

Biostratigraphy and depositional environments of the Early Eocene Margalla Hill Limestone, Kohala-Bala area, Haripur, Hazara Fold-Thrust Belt, Pakistan

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Abstract

This research paper deals in biostratigraphy and depositional environments of the Early Eocene Margalla Hill Limestone found in Kohala-Bala area, Haripur from the southern Hazara Fold-Thrust Belt (north western Himalayan Fold-Thrust Belt). The stratigraphy ranges in age from Pre-Cambrian to Holocene. The Margalla Hill Limestone having limestone with thin inter-beds of claystone and marl is 136m thick, and has conformable lower contact with Patala Formation of the Palaeocene age. The upper contact (conformable) with Chorgali Formation of the Eocene age is not exposed here.

The Margalla Hill Limestone is described here as having a wide variety of faunal and floral assemblage; includes larger benthic forams, planktic forams, echinoderms, mollusks and dasycladacean algae. Their comparative studies suggest Middle Illeridian-2 age. There were three microfacies recognized; 1) Miliolid Lockhartia Mud-Wackstone Microfacies, inferred the deposition in a low energy, restricted circulation with slightly high salinity in a lagoonal environment of the inner shelf, 2) Nummulitic Wack-Packstone Microfacies, inferred to be deposited in a subtidal conditions of the carbonate shelf and 3) Benthic Foraminiferal Wack-Packstone Microfacies, representing deposition in the distal middle shelf area relatively further offshore. The microfacies are frequent in the section, which reveal changing sea level conditions.

Keywords: Eocene; Shelf carbonates; North Pakistan.

1. Introduction

The Kohala-Bala area lies on Lat. 33° 53' N and Long. 73° 12' E on the Survey of Pakistan Toposheet No. 43 G/1 in the southern Hazara Fold-Thrust Belt, Pakistan, which is part of north-western Himalayan Fold-Thrust Belt (Fig. 1). This belt is situated to the north of Potwar Basin and south of Mansehra Metamorphic Zone (Baig and Lawrence, 1987) and is bounded by Panjal Fault in the north and Muree Fault in the south (Hylland and Riaz, 1988; Iqbal et al., 2007). The Stratigraphy of the Hazara Fold-Thrust Belt ranges in age from Eo-Cambrian to Miocene. The sedimentary succession includes Early Eocene

Margalla Hill Limestone (Fig. 2) of the Kohala Bala in southern Hazara (Latif, 1970a). Previously, Latif (1970 a,b; 1976) carried out litho-biostratigraphy of the area, established stratigraphic units and prepared a geological map. His study also includes the Kohala-Bala area, however, the latest work on Kohala-Bala by Munir et al. (1997) includes the litho-biostratigraphy (lower Tertiary). This study on Margalla Hill Limestone is aimed to determine the allochemical constituents, recognize various textural types, microfacies based on field and petrographic data and interpret the depositional environments along with depositional model and biostratigraphy based on Schaub (1981) biozones.

