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Foraminiferal Biostratigraphy and Paleoenvironments of the Paleocene Lockhart Limestone from Kotal Pass, Kohat, Northern Pakistan

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ABSTRACT

The present study deals with foraminiferal biostratigraphy and its paleoenvironmental interpretations for Middle to Late Paleocene carbonate sequence of Lockhart Limestone in Kotal section of north Pakistan. The foraminiferal assemblages provided a good database for biostratigraphic subdivision and identification of two planktonic biozones. Planktonic biozones recorded from study area include: Middle Paleocene *Morozovella angulata* Zone and Late Paleocene *Planorotalites pseudomenardii* Zone. Overlapping last occurrence of the *Morozovella velascoensis* with the last occurrence of *Planorotalites pseudomenardii* has been observed. This might be due to the long range of *Planorotalites pseudomenardii* on this continent as recorded in literature. Comparisons of these biozones with standard planktonic zonations have been presented. Many benthonic larger and smaller foraminifers of Middle-Late Paleocene interval have been recorded.

Inner neritic to middle neritic shelf environments of deposition for Lockhart Limestone in Kotal pass section of north Pakistan has been interpreted based on planktonic / benthonic (P/B) ratio, the total foraminiferal abundance and their diversification / preservation.

INTRODUCTION

The Kohat-Kotal Pass is a part of western Lesser Himalayan mountainous chain and represents the Hill-Ranges of the northern Pakistan. Geographically it is located at the southern margin of Peshawar Basin and laterally ranges into Attock Cherat Ranges in the east and Samana Range in the west. Towards south the Kohat Foreland Fold and Thrust Belt bound it. The Kohat-Kotal section exposes a thick sequence of Jurassic to Paleocene rocks, which constitutes the hanging wall sequence of the Main Boundary Thrust (MBT) along which Jurassic rocks of the section are thrusted southward over the Eocene-Miocene succession (Muree Formation) of the Kohat Foreland Basin (Figure 1). The study area has well-developed imprints of deformation, associated with Himalayan collision. The structure of the area associated along Main Boundary Thrust is spread over an area of approximately 22 Kilometer wide Range in Kohat Hill Ranges (Ghuari, et al., 1983; Khan et al., 1990). The Main Boundary Thrust (MBT) brings the Mesozoic-Cenozoic shelf sediments of Hill Ranges (Kala Chitta, Kohat and Samana) tectonically over pile of mollase sediment deposited in Foreland Basin of Kohat and Potwar Basin. (Hussain, 1984). Disruption along Main Boundary Thrust (MBT) Zone started probably around early Miocene time as seen by the evolvement of Miocene Murree Formation in the deformation (Burbank; 1983). The rocks exposed around the study area range from Jurassic to Miocene in age. Around the study area, the mollase sediment of Miocene age (Murree Formation) is exposed having tectonic contact with limestone of Jurassic age (Samana Suk Formation), the light color Cretaceous Limestone (Kawagarh Formation) is next abundant rock exposed in the area. Another best exposure of the rock in the study area near Gamkol Sharif is the Lumshiwal Formation with synclinal view of both sides with the Kawagarh Formation.

Kotal pass section of Kohat area is one of the most important localities in Pakistan stratigraphy, which provide an excellent opportunity to study Paleocene Tethyan sediments both in term of its lithological characteristics as well as its fossils contents. Various workers have visited this area and produced valuable record on the structural framework, general stratigraphy and sedimentological aspects of the area, but lacking the biostratigraphic aspect for the Paleocene Lockhart Limestone. Various workers in the Hazara, Salt Range, Samana and Kala Chitta ranges have judged micropaleontology of the Lockhart Limestone, but Kotal section is totally devoid of such records and provided an excellent opportunity to study foraminiferal micropaleontology. Moreover different workers have interpreted the stratigraphic nomenclature in different ways, leading to the confusion of stratigraphic units identification. These problems are rooted in the history of the science, in part because of the long-term isolation of workers and because many are not fully acquainted with modern stratigraphic and paleontologic concepts. The solution is a fully integrated, multi-taxa study that will produce the data necessary to establish the context for a modern understanding of the regional stratigraphic/biostratigraphic setup and chronologically controlled events like Paleoenvironmental conditions. However, the present research is the first comprehensive study of its kind, which provides contribution to the regional stratigraphic framework and the comparison of Lockhart Limestone biostratigraphy at Kotal section with worldwide-established standard planktonic zonations.

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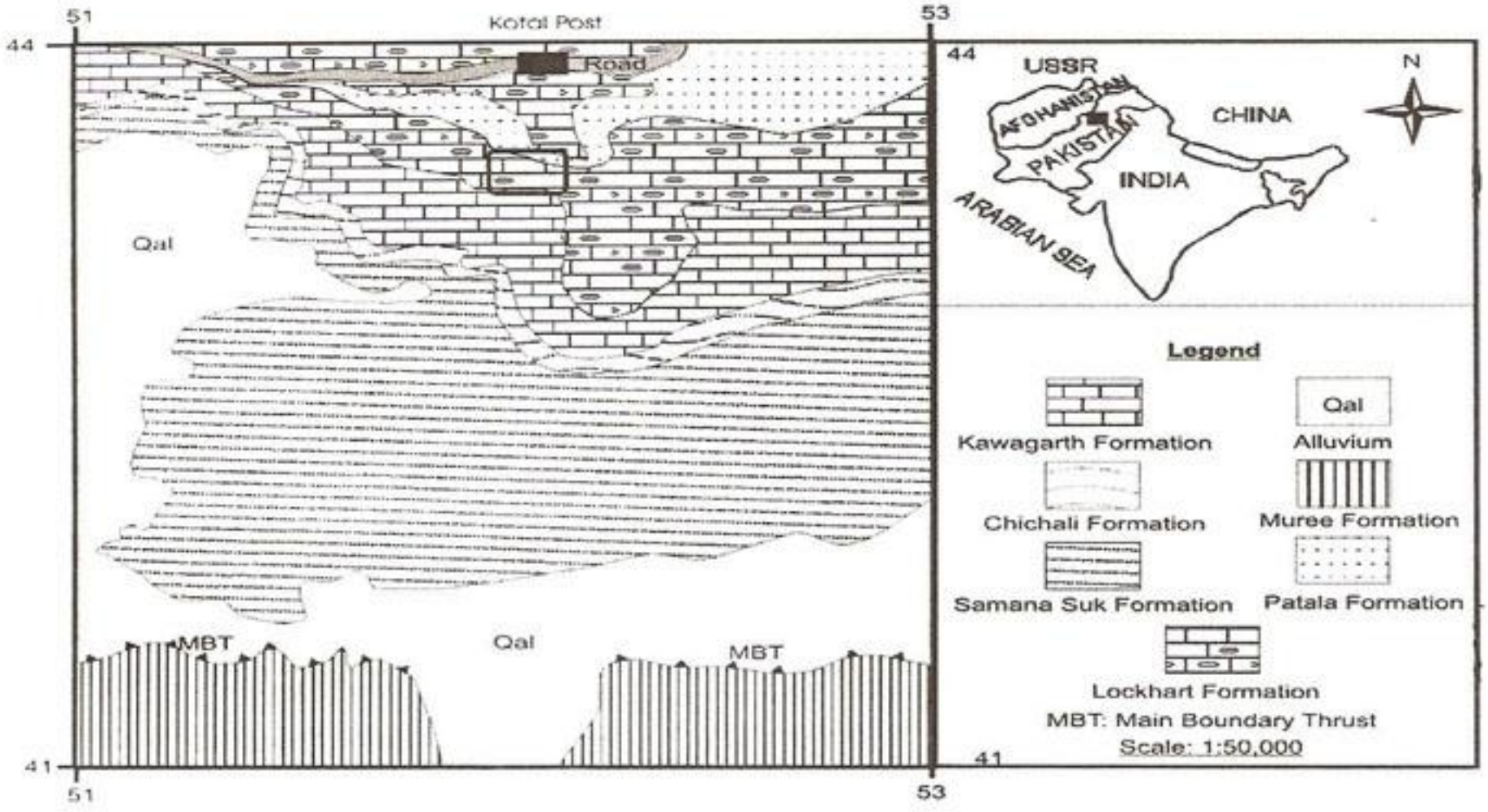


Figure 1- Geological map of the Kotal Pass section, Kohat, NWFP, Pakistan (Rectangle indicates studied section).

PREVIOUS WORK

The pioneer work on the micropaleontology of Lockhart Limestone was that carried out by Davies (1930) in the Samana Range (Kohat Region) and has described many Late Paleocene larger benthonic foraminifers. In 1937 Davies and Pinfold described and illustrated the characteristic Paleocene benthonic larger foraminiferal species from Lockhart Limestone in the Salt Range including *Operculina subsalsa, O. patalensis, Miscellanea miscella, M. atampi, Lockhartia haimei, L. newboldi, Discocyclina ranikotensis, Dictyoconoides flemengi, Fasciolites globosa, Assilina dandotica and Nummulites nuttali.*

The limestone beds of the same sequence in the Hazara area have yielded rich assemblages of foraminifers for example *Lockhartia conditi, L. conica, L.haimei, Daviesina khatiyaahi, Rotalia trochidiformis, R. prevail, Globorotalia uncinata, Globigerina tringularis, Textularia smithvillensis, Triloculinaa trigonula, Pseudogloborotalia khairabadensis, Miscellanea miscella, Actinosiphon punjabensis* etc and assigned Middle to Late Paleocene age (Raza 1967, Cheema 1968, Latif 1976, Munir et al. 1997 and Mirza et al. 2000). Another very useful contribution to the foraminiferal biostratigraphy was that made by Akhtar and Butt (1999) from the Kala Chitta region, where Lockhart Limestone encountered with Late Paleocene larger benthonic species. In addition Afzal and Butt (2000) have provided valuable informations on the planktonic foraminiferal zonations from the Lower Tertiary of the western Salt Range. Near the boundary of Patala and Lockhart in the Salt Range Afzal and Butt (2000) have established the last occurrence of *Planorotalites pseudomenardii,* which has shown longer range covering the interval of the standard *Planorotalites pseudomenardii* and *Morozovella velascoensis* and first occurrence of *Muricoglobigerina soldadoensis* with the influx of many other planktonic species of *Morzovella, Planorotalites, Acarinina* and *Pseudohastigerina.*

STRATIGRAPHY

In the study area the rocks range in age from Jurassic to Miocene entrenched with complex structural framework. The Jurassic Samana Suk Formation has a thrusted contact with Miocene Muree Formation near the Kohat city road (Ghauri et al., 1983). The Middle Jurassic Samana Suk Formation, Early Cretaceous Chichali and Lumshiwal Formations, the Late Cretaceous Kawagarh Formation and Early Tertiary formations (Lockhart Limestone and Patala) are folded into east-west trending anticlines and synclines. The Early Tertiary sequence consists of Lockhart Limestone and Patala Formation, while missing Hangu Formation in the area. General stratigraphic correlation of the Early Tertiary succession is given in the figure 2 and general stratigraphy of Kotal Pass section is given in table 1.

