample KSR-3.
Age: Middle Eocene.
Depositary: Geological Survey of Pakistan.
Diagnosis: Test elongate, triangular in outline, biserial throughout, septa zigzag line, surface ornamented by longitudinal striations, aperture at the base of apertural face.
Remarks: This Eocene species is characterized by its zigzag sutures and numerous longitudinal striation ornamentation. It is endemic, so far, from Pakistan.

***Bolivina sorangensis* Haque, 1960 - (Pl. 1, figure 2)**

1960 *Bolivina sorangensis* Haque, p. 26, pl. 3, fig. 6. ●

Remarks: This Eocene species has elongate keeled test, and is characterized by its the initial tapering part covered with numerous longitudinal ribs, while the top part smooth and have 4 rows of biserial chambers, sutures distinct and curved. It is endemic, so far, from Pakistan.

***Bolivina soriensis* Haque, 1960 - (Pl. 1, figure 3)**

1960 *Bolivina soriensis* Haque, p. 26, pl. 3, fig. 1. ●

Remarks: This Eocene species is characterized by its generally rhomboid in outline with keel, 6-7 rows of biserial chambers, suture distinct curved, aperture elongate terminal. The Egyptian Middle Eocene figured specimen *Bolivina crenulata* of Fahmy (1975, pl. 3, fig. 13) (*non* Cushman, 1936) is closely related to the Pakistanian *B. soriensis* Haque.

Superfamily Loxostomatacea Loeblich & Tappan, 1962
Family Loxostomatidae Loeblich & Tappan, 1962
Genus *Loxostomum* Ehrenberg, 1854
Type species *Loxostomum subrostratum* Ehrenberg, 1854

***Loxostomum pakistanica* Anan, n. sp. - (Pl. 1, figure 4)**

1960 *Loxostomum* sp. Haque, p. 27, pl. 1, fig. 10. ●

Holotype: Illustrated specimen in Pl. 1, fig. 4 x 70.
Dimension: Length 60 mm, width 24 mm in the top part of the test.
Etymology: After the Islamic Republic of Pakistan.
Type locality: Sor Range, Quetta District, West Pakistan, sample KSR-3.
Age: Middle Eocene.
Depositary: Geological Survey of Pakistan.
Diagnosis: Test elongate, chambers biserially arranged and increasing as added, followed by three uniserial chambers, sutures strongly depressed, surface rough and pustulosa, aperture wide open terminal on produced neck with lip.
Remarks: This Eocene species is characterized by its rugose surface, three end uniserial chambers with rounded periphery. It is endemic, so far, from Pakistan.

***Loxostomum rugosum* Haque, 1960 - (Pl. 1, figure 5)**

1960 *Loxostomum rugosum* Haque, p. 27, pl. 1, fig. 3. ●

Remarks: This Eocene species has rugose surface elongated test, chambers biserial arrangement ends with one uniserial chamber with oval open terminal aperture. It is endemic, so far, from Pakistan.

Superfamily Turrilinacea Cushman, 1927
Family Stainforthiidae Reiss, 1963
Genus *Hopkinsina* Howe & Wallace, 1932
Type species *Hopkinsina danvillensis* Howe & Wallace, 1932

***Hopkinsina haquei* Anan, 2020 - (Pl. 1, figure 6)**

1956 *Hopkinsina* sp. Haque, p. 138, pl. 28, fig. 9. ●
2020a *Hopkinsina haquei* Anan, p. 4, pl. 1, fig. 16.

Remarks: This Early Eocene species has triserial initial portion followed by uniserial chambers, surface smooth, and wide opening terminal aperture. It characterized by its smooth surface, elongate terminal aperture bounded by lip. This diagnostic species was recorded, so far, in Pakistan.

Superfamily Buliminacea Jones, 1875
Family Siphogenerinoididae Saidova, 1981
Subfamily Tubulogenerininae Saidova, 1981
Genus *Rectuvigerina* Mathews, 1945
Type species *Siphogenerina multicostata* Cushman & Jarvis, 1929

***Rectuvigerina lakiensis* (Haque, 1956) - (Pl. 1, figure 7)**

1956 *Uvigerina lakiensis* Haque, p. 136, pl. 29, figs. 1, 2. ●

Remarks: This Paleocene species has elongate test, 4-6 triserial whorls increasing gradually in relative height, later uniserial, final chamber nearly central in position with thick elongate neck, sutures nearly horizontal and depressed, surface with numerous longitudinal ribs that may continuous across the sutures or discontinuous, aperture terminal on a neck with broad phialine lip. This diagnostic species was recorded, so far, in Pakistan.

Family Buliminidae Jones, 1875
Genus *Bulimina* d'Orbigny, 1926
Type species *Bulimina marginata* d'Orbigny, 1926

***Bulimina nammalensis* Haque, 1956 - (Pl. 1, figure 8)**

1956 *Bulimina nammalensis* Haque, p. 127, pl. 29, fig. 6. ●

Remarks: This Paleocene species has small to medium test, tapering initial part, 4-6 triserial whorls, sutures distinct depressed, the lower part ornamented by longitudinal ribs except the last three chambers smooth, aperture elongate at the last chamber. This diagnostic species was recorded, so far, in Pakistan.

***Bulimina pseudoquadrata* Haque, 1956 - (Pl. 1, figure 9)**

1956 *Bulimina pseudoquadrata* Haque, p. 124, pl. 20, fig. 2. ●

Remarks: This Paleocene species has medium smooth elongate test, pointed initial part, consisting of 4-5 whorls, sutures distinct and depressed, aperture elongate at apex of the last chamber. It was recorded, so far, in Pakistan.

Family Buliminellidae Haeckel, 1894
Subfamily Uvigerininae Haeckel, 1894
Genus *Eouvigerina* Thalmann, 1952
Type species *Eouvigerina americana* Cushman, 1926

***Eouvigerina subproboscidea* (Haque, 1956) - (Pl. 1, figure 10)**

1956 *Uvigerina subproboscidea* Haque, p. 135, pl. 27, fig. 8. ●
2000 *Uvigerina subproboscidea* Haque - Abul-Nasr, p. 68, fig. 12. 4.

Remarks: This Paleocene species has elongate rounded periphery biserial test, initial end with a spine, final chamber nearly centrally located, aperture open terminal on a tubular neck and bordered by a phialine lip, surface with numerous fine spines. It was recorded from Pakistan and Egypt.

Genus *Uvigerina* d'Orbigny, 1826
Type species *Uvigerina pygmaea* d'Orbigny, 1826

***Uvigerina sori* Haque, 1960 - (Pl. 1, figure 11)**

1960 *Uvigerina sori* Haque, p. 28, pl. 3, fig. 2. ●

Remarks: This Early Eocene species has small fusiform triserial test, chambers inflated, sutures depressed, wall covered by several ribs, aperture terminal with a short neck and slightly developed lip. It was recorded, so far, in Pakistan.

Subfamily Angulogerininae Galloway, 1933
Genus *Angulogerina* Cushman, 1927
Type species *Uvigerina angulosa* Williamson, 1858

***Angulogerina laevigata* Haque, 1956 - (Pl. 1, figure 12)**

1956 *Angulogerina laevigata* Haque, p. 137, pl. 27, fig. 2. ●

Remarks: This Paleocene species has elongate triserial test and triangular throughout, sutures curved and slightly depressed, surface smooth, aperture terminal on neck. It was recorded, so far, in Pakistan.

***Angulogerina dubia* Haque, 1960 - (Pl. 1, figure 13)**

1960 *Angulogerina selseyensis dubia* Haque, p. 28, pl. 3, fig. 9. ●

Remarks: This Early Eocene species has triserial test and triangular throughout, aperture open rounded terminal on neck and bordered by a narrow lip, surface smooth and finely perforate. It was recorded, so far, in Pakistan.

Family Reussellidae Cushman, 1933
Genus *Reussella* Galloway, 1933
Type species *Verneuilina spinulosa* Reuss, 1850

***Reussella johnstoni* Haque, 1960 - (Pl. 1, figure 14)**

1960 *Reussella johnstoni* Haque, p. 27, pl. 5, fig. 6. ●

1975 *Reussella* sp. 2 - Fahmy, p. 323, pl. 3, fig. 29.

2000 *Reussella johnstoni* Haque - Sztràkos, p. 166.

2019 *Reussella* sp. - Khanolkar & Saraswati, p. 8, pl. 6 r.

2020b *Reussella johnstoni* Haque - Anan, p. 72, pl. 1, fig. 11.

Remarks: This Early Eocene species is characterized by its pyramidal triserial test, chambers enlarging gradually, sutures curved and oblique. It seems that the Egyptian figured specimen of Fahmy (1975) is closely related to the Pakistanian species. It was recorded from Pakistan, India, Egypt (S. Tethys) and France (N. Tethys).

Superfamily Fursenkoinacea Loeblich & Tappan,1961
Family Fursenkoinidae Loeblich & Tappan,1961
Genus *Fursenkoina* Loeblich & Tappan,1961
Type species *Virgulina squammosa* d'Orbigny,1826

***Fursenkoina dubia* (Haque, 1956) - (Pl. 1, figure 15)**

1956 *Virgulina dubia* Haque, p. 129, pl. 20, fig. 9; pl. 25, figs. 3, 4. ●
2003 *Fursenkoina* sp. Ali, pl. 8, fig. 14.
2019a *Fursenkoina dubia* (Haque); Anan, p. 32, fig. 9a-d.
2020c *Fursenkoina dubia* (Haque); Anan, p. 8, pl. 2, fig. 7.

