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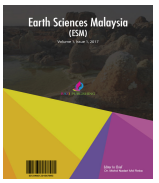

PETROGRAPHY OF PALEOGENE CARBONATES IN KALAMULA AND KHURSHEEDABAD AREA, KAHUTA, AZAD KASHMIR

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ABSTRACT

ABSTRACT: The rocks exposed in the study area are carbonates of Lockhart Limestone. The carbonates are nodular, thin to thick bedded, fossiliferous with minor intercalcations of marl. The microfacies investigation was carried out in two different geological field sections based on field and petrographic data in the area. The carbonate microfacies are, Micritic Crystalline Carbonate Mudstone-Wackstone Micrifacie (LMF-1), Mixed Bioclastic Mudstone-Packstone Microfacies (LMF-2) and Benthic Foraminiferal wacke-Packstonet Microfacies (LMF-3). The recognized fossils are Algaes, Texularia, Tokhartia sp, Opperculina, Assilina sp, Nimmulites sp, Ranikothalia sp, Mascellena sp, Nodosaria and Milliolid. The deposition of limestone with larger benthic foraminifer took place. The large Foraminifera's and dasycladacean algae in the rocks indicate shallow marine shelf environment. The carbonate microfacies suggested limestone deposition under clastic free shallow shelf conditions. The predominantly wackstone to packstone fabric nodularity in limestone and presence of fossils suggest deposition in shallow marine environment.

1. Introduction

The Himalayas are formed as a result of collision between Indian and Eurasian plates. Ganssar [1] subdivided the Himalayas into Sub Himalayas, Lesser Himalayas and Higher Himalayas. The study area lies in lesser Himalayas bounded by MBT and PT (Fig. 1). The Carbonate rocks are confined to the Pir Panjal Range in Kashmir. Geographically these rocks are exposed in the Kalamula and Khursheedabad area (Fig. 2). Fused nodular fossiliferous carbonate rocks of Paleocene age are exposed in this area.

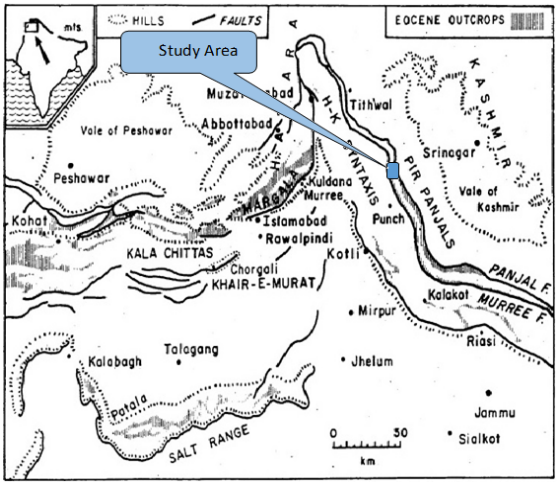

Figure 1: Map of NW Himalaya showing study area (after Wells, N. A. and P.D. Gingerich, 1987).

1.1 Geological Setting:

The study area lies in the eastern limb of HKS in Lesser-Himalayas (Fig. 1). Lesser Himalayas are bounded by MBT towards the South and MCT towards the North. The rock units in the area are folded, MBT are comparatively less deformed and fractured. Rocks in the area are from Pre Cambrian to Quaternary and consist of sedimentary, volcanics and imetamorphic. The unconformities are marked while some contacts are faulted. The oldest unconformity is between Dogra Slates and Gondwana Group of Carboniferous marked by the presence of conglomerate bed (Fig. 2). Second unconformity is present between Panjal Formation of Permo Carboniferous and Lockhart Limestone of Paleocene age. Chorgali Formation which is marked in other areas is missing here and Patala Formation exhibits a faulted contact with Kuldana Formation (Fig. 2). Another unconformity is marked between Kuldana Formation of Eocene age and Murree Formation of Miocene age in the area.