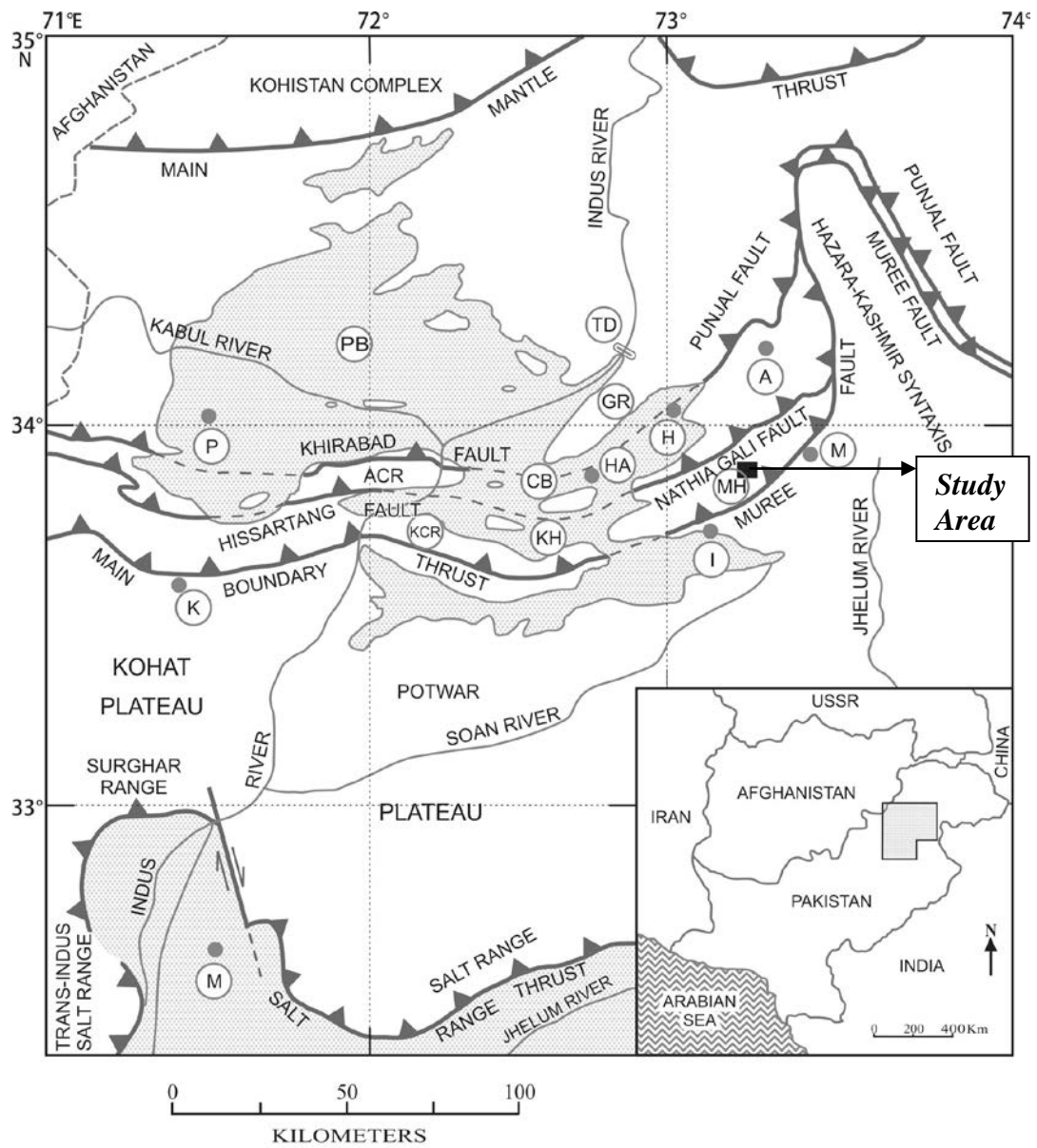


Fig. 1. Tectonic map of Northern Pakistan, Showing major structural boundaries. P=Peshawar; PB=Peshawar Basin; TD=Terbel Dam; A=Abbottabad; M=Muree; I=Islamabad; MH=Margalla Hills; H=Haripur; GR=Gandghar Range; HA=Hasan Abdal; KH=Kherimar Hills; CB=Cambellpore Basin; ACR=Attock-Cherat Range; KCR=Kala Chitta Range; K= Kohat; M= Mianwali (modified after Hyll and Riaz, 1988; Iqbal et al., 2007).

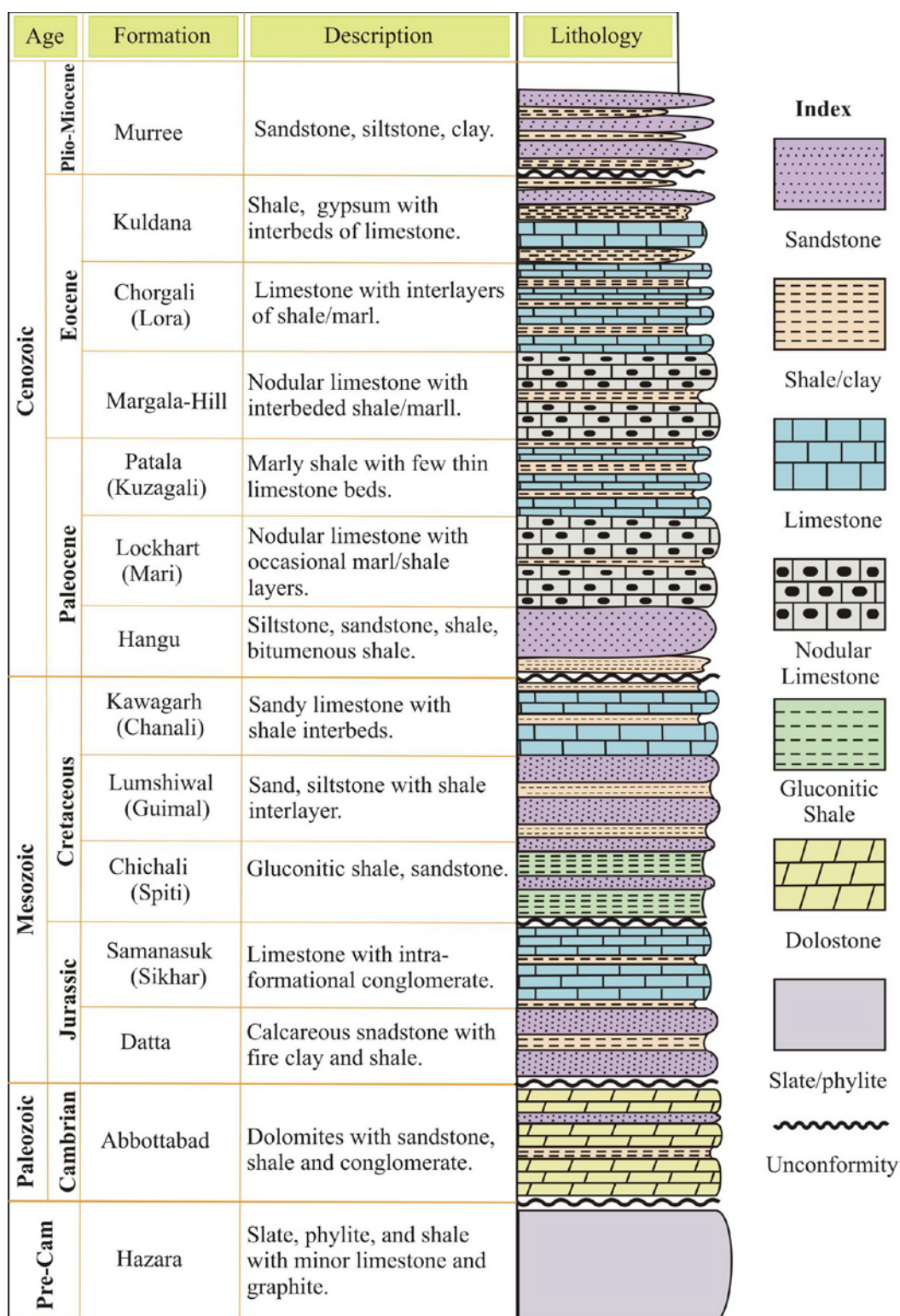


Fig. 2. Generalized stratigraphic column of Hazara area, Khyber Pakhtunkhwa, Pakistan (after Latif, 1970a).

2. Material and Methods

The Margalla Hill Limestone consists of limestone with thin inter-beds of clay stone and marl. The limestone is grey to dark grey, weathering pale yellow, fine to medium grained, nodular (nodules range from 2 to 35cm), medium to thick bedded and rarely massive. The marl is grey to brownish grey. The unit is well developed in Hazara, Kalachitta, eastern Kohat and Potwar. It is 100 m thick in Shahdara (a type section in south east Hazara) and 80 m at south west of Jhallar, Kalla Chitta (a reference locality; Shah, 1977).