Remarks: Loeblich & Tappan (1961) choice the *Virgulina squammosa* as the type species of their genus *Fursenkoina*. The Late Paleocene-Early Eocene species *F. dubia* has an elongated biserial test, rounded to ovate in section, slightly inflated chambers, the biserial twisted chambers throughout the test axis, suture depressed with smooth surface. It seems that the Egyptian figured form of Ali (2003, pl. 8, figure 14) is mostly related to Haque' species. Our figured specimen from Gabal Duwi, Egypt of Anan (2020c, pl. 2, fig. 7) is closely related to the holotype of *F. dubia*, especially in the initial part of the test. It was recorded, so far, from Pakistan and Egypt.

***Fursenkoina nagappai* (Haque, 1956) - (Pl. 1, figure 16)**

1956 *Virgulina cylindrical* Cushman & Bermudez var. *nagappai* Haque, p. 180, pl. 20, fig. 6. ●

Remarks: This Late Paleocene species has narrow elongate smooth test with plane of biserially twisted, rounded to ovate in section, slightly inflated chambers throughout the test axis, aperture narrow and elongate extending up the face of the final chamber. It was recorded, so far, in Pakistan.

***Fursenkoina nammalensis* (Haque, 1956) - (Pl. 1, figure 17)**

1956 *Virgulina nodosa* Stewart & Stewart var. *nammalensis* Haque, p. 124, pl. 20, figs. 7, 8. ●

Remarks: This Late Paleocene species has small elongate smooth test, biserial twisted, 3-4 biserial whorls increasing rapidly in relative height. It is characterized by the last two chambers in the last whorl consist about one half of the test, aperture narrow and elongate extending up the face of the final chamber. It was recorded, so far, in Pakistan.

***Fursenkoina pseudoacuta* (Haque, 1960) - (Pl. 1, figure 18)**

1960 *Virgulina pseudoacuta* Haque, p. 25, pl. 4, fig. 5.

Remarks: This Early Eocene species has narrow elongate biserial smooth test, last chamber with a tendency to become uniserial, aperture interiomarginal extending up from the base of the final chamber. It was recorded, so far, in Pakistan.

***Fursenkoina robusta* Haque, 1956 - (Pl. 1, figure 19)**

1956 *Virgulina dubia* var. *robusta* Haque, p. 129, pl. 17, figs. 3, 4. ●

Remarks: This Late Paleocene species has small elongate smooth biserial twisted test, 3-4 biserial whorls increasing rapidly in relative height, last two chambers in the last whorl consist about one third of the test, aperture extending up from the base of the final chamber. It was recorded, so far, in Pakistan.

Superfamily Pleurostomellacea Reuss, 1860
Family Pleurostomellidae Reuss, 1860
Subfamily Pleurostomellinae Reuss, 1860
Genus *Pleurostomella* Reuss, 1860
Type species *Dentalina subnodosa* Reuss, 1851

***Pleurostomella haquei* Anan, 2019 - (Pl. 1, figure 20)**

1960 *Pleurostomella* n. sp. Haque, p. 28, pl. 5, fig. 7. ●
2019b *Pleurostomella haquei* Anan, p. 175, pl. 1, fig. 10.

Remarks: This Early Eocene Pakistanian species has elongate lax biserial test, and the final uniserial chamber inflated and nearly globular. It was recorded, so far, in Pakistan.

Superfamily Discorbacea Ehrenberg, 1838

Family Bagginidae Cushman, 1927
Subfamily Baggininae Cushman, 1927
Genus *Sakhiella* Haque, 1956
Type species *Sakhiella nammalensis* Haque, 1956

***Sakhiella nammalensis* Haque, 1956 - (Pl. 1, figure 21)**

1956 *Sakhiella nammalensis* Haque, p. 155, pl. 10, fig. 1. ●
2002 *Sakhiella nammalensis* Haque - Al-Hitmi, p. 49, pl. 3, fig. 10.

Remarks: This Paleocene species has biconvex trochospiral test but with spiral side completely involute, aperture extending from umbilicus to the periphery covered by a distinct umbilical flap. It was originally recorded from Paleocene of Pakistan, but from Maastrichtian subsurface rocks of Simsima Formation of Qatar (2002).

Genus *Valvulineria* Cushman, 1926

Type species *Valvulineria californica* Cushman, 1926

***Valvulineria hillsi* Haque, 1956 - (Pl. 1, figure 22)**

1956 *Valvulineria hillsi* Haque, p. 161, pl. 12, fig. 1. ●

Remarks: This Paleocene species has rounded trochospiral biconvex smooth test, chambers enlarging gradually, 2-3 whorls, five chambers in the last whorl consists the most size of the test, umbilical side with depressed umbilicus, aperture umbilical-extraumbilical arch covered by imperforate apertural lip. It was recorded, so far, in Pakistan.

***Valvulineria nammalensis* Haque, 1956 - (Pl. 1, figure 23)**

1956 *Valvulineria nammalensis* Haque, p. 159, pl. 7, fig. 10. ●
1993 *Valvulineria* sp. Anan, p. 316, pl. 3, fig. 3.
2019a *Valvulineria nammalensis* Haque - Anan, p. 32, pl. 1, fig. 12.

Remarks: This Paleocene-Early Eocene species has two and a half dorsal whorl, 9-10 ventral chambers, and interiomarginal umbilical-extraumbilical aperture with broad thin apertural flap projecting over the umbilicus. It seems that *Valvulineria* sp. of Anan (1993) from Jabal Malaqet of UAE is mostly related to the Pakistanian species, which considered, so far, the second record of it outside Pakistan.

***Valvulineria patalaensis* Haque, 1956 - (Pl. 1, figure 24)**

1956 *Valvulineria patalaensis* Haque, p. 162, pl. 12, fig. 2. ●
2016 *Valvulineria patalaensis* Haque - Ahmad et al., p. 140, pl. 2, fig. 11.

Remarks: This Paleocene species has rounded trochospiral biconvex test with rugose surface, the dorsal side consists of 2 whorls, 7 chambers enlarging gradually in the last whorl consists the most size of the test, thin imperforated apertural flap cover the umbilicus completely. It was recorded, so far, in Pakistan.

***Valvulineria ranikotensis* Haque, 1956 - (Pl. 1, figure 25)**

1956 *Valvulineria ranikotensis* Haque, p. 161, pl. 17, fig. 10 ●; pl. 19, fig. 16; p. 196, pl. 31, fig. 11.

Remarks: This Paleocene species has semi-rounded test, 9 ventral chambers in the last whorl enlarging gradually as added, surface covered with fine striation, the imperforated apertural flap cover completely the umbilical area. It was recorded, so far, in Pakistan.

Superfamily Discorbacea Ehrenberg, 1838
Family Eponididae Hofker, 1951
Subfamily Eponidinae Hofker, 1951
Genus *Cribrogloborotalia* Cushman & Bermúdez, 1936
Type species *Cribrogloborotalia marielina* Cushman & Bermúdez, 1936

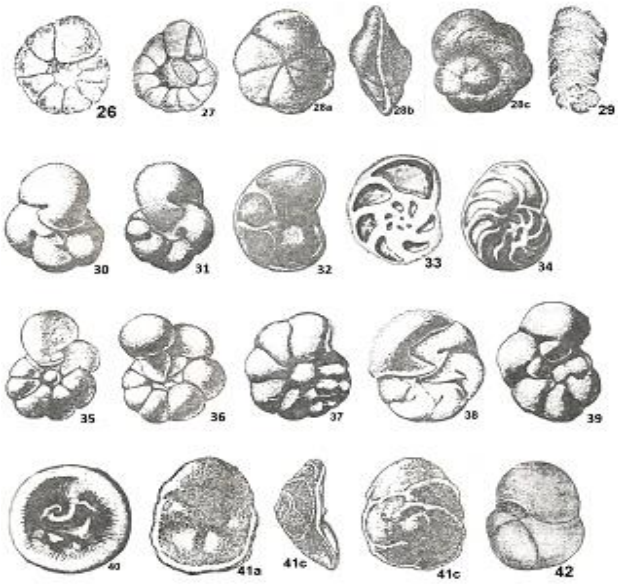

Plate 2. Figure 26: *Cribrogloborotalia challinori* x 35, **27:** *C. platti* x 20, **28a-c:** *Eponides pakistanica* x 85, **29:** *Rectoeponides dubia* x 35, **30:** *Hyderia dubia* x 40, **31:** *H. crookshanki* x 40, **32:** *Stomatorbina brauhii* x 30, **33**: *S. ranikotensis* x 25, **34:** *S. toddae* x 20, **35:** *Discorbis dubiformis* x 90, **36:** *D. globiformis* x 50, **37:** *D. metingensis* x 25, **38:** *D. pseudovesicularis* x 50, **39:** *D. sindensis* x 40, **40:** *Neoconorbina geei* x 45, **41a-c:** *Rosalina haquei* x 60, **42:** *Sphaeroidina dubia* x 35.