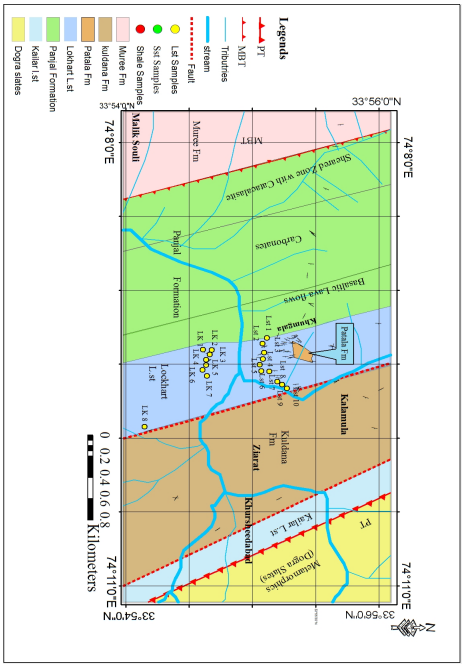

Figure 2: Geological and sample location map of the project area.

Table 2.1: Stratigraphic column of Kahuta (Modified after Khan, 1994; Ashraf and Chaudhry, 1980).

Formation	Age	Characteristics
Quaternary	Recent to sub recent	Mainly gravels, boulders, sands but also some clays, glacial and glaciofluvial deposits on higher elevations.
UNCONFORMITY		
Murree Formation	Oligocene to Lower Miocene.	Reddish brown to greyish, fine to coarse grained sandstone and reddish shales.
UNCONFORMITY		
Kuldana Formation	Eocene	Red, maroon, purple and green shales with hard sandstone beds.
Margala Hill Limestone	Lower Eocene	Bitumenous black (yellowish grey and flaggy) limestone. Grey, green and khaki shales.
Patala Formation	Late Paleocene	Creamish to dark brown splintery shale and subordinate fine to medium grained nodular limestone.
Lockhart Limestone	Paleocene	Grey to light grey medium to thick bedded, fossiliferous and nodular limestone.
UNCONFORMITY		
Panjal Formation	Permo-Carboniferous	Basal agglomeratic slates and basaltic lava flows.
Gondwana Group	Carboniferous	Basal quartz conglomerate bed, slates and argillaceous sandstone.
UNCONFORMITY		
Kailar formation	Cambrian	Marble with calcareous schist and quartzite and dolomite.
Dogra Slates	Pre-Cambrian	Grey, dark grey to black slates, The Dogra slates also contain volcanics which have been called the ''Dogra Trap'' (Wadia, 1928). This trap is amygdaloidal as well as free from amygdules.

2. Materials and methods:

Carbonates of Paleocene age were selected for research work which are exposed in Kalamula and Khursheedabad areas (Figs. 2) in Betar valley. The color of limestone is dark grey to grey in the study area. The limestone is hard and compacted. In Khumgala to Kalamula section it forms hill topography. Solution weathering and pot holes are commonly observed in the section. Calcite veins and fossils are clearly seen on the surface of the limestone. In Khursheedabad section shales are interbedded in limestone near the base (Fig. 5). Fused nodules are common in middle section and nodularity increased towards the top. The basal contact of limestone is unconformable with Panjal formation and upper contact is normal at some places with Patala Formation and at some places it is faulted with Kuldana Formation. On the basis of fossils like Algae sp, Lokhartia sp, Assilina sp, Nimmulite sp, and Milliolid sp, the formation is marked as Lockhart Limestone of Paleocene age. The field work was carried out in the study area to obtain geological data. Topographic sheet was used for the location of the rock samples collection. The dip and strike of the beds was measured by using Brunton compass. The geological hammer was used to take the samples from the outcrops. Hand lens (10x, 20x) was used for study of the megascopic features of the rock units in the field. Camera was used to take the photographs of the prominent features present on the rock units. Brunton compass, measuring tape and survey pol were used for section measurement. This research study was completed in two phases, field and laboratory work. Field work consists of

1. Rock samples collection for petrographic studies
2. Photography of outcrop sections
3. Recording geological data i.e. contact relationship and structural details
4. Measurement of stratigraphic section of the area

The geological and sample location map (Fig. 2) of the area was prepared using Toposheet no. 43K/1 of the Survey of Pakistan. The nineteen fresh and representative limestone samples of different color and texture were selected for thin section preparation. Thin sections were studied using LEICA DM750 polarizing microscope with attached LEICA EC3 camera in the petrology laboratory of the Institute of Geology.