The age of the formation is Early Eocene and contains fossils like foraminifers, molluscs and echinoids. Raza (1967), Cheema (1968) and Latif (1970b) recorded a number of foraminifers from the formation. The lower and upper contacts with the Patala Formation and the Chorgali Formation, respectively, are conformable (Shah, 1977).

The exposures of the formation within Hazara have been traced as north as Nawanshehr and as far south as Ratta Hotar (Khan, 2007). About 136m of exposed section was measured in south east Hazara in Kohala-Bala with help of Jacob Staff and measuring tape, the observation were recorded in a log and described, random sampling were carried out at site of facies change, their top and bottom were marked. Thirty one thin sections were prepared for detail petrographic studies (Fig. 3). Classification of rocks is based on Dunham (1962) and identification of microfacies and interpretations are based on Flügel (2004). Standard microfacies scheme of Wilson (1975) is used to compare identified microfacies. The biostratigraphy of the formation is carried out and has been compared with the biozones made by Schaub (1981).

3. Results

3.1. Microfacies

Three microfacies are recognized within the Margalla Hill Limestone on the basis of their discrete texture, allochems type, fossil contents and sedimentary structures. These microfacies are:

1) *Milliolid Lockhartia* Mud-Wackestone Microfacies, 2) *Nummulitic* Wack-Packstone Microfacies, and 3) Larger *Benthic Foraminifera* Wack-Packstone Microfacies (Plates 1 and 2), which are described below:

3.1.1. *Milliolid Lockhartia* mud-wackestone microfacies (MF-1)

The *Milliolid Lockhartia* Mud-Wackestone Microfacies are represented by thin section numbers M8, M11, M23, M26, M27 and M28 representing a total thickness of 17m (Fig. 4). These thin sections in the field represents nodular limestone with intercalation of claystone, the limestone is distinguished by weathered light grey colour and dark grey colour on the fresh surface. The individual nodule varies in size from 2-35cm.

The allochemical constituents of the microfacies predominantly comprises bioclasts, mostly represented by large benthic foraminifers and *Milliolid*. The allochem and matrix ratio is 3:7, according to visual estimation, the average relative abundance of various faunal and floral constituents is *Lockhartia* (15%), *Operculina* (1%) and *Milliolid* up to (7%). The texture of the rocks vary from lime mudstone to wackstone (Plate-1: A-C).

3.1.2. *Nummulitic* wack-packstone microfacies (MF-2)

The *Nummulitic* wack-packstone microfacies comprises nodular fabric and vary in colour from light to dark grey. The microfacies is represented by six thin section numbers: M12, M15, M17, M21, M24 and M25, found within a total thickness of 20m (Fig. 4). The microfacies is dominated by entire to fragmental *Nummulities* with *Lockhartia*, *Assilina*, *Operculina*, *Milliolid*, *operculina*, echinoderm and *morozvella*. The average relative abundance of various faunal and floral constituents is: *Nummulities* (upto 55%), *Lockhartia* sp. (5-12%), *assilina* (1-25%), *Operculina* (4-15%), *Milliolid* (2-3%), *Operculina* (2-5%), *echinoderm* (1-2%) and *Morozvella* (2-3%). The ratio of allochem to matrix ratio is 2:1, which classify them as wack-packstone (Dunham, 1962; Plate-1: D-H).