***Cribrogloborotalia challinori* Haque, 1956 - (Pl. 2, figure 26)**

1956 *Cribrogloborotalia challinori* Haque, p. 188, pl. 14, fig. 6. ●

Remarks: This Paleocene species has planoconvex smooth test, keeled rounded outline, 9 subconical chambers in the last ventral side, wide open umbilicus, sutures nearly radial depressed, aperture numerous rounded pores scattered over the flattened sharply angular margin of the apertural face. It was recorded, so far, in Pakistan.

***Cribrogloborotalia platti* Haque, 1956 - (Pl. 2, figure 27)**

1956 *Cribrogloborotalia platti* Haque, p. 189, pl. 34, fig. 4. ●

Remarks: This Late Paleocene species has planoconvex smooth test, thick keeled rounded outline, 10 subconical chambers in the last ventral side, wide open umbilicus, sutures nearly radial depressed, aperture numerous rounded pores scattered over the umbilical area and also in the apertural face. It was recorded, so far, in Pakistan.

Genus *Eponides* de Montfort, 1808

Type species *Nautilus repandus* Fichtel & Moll, 1798

***Eponides pakistanica* Anan, n. sp. - (Pl. 2, figure 28a-c)**

1960 *Eponides* (?) sp. Haque, p. 30, pl. 1, fig. 8. ●

Holotype: Illustrated specimen in Pl. 2, fig. 28 x 85.
Dimension: Length 50 mm, width 44 mm.
Etymology: After the Islamic Republic of Pakistan.
Type locality: Sor Range, Quetta District, West Pakistan, sample KSR-3.
Age: Middle Eocene.
Depositary: Geological Survey of Pakistan.
Diagnosis: Test biconvex, periphery keeled, two whorls in the dorsal side, 6 chambers in the last ventral side, sutures slightly curved in ventral side but strongly curved in the dorsal side, sutures finally perforate to faintly pustulose, aperture low interiomarginal extending from umbilical to periphery bordered by a narrow lip.
Remarks: This species is characterized by its tight coiled test, 6 chambers in the last whorl, lack of supplementary areal opening. It was recorded, so far, in Pakistan.
Genus *Rectoeponides* Cushman, & Bermúdez, 1936
Type species *Rectoeponides cubensis* Cushman, & Bermúdez, 1936

***Rectoeponides dubia* Haque, 1956 - (Pl. 2, figure 29)**

1956 *Rectoeponides dubia* Haque, p. 153, pl. 6, fig. 6. ●

Remarks: This Maastrichtian-Early Eocene species is characterized by its trochospirally enrolled early stage with one and more volution, alter stage uncoiled, suture slightly depressed with terminal and rounded aperture. It seems that the *Stichocibicides* sp. (after LeRoy, 1935) is closely related to *Karreria fallax* Rzehak (1891) as previously noted by Anan (2019, p. 33). It was recorded also from the Rockall Bank in the North Atlantic (Berggren, 1974, p. 444, pl.4, fig. 9), France (Sztrákos, 2005, p.189, pl.17, fig. 18), Tunisia (Aubert & Berggren, 1976, p. 468, pl.12, fig. 5), Egypt (LeRoy, 1953, p. 51, pl. 8, fig. 27) and (Luger, 1985, p.113, pl. 9, figs. 11,12).

Genus *Hyderia* Haque, 1962
Type species *Hyderia dubia* Haque,1962

***Hyderia dubia* Haque, 1962 - (Pl. 2, figure 30)**

1962 *Hyderia dubia* Haque, p. 23, pl. 1, figs. 11-13. ●
1988 *Hyderia dubia* Haque - Loeblich & Tappan, p. 553, pl. 600, figs. 1-3.

Remarks: This Early Eocene species has low trochospiral test with flattened dorsal side and involute umbilical side, 5-6 subglobular chambers enlarge rapidly as added, each produced into a broad umbilical flap on umbilical side, aperture a low interiomarginal slit open beneath the umbilical apertural flap. It was recorded, so far, in Pakistan.

***Hyderia crookshanki* Haque, 1962 - (Pl. 2, figure 31)**

1962 *Hyderia crookshanki* Haque, p. 23, pl. 2, figs. 15-17. ●

Remarks: This Early Eocene species has low trochospiral test with flattened dorsal side and involute umbilical side, 5-6 subglobular chambers enlarge rapidly as added. It differs from the *H. dubia* by its more chamber numbers of in the last whorl and more compressed test. It was recorded, so far, in Pakistan.

Family Mississippinidae Saidova, 1981
Subfamily Stomatorbininae Saidova, 1981
Genus *Stomatorbina* Doreen, 1948
Type species *Lamarckina torrei* Cushman & Bermúdez, 1937

***Stomatorbina brauhii* Haque, 1960 - (Pl. 2, figure 32)**

1960 *Stomatorbina brauhii* Haque, p. 31, pl. 3, fig. 8. ●

Remarks: This Early Eocene species has biconvex low trochospiral keeled test, 4-5 semilunate chambers, sutures curved elevate and limbate, aperture narrow low interiomarginal slit partly covered by a triangular umbilical flap. It was recorded, so far, in Pakistan.

***Stomatorbina ranikotensis* Haque, 1956 - (Pl. 2, figure 33)**

1956 *Stomatorbina ranikotensis* Haque, p. 189, pl. 8, fig. 2.
1985 *Stomatorbina ranikotensis* Haque - Hasson, p. 360.

Remarks: This Paleocene species has rounded test with 6 chambers in the last whorl, limbate curved sutures on both sides. It was recorded, so far, in Pakistan.

***Stomatorbina toddae* Haque, 1960 - (Pl. 2, figure 34)**

1960 *Stomatorbina toddae* Haque, p. 32, pl. 2, fig. 6. ●

Remarks: This Early Eocene species has semi-circular biconvex thick keeled test, 10 triangular chambers in the last whole of ventral side, sutures depressed in the ventral, but limbate thick elevated in the dorsal side. It was recorded, so far, in Pakistan.

Family Discorbidae Ehrenberg, 1838
Genus *Discorbis* Lamarck, 1804
Type species *Discorbis vesicularis* Lamarck, 1804

Discorbis dubiformis* (Haque, 1960) - (Pl. 2, figure 35*)

1960 *Pararotalia* (?) *dubiformis* Haque, p. 3, pl. 5, fig. 5. ●

Remarks*:* This Early Eocene species has concave-convex smooth test, highly convex trochospiral side, seven inflated chambers in the last ventral whorl, umbilical margin extending into the umbilical area as a narrow flap, umbilicus open, sutures curved and depressed, interiomarginal-extraumbilical aperture with lip. It was recorded, so far, in Pakistan.

***Discorbis globiformis* Haque, 1962 - (Pl. 2, figure 36)**

1962 *Discorbis globiformis* Haque, p. 21, pl. 1, figures 3-5. ●
2002 *Discorbis globiformis* Haque - Al-Hitmi, p. 49, pl. 3, fig. 11.
2019a *Discorbis globiformis* Haque - Anan, p. 32, pl. 1, fig. 8.

Remarks: This Early Eocene species is distinguished by its gradually inflated chambers and increasing gradually, highly trochospiral coil, umbilical region wide and covered by a long flap with smooth surface. This species was originally recorded from Pakistan, but from the Maastrichtian subsurface rocks of Qatar (Al-Hitmi, 2002).

***Discorbis metingensis* Haque, 1962 - (Pl. 2, figure 37)**

1962 *Discorbis metingensis* p. 21, pl. 2, figs. 18-20. ●

Remarks: This Early Eocene species has low trochospiral test, inequally biconvex test with 9-10 chambers in the last whorl in the ventral side, about two and a half whorls in the dorsal side, sutures slightly curved and depressed, aperture a low interiomarginal extraumbilical arch. It was recorded, so far, in Pakistan.

***Discorbis pseudovesicularis* Haque, 1962 - (Pl. 2, figure 38)**

1962 *Discorbis pseudo-vesicularis* Haque, p. 22, pl. 1, figs. 6-8. ●

Remarks: This Early Eocene species has low trochospiral test, inequally biconvex test with 7-8 chambers in the last whorl in the ventral side, a triangular elongate alar projection extends from the umbilical margin of each chamber over the umbilical region. It was recorded, so far, in Pakistan.

***Discorbis sindensis* Haque, 1962 - (Pl. 2, figure 39)**

1962 *Discorbis sindensis* Haque, p. 21, pl. 1, figs. 14-16. ●

Remarks: This Early Eocene species has low trochospiral test, inequally biconvex keeled test with 5-6 inflated chambers in the last whorl in the ventral side, about one and a half whorls in the dorsal side, a triangular elongate flap extends from the umbilical margin of each chamber over the umbilical region, sutures slightly curved and depressed, finely perforate with smooth surface. It was recorded, so far, in Pakistan.

Family Rosalinidae Reiss, 1963
Genus *Neoconorbina* Hofker, 1951
Type species *Rosalina orbicularis* Terquem, 1876

***Neoconorbina geei* Haque, 1962 - (Pl. 2, figure 40)**

1962 *Neoconorbina geei* Haque, p. 22, pl. 2, figs. 21-23. ●
1985 *Neoconorbina geei* Haque - Hasson, p. 358.

Remarks: This Early Eocene species has low conical trochospiral circular smooth test, spiral side convex with three visible whorls increasing rapidly in breadth, final chamber occupying half of the periphery, concave open umbilicus, sutures curved, periphery acutely angled. It was recorded, so far, in Pakistan.