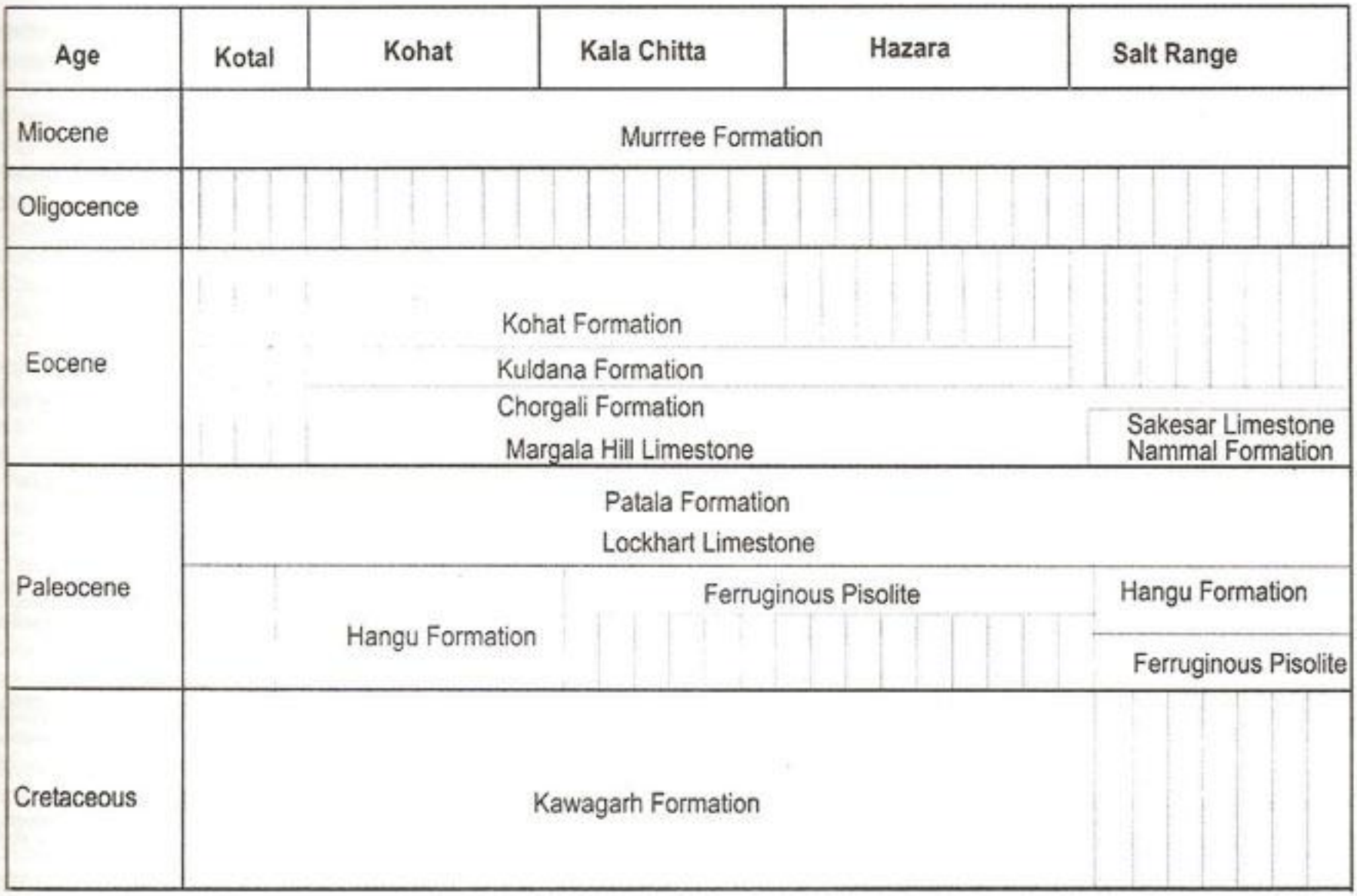


Figure 2- Stratigraphic sequence of the Early Tertiary successions in northern Pakistan with those studied in Kotal section.

Table 1. General Stratigraphy of Kotal section, Kohat Northern Pakistan (Reproduced after Ghuari et al., 1983).

S.No.	FORMATIONS	GEOLOGICAL AGE	LITHOLGY
7	**Murree Formation**	**Miocene**	Sandstone, shale, siltstone and . intra-formational conglomerate.
6	**Patala Formation**	**Paleocene**	Coarsed-grained mudstone, shale, marl, limestone, silts stone, sandstone and micro-conglomerate.
5	**Lockhart Limestone**	**Paleocene**	Light to dark grey nodular limestone
4	**Kawagarh Formation**	**Cretaceous**	Light to medium Grey, finely crystalline to aphanitic limestone.
3	**Lumshiwal Formation**	**Cretaceous**	Dark glauconitic and calcareous sandstone.
2	**Chichali Formation**	**Cretaceous**	Silty arenaceous and glauconitic sandy shale.
1	**Samana Suk Formation**	**Jurassic**	Medium Grey, well-jointed limestone and dolomite.

Lockhart Limestone

The term "Lockhart Limestone" of Davies (1930) has been extended to similar units exposed on other parts of the Kohat-Potwar and Hazara area by the Stratigraphic Committee of Pakistan (Shah 1977).

In the study area it is composed of light to dark grey limestone, which is yellowish brown to black on weathered surface, medium to thick bedded, but generally massive, forming steep cliffs. The Lockhart Limestone shows well-developed nodularity with the variable size nodules and greatly diverse grade of nodularity, which leads to the establishment of three lithostratigraphic units (Figure 3). Unit 1 is mainly composed of medium to thin bedded

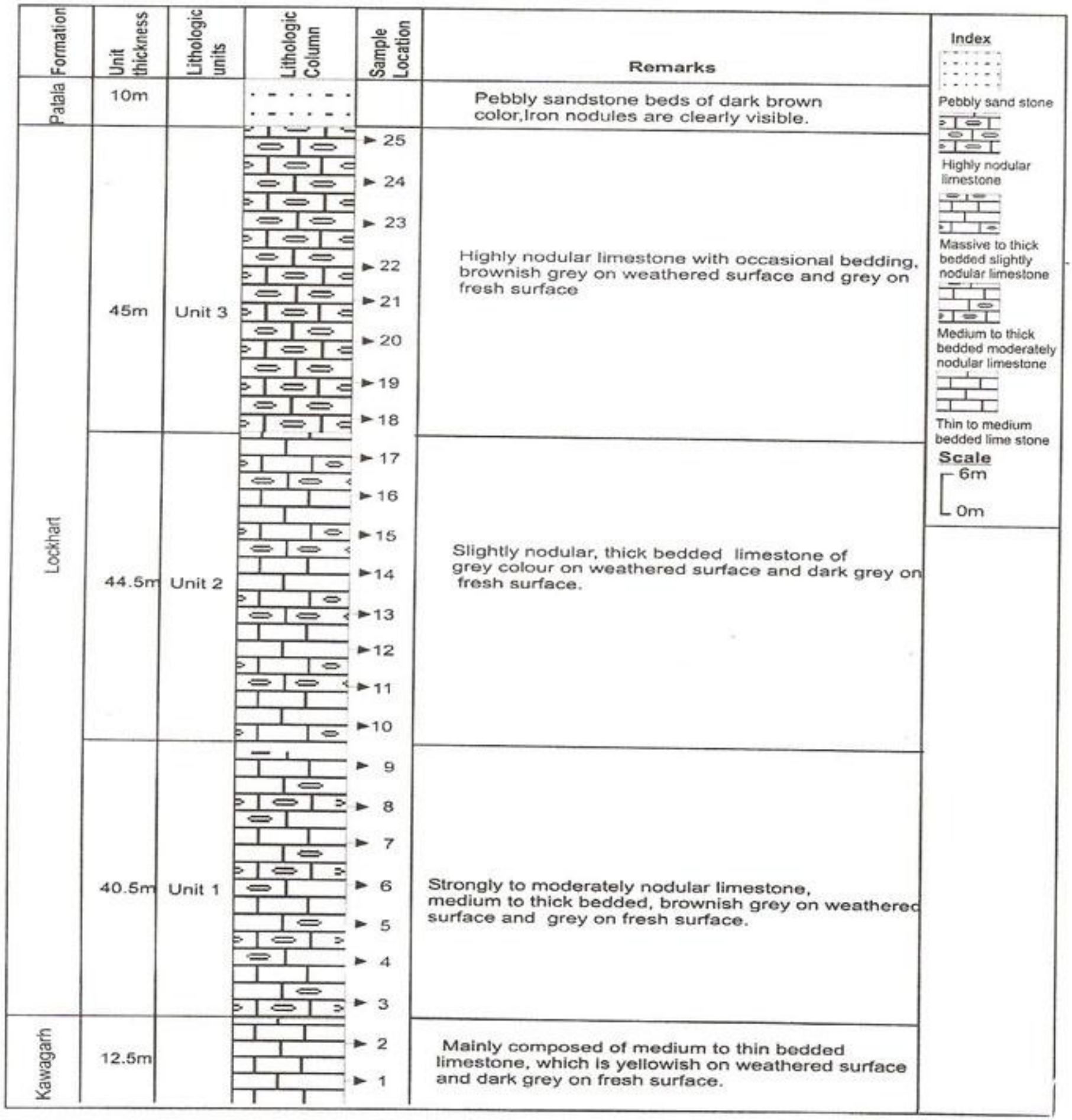


Figure 3- Lithostratigraphic column showing location of the samples of the studied section in the Kotal Pass area, Kohat, NWFP, Pakistan.

limestone, which is yellowish on weathered surface and dark grey on fresh surface, unit 2 comprised of medium to thin bedded limestone, yellowish on weathered surface and dark grey on fresh surface while unit 3 is slightly nodular, thick bedded limestone of grey color on weathered surface and dark grey on fresh surface.
At places the iron nodules are also present. The formation is generally bituminous and gives off fetid odor on fresh surfaces.