Plate 1

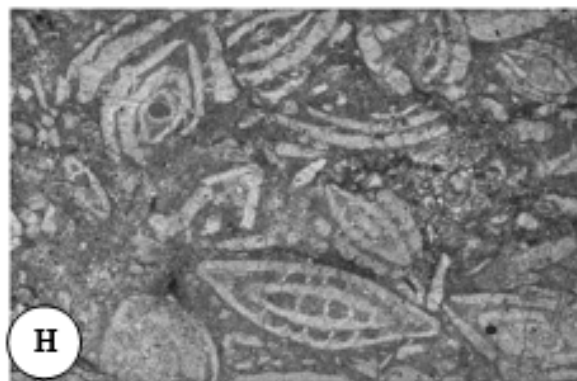
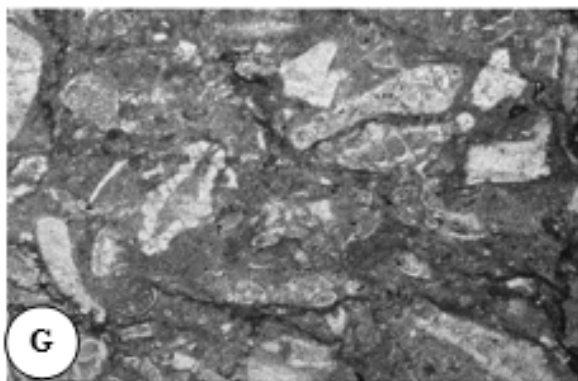
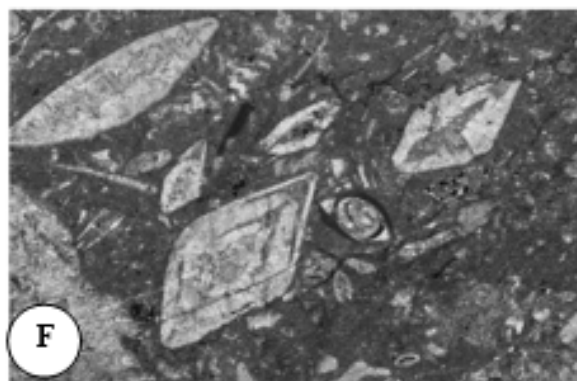
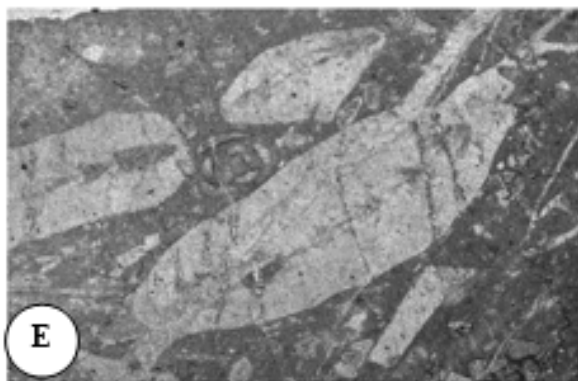
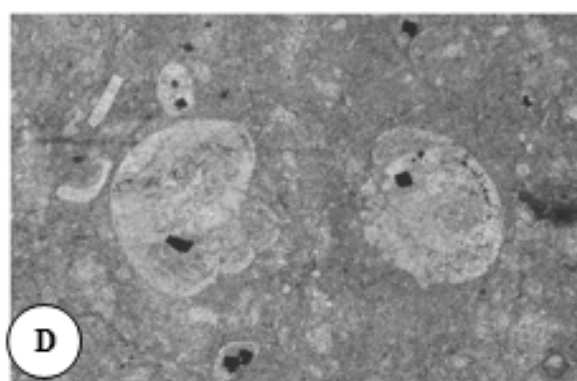
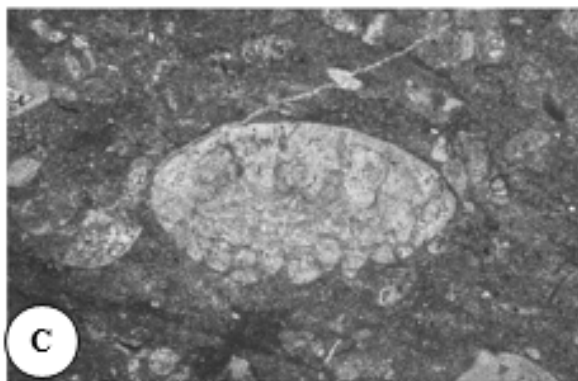
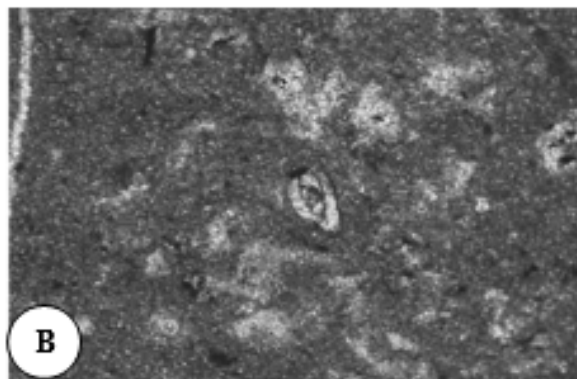
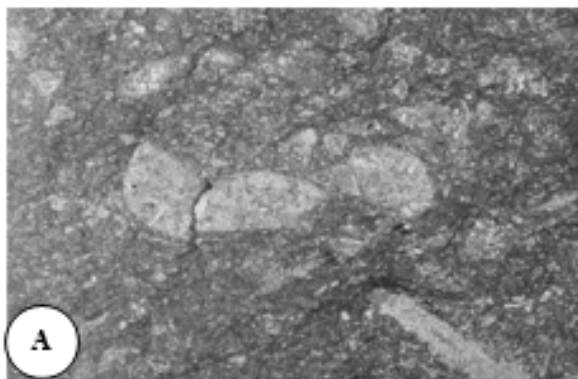


Plate 1

- A: Photomicrograph of *Lockhartia* sp. and *Rotalia trochidiform* of *Milliolid* Lockhartia mud-wackestone microfacies (PPL. Mag. x4).
- B: Photomicrograph showing *Milliolid* of *Milliolid* Lockhartia Mud-Wackestone (PPL. Mag. x4).
- C: Photomicrograph of *Lockhartia conditi* in *Milliolid* Lockhartia mud-wackestone microfacies (PPL. Mag. x4).
- D: Photomicrograph showing *Lockhartia conditi* and *Lockhartia* sp. of nummulitic wacke-packestone microfacies (PPL. Mag. x4).
- E: Photomicrograph of *Assilina grannulosa*, *quincolocolina* and *Assilina spinosa* of nummulitic wacke packestone microfacies (PPL. Mag. x4).
- F: Photomicrograph showing *Nummulitic* sp., *Milliolid* and *Assilina* sp. of nummulitic wacke-packestone microfacies (PPL. Mag. x4).
- G: Photomicrograph displaying *Operculina jiwani*, bivalve fragment and *Ranikothalia sahnii* of nummulitic wacke-packestone microfacies (PPL. Mag. x4).
- H: Photomicrograph showing Nummulitic Packestone having *Nummulitic dijodijokartae* of nummulitic wacke-packestone microfacies (PPL. Mag. x4).

3.1.3. Larger benthic foraminifera microfacies (MF-3)

This Microfacies is characterized by light brown, thin to medium, nodular-bedded limestone and is occasionally brecciated with clay interbeds. It is represented by thin sections: M1, M2, M3, M4, M5, M6, M7, M9, M10, M13, M14, M16, M18, M19, M20, M22, M29, M30 and M31, covering a total thickness of 99m in which 43.3m is covered sequence (Fig. 4).

The rocks are composed of skeletal constituents, represented by operculina, assilina, milliolid, discocyclina and echinoderms, which make it quite similar to the MF-2 Microfacies but is different in terms of relative abundance of skeletal constituents, which is more cosmopolitan in nature than MF-2 Microfacies. The average relative abundance of various faunal and floral constituents is *nummulities* (upto 20%), *Assilina* (up to 30%), *Discocyclina* (10-15%), *Milliolid* (2-3%), *Morozvella* (up to 1%), echinoid (up to 3%). The allochem and matrix ratio is 3:4, and they are classified as wack-packstone according to Dunham (1962; Plate-2: A-H).