Genus *Rosalina* d'Orbigny, 1826
Type species *Rosalina globularis* d'Orbigny, 1826

***Rosalina haquei* Anan, n. sp. - (Pl. 2, figure 41a-c)**

1960 *Rosalina* sp. Haque, p. 29, pl. 1, fig. 6. ●
Holotype: Illustrated specimen in Pl. 2, fig. 41a-c x 60.
Dimension: Length 43 mm, width 35 mm.
Etymology: In the honor of Pakistanian micropaleontologist A.F.M. Mohsenul Haque.
Type locality: Sor Range, Quetta District, West Pakistan, sample KSR-1.
Age: Middle Eocene.
Depositary: Geological Survey of Pakistan.
Diagnosis: Test trochospiral smooth circular, concavo-convex, gradually enlarge nearly subtriangular chambers, the final chamber occupying about one-third of the test, sutures straight depressed in concave ventral side but curved raised limbate in the convex dorsal side, umbilicus open but bordered by a triangular umbilical flap.

Remarks: This species is characterized by its circular concavo-convex smooth test, and a triangular umbilical flap on the open umbilicus. It was recorded, so far, in Pakistan.

Family Sphaeroidinidae Cushman, 1927

Genus *Sphaeroidina* d'Orbigny, 1826

Type species *Sphaeroidina bulloides* d'Orbigny, 1826

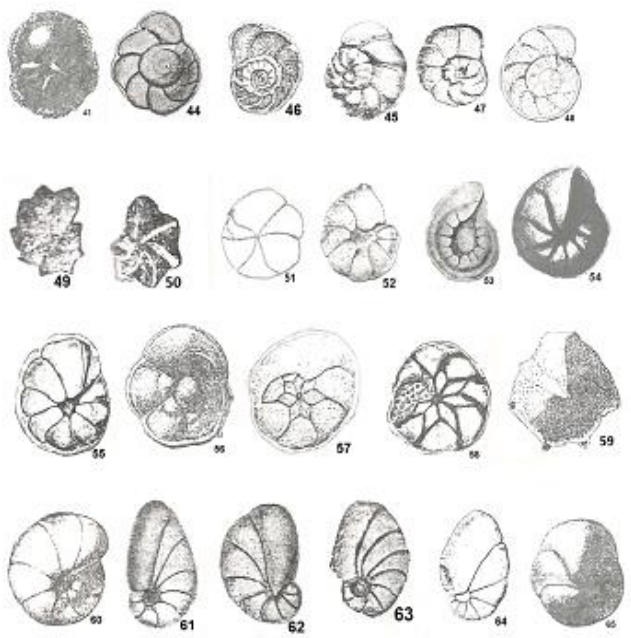

Plate 3. Figure 43: *Siphonina khirthari* x 100, **44:** *Cibicidoides cristata* x 45, **45:** *C. ghalibi* x 25, **46:** *C. nammalensis* x 75, **47:** *C. patalaensis* x 50, **48:** *C. punjabensis* x 50, **49:** *Woodella granosa* x 35, **50:** *W. nammalensis* x 40, **51:** *Epistominella dubia* x 80,**52:** *Pseudogloborotalia khirabadensis* x 30, **53:** *P. paleocenica* x 30, **54:** *P. ranikotensis* x 30, **55:** *P. oblonga* x 30, **56:** *Asterigerinata baluchistanensis* x 120, **57:** *A. cuniformis* x 100, **58:** *A. nammalensis* x 60, **59:** *Asterigerina brencei* x 90, **60:** *Nonionella haquei* x 75, **61:** *N. lakiensis* x 140, **62:** *N. minuta* x 120, **63:** *N. nammalensis* x 90, **64:** *N. thalmanni* x 95, **65:** *Alabamina daubifera* x 30.

***Sphaeroidina dubia* Haque, 1956 - (Pl. 2, figure 42)**

1956 *Sphaeroidina* (?) *dubia* Haque, p. 172, pl. 14, fig. 9. ●

Remarks: This Late Paleocene species has trochospiral coiling subglobular smooth test, embracing hemispherical 4chambers, aperture a crescentic opening near the base of the large last chamber, bordered by a narrow lip. It was recorded, so far, in Pakistan.

Superfamily Siphoninacea Cushman, 1927
Family Siphoninidae Cushman, 1927
Subfamily Siphonininae Cushman, 1927
Genus *Pulsiphonina* Brotzen, 1948
Type species *Siphonina prima* Plummer, 1927

***Pulsiphonina khirthari* (Haque, 1960) - (Pl. 3, figure 43)**

1960 *Siphonina khirthari* Haque, p. 32, pl. 1, fig. 9. ●

Remarks: This Early Eocene species has lenticular biconvex trochospiral test, circular in outline, periphery angular keeled with beaded margin, 5 subtriangular chambers, sutures depressed and crescentic on dorsal side, nearly radial on umbilical side, aperture a low narrow interiomarginal opening at the periphery on the umbilical side, but not produced on a short neck as in the genus *Siphonina* Reuss, 1850. It was recorded, so far, in Pakistan.

Superfamily Discorbinellacea Sigal, 1956
Family Parrelloididae Hofker, 1951
Genus *Cibicidoides* Thalmann, 1939
Type species *Truncatolina mundula* Brady, Parker & Jones, 1890

***Cibicidoides cristata* (Haque, 1956) - (Pl. 3, figure 44)**

1956 *Cibicides alleni* (Plummer) var. *carinata* Haque, p. 208, pl. 33, fig. 4. ●
1959 *Cibicides alleni cristata* Haque - Thalmann, p. 130.

Remarks: Thalmann noted that some species which have homonyms with other species should be renamed by their respective authors without delay in accordance with the "International Rules of Zoological Nomenclature". For that, the Haque's subspecies *carinata* changed to the *cristata*, (Thalmann, 1959). This Late Paleocene species has lenticular trochospiral biconvex and biumbonate smooth test, with about 3 dorsal whorl, nine chambers in the final ventral whorl, sutures curved and limbate on the spiral side but nearly straight radial on the ventral side, periphery angular and keeled, aperture a low interiomarginal and equatorial arch at the base of the apertural face on the periphery. It was recorded, so far, in Pakistan.

***Cibicidoides ghalebi* (Haque, 1956) - (Pl. 3, figure 45)**

1956 *Cibicides multifaria* (Schwager) *limbata* Haque, p. 205, pl. 16, fig. 5. ●
1959 *Cibicides multifaria ghalebi* Haque - Thalmann, p. 130.

Remarks: The Haque's subspecies *limbata* changed to the *ghalebi*, after (Thalmann, 1959). The *C. ghalebi* is closely related to the Paleocene *C. vulgaris* (Plummer, 1927, p. 145, pl. 10, fig. 3) but it differs by having more chambers dorsal side, about two and a half whorls than one and a half in the latter, and less inflated last chamber. It was recorded, so far, in Pakistan.

***Cibicidoides nammalensis* (Haque, 1956) - (Pl. 3, figure 46)**

1956 *Cibicides mensilla* (Schwager) var. *nammalensis* Haque, p. 205, pl. 20, fig. 10. ●
2005 *Cibicidoides nammalensis* (Haque) - Sztràkos, p. 226, pl. 15, fig. 35.
2016 *Cibicides mensilla* (Schwager) var. *nammalensis* Haque - Ahmad et al., p. 140, pl. 2, fig. 6.
2019a *Cibicidoides nammalensis* (Haque) - Anan, p. 32, pl. 2, fig. 14a-c.
2020b *Cibicidoides nammalensis* (Haque) - Anan, p. 73, pl. 1, fig. 15.

Remarks: This Paleocene-Early Eocene species has biconvex test with keel, about 10 chambers in the ventral side with umbo. It was recorded from Pakistan (S. Tethys) and France (N. Tethys).

***Cibicidoides patalaensis* (Haque, 1956) - (Pl. 3, figure 47)**

1956 *Cibicides lobatulus* (Walker & Jacob) var. *patalaensis* Haque, p. 209, pl. 16, fig. 6. ●

Remarks: This Paleocene-Early Eocene species is closely allied to *C. nammalensis* (Haque) but differs by having a distinct peripheral keel. It was recorded, so far, in Pakistan.

***Cibicidoides punjabensis* (Haque, 1960) - (Pl. 3, figure 48)**

1960 *Cibicides punjabensis* Haque, p. 42, pl. 6, fig. 1. ●
2019 *Cibicides punjabensis* Haque - Khanolkar & Saraswati, p. 8, fig. 6x.

Remarks: This Early Eocene species has trochospiral planoconvex smooth test, ventrally rather strongly convex with small ventral umbilical plug, 10-12 chambers in the last whorl increasing gradually in size as added, sutures curved in both sides, periphery sharply rounded with distinct keel, aperture peripheral with lip. This species is closely allied to *C. farafraensis* LeRoy (1953, p. 24, pl. 10, figs. 1-3) but differs by having more chambers in the last whorl and acute periphery with distinct keel around the whole test. It was recorded, so far, from Pakistan and India (S. Tethys).

Genus *Woodella* Haque, 1956

Type species *Woodella granosa* Haque, 1956

Woodella granosa* Haque, 1956 - (Pl. 2, figure 49*)

1956 *Woodella granosa* Haque, p. 194, pl. 18, fig. 2. ●
1988 *Woodella granosa* Haque - Loeblich & Tappan, p. 573, pl. 626, figs. 4-8.