The contact relationship of the Lockhart Limestone in the studies section is quite clear: its lower contact was marked on the basis of abrupt shift from unfossiliferous yellowish, medium to thin-bedded limestone of Kawagarh Formation to a fossiliferous, grayish, medium to thick-bedded nodular limestone of Lockhart Limestone, while the upper contact was marked by same abrupt change from nodular limestone of Lockhart Limestone to pebbly sandstone of Patala Formation.

Present study on Lockhart Limestone at Kotal Pass section for the first time has proved rich assemblages of Paleocene foraminifers including following smaller benthonic like; *Cibicides multifarius*, *Cibicides cf. Lobalatus*, *Cibicides alleni*, *Textularia sp*, *Textularia punjabensis.*, *Textularia agglutinins*, *Bigenerina sp*, *Discorbis vesicularis*, *Cibicides nammalensis*, *Quinqueloculina ranikotensis,*, *Quinqueloculina lamarckiana*, *Biloculina contraria*, *Silicina epigona*, *Nonoinella cretacea*, *Bulimina reussi,* , *Marginulina glabra* and *Valvulineria danvellensis*, Larger benthonic are represented by following species; *Lochkartia haimei*, *Lockhartia conditi*, *Lockhartia tipperi*, *Lockhartia conica*, *Lockhartia diversa* , *Rotalia trochidiformis*, *Daviesina khatiyahi*, *Daviesina langhami*, *Sakesaria dukhani*, *Sakesaria sp*, *Valvulineria danvillensis* ,*Dictyokathina simplex*, *Kathina selveri sp.*, *Operculina subsalsa*, *Operculina salsa*, *Assilina subspinosa*, *Miscellanea miscella*, *Ranikothalia sindensis*, *Ranikothalia nuttalli*, *Discocyclina ranikotensis*, *Discocyclina seunesi* , *Pseudophragmina stephensoni*, *Actinosiphon tibetica*, *Actinosiphon semmesi*, *Lepidocyclina sP.*, *Lepidocyclina punjabensis*, *Eoannularia eocenica*, *Pleurostomella rimosa* and following planktonic foraminifers; *Planorotalites pseudomenardii*, *Planorotalites chapmani*, *Morozovella angulata*, *Morozovella velascoensis*, *Globorotalia pusilla*, *Morozovella abundocamerata*, *Pseudohatigerina sp.*, *Subbotina linaperta* and *Globigerina rubra*.

BIOSTRATIGRAPHY

In Kotal pass area of Kohat the present research is the first ever-comprehensive study of its kind, which provides contribution towards the foraminiferal biostratigraphy of the late Paleocene Lockhart Formation and its integration with standard planktonic zonations.

The biostratigraphic results are based on the study of the twenty-five surface rock samples including two from Kawagarh Formation (barren) and twenty-three from Lockhart Formation. A foraminiferal frequency distribution, stratigraphic range and biozonations of the about nine planktonic, fourteen smaller benthonic and twenty-seven larger benthonic species are given in figure 3 and the comparative zonal schemes of various authors (Figure 4) are also presented.

Larger benthonic foraminifers contribute a major part of the recorded foraminifers including some very important age indicator species like; *Lockhartia haimei*, *Lockhartia conditi* which are reported from the upper Paleocene (Lockhart Formation) of Kala Chitta Range by Akhtar and Butt (1999), also reported from the Paleocene of Thal, Ranikot (upper Ranikot), Salt range, Northern Somaliland and the upper and middle Paleocene of Qatar, *Miscellanea miscella* was reported from the upper Paleocene Lockhart and Patala Formations of Kala Chitta Ranges by Akhtar and Butt (1999) and from the upper Ranikot of Sind by Leppig (1988), *Operculina subsalsa* was reported from the upper Paleocene of Kala Chitta and *Discocyclina ranikotensis* was described from the middle to upper Paleocene of Salt Range, upper Paleocene of Thal and Upper Ranikot by Latif (1976). Among the smaller benthonic foraminifera many species recorded are not significant for stratigraphic determinations due to their long stratigraphic range i.e. mostly ranging from late Paleozoic to recent e.g *Textularia sp.*, *Bigenerina nodosaria*, *Discorbis vesicularis*, *Biloculina contraria* etc, but few of them are reported only from Paleocene successions like; *Cibicides multifarious* (Schwager) has been reported from the upper Paleocene of the Nammal gorge, western Salt Range by Haque (1956), *Cibicides cf. lobalatus* has been recorded from the upper Paleocene of Texas, Alabama, Mississippi, Arkansas in N. America and from Hazara area (Haque, 1956) and *Cibicorbis nammalensis* from the upper Paleocene of Salt Range (Haque, 1956) and Hazara area Latif (1976). The Planktonic foraminiferal assemblages of the recorded foraminifers are comparatively scarce than smaller and larger benthonics, but characterized by few very important zonal markers like; *Morozovella angulata* and *Planorotalites pseudomenardii*, which made them an important tool for biostratigraphic analysis and its integration with standard stratigraphic zonations. The details of the planktonic foraminiferal zonations established in present study are given below:

Planktonic Foraminiferal Zonations

Planktonic foraminifers recovered are common and well preserved in the middle portion of the Lockhart Limestone, while upper and lower parts favor medium to minor preservations. The Kawagarh and Patala Formations are completely barren of foraminifers in the study area. Two planktonic foraminiferal zones were identified during present study. Correlation of the here proposed biozones with their coeval and inter-regional schemes are illustrated in figure 5. The biozones are discussed as follow:

Morozovella angulata Zone

Definition: This is an interval zone and characterized by the interval between the lowermost occurrence (fa, fo) of *Globanomalina (Planorotalites) pseudomenardii* and lowermost occurrence (fa, fo) of *Morozovella angulata*.

Other characteristic species: *Muricoglobigerina rubra, Planorotalites chapmani and Pseudohatigerina sp.*

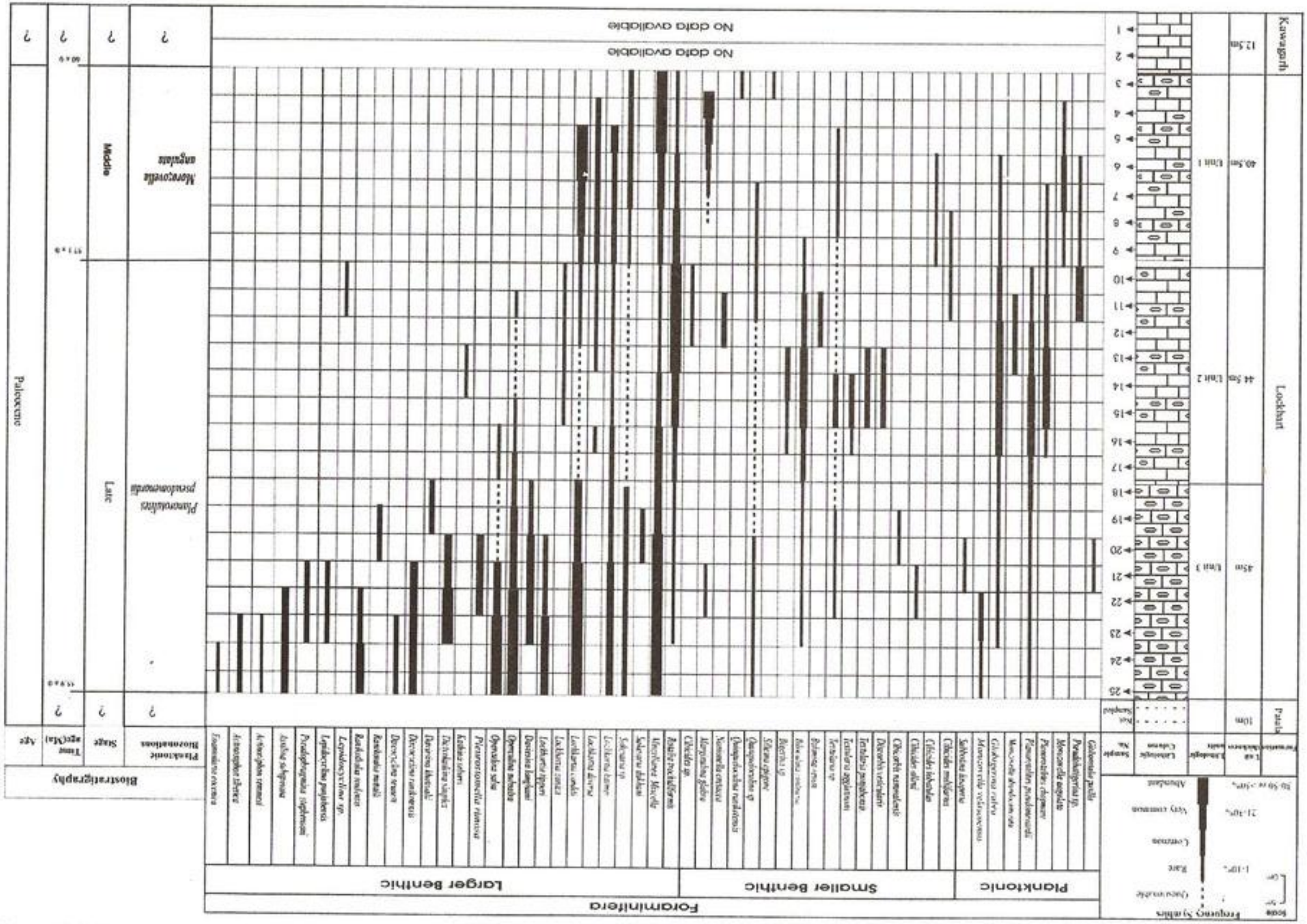
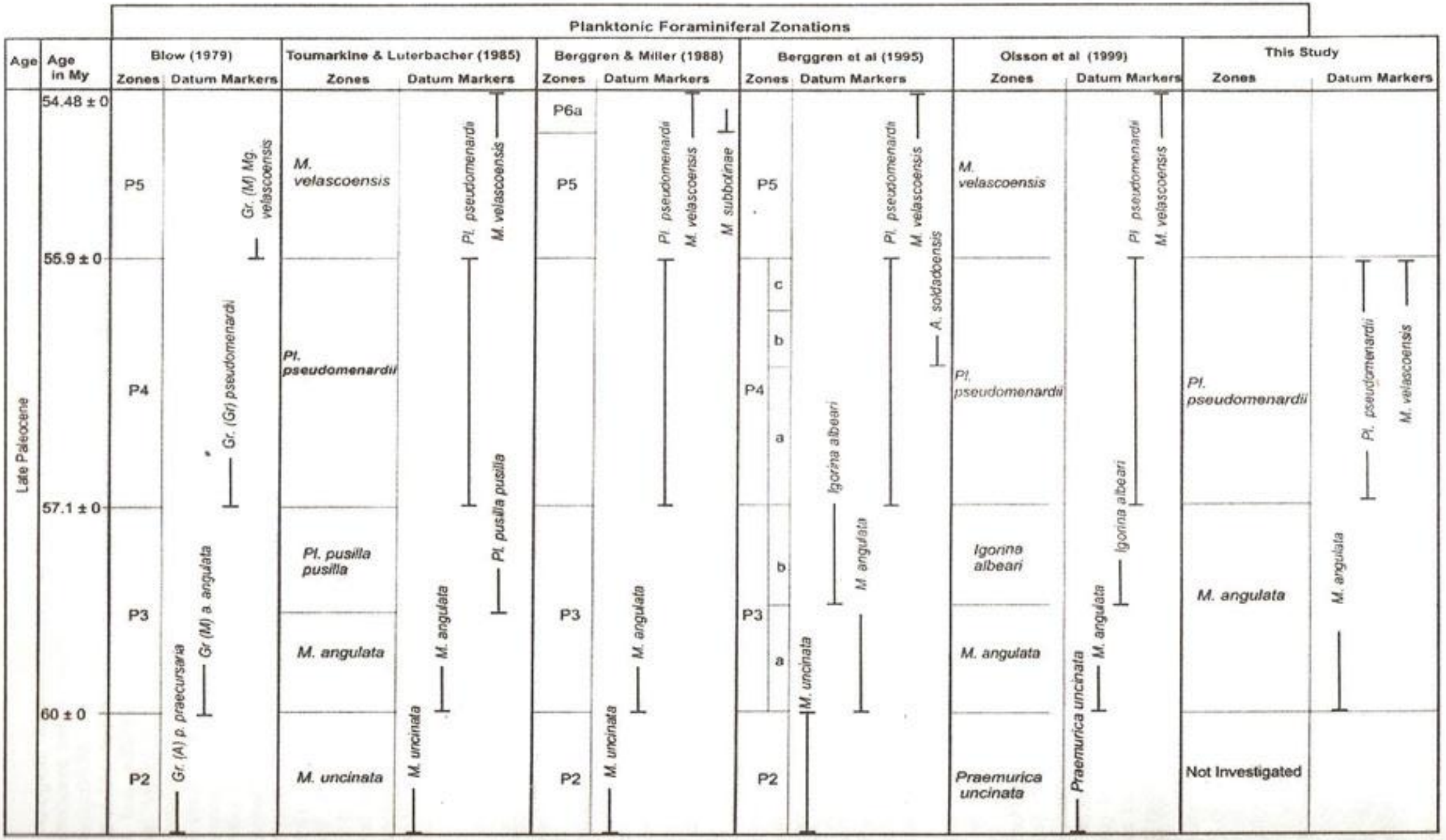