3.2. Biostratigraphy

In the present study the Margalla Hills Limestone has been investigated for

comprehensive documentation of the distribution of larger benthic foraminifera. One larger benthic foraminiferal biozone has been established. Range distribution of the larger benthic foraminifera abundance, biozonation and comparison with biostratigraphic biozonal schemes of Schaub (1981) has been presented (Fig. 5). Following biozone has been identified and described below:

3.2.1. *Nummulites globulus/Nummulites atacicus* biozone

Definition: The range distribution between the first simultaneous occurrence to the last occurrence *Nummulites globulus* and *Nummulites atacicus* in Margallah Hill Limestone (136m) interval defines the lower and upper boundaries of this biozone.

Associated Assemblages: The larger benthic foraminifera that range through this biozone in Margallah Hill Limestone (136m) interval includes *Ranikothalia nuttali*, *Nummulites thalicus*, *Nummulites Davisie*, *Nummulites subdavisie*, *Nummulites pinfoldi*, *Nummulites planulatus*, *Assilina granulosa*, *Assilina pustulosa*, *Alveolina pasticilata*, *Alveolina conradi*, *Alveolina elliptica*, *Lockhartia conica*, *Lockhartia conditi*, *Lockhartia hunti*, *Discocyclina ranikotensis*, *Discocyclina seunesi* and *Rotalia trochidoformis*.

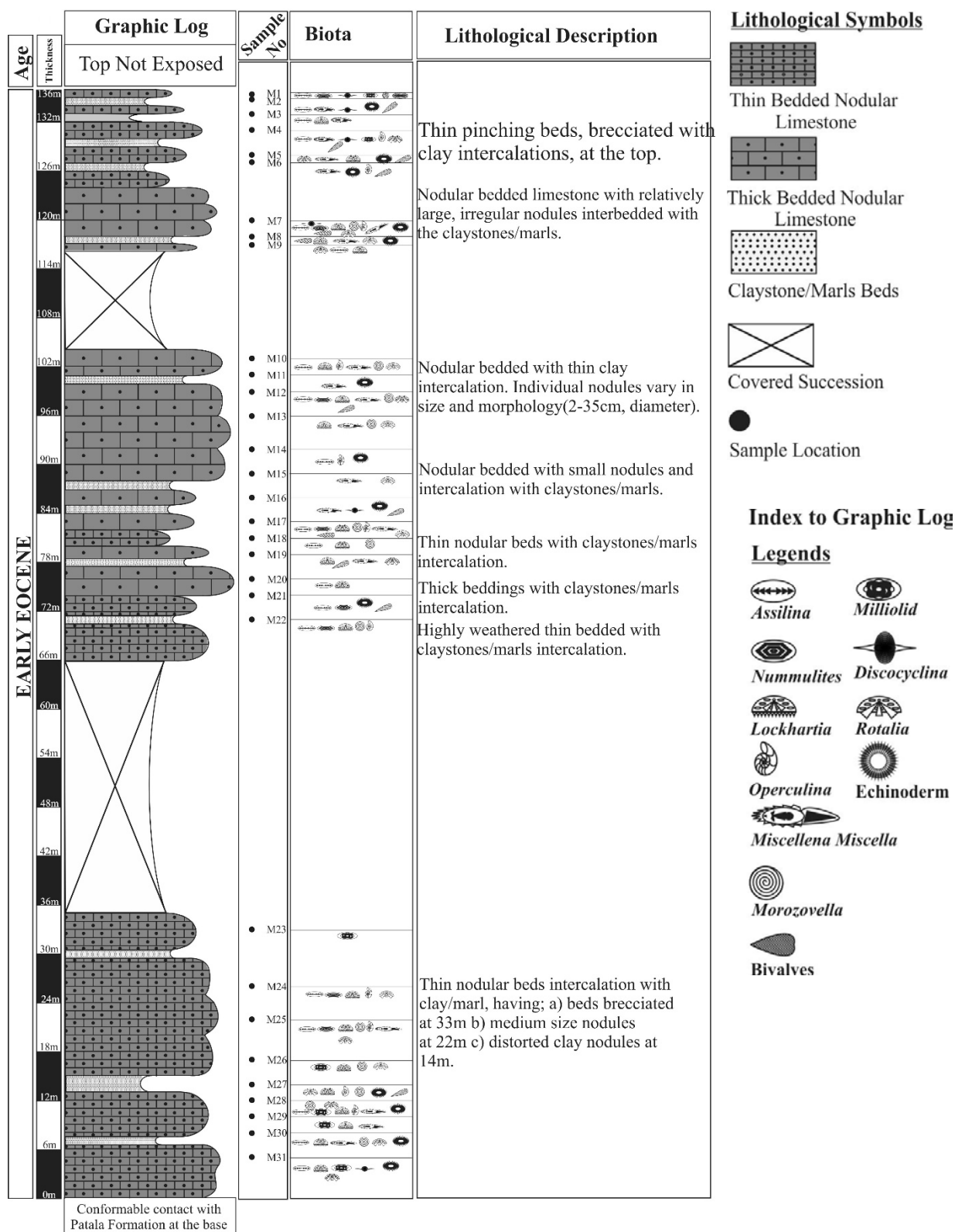


Fig. 3. Measured section of the Margalla Hill Limestone, District Haripur, Khyber Pakhtunkhwa.