Remarks *:* This Late Paleocene species has trochospiral planoconvex test, 9-10 angular inflated centrally and peripherally spinose chambers in the final whorls, sutures straight radial depressed, periphery angular, aperture a low interiomarginal equatorial arch at the base of the apertural face. It is, so far, an endemic in Pakistan.

***Woodella nammalensis* Haque, 1956 - (Pl. 3, figure 50)**

1956 *Woodella nammalensis* Haque, pl. 3, fig. 1; pl. 18, figs. 1, 7. ●

Remarks*:* This Late Paleocene species differs from *W. granosa* by having 6-7 chambers in the last whorl than 9-10 chambers of the latter. It is, so far, an endemic in Pakistan.

Family Pseudoparrellidae Voloshinova, 1952
Subfamily Pseudoparrellinae Voloshinova, 1952
Genus *Epistominella* Husezima & Maruhasi, 1944
Type species *Epistominella pulchella* Husezima & Maruhasi, 1944

Epistominella dubia* Haque, 1956 - (Pl. 3, figure 51*)

1956 *Epistominella dubia* Haque, p. 144, pl. 20, fig. 1. ●

Remarks*:* This Late Paleocene species has small inequally biconvex trochospiral smooth test, 6 chambers in the last ventral whorl, 3 dorsal whorls, sutures nearly straight to oblique, aperture an interiomarginal slit extending up into the apertural face. It is, so far, an endemic in Pakistan.

Family Victoriellidae Chapman & Crespin, 1930
Subfamily Carpenteriinae Saidova, 1981
Genus *Gyroidinella* Le Calvez, 1949
Type species *Gyroidinella magna* Le Calvez, 1949
Genus *Pseudogloborotalia* Haque, 1956
Type species *Pseudogloborotalia ranikotensis* Haque, 1956

***Pseudogloborotalia khirabadensis* Haque, 1956 - (Pl. 3, figure 52)**

1956 *Pseudogloborotalia khirabadensis* Haque, p.187, pl.14, fig. 7; pl.19, figs.18, 19; pl. 27, fig. 5. ●

Remarks*:* This Late Paleocene species has planoconvex trochospiral smooth test, 8 chambers in convex ventral side with angular wide umbilical shoulders, sutures nearly straight incised in the ventral side, aperture a low interiomarginal arch between umbilical shoulder and keeled periphery. It is, so far, an endemic in Pakistan.

Pseudogloborotalia paleocenica* Haque, 1956 - (Pl. 3, figure 53*)

1956 *Pseudogloborotalia paleocenica* Haque, p. 186, pl. 19, figs. 20, 21; pl. 34, fig. 6. ●

Remarks*:* This Late Paleocene species differs from *P. khirabadensis* 12 wide deep ventral chambers. It is recorded in Pakistan.

Pseudogloborotalia ranikotensis* Haque, 1956 - (Pl. 3, figure 54*)

1956 *Pseudogloborotalia ranikotensis* Haque, p. 185, pl. 19, fig. 17. ●
1988 *Pseudogloborotalia ranikotensis* Haque - Loeblich & Tappan, p. 594, pl. 654, figs. 7-10.

Remarks: This Late Paleocene species differs from all representatives of the genus by its highly umbilical shoulders and narrow deep umbilicus. It is, so far, an endemic in Pakistan.

Pseudogloborotalia oblonga* Haque, 1956 - (Pl. 3, figure 55*)

1956 *Pseudogloborotalia ranikotensis* var. *oblonga* Haque, p. 185, pl. 10, fig. 2; pl. 34, fig. 2. ●

Remarks*:* This Late Paleocene species differs from *P. ranikotensis* by having bigger test size and less high umbilical shoulders and thicker periphery keel. It is, so far, an endemic in Pakistan.

Superfamily Asterigerinacea d'Orbigny, 1839
Family Asterigerinatidae Reiss, 1963
Genus *Asterigerinata* Bermúdez, 1949
Type species *Asterigerinata dominicana* Bermúdez, 1949

Asterigerinata baluchistanensis* Haque, 1960 - (Pl. 3, figure 56*)

1960 *Asterigerinata baluchistanensis* Haque, p. 33, pl. 4, fig. 3. ●

Remarks*:* This Early Eocene species has discoidal convex dorsal side and concave ventral keeled test, 5 semilunate chambers in the ventral side increasing gradually as added, sutures strongly oblique and slightly depressed in the ventral side but limbate raised in the other side, aperture a low interiomarginal arch. It is, so far, an endemic in Pakistan.

***Asterigerinata cuniformis* (Haque, 1956) - (Pl. 3, figure 57)**

1956 *Asterigerina cuniformis* Haque, p. 165, pl. 22, fig. 5. ●
2000 *Asterigerinata* cf. *cuniformis* Haque - Sztràkos, p. 169.
2020b *Asterigerinata cuniformis* Haque - Anan, p. 73, pl. 1, fig. 17.

Remarks: This Late Paleocene-Middle Eocene species has discoidal convex dorsal and concave ventral test with more elevated dorsal side, 6-8 chambers visible in the last whorl with peripheral keel. It was recorded from Pakistan (S. Tethys) and also from France (N. Tethys).

Asterigerinata nammalensis* (Haque, 1956) - (Pl. 3, figure 58*)

1956 *Asterigerina texana* (Stadnichena) var. *nammalensis* Haque, p. 164, pl. 24, fig. 1. ●

Remarks*:* This Late Paleocene species has 7-8 chambers in the last whorl, the umbilical end of each chamber secondarily covered by a convex ovoid coverplate, those of the final whorl producing a rosette around the central umbilical plug, aperture a low interiomarginal arch bordered by short radiating grooves and pustules. It is, so far, an endemic in Pakistan.

Family Asterigerinidae d'Orbigny, 1839
Genus *Asterigerina* d'Orbigny, 1839
Type species *Asterigerina carinata* d'Orbigny, 1839

Asterigerina brencei* Haque, 1960 - (Pl. 3, figure 59*)

1960 *Asterigerina brencei* Haque, p. 33, pl. 2, fig. 3.
2006 *Asterigerina brencei* Haque - Ortiz & Thomas, p. 112, Pl. 4, fig. 4.
2006 *Asterigerina brencei* Haque - Cimerman et al., p. 36, pl. 10, figs. 1- 2 . ●
2020b *Asterigerina brencei* Haque - Anan, p. 73, pl. 1, fig. 18.

Remarks: This Eocene species has planoconvex trochospiral circular test with an imperforate keel, ventral side high conical, 7-8 chambers in the last whorl gradually increasing in size as added, ventral sutures flush and fairly curved, dorsal sutures curved and limbate. aperture interiomarginal, a narrow ventral slit. It is distinguished by the peripheral prolongation of the chambers on the ventral side. It was recorded from Pakistan (S. Tethys), and also Spain and Slovenia (N. Tethys*).*

Superfamily Asterigerinacea d'Orbigny, 1839

Family Nonionidae Schultze, 1854
Subfamily Nonioninae Schultze, 1854
Genus *Nonionella* Cushman, 1926
Type specie *Nonionella miocenica* Cushman, 1926

Nonionella haquei* Anan, 2019 - (Pl. 3, figure 60*)

1956 *Nonionella* sp. Said & Kenawy, p. 156, pl. 7, fig. 21.
1960 *Nonionella* sp. Haque, p. 24, pl. 6, fig. 2. ●
2019a *Nonionella haquei* Anan, p. 33, pl. 2, fig. 15.

Remarks: This Paleocene-Eocene species has small inflated test, and equally biconvex but not symmetrically developed, periphery rounded, chambers about twelve in the last formed whorls, suture distinct, aperture a slit on the periphery at the base of the last chamber. It seems that the Paleocene *Nonionella* sp. Said & Kenawy and the Early Eocene *Nonionella* sp (Said and Kenawy, 1956). Haque are strongly falls within the same morphological characters (Haque, 1960). The Early Eocene *N. haquei* differs from the Early Eocene Egyptian *N. africana* of LeRoy (1953, p. 42, pl. 10, figs. 9-11) by having larger and more elongated test and chambers. It was recorded from Pakistan and Egypt.

Nonionella lakiensis* Haque, 1956 - (Pl. 3, figure 61*)

1956 *Nonionella lakiensis* Haque, p. 118, pl. 29, fig. 3. ●

Remarks*:* This Late Paleocene species has small slightly compressed smooth test in a low trochospiral coil, 9 chambers progressively enlarging with a flaplike projection overhanging the wide umbilicus, sutures slightly curved, aperture a small interiomarginal and nearly equatorial arch. It is, so far, an endemic in Pakistan.

Nonionella minuta* Haque, 1956 - (Pl. 3, figure 62*)

1956 *Nonionella jacksonensis* Cushman var. *minuta* Haque, p. 117, pl. 29, fig. 4. ●

Remarks*:* This Late Paleocene species has small slightly compressed smooth test in a low trochospiral coil, 9 chambers progressively enlarging, the final chamber extends to cover most umbilicus, aperture a small interiomarginal and nearly equatorial arch. It is, so far, an endemic in Pakistan.