Figure 4- Schematic columnar section, frequency distribution and stratigraphic range chart of planktonic, smaller and larger benthic foraminiferal species and planktonic foraminiferal biozonations of the Lockhart Limestone, Kotal Pass area, Kohat, NWFP, Pakistan (time age in Ma is adopted after Breggren, 1997) index for the lithologic column is same as figure 3.

Figure 5- Comparison of important planktonic foraminiferal zonal schemes and marker species proposed by various researchers for upper Palaeocene interval with those used in this study (*M= Morozovella; PL = Planorotalites; Gr= Globorotalia and Mg = Muricoglobigerina)* million age is adopted from Berggren, 1997.



Remarks: This interval coincides with P3 zone of Blow (1979), Berggren and Miller (1988), *Morozovella angulata* and *Planorotalites pusilla pusilla* zone of Toumarkine and Luterbacher (1985), P3a, b zones of Berggren et al. (1995) and *Morozovella angulata and Igorina albeari* zones of Olsson et al. (1999) figure 4. *Planorotalites pseudomenardii* Zone of present study conformably overlies this zone. It is also equivalent to *Morozovella angulata* and *Igorina pusilla pusilla* Zones of El-Nady and Shahin (2001) and El-Nady (2005).The lower part of Lockhart Limestone (from sample no. 4 to 9 Figure 4) characterized this interval. This is a Middle Paleocene interval.

Planorotalites pseudomenardii Zone

Definition: It is define as total range of Planorotalites *pseudomenardii* (interval between first and last occurrence of *Planorotalites pseudomenardii*).

Other characteristic species: *Globigerina rubra, Planorotalites abundocamerata, Planorotalites pseudomenardii, Planorotalites chapman, Morozovella velascoensis, Subbotina linaperta* and *Pseudohatigerina sp*

Remarks: This coincides with the P4 zone proposed by Toumarkine and Luterbacher (1985), Berggren et al. (1995) and Olsson et al. (1999). It is also equivalent to that of Bolli (1966), Berggren (1969a, b), Beckmann et al. (1969), Postuma (1971), Blow (1979), El-Nady and Shahin (2001) and El-Nady (2005).

Lowermost part of unit 2 (sample no. 11 Figure 3) of Lockhart Limestone yielded slightly to moderately preserved *Planorotalites pseudomenardii* defining the lowermost boundary of *Planorotalites pseudomenardii* Zone. Gradual increase in the preservation grade was recorded in the upper part of slightly nodular limestone (unit 2) particularly from sample no. 11 to 16 (Figure 3). Gradual decrease in preservation grade and population toward the top of unit 3 ultimately come up to disappearance of *Planorotalites pseudomenardii* near sample no. 24, which marked the uppermost boundary of the *Planorotalites pseudomenardii* Zone. Overlapping last occurrence of the *Morozovella velascoensis* with the last occurrence of *Planorotalites pseudomenardii* has been observed from the uppermost part of Lockhart Limestone. This produced difficulty to establish *Morozovella velascoensis* zone above the last occurrence of *Planorotalites pseudomenardii* as recorded in literature around the world. Two possible explanations can be made for the phenomena of overlapping last occurrence of *Morozovella velascoensis* and the last occurrence of *Planorotalites pseudomenardii* in Kotal section of north Pakistan;

1. Diachronous last occurrence of *Planorotalites pseudomenardii:* this can be explained from the work of Berggren et al. (1995), who recorded first occurrence of *Planorotalites pseudomenardii* at different paleomagnetic chron levels, which support the doubts about its diachronous last occurrence.
2. Long range of *Planorotalites pseudomenardii:* Weiss (1988, 1993) in the Khairabad and the Nammal Gorge sections showed the last occurrence of *Morozovella velascoensis* before the last occurrence of *Planorotalites pseudomenardii.* Berggren et al. (1995) observed that *Planorotalites pseudomenardii* overlapping with younger *Muricoglobigerina soldadoensis* and also with *Morozovella subbotinae* (Afzal and Daniel, 19991, Arenillas and Molina, 1996). Blow (1979) mentioned a longer range of *Planorotalites pseudomenardii* and extended it into his P7 Zone, a horizon equivalent to an Early Eocene age. In addition Afzal and Butt (2000) recorded last occurrence of *Morozovella velascoensis* just before or at the last occurrence of *Planorotalites pseudomenardii.* They noted that in most of the sections in Salt Range the total range of *Planorotalites pseudomenardii* exceeds the last occurrence of *Morozovella velascoensis* and to occur with other younger assemblages. These favor the idea of long range of *Planorotalites pseudomenardii* on this continent as reported earlier by Afzal and Butt (2000).

PALEOENVIRONMENTS

The reconstruction of water depth is an important factor to explain the paleoecology/paleoenvironments. Qualitative and quantitative foraminiferal analysis provides a high-resolution database for the biostratigraphy and determines the main paleoenvironmental parameters. These parameters include the planktonic/benthonic (P/B) ratio, the total foraminiferal abundance and their diversification (Figure 4 & 6). During the normal condition the percentage of P/B ratio increases with water depth and depends mainly on the relative difference of paleoproductivity of both planktonic and benthonic foraminifera (Murray, 1976, Shahin, 2001). The productivity of planktonic foraminifera is higher in open pelagic waters and that of benthonic foraminifera is higher in a shallow neritic environment (Van Der Zwann, 1982; Van Morkhoven et al., 1986; Shahin, 2001). The larger benthonic foraminifers are the most common constituents of the late Paleocene–Early Eocene carbonate platforms (Hottinger, 1998) and they are of tropic in nature; lived within shallow photic zone in symbiosis with algae (Scheibner et al., 2005).