3. Results and discussion:

3.1 Petrography of Limestone of Kalamula and Khursheedabad:

Petrography is the microscopic study of thin sections under microscope to determine mineralogy, composition, textures and fossils. Firstly thin sections of rock sample were prepared then labelled and finally studied under petrographic microscope. The photomicrographs were taken. Nineteen limestone samples at regular interval were selected for thin section preparation. Microscopic studies shows that carbonates are composed of bioclast, micrite, detrital grains and calcite cement. The study includes the petrography of Lockhart Limestone. The petrographical data revealed that the rocks are comprised of micrite and fossiliferous limestone. Fossils found in the rock samples are Dacycladacian Algae, Spirozoa Algae, Texularia, Lockhartia sp, Ranikothalia sp, Mascellena sp, Operculina Nodosaria, Nimmulites sp, Assilina sp and Milliolid sp in packstone to wackestone microfacies.

Facies were identified by correlating with classification of Folk [3] and Dunham [4]. Crystalline carbonate and mudstone microfacies were also identified. Intraclasts are present in the mudstone microfacie. Three microfacies were identified on the basis of fossils. The fossil assemblage in the limestone indicates a shallow marine shelf conditions. The microfacies identified are described as below:

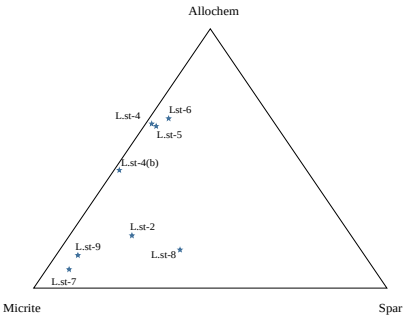

Figure 3: Ternary composition diagram showing regions of Paleocene limestone in Kalamula section (Folk1959).

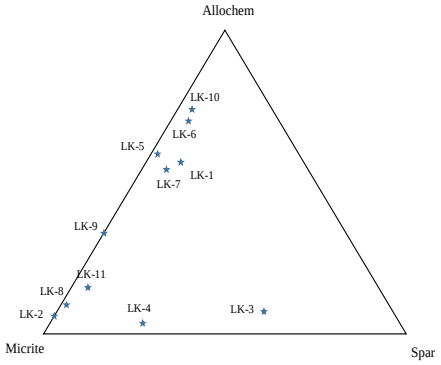

Figure 4: Ternary composition diagram showing regions of Paleocene limestone in Khursheedabad section (Folk 1959).

Table 4.1.1: Showing modal analysis of limestone in Kalamula section.

Sample Numbers	Lst-2	Lst-4	Lst-4 (B)	Lst-5	Lst-6	Lst-7	Lst-8	Lst-9
Spar	14	2	2	3	5	7	30	6
Micrite	20	33	47	28	22	80	40	68
Bioclast	1	60	40	50	50	3	5	4
Organic Material	2	1	1	3	6	1	3	3
Pyrite	-	-	-	-	-	-	-	1
Calcite	50	4	10	15	15	3	10	10
Hematite	-	-	-	1	2	2	1	2
INTERCLAST								
Quartz	7	-	-	-	-	4	8	6
Plagioclase	1	-	-	-	-	-		-
Clay	5	-	-	-	-	-	3	-
Folk,s classification	Bio Micrite	Bio Micrite	Bio Micrite	Bio Micrite	Bio Micrite	Bio Micrite	Bio Micrite	Bio Micrite
Dunham,s classification	Crystalline Carbonate	Pack stone	Wake-pack stone	Pack stone	Pack stone	Mud stone	Crystalline Carbonate	Mudstone to Wake-stone

Table 4.1.2: Showing recalculated values of Allochems, micrite and sparite in Kalamula section.