Nonionella nammalensis* Haque, 1956 - (Pl. 3, figure 63*)

1956 *Nonionella cretacea nammalensis* Haque, p. 116, pl. 6, figs. 2, 5, 8. ●

Remarks*:* This Late Paleocene species has small slightly compressed smooth test in a low trochospiral coil, 9 chambers progressively enlarging, with a flaplike projection overhanging the wide umbilicus, aperture a small interiomarginal and nearly equatorial arch. It is, so far, an endemic in Pakistan.

Nonionella thalmanni* Haque, 1956 - (Pl. 3, figure 64*)

1956 *Nonionella escavata* d'Orbigny var. *nammalensis* Haque, p. 116, pl.

33, fig. 5. ●

1959 *Nonionella excavata thalmanni* Haque - Thalmann, p. 130.

Remarks*:* This Late Paleocene species has small slightly compressed smooth test in a low trochospiral coil, 7 chambers progressively enlarging with a flaplike projection overhanging the wide umbilicus, the last chamber occupied about one third of the test, aperture a small interiomarginal and nearly equatorial arch. It is, so far, an endemic in Pakistan.

Superfamily Chilostomellacea Brady, 1881
Family Alabaminidae Hofker, 1951
Genus *Alabamina* Toulmin, 1941
Type species *Alabamina wilcoxensis* Toulmin, 1941

Alabamina daubifera **(Haque, 1960) - (Pl. 3, figure 65*)***

1960 *Globorotalites daubifera* Haque, p. 38, pl. 4, fig. 4. ●

1985 *Alabamina daubifera* (Haque) - Hasson, p. 358.

Remarks*:* This Eocene species lenticular trochospiral smooth biconvex test, not planoconvex in the genus *Globorotalites*, 5 close coiled highly convex ventral chambers, 3 whorls in the dorsal side, sutures curved and depressed, aperture an interiomarginal slit beneath the deeply indented apertural face (Brotzen, 1942). It was recorded from Pakistan and Saudi Arabia.

Family Heterolepidae Gonzáles-Donoso, 1969

Genus *Anomalinoides* Brotzen, 1942

Type species *Anomalinoides plummerae* Brotzen, 1942

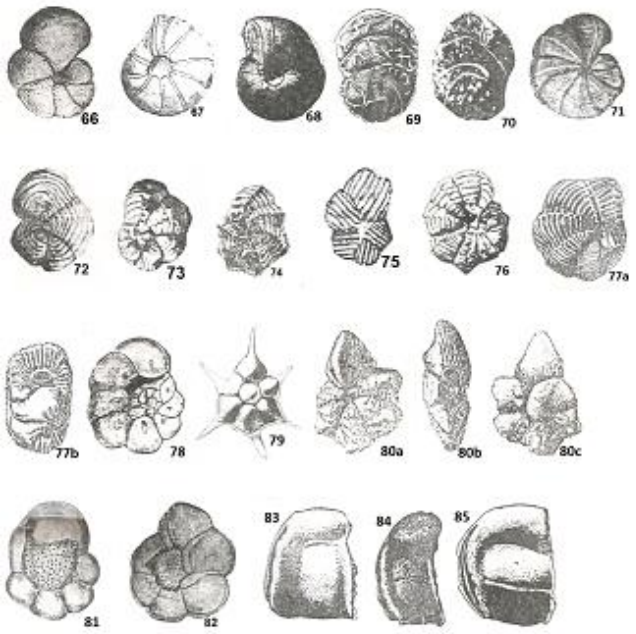

Plate 4. Figure 66: *Anomalinoides bandyi* x 35 , **67:** *Gyroidinoides sarwari* x 40, **68:** *G. tayyabi* x 25, **69:** *Colites galeebi* x 30, **70:** *C. ornatus* x 30, **71:** *Ornatanomalina acuta* x 50, **72:** *O. crookshanki* x 30, **73:** *O. elegantula* x 30, **74:** *O. geei* x 30, **75:** O. *glaessneri* x 50, **76:** *O. hafeezi* x 30, **77a,b:** *O. pakistanica* x 45 , **78:** *Pseudowoodella mamilligera* x 60, **79:** *Pararotalia khirthari* x 45, **80a-c:** *P. pakistanica* x 55, **81:** *Cincoriola ovoidea* x 40, **82:** *C. patalaensis* x 30, **83:** *Soriella arbicularis* x 50, **84:** *S. schoechlei* x 55, **85:** *S. sindensis* x 45.

Anomalinoides bandyi **(Haque, 1956) - (Pl. 4, figure 66*)***

1956 *Anomalina bandyi* Haque, p. 191, pl. 16, figs. 11, 12. ●
1985 *Anomalina bandyi* Haque - Hasson, p. 360.
2007 *Anomalinoides bandyi* (Haque, 1956) - Gibson, E9, p. 34.

Remarks*:* This Late Paleocene species has large robust smooth low trochospiral test, 6-7 inflated chambers, sutures radial nearly curved and depressed, umbilical area wide and depressed, periphery rounded, aperture a low interiomarginal arch extending onto the spiral side. Haque noted that this species was recorded only in the Lockhart and Patala Formations in the Nammal George section, and these formations were considered to be shallow marine origin, while the uppermost bed of the Patala Formation had been deposited in deeper water marine environment (Haque, 1956; Gibson, 2007). It was recorded from Pakistan and Saudi Arabia.

Family Gavelinellidae Hofker, 1956
Subfamily Gyroidinoidinae Saidova, 1981
Genus *Gyroidinoides* Brotzen,1942
Type species *Rotalina nitida* Brotzen,1942

Gyroidinoides sarwari **(Haque, 1956) - (Pl. 4, figure 67)**

1956 *Gyroidina girardana* (Reuss) var. *limbata* Haque, p. 150, pl. 27, fig. 3. ●
1959 *Gyroidina girardana sarwari* Haque - Thalmann, p. 130.

Remarks*:* This Late Paleocene species has planoconvex trochospiral smooth test, highly convex 10 chambers in the umbilical side with open wide umbilicus, sutures radial limbate raised slightly curved, aperture a low interiomarginal slit extending from the periphery to the umbilicus. It is, so far, an endemic in Pakistan.

Gyroidinoides tayyabi **(Haque, 1960) - (Pl. 4, figure 68*)***

1960 *Gyroidina tayyabi* Haque, p. 29, pl. 4, fig. 6 . ●

Remarks*:* This Eocene species has planoconvex trochospiral smooth test, highly convex 10-12 chambers in the umbilical side with open wide umbilicus, sutures radial slightly curved, aperture a low interiomarginal slit extending from the periphery to the umbilicus. It is, so far, an endemic in Pakistan.

Superfamily Chilostomellacea Brady, 1881
Family Coleitidae Loeblich & Tappan, 1984
Genus *Coleites* Plummer, 1934
Type species *Pulvinulina reticulosa* Plummer, 1927

Coleites galeebi **Haque 1960 - (Pl. 4, figure 69*)***

1960 *Coleites galeebi* Haque, p. 32, pl. 5, fig. 8. ●
2006 *Coleites galeebi* Haque - Ortiz & Thomas, p. 117, pl. 7, figs. 1-2.
2020b *Coleites galeebi* Haque - Anan, p. 73, pl. 1, fig. 20.

Remarks: This Eocene species has trochospiral equally biconvex test in the early stage but later uncoiled and flattened, wall calcareous strongly ornamented by a coarse reticulation obscuring the entire surface, about six chambers in the final whorl separated by indistinct curved sutures. This species was recorded, so far, from Pakistan (S. Tethys) and Spain (N. Tethys*).*

Colites ornatus **Haque, 1956 - (Pl. 4, figure 70*)***

1956 *Colites ornatus* Haque, p. 143, pl. 12, figs. 3-5. ●

Remarks*:* This Late Paleocene species has trochospiral equally biconvex test in the early stage but later uncoiled and flattened, chambers covered by ornate granular surface, sutures curved, aperture elongate and terminal. It is recorded in Pakistan.

Superfamily Rotaliacea Ehrenberg, 1939
Family Rotaliidae Ehrenberg, 1839
Subfamily Cuvillierininae Loeblich & Tappan, 1964
Genus *Ornatanomalina* Haque, 1956
Type species *Ornatanomalina geei* Haque, 1956

Remarks: The full descriptions of eight species of the genus *Ornatanomalina* of Haque, 1956 (*Ornatanomalina acuta, O. crookshanki, O. elegantula, O. geei, O. glaessneri, O. hafeezi* and *O. pakistanica*) are included (Anan, 2021).

Ornatanomalina acuta Haque, 1956 - (Pl. 4, fig. 71)
Ornatanomalina crookshanki Haque, 1956 - (Pl. 4, fig. 72)
Ornatanomalina elegantula Haque, 1956 - (Pl. 4, fig. 73)
Ornatanomalina geei Haque, 1956 - (Pl. 4, fig. 74)
Ornatanomalina glaessneri Haque, 1956 - (Pl. 4, fig. 75)
Ornatanomalina hafeezi Haque, 1956 - (Pl. 4, fig. 76)
Ornatanomalina pakistanica Anan, 2021a - (Pl. 4, fig. 77)

Genus *Pseudowoodella* Haque, 1956
Type species *Pseudowoodella mamilligera* Haque, 1956

Pseudowoodella mamilligera* Haque, 1956 - (Pl. 4, figure 78*)

1956 *Pseudowoodella mamilligera* Haque, p. 202, pl. 33, fig. 2. ●

Remarks*:* This Late Paleocene species has trochospiral nearly equally convex test, 7-9 chambers in the final whorls, sutures radially depressed, surface in spiral side with a prominent spinules, umbilical side strongly pustulose, aperture interiomarginal and equatorial. It is, so far, an endemic in Pakistan.