A drastic decreasing in the P/B ratio as well as in the total foraminiferal number and its diversification is clearly observed in the basal part (unit 1) of the Lockhart Limestone just during the Middle Paleocene *Morozovella angulata* Zone (Figure 4 & 6). High percentage (40-60 %) and grade of preservation of shallow water lager benthonic; *Lochkartia conditi, Lochkartia diversa, Lochkartia haimei* and *Miscellanea miscella* and low density of planktonic foraminifers clearly suggesting inner neritic shelf zone and reflect a shallow marine environment of deposition for lower to middle part of unit 1. The upper part of *Morozovella angulata* Zone and lower to middle part of *Planorotalites pseudomenardii* Zone reflect a gradual increase in P/B ratio an average of 40/25 % and appearance of many new species of planktonic foraminifers like; *Pseudohatigerina sp., Planorotalites chapmani, Planorotalites pseudomenardii, Planorotalites abundocamerata, Globigerina rubra* indicates a rise in sea level and surface water productivity. This gradual rise in sea level indicates a gradual shift from shallow inner neritic shelf zone to comparatively deeper marine environment of middle neritic

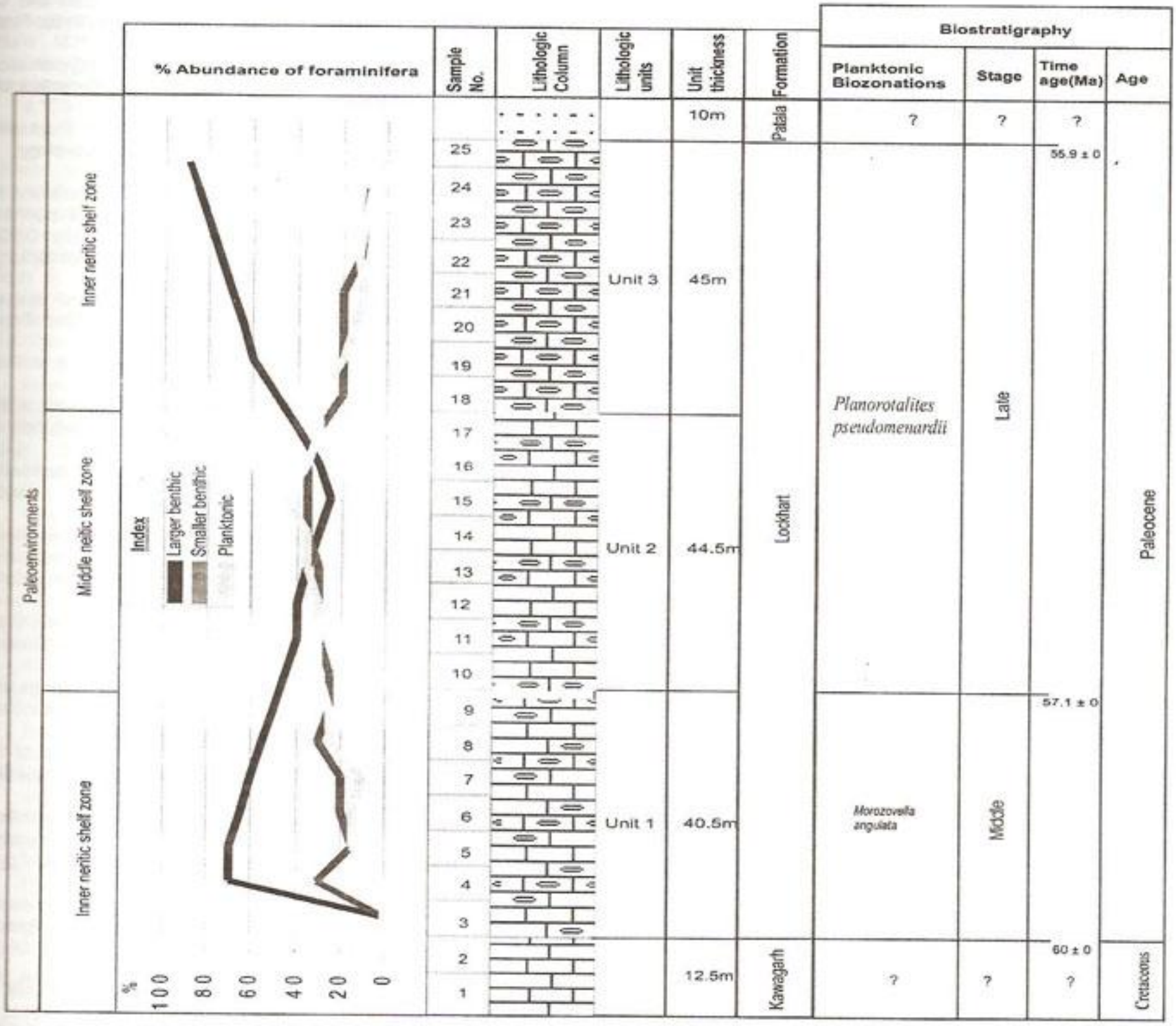


Figure 6- The relative frequency of the planktonic, smaller benthic and larger benthic foraminifers is plotted against lithology and biostratigraphy interpretation of paleoenvironments for Lockhart Formation in the Kotal Pass area, Kohat, NWFP, Pakistan (index and scale for the lithologic column is same as figure 3).

shelf zone for the deposition of upper part of unit 1 to middle of unit 2 (Figure 6). Many new species of larger benthonic emerge in the upper half of *Planorotalites pseudomenardii* Zone including; *Actinosiphon tibetica, Actinosiphon semmesi, Assilina subspinosa, Pseudophragmina stephensoni, Lepidocyclina punjabensis, Lepidocyclina sp., Ranikothalia sindensis, Ranikotalia nuttalli, Discocyclina seunesi, Discocyclina ranikotensis, Daviesina khatiyahi, Dictyokathina simplex, Kathina selveri, Pleurostomella rimosa, Operculina salsa, Operculina subsalsa, Daviesina langhami* and dominated (up to 80%) the uppermost *Planorotalites pseudomenardii* Zone. At the same time planktonic species became scarce (10%) and most of species disappeared in the topmost *Planorotalites pseudomenardii* Zone (Figure 4 & 6). These conditions reflect lowering of the sea level and surface water productivity accelerating the disappearance of some planktonic foraminiferal assemblages (Shahin, 2001), which can be referred to shallow marine inner neritic shelf zone for the deposition of upper part (unit3) of Lockhart Limestone.

The oscillation of sea level in the Kotal section of north Pakistan during *Morozovella angulata* Zone can be interpreted as a gradual rise right from the base (unit 1) of Lockhart Limestone, which persisted to the middle part of

Planorotalites pseudomenardii Zone and a period of gradual sea level fall started from the middle *Planorotalites pseudomenardii* Zone, which continued to the last occurrence of *Planorotalites pseudomenardii*, that is the topmost portion of shallow marine carbonate sequence (Lockhart Limestone) in Kotal section, followed by completely non-carbonate marginal marine pebbly sandstone beds of Patala Formation (Figure 6).

CONCLUSIONS

1. The Middle to late Paleocene Lockhart Limestone contains a variety of stratigraphically important benthonic foraminiferal species.
2. Two planktonic foraminiferal zones: Middle Paleocene *Morozovella angulata* Zone and Late Paleocene *Planorotalites pseudomenardii* Zone have been established.
3. Overlapping last occurrence of the *Morozovella velascoensis* with the last occurrence of *Planorotalites pseudomenardii* has been recorded.
4. A longer range has been observed for *Planorotalites pseudomenardii* covering the standard *Planorotalites pseudomenardii* Zone and *Morozovella velascoensis* Zone.
5. Middle to Late Paleocene age is assigned to Lockhart Limestone at Kotal section of north Pakistan.
6. Deposition of Lockhart Limestone took place in the inner neritic to middle neritic shelf zone of comparatively shallow marine carbonate framework.

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PLATES DESCRIPTION

PLATE 1:

Figure # 1: Species: *Lochkartia haimei, Sample#* 16, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 2: Species: *Lochkartia conditi,* Sample# 8, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.14x

Figure # 3: Species: *Sakesaria* sp., Sample#23, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 4: Species: *Lockhartia tipperi*, Sample# 10, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 5: Species: *Lockartia conica* , Sample# 11 Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure# 6: Species: *Dictyokathina simplex*. Sample# 20, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 7: Species: *Lockhartia diversa* sp. Sample# 16, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.14x

Figure # 8: Species: *Rotalia trochidiformis*, Sample# 18, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 9: Species: *Sakesaria dukhani* sp. Sample#19, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 10: Species: *Daviesina khatiyahi.* Sample# 17, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 11: Species: *Daviesina langhami* Sample# 23, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 12: Species: *Cibicides sp.* Sample#11, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

PLATE 2:

Figure # 1: Species: *Kathina selveri sp.* Sample# 13, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 2: Species:, *Planorotalites chapmani* Sample# 11, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

Figure # 3: Species: *Morozovella angulata* Sample# 10, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

Figure # 4: Species: *Planorotalites pseudomenardii* Sample# 12, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

Figure # 5: Species: *Pseudohatigerina sp.*. Sample# 10, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x.

Figure # 6: Species: *Assilina sp.* Sample# 21, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

Figure # 7: Species: *Morozovella abundocamerata* Sample# 13, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

Figure # 8: Species: *Subbotina linaperta* Sample# 9, LockharFormation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

Figure # 9: Species: *Pseudohatigerina sp.,* Sample# 6, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

Figure # 10: Species: *Subbotina sp.,* Sample# 10, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

Figure # 11: Species: *Cibicides multifarious* Sample# 10, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 12: Species: *Cibicides cf. lobalatus* Sample# 11, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

PLATE 3:

Figure # 1: Species: *Cibicides alleni* Sample# 21, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

Figure # 2: Species: *Textularia Sp.* Sample# 21, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

Figure # 3: Species: *Textularia punjabensis sp. nov.* Sample# 14, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

Figure # 4: Species: *Textularia agglutinins*, Sample# 16, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

Figure # 5: Species: *Bigenerina sp* Sample#11 Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

Figure # 6: Species: *Operculina subsalsa* Sample# 15 Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 7: Species: *Operculina salsa* Sample# 17, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 8: Species: *Assilina subspinosa* Sample# 22, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 9: Species: *Miscellanea miscella* Sample# 6, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 10: Species: *Ranikothalia sindensis(10a) and Morozovella velascoensis (10b)* Sample# 23, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.14x

Figure # 11: Species: *Ranikothalia nuttalli* Sample# 18, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.14x

Figure # 12: Species: *Discocyclina ranikotensis* Sample# 23, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.14x

PLATE 4:

Figure # 1: Species: *Discocyclina seunesi* Sample# 23, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 2: Species: *Pseudophragmina (athecocyclina) stephensoni* Sample# 22, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 3: Species: *Actinosiphon tibetica* Sample# 23, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.14x

Figure # 4: Species: *Actinosiphon semmesi* Sample# 23, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

Figure # 5: Species: *Lepidocyclina sp* Sample# 10, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 6: Species: *Lepidocyclina (polylepidina) punjabensis* Sample# 22, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 7: Species: *Eoannularia eocenica* Sample# 23, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.14x

Figure # 8: Species: *Morozovella velascoensis* Sample#25 Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

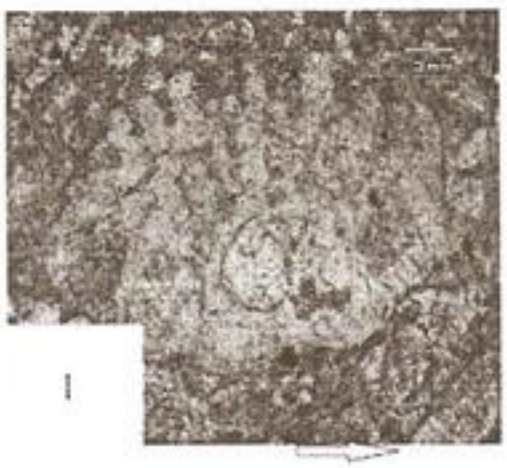
Figure # 9: Species: *Cibicides nammalensis* Sample# 18. Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