Sections	Lst-2	Lst-4a	Lst-4b	Lst-5	Lst-6	Lst-7	Lst-8	Lst-9
Percentage	%	%	%	%	%	%	%	%
Allochems	29	63	45	62	65	7	19	12
Micrite	20	35	53	34	29	86	46	81
Sparite	29	2	2	4	6	7	35	7

Table 4.1.3: Showing modal analysis of limestone in Khursheedabad section.

Sample No.	LK-1	LK- 2	LK-3	LK-4	LK-5	Lk-6
Spar	30	-	58	25	2	5
Micrite	56	90	30	68	33	22
Bioclast	4	3	6	3	50	65
Organic Material	3	3	1	-	3	2
Dolomite	-	-	-	-	-	-
Calcite	6	-	3	2	10	5
Hematite	-	2	2	2	1	1
INTERCLAST						
Quartz	1	-	-	-	1	-
clay	-	2	-	-	-	-
Folk,s classification	Bio-Micrite	Bio-Micrite	Bio-Sparite	Bio-Micrite	Bio-Micrite	Bio-Micrite
Dunham,s classification	Crystalline carbonate	Mudstone	Crystalline carbonate	Wake stone	Wake to packstone	Pack stone

Table 4.1.4: Showing modal analysis of limestone in Khursheedabad section.

Sample No.	LK-7	LK-8	LK-9	LK-10	LK-11
Spar	6	2	0	3	4
Micrite	36	84	10	18	70
Bioclast	50	8	-	60	10
Organic Material	7	3	4	3	3
Dolomite	-	-	69	-	-
Calcite	1	3	12	15	10
Hematite	-	-	-	-	-
INTERCLAST					
Quartz	-	-	5	1	-
clay	-	-	-	-	3
Folk,s classification	Bio-Micrite	Bio-Micrite	Dolomite	Bio-Micrite	Bio-Micrite
Dunham,s classification	Wake-packstone	Mudstone	Dolomite	Packstone	Mudstone

Table 4.1.5: Showing recalculated values of Allochems, micrite and sparite in Khursheedabad section

Sample No	Lk-1	Lk-2	Lk-3	Lk-4	Lk-5	Lk-6	Lk-7	Lk-8	Lk-9	Lk-10	Lk-11
Percentage	%	%	%	%	%	%	%	%	%	%	%
Allochems	54	5	6	3	59	70	54	9	33	74	15
Micrite	39	95	32	71	39	25	39	89	67	22	80
Sparite	7	0	62	26	2	5	7	2	0	4	5

3.1.1Micritic Crystalline Carbonate Mudstone Wackstone Microfacie(LMF-1):

Description

This microfacie is comprised of thinly laminated fractured, dark grey limestone beds with thin beds of interbedded black shales. Thin section studies show that rock sample consist of crystalline carbonate, mudstone to wackstone microfacies. Micrite and spar is the dominant constituent of the rock samples. Styolites, calcite veins, albite plagioclase and quartz grains were found in the microfacie. This microfacie is represented by four thin sections at Kalamula and five thin sections at Khursheedabad. The total thickness of this microfacie is 42 meter in Khursheedabad and is repeated two times from base to 42m and at 149m hights respectively (Fig. 5).

Interpretation

Dominating presence of lime mud indicates that this facie is deposited in low energy, calm and shallow water lagoonal environment often on the edge of channels. This micrifacie is similar to SMF-22 of Wilson [5] and [6] Flugel [7].

3.1.2 Mixed Biolastic Mudstone-Packstone Microfacies (LMF-2):

Description

This microfacie comprised of medium bedded greyish limestone with minor shale. It consists of mudstone-packstone microfacie. Dasycladacean algae, Spirozoa Algaes, Operculina, Texularia, mixed fossil and broken fragments of fossils are found. This microfacie is represented by one thin sections at Kalamula and three thin sections at Khursheedabad. The total thickness of this microfacie is 30 meter in Khursheedabad and is repeated two times at 70m and 190m hights respectively (Fig. 5).