Subfamily Pararotaliinae Reiss, 1963
Genus *Pararotalia* Le Calvez, 1949
Type species *Rotalia inermis* Terquem, 1882

Pararotalia khirthari* Haque, 1960 - (Pl. 4, figure 79*)

1960 *Pararotalia khirthari* Haque, p. 3, pl. 6, fig. 5. ●
2010 *Pararotalia khirthari* Haque - Anan, p. 171.

Remarks: This Middle-Late Eocene species has low trochospiral test with axially pointed long spine for each 6 chamber. This diagnostic species was recorded, so far, in Pakistan and UAE .

Pararotalia pakistanica* Anan, n. sp. - (Pl. 4, figure 80a-c*)

1960 *Pararotalia* (?) sp. p. 31, pl. 4, fig. 2. ●
Holotype*:* Illustrated specimen in Pl. 4, fig. 80 x 55.
Dimension*:* Length 45 cm, width 33cm.
Etymology*:* After the Islamic Republic of Pakistan.
Age*:* Middle-Late Eocene.
Depository*:* Pakistan Geological Survey Memoirs.

Diagnosis*:* This diagnostic species has low trochospiral coil test, nearly biconvex, 6-7 elongate triangular chambers in both sides and centrally elevated on spiral side, narrow umbilicus, sutures radially depressed on ventral side but curved back at the periphery on the spiral side, periphery carinate and peripheral outline lobulate, surface pustulose ornamented, aperture interiomarginal with a lip.

Remarks*:* The Pakistanian new species *P. pakistanica* is distinguished by having triangular elongate chambers, pustulose ornamentation and closed umbilical area. It differs mainly from *P. audouini* (d'Orbigny) by its open narrow umbilicus than the latter by its prominent umbilical plug. It seems that the figured specimen *Pararotalia armata* of Cherif et al. (1992, p. 52, pl. 4, fig. 13) from Early Miocene of Jabal Hafit (UAE) is closely related to this Pakistanian species. For that it is recorded, so far, from Pakistan and UAE.

Subfamily Rotaliinae Ehrenberg, 1839
Genus *Cincoriola* Haque, 1958
Type species *Punjabia ovoidea* Haque, 1956

Cincoriola ovoidea* Haque, 1956 - (Pl. 4, figure 81*)

1956 *Punjabia ovoidea* Haque, p. 153, pl. 30, fig. 1. ●

Remarks*:* Loeblich & Tappan (1988) considered the genera *Cincoriola* and *Punjabia,* both of Haque as synonymous. This Late Paleocene species has low trochospiral smooth text, nearly circular in outline, 6 inflated chambers in the last whorl, spiral side slightly concave with sharply angled shoulder, sutures depressed, umbilical region filled with pillarlike mas. It is, so far, an endemic in Pakistan.

Cincoriola patalaensis* Haque, 1956 - (Pl. 4, figure 82*)

1956 *Punjabia patalaensis* Haque, p. 153, pl. 34, fig. 1. ●

Remarks*:* This Late Paleocene species has low trochospiral smooth text, spiral side slightly convex, 7 inflated chambers in the last whorl, umbilical region filled with pillarlike mas, sutures depressed, aperture an interiomarginal slit near the umbilicus, periphery keeled. It is, so far, an endemic in Pakistan.

Genus *Soriella* Haque, 1960
Type species *Soeriella schoechlei* Haque, 1960

Soriella arbicularis* Haque, 1960 - (Pl. 4, figure 83*)

1960 *Soriella arbicularis* Haque, p. 39, pl. 5, fig. 1. ●

Remarks*:* This Eocene species has a low planispiral trochospiral smooth test with angular and truncated margins, 7 chambers in the last whorl, umbilical side highly elevated umbilical shoulders surrounding a narrow elongate umbilicus that is filled with a horizontal plates from the chambers and by vertical plates, surface coarsely perforate, aperture consist of a row of opening at the base of the chambers. It was recorded, so far, from Pakistan.

Soeriella schoechlei* Haque, 1960 - (Pl. 4, figure 84*)

1960 *Soeriella schoechlei* Haque, p. 39, pl. 1, fig. 7. ●

Remarks*:* Loeblich & Tappan (1988) treated the Indian form *Indicola rajasthanensis* Singh & Kalia (1970) as a junior synonym of the Pakistanian *Soriella schoechlei* Haque. For that it is recorded, so far, from Pakistan and India. This Eocene species differs from *S. arbicularis* by having 6 chambers in the last whorl, less highly elevated umbilical shoulders and more convex umbilical side. It was recorded, so far, from Pakistan.

Soeriella sindensis* (Haque, 1962) - (Pl. 4, figure 85*)

1962 *Gyroidinella (?) sindensis* Haque, p. 20, pl. 3, figs. 9-12. ●

Remarks*:* This Early Eocene has large trochospiral planoconvex smooth test, ventral side elevated and subconical with large deep umbilicus containing pillars partially fuse, 3 dorsal whorls and 7 chambers in the last whorl increasing gradually as added, sutures limbate and slightly raised in the dorsal side, periphery rounded, aperture an elongate interiomarginal slit extending from the periphery to umbilicus. It is, so far, an endemic in Pakistan.

4. PALEOGEOGRAPHY

Most of the eighty five Pakistanian recorded species are an endemic to Pakistan, except nineteen species of them were recorded in some localities in Southern and Northern Tethys (Figure 1). Southern Tethys, includes: India (*Cibicidoides punjabensis*), Qatar (*Sakhiella nammalensis, Discorbis globiformis, Ornatanomalina hafeezi*), UAE (*Valvulineria nammalensis, Pararotalia khirthari, P. pakistanica*), SA (*Alabamina daubifera, Anomalinoides bandyi*), Egypt (*Euuvigerina subproboscidea, Reussella johnstoni, Fursenkoina dubia, Nonionella haquei*), Nigeria (*Ornatanomalina hafeezi*). Northern Tethys, includes: France (*Cibicidoides nammalensis, Asterigerinata cuniformis*), Spain (*Asterigerina brencei, Colites galeebi*), Slovenia (*Asterigerina brencei*). The Middle-Late Eocene horizon (P14-P16) of Jabal Hafit (UAE) yields 66 of Rotaliid benthic foraminiferal species compared with 40 in Pakistan, 38 in North Atlantic, 34 in West Europe, 32 in Egypt, 26 in East Pacific, 20 in Central Europe, 18 in South Atlantic, 17 in East Europe, 7 in West Pacific, 6 in Arabian Sea, The existence of a marked differences between the number of recorded benthic foraminiferal species in the closest or farest localities in respect with J. Hafit (UAE) may be due to one or more causes: the differences in the paleoenvironmental conditions (i.e. depth, water temperature, salinity, nutrients, dissolved oxygen, land barrier, etc.), not detailed or detected studies, the deficiency of available literatures, or also due to less homogeneity in the species concept between different authors.

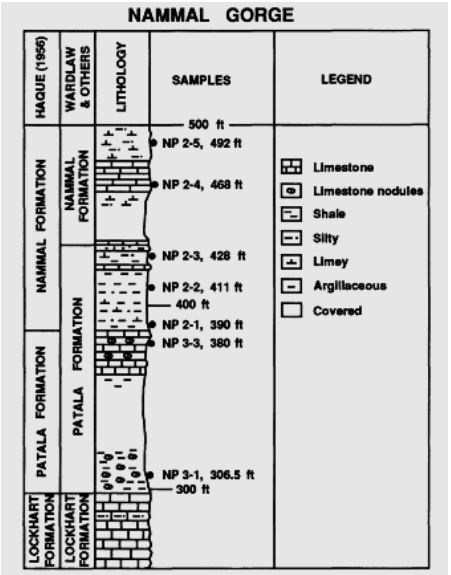

Figure 3: Lithostratigraphic section in Nammal Gorge at Nammal Dam: Patala and Nammal Formations of the Nammal Gorge, Salt and Sor Ranges of Pakistan (after Gibson, 2007).

Berggren suggested that during the Paleogene, the fauna of the Mediterranean and the Indo-Pacific exhibit pronounced similarities, which indicate that the connection between the two areas was mentioned by a marine seaway, and the East Atlantic fauna was much more closely related to the fauna than it is today (Berggren, 1971). Some researchers noted the extended realms of Tethys, Indo-Pacific with Atlantic during the Late Eocene time (Moore et al., 1978). Some group researchers noted that the continuous marine Paleogene connection between the area occupied by the present-day Mediterranean and the Indian Ocean had been lost by mid Burdigalian (early Miocene) times when a land bridge connected SW Asia to Arabia, which means that the faunas of the Mediterranean and Indo-West Pacific began to diverge, and the final disconnection must have been caused by a general elevation of this region rather than by a global eustatic change (Adams et al., 1983). Anan concluded that the Tethyan realm during the Middle-Late Eocene extends to the southeast and connected with the Indo-Pacific realm via seaway separating Arabia from Iran-India region (Anan, 1995).