Figure # 10: Spcies: *Quinqueloculina sp.,* Sample#3 Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

Figure # 11: Spcies: *Quinqueloculina lamarckiana* Sample# 21, Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.30x

Figure # 12: Spcies: *Biloculina contraria* Sample#22 Lockhart Formation, Kotal Pass, Kohat, N.W.F.P, Pakistan.20x

PLATE 1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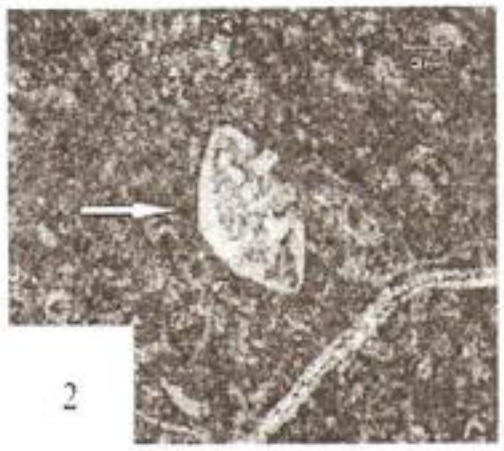
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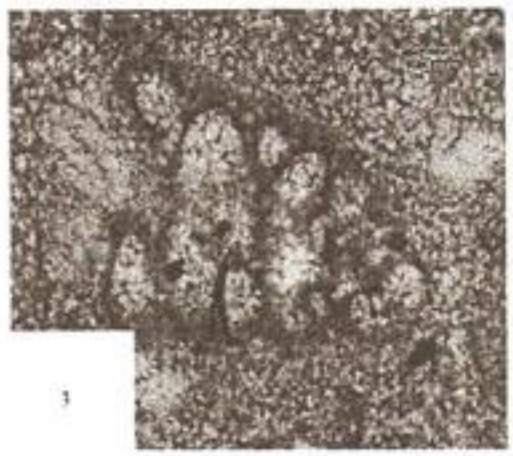
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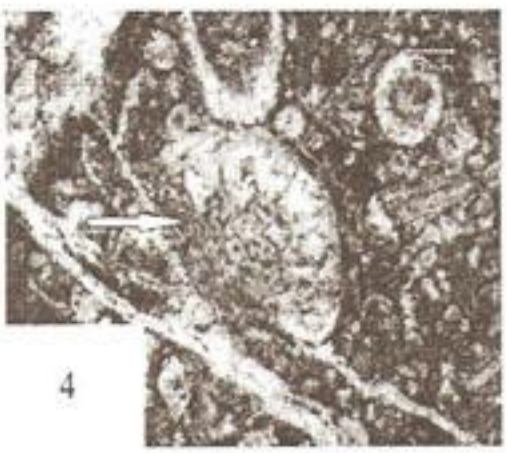
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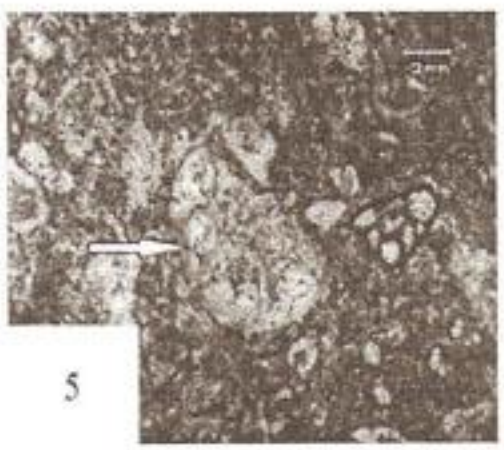
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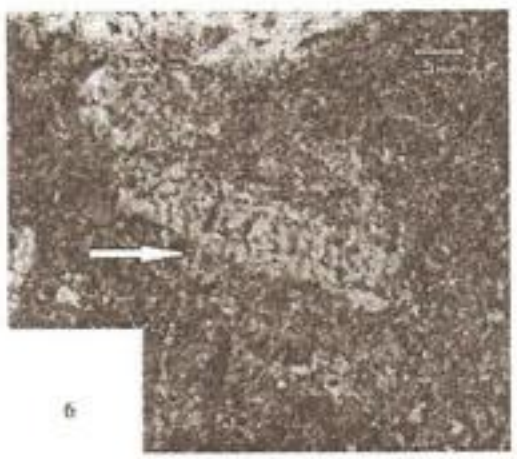
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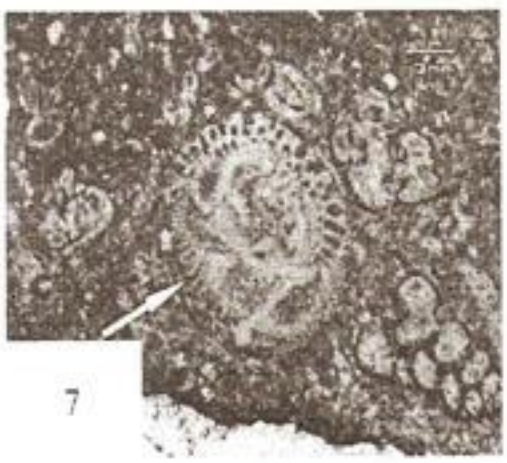
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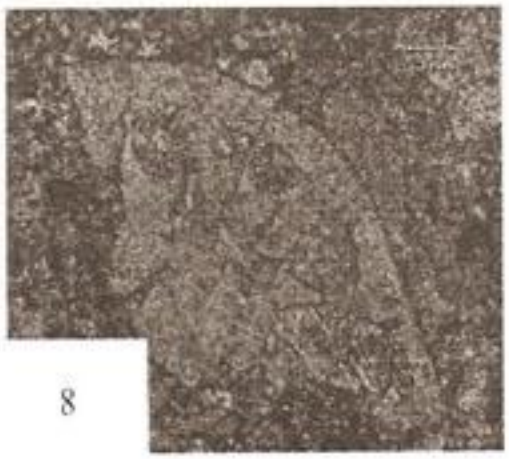
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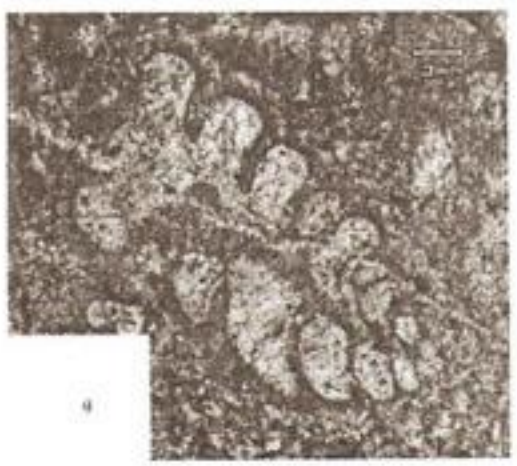
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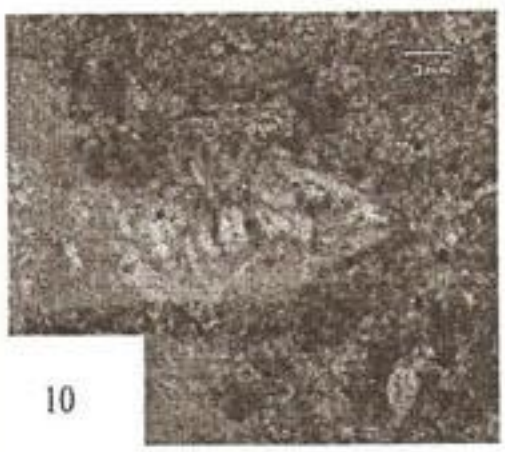
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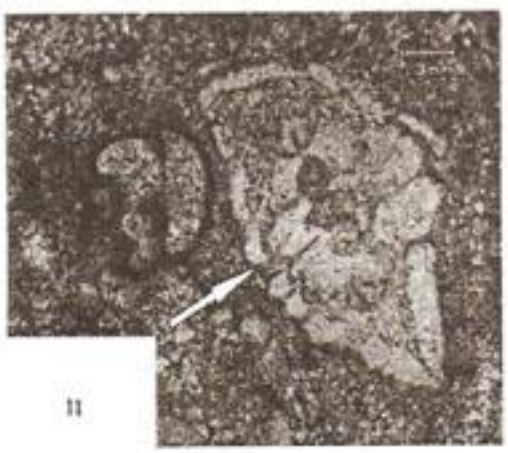
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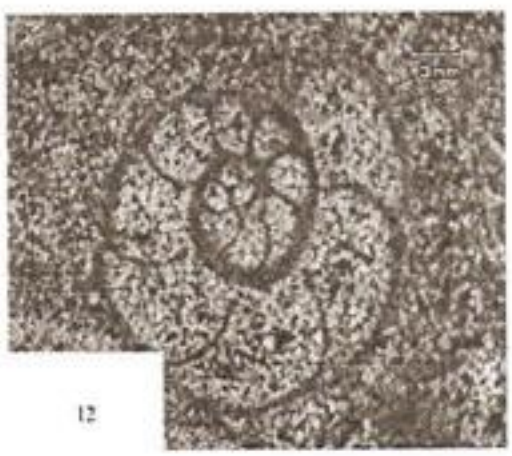
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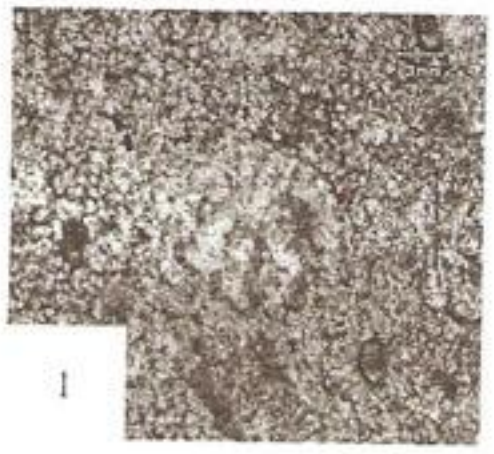
PLATE 2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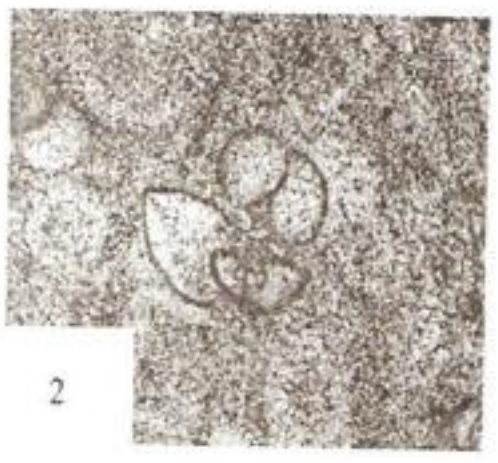
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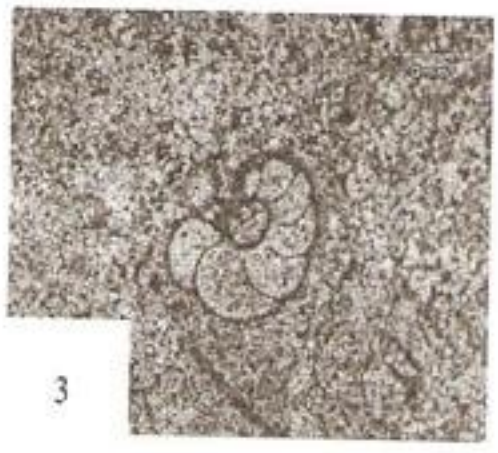
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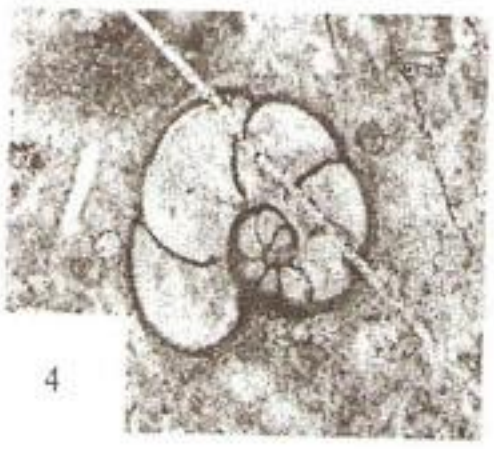
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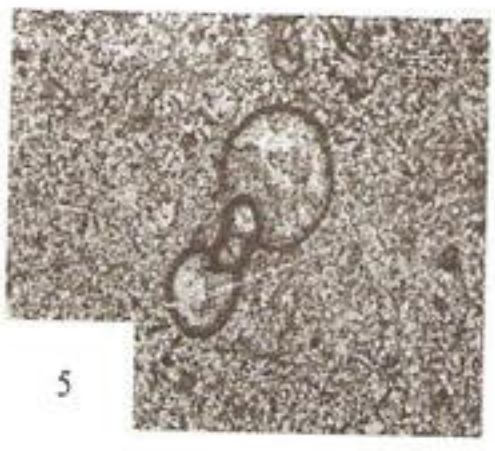
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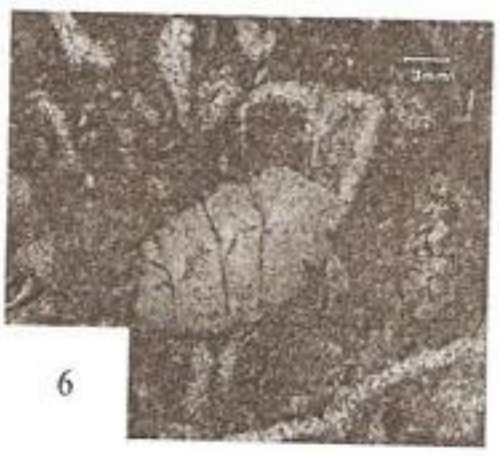
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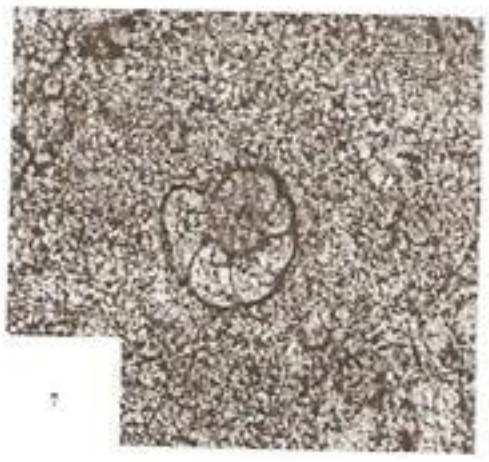
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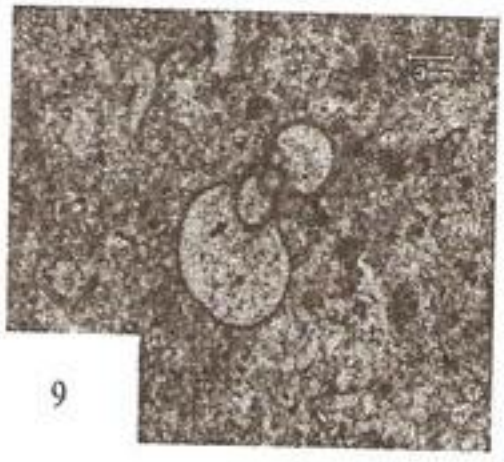
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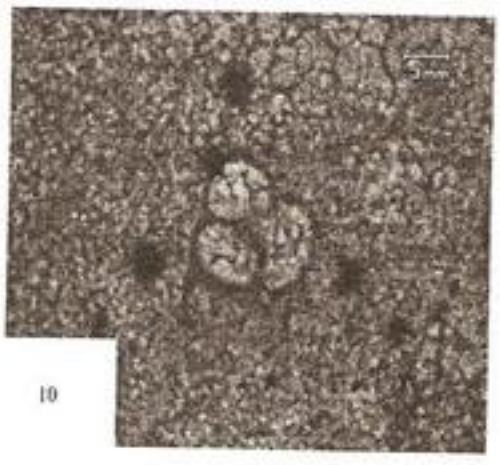
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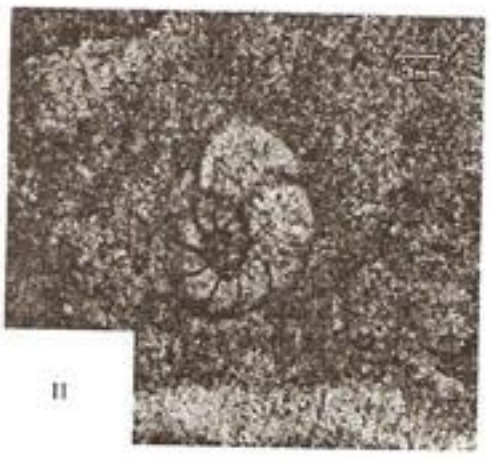
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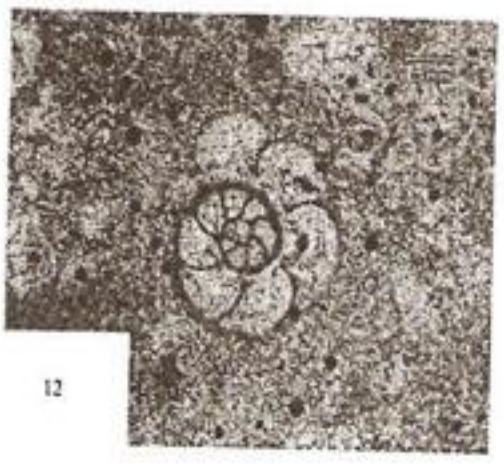
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PLATE 3