3.1.3 Benthic Foraminiferal Wacke-Packstone Microfacies (LMF-3):

Description

This microfacie consists of massive nodular, highly fossilferous whitish grey limestone. Large foraminiferas are found in this facie. Fossils identified are Dasycladacean algaes, Spirozoa algae, Assilina sp, Milliolid, Discocyclina ranikotensis, Operculina salsa, Lockhartia sp, Miscellanea miscella, Ranikothlia sindensis, Ranikothalia sp, Quinqueloculina sp, Nodosaria sp, Textularia [8]. This microfacie is represented by three thin sections at Kalamula and three two thin sections at Khursheedabad. The total thickness of this microfacie is 28 meter in Khursheedabad and is repeated two times at 100m and 120m hights respectively (Fig. 5).

Interpretation

There is a large variety of large benthic foramaminiferas. Well-developed fossils indicates normal salinity. Micrite matrix shows deposition under low energy conditions relatively deeper middle shelf area. This microfacie is similar to SMF-8 and 9 based on Wilson [5] and [6] Flugel [7].

The middle to late Paleocene Lockhart Limestone contains a variety of stratigraphically important benthonic foraminiferal bioclasts. Deposition of Lockhart Limestone took place in the inner neritic to middle neritic shelf zone of comparatively shallow marine carbonate environment. Fossils of shallow shelf zones were found which conforms the shallow shelf deposition of the Lockhart Formation.

Plate 1

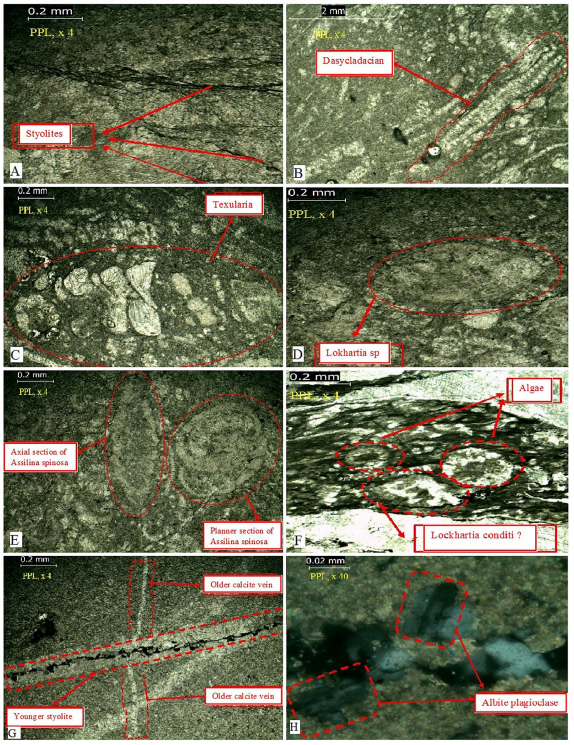

PLATE 1

Fig. A: Photomicrograph showing styolite in crystalline carbonate LST-2.

Fig. B: Photomicrograph showing Dasycladacian algae in packstone LST-4a.

Fig. C: Photomicrograph showing Texularia in packstone LST-4b.

Fig. D: Photomicrograph showing Lokhartia sp in packstone LST-5.

Fig. E: Photomicrograph showing Axial and planer section of Assilina spinose in packstone LST-5.

Fig. F: Photomicrograph showing Algae and lokharcia conditi? in packstone LST-5

Fig. G: Photomicrograph showing older calcite vein cut by younger styolite in mudstone LST-7.

Fig. H: Photomicrograph showing albite plagioclase in mudstone LST-7.