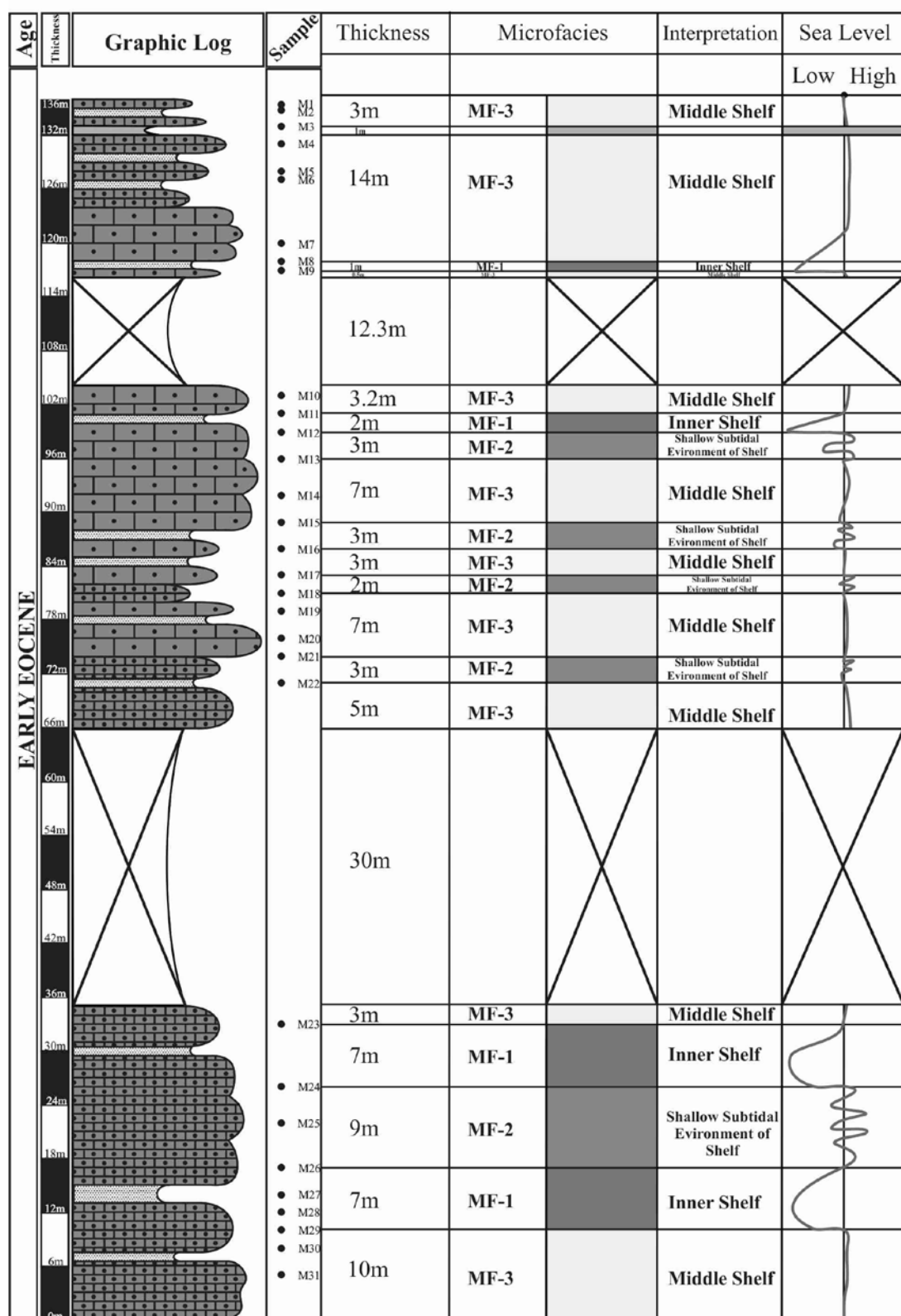


Fig. 4. Columnar section of the Margalla Hill Limestone showing microfacies distribution and interpretation in Kohala Bala, Haripur District, Khyber Pakhtunkhwa.

Plate 2

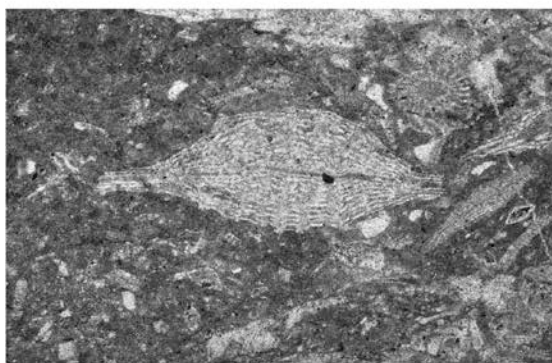
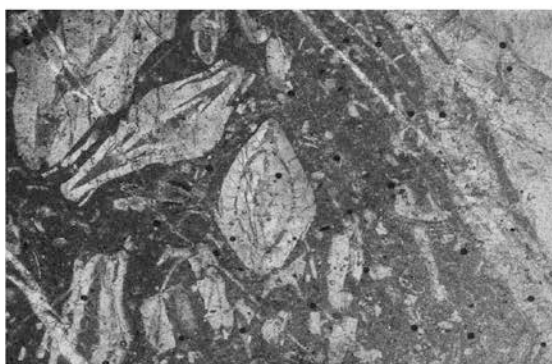
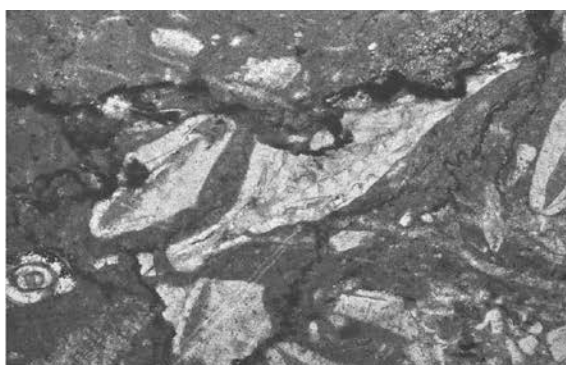


Plate 2

- A: Photomicrograph showing *Ranikothalia sahnii*, *Assilina spinosa* and *Milliolid* of larger benthic foraminifers microfacies (PPL. Mag. x4).
- B: Photomicrograph showing *Assilina grannulosa*, *Assilina* sp. all along the photomicrograph, Nummulitic sp. and unknown sp. of larger benthic foraminifers microfacies (PPL. Mag. x4).
- C: Photomicrograph showing *Nummulitic atacicus*, *Ranikothalia sahnii* and *Assilina supspinosa* of larger benthic foraminifers microfacies (PPL. Mag. x4).
- D: Photomicrograph showing broken fragment of *Ranikothalia sindensis* and *Assilina* sp. of larger benthic foraminifers microfacies (PPL. Mag. x4).
- E: Photomicrograph showing *Discocyclina dispansa* and echinoderm of larger benthic foraminifers microfacies (PPL. Mag. x4).
- F: Photomicrograph showing *Assilina subspinosa*, *Ranikothalia* sp., and echinoderm of larger benthic foraminifers microfacies (PPL. Mag. x4).
- G: Photomicrograph showing *Milliolid* and *Operculina subsalsa* of larger benthic foraminifers microfacies (PPL. Mag. x4).
- H: Photomicrograph showing Echinoderm plate, *Lockhartia tipperi* and *Miscellanea miscella* of larger benthic foraminifers microfacies (PPL. Mag. x4).