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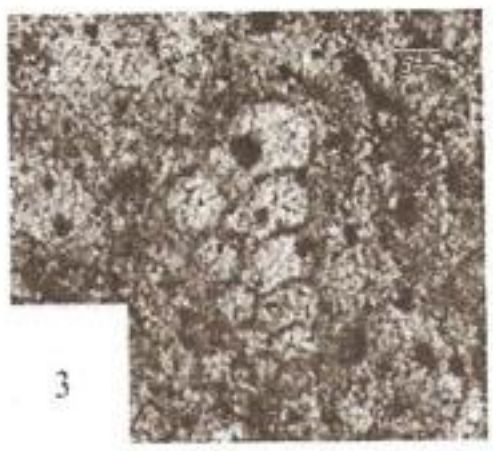
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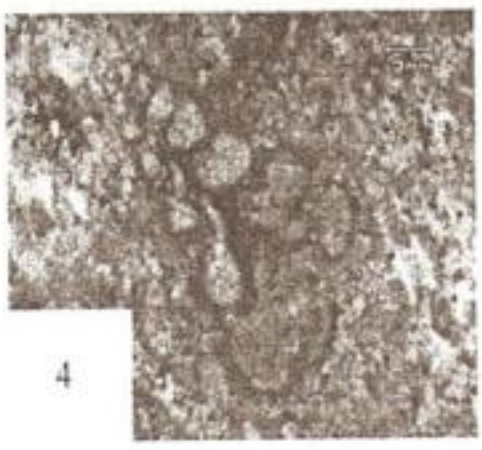
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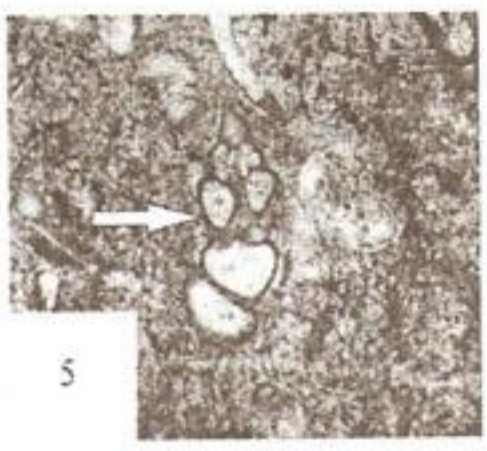
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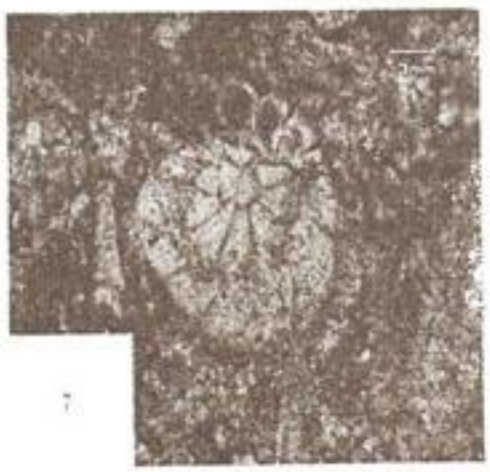
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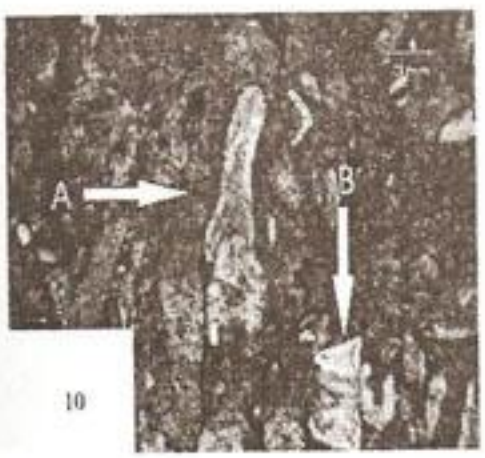