Haynes and Nwabufo-Ene suggested wider Tethyan connections, as far as the Carpathian and Pakistan (Haynes and Nwabufo-Ene, 1998). Rögl noted that by the end of the Eocene the Tethys Ocean had already vanished, a new Indian Ocean was born, the western end of the Tethys was reduced to a Mediterranean Sea, Europe was still an archipelago and intercontinental seas covered large areas of the European platform and of western Asia (Rögl, 1999). Meulenkamp and Sissingh noted that the Arabian Platform, still largely covered by the sea in Early to Middle Eocene times, was subject to a major regression in the Middle to Late Eocene (Meulenkamp and Sissingh, 2003). A group researchers noted that the Eocene is an important Epoch for carbonate depositions in Pakistan (Khawaj et al., 2018). It was the time of marine transgression that is why it represents the period of sedimentation throughout the Indus basin, and the analysis of larger benthic foraminifers indicate the sequence deposited in a Neotethys, an open sea, upper slope to outer shelf shallow marine environments and the limestone and shale facies were dominated and that area is part of the eastern Tethyan region and was excellent for the tropical to sub-tropical marine sedimentary deposition.

5. PALEOENVIRONMENT

The foraminiferal contents of the Paleocene-Early Eocene succession at the Ranikot and Laki Formations of the Nammal Gorge, Salt and Sor Ranges of Pakistan have been investigated to assess the paleoenvironmental conditions prevailing during the deposition of these strata. Haque correlated the Nammal Formation with the Midway-Type Fauna (MTF) (Haque, 1956). Keller noted that general cooling trend between Middle Eocene to early Late Oligocene is indicated by the successive replacement of warm Middle Eocene surface water species (planktic) by cooler Late Eocene intermediate water species (Keller, 1983). Anan noted that the costate uvigerinid and buliminid forms as indicative of outer neritic depths (150-200 m) and the abundance of these forms around the Middle/Upper Eocene horizon in Egypt may be regarded of an outer neritic environment, while the rarity of it in some horizons may represent a fall in sea level that eventually shallower to less than 100 m, and the *Pararotalia* spp. are of shallow neritic species <200 m (Anan, 1994).

Anan noted that in the Late Eocene time in the UAE and surrounding area had been located in the tropical and warm-temperate region based on many faunal environmental elements (presence of keel, accessory apertures, and tubular spines in some planktic foraminiferal assemblage, high P/B ratio, rich miliolids and nummulitids assemblage in some horizons) (Anan, 1995). Nomura and Brohi noted that the Southern Pakistan (Figure 4) with its variety of Mesozoic and Cenozoic sedimentary rocks, is an ideal place to test the Indian-Asian convergence model from the view point of paleoenvironmental changes (Nomura and Brohi, 1995). The Cretaceous to Paleocene benthic foraminiferal assemblages along the Gai River in southern Pakistan, and this river cuts across the Kirthar Range and exposes a good lithostratigraphic succession of Cretaceous-Oligocene marine sediments. Such a collision event should have led to distinct environmental changes in the Tethys Sea and the Indian Ocean, and by the time of magnetic anomaly 29, the Tethys Sea has been reduced to a long channel. Despite northward movement of the Indian continent at the rate of 18-19.5 cm/yr, the Tethys Sea remained without restricted deep-water circulation. Shafique noted that the basal part of the Patala Formation is interpreted as shallow marine; while the top is deep marine (Shafique, 2001).

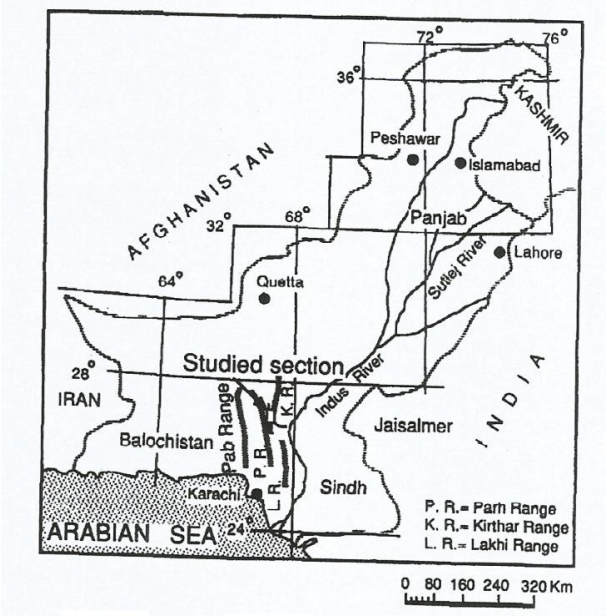

Figure 4: Pab Range, Kirthar Range and Lakhi Range in the Balochistan area, Southern Pakistan.

There was an abrupt change in basin setting of the region during the Late Paleocene to Early Eocene time as deep marine bathyal deposits of Patala Formation overlay the shallow marine strata of the Lockhart Limestone. Gibson noted that the Lockhart (mainly limestone), Patala (mainly shale) and Nammal Formation (mainly nodular limestone) have been deposited predominantly in shallow marine environments (about 100 ft ~ 30 m deep), and the change of lithology from carbonate to shale must be largely related to the supply of the fine clastic material rather than to water depth (Gibson, 2007). Jones noted that the benthic foraminifera are the most important group of fossils in palaeobathymetric interpretation in the Indian subcontinent, and those from the Paleogene formations of Pakistan represent a range of predominantly shallow marine carbonate environments and palaeobathymetries (Jones, 2014).

Khanolkar and Saraswati noted that the presence of some genera, i.e. *Nonion, Quinqueloculina, Cibicides, Elphidium, Rotalia* and *Pararotalia,* together with a low abundance of larger benthic foraminifera, suggest water depths within 10–15m (Khanolkar and Saraswati, 2016). Some researchers noted that the Panoba Formation in Kohat sub-basin of the Indus Basin, Northern Pakistan (north of Salt and Sor Ranges, Figure 5) exposes excellent early Eocene Tethyan section (equivalent of E1 and E2 planktic foraminiferal biozones), and this formation was deposited in a variety of setting ranging from middle-upper bathyal zone environments (Ahmad et al., 2016). In other study, researchers noted that the Eocene is an important Epoch for carbonate depositions in Pakistan, and it was the time of marine transgression (Khawaj et al., 2018).

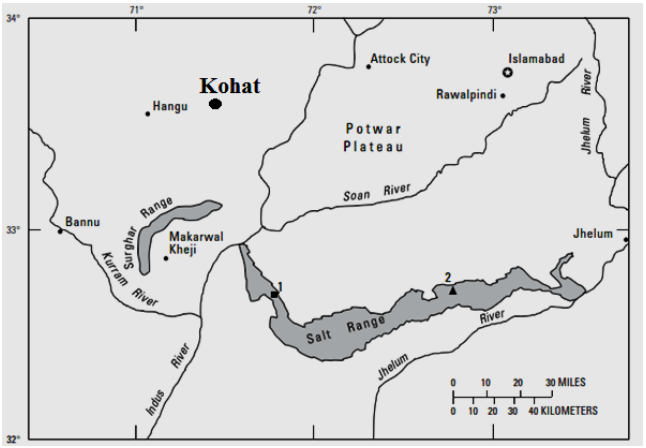

Figure 5: The Salt Range study area in Northern Pakistan showing locations at the section study 1 Nammal Dam section, and Kohat sub-basin, Northern Pakistan (after Gibson, 2007).

6. CONCLUSION

The rich and well-preserved large number of tests available throughout the Late Paleocene-Late Eocene Pakistanian eighty five Rotaliid benthic

foraminiferal species from the Ranikot, Nammal and Laki Formations of the Nammal Gorge, Salt and Sor Ranges of Pakistan belong to forty genera have been studied and are systematically listed. Five out of these species are believed to be new: *Bolivina pakistanica*, *Loxostomum pakistanica*, *Eponides pakistanica*, *Rosalina haquei* and *Pararotalia pakistanica.* Though, the material shows some endemism effect which points to a restricted or partially restricted bottom conditions. Only nineteen species of the eighty five species were recorded in some other localities in Southern Tethys (India, Qatar, UAE, SA, Egypt, Nigeria) and Northern Tethys (France, Spain, Slovenia). Haque noted that many foraminiferal forms which were recorded from Europe and Egypt are also recorded in Pakistan, which emphasizes the interpretations that have been presented by different authors about the extended realms of Indo-Pacific via ancestral Tethys, which was connected with the ancestral Atlantic Ocean. Nomura & Brohi noted that the Southern Pakistan with its variety of Mesozoic and Cenozoic sedimentary rocks, is an ideal place to test the Indian-Asian convergence model from the view point of paleoenvironmental changes. The Cretaceous to Paleocene benthic foraminiferal assemblages along the Gai River in southern Pakistan, and this river cuts across the Kirthar Range and exposes a good lithostratigraphic succession of Cretaceous-Oligocene marine sediments. Such a collision event should have led to distinct environmental changes in the Tethys Sea and the Indian Ocean, and the Tethys Sea has been reduced to a long channel. Despite northward movement of the Indian continent at the rate of 18-19.5 cm/yr, the Tethys Sea remained without restricted deep-water circulation. Anan noted that due to the high abundance of pelagic Pakistanian foraminiferal assemblage represents middle-outer neritic environment (100-200 m depth) and shows an affinity with " Midway-Type Fauna" MTF.

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