4. Discussion

4.1. Depositional environments

The milliolid foraminifera mud-wackestone microfacies (MF-1) is distinguished by moderate diversity of allochemical constituents dominated by milliolid. The milliolid foraminifers are indicative of secured muddy inner platform (Flügel, 2004). The microfacies is dominated by mud-wackestone with appreciable amount of lime mud within the depositional fabric and is indicative of low energy conditions, the only condition in which mud could settle down. Thus, the occurrence of *Milliolid* foraminifers with other larger foraminifers and low energy conditions suggested from depositional texture, the microfacies is deduced to form in a low energy, restricted circulation with high salinity in a lagoonal environment of the inner shelf (Geel, 2000). Such an environment is separated by a barrier from main sea and is supplied by marine waters either through narrow inlets or during stormy conditions (Tucker and Wright, 1990). The carbonate deposition generally occurs below wave base conditions. This microfacies is similar to SMF-8 of Wilson (1975).

The nummulitic wack-packstone microfacies (MF-2) is chiefly composed of *nummulities* and micritic as a matrix. The nummulitic foraminifers are benthic organism recorded from depths of 20 to 130m (Reiss and Hottinger, 1984). The

Nummulities normally occur in subtidal habitat, where situation favors the deposition of lime mud. The assemblages of *Nummulities* with other larger benthic foraminifers backup this interpretation. The indication of echinoderms in the microfacies suggests normal marine salinity conditions of open circulation. Therefore, the microfacies is inferred to be deposited in shallow subtidal environment of shelf.

The larger benthic foraminifera microfacies (MF-3) is described by variety of fauna; include discocyclina, *Nummulities*, *Assilina*, *Milliolid*, *Morozvella*, and echinoderm and micrite as a matrix. The occurrence of echinoderms and a variety of foraminiferal associations indicate open marine conditions of normal salinity. The micrite shows the deposition below wave base under low energy conditions. The microfacies are, therefore, interpreted to have deposited in relatively offshore middle shelf area. This interpretation is also supported by lack of land-derived terrigenous clastic input and high diversity of faunal assemblages as compared to other microfacies identified in the Margalla Hill Limestone.

Based on identification of carbonate microfacies, the Margalla Hill Limestone is interpreted to represent deposition under clastic free, shallow shelf conditions (Fig. 6). Lateral variation of the microfacies is evident of sea level changes in the Margalla Hill Limestone (Figs. 4 and 6).

A comparison of Larger Benthic Foraminiferal Biozones of the Margalla Hill Limestone with the Nummulitid Biozones of Schaub (1981), suggests *Assilina*

leymerie/Nummulites globulus Biozone of Schaub (1981), which is equivalent to the *Alveolina carbarica* Biozone of Hottinger (1960) and SBZ 8 biozone of Serra-Kiel et al. (1998). This comparison confirms a Middle Illerdian-2 age of the Margall Hills Limestone.