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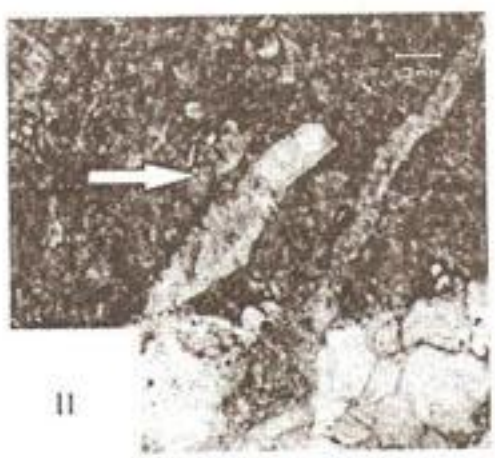
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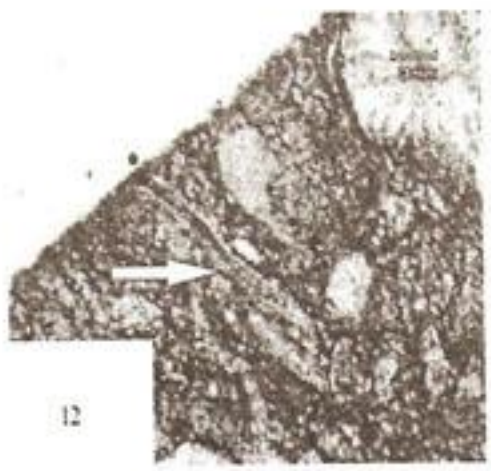
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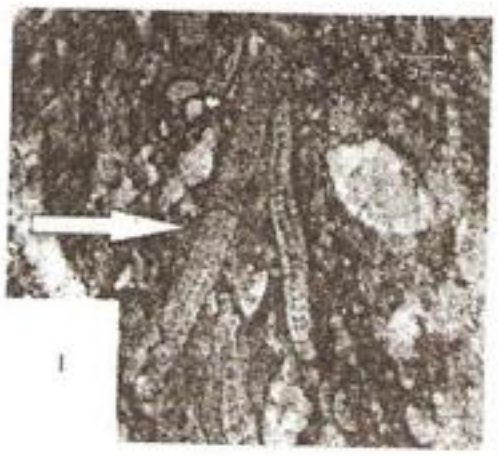
PLATE 4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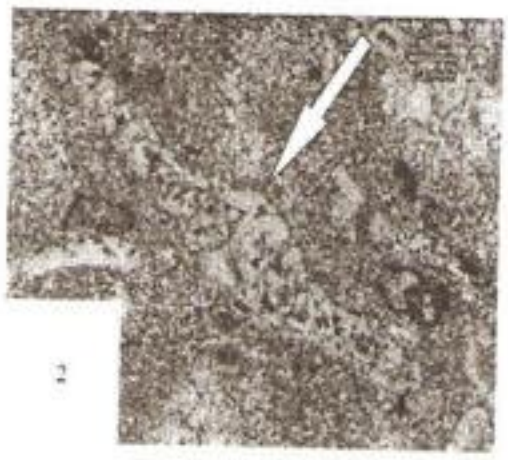
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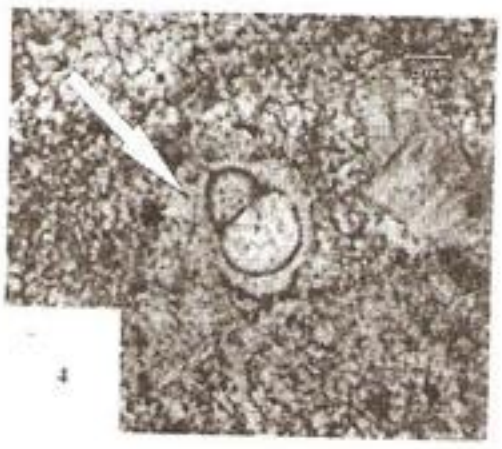
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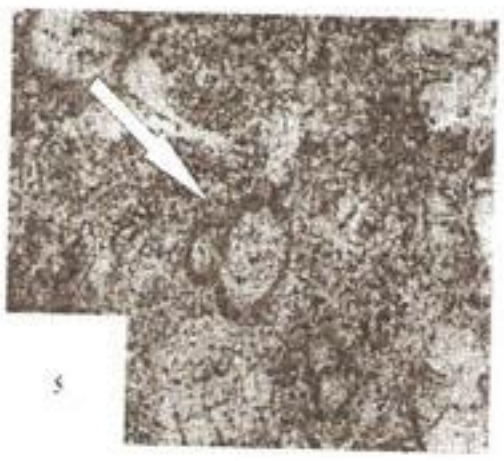
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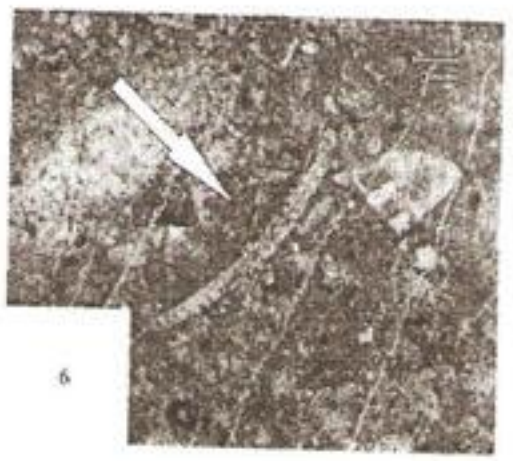
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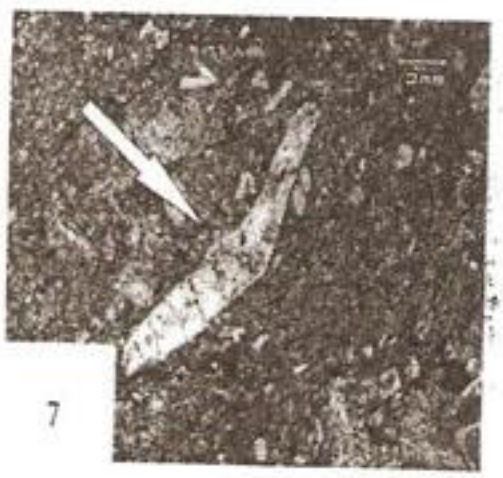
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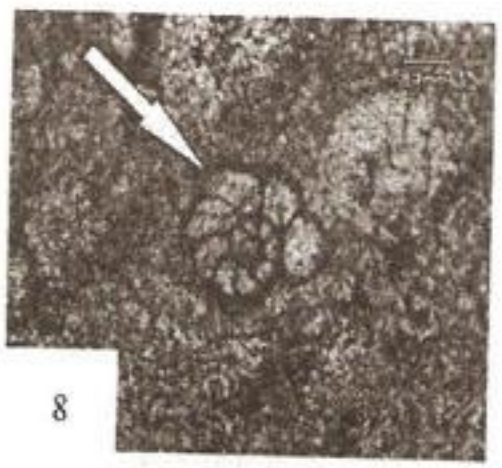
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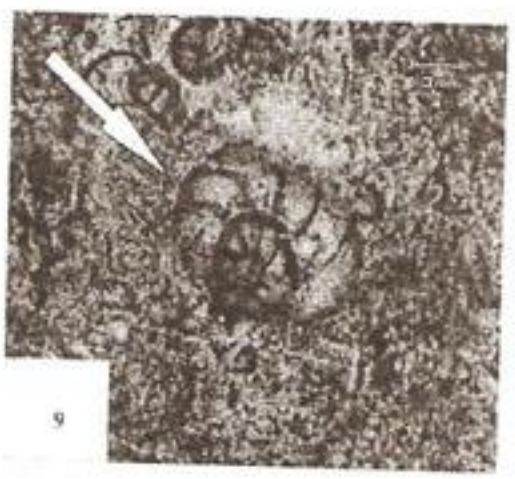
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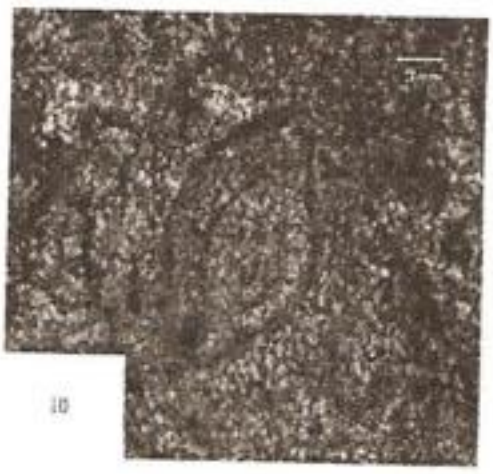
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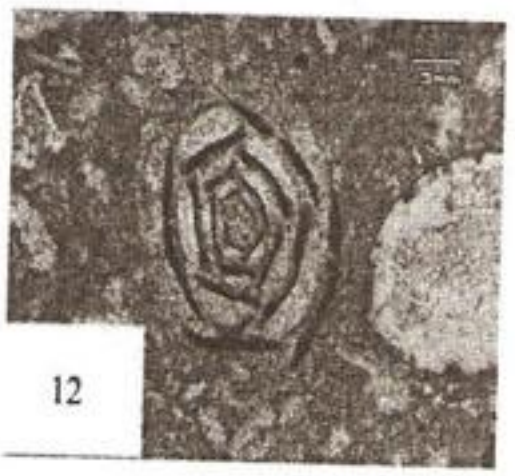
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