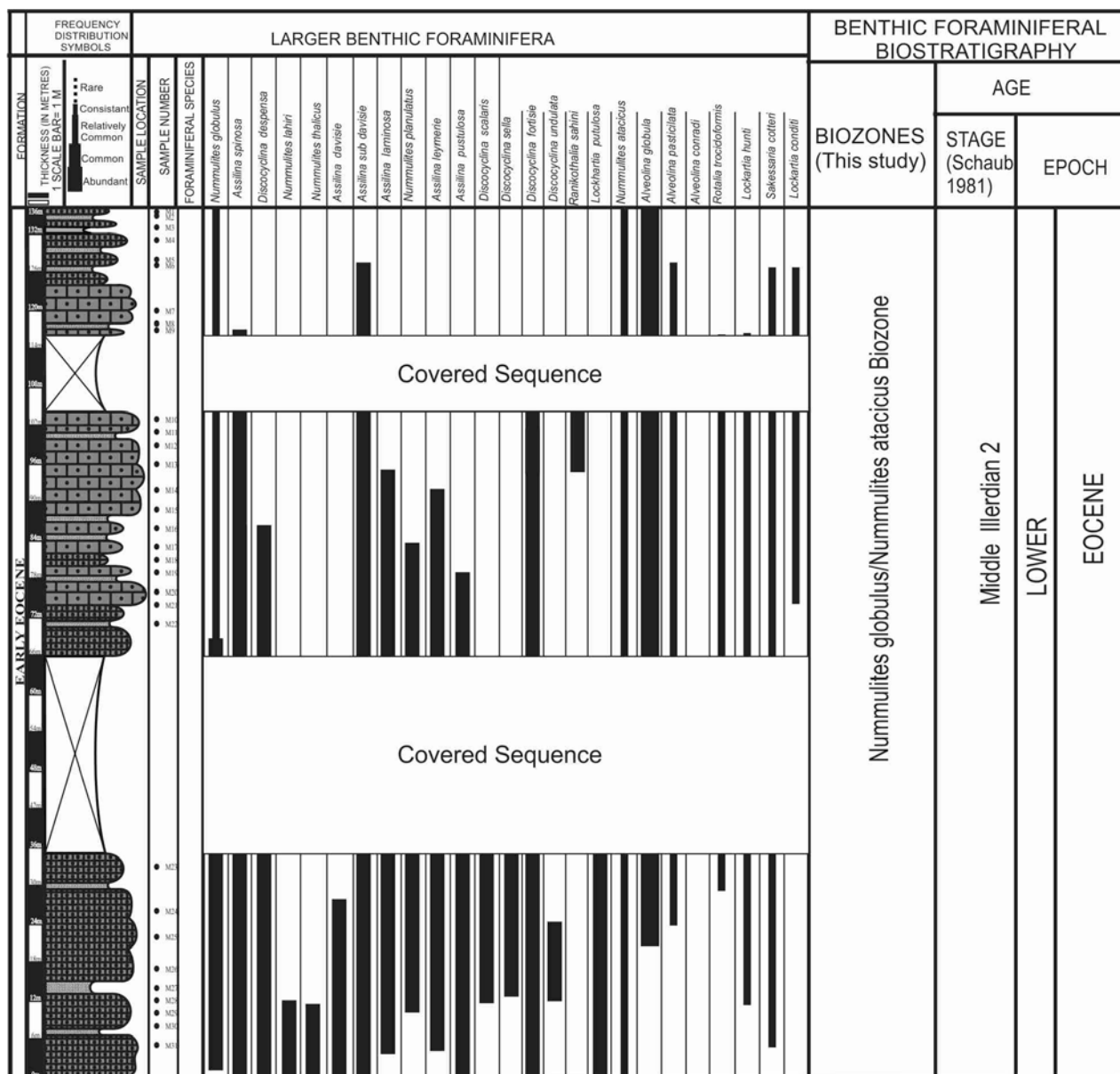


Fig. 5. Range distribution, abundance and biozonation chart of larger benthic foraminifera in Margalla Hill Limestone exposed in the Haripur District, Khyber Pakhtunkhwa.

Depositional Model

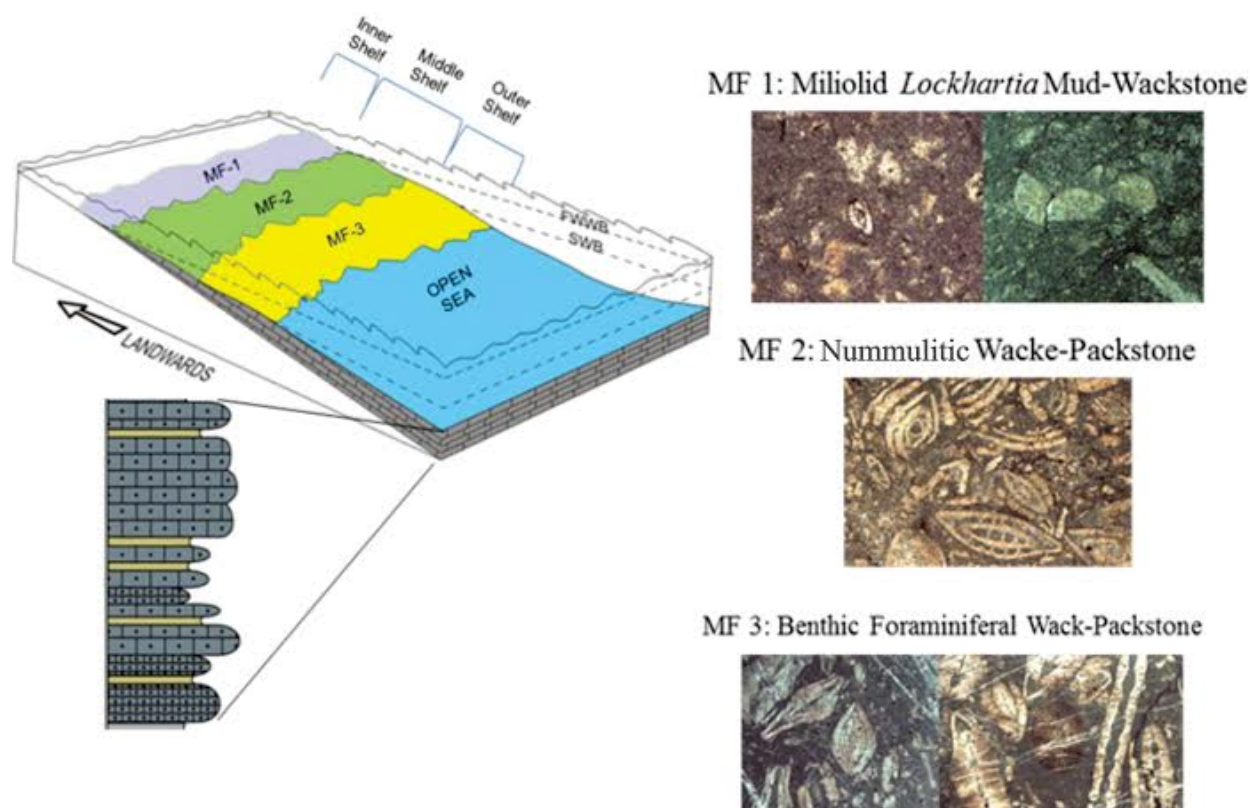


Fig. 6. Depositional setting of Margalla Hill Limestone. FWWB= Fair weather wave base, SWB= Storm wave base.

5. Conclusions

The Margalla Hill Limestone comprises of light to dark grey nodular limestone with claystone and marl interbeds and is about 136m thick at the Kohala Bala. The formation is characterized by variety of faunal and floral assemblages of foraminifers, mollusks and echinoderms. The biostratigraphic age assigned on the basis of larger benthic foraminifera is Middle Illderian 2 of Early Eocene. Three microfacies are identified, which include; 1) Miliolid *Lockhartia* mud-wackstone microfacies, 2) *Nummulitic* wack-packstone microfacies, and 3) larger benthic foraminiferal wack-packstone microfacies. On the basis diagnostic criteria of microfacies, the Margalla Hill Limestone is interpreted to have been deposited in a shallow shelf area characterized by normal marine salinity with varying conditions of water depth, salinity, and energy.

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