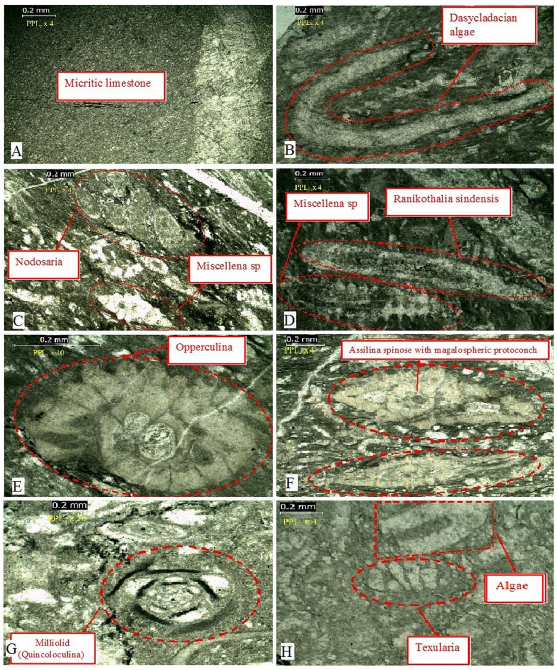

PLATE 2

Fig. A: Photomicrograph showing micritic limestone in crystalline carbonate LK-1.

Fig. B: Photomicrograph showing Dasycladacian algae in wack to packstone LK-5.

Fig. C: Photomicrograph showing Mascellena sp & Nodosaria in wack to packstone LK-5.

Fig. D: Photomicrograph showing Ranikothalia sindensis and Missilina sp in wack to packstone LK-5.

Fig. E: Photomicrograph showing opperculina in packstone LK-6.

Fig. F: Photomicrograph showing Assilina spinose with magalospheric protoconch in packstone LK-6.

Fig. G: Photomicrograph showed Milliolid (Quincoloculina) in packstone LK-7.

Fig. H: Photomicrograph showing Texularia and algae in packstone LK-10.

3.2 Depositional Settings of Lockhart Limestone:

The deposition of Lockhart Limestone with larger benthic foraminifera took place during the upper Paleocene after the transgression of the sea water in the area. Lockhart Limestone microfacies are indicative of marine shallow shelf environments. Topographically the formation forms ridges and cliffs. The Lockhart Limestone is present between the Panjal Formation and Kuldana Formation. The limestone is dirty grey to light grey on weathered surfaces and grey to dark grey on fresh surfaces. The limestone contains secondary calcite veins. The Lockhart Limestone is dominantly nodular and massive with subordinate shale intercalations. The nodular habit of the limestone seems to be of sedimentary origin. The shales and marl are interbedded with this nodular limestone in the lower part. There is a marked decrease of nodules towards the middle part of the unit. However, nodularity increases towards its top. Microfossils of foraminifer can be seen on the weathered surfaces in the form of tiny speaks less than one millimeter. The massive portions of limestone show diffused nodularity. Nodules are generally 2 – 6 centimeters in long direction and 1-5 centimeter in width. Based on carbonate microfacies identification and interpretation, the Lockhart Limestone exhibits deposition under clastic free shallow shelf conditions. Presence of wide variety of fauna, predominantly wackstone to packstone fabric of rocks and nodular nature support the above interpretation. The foraminifers like Lockhartia, Assilina, Discocyclina and Ranikothalia are present in the Lockhart limestone. The larger foraminifera are known to characterize the shallow shelf carbonate environments. The Lockhart Limestone represents a shallow shelf carbonate platform as is evidenced by the occurrence of a number of larger foraminifera and dasycladacean algae in the formation. It is inferred that relatively constant water depth was maintained during accumulation of entire sequence. This is an indication of shallow shelf deposits. The inner and middle shelfs are the sub environments in which three major types of microfacies were marked which includes 1) Micritic Crystalline Carbonate Mudstone-Wackstone Micrifacie (LMF-1), 2) Mixed Bioclastic Mudstone-Packstone Microfacies (LMF-2) and 3) Benthic Foraminiferal wacke-Packstonet Microfacies (LMF-3; Fig. 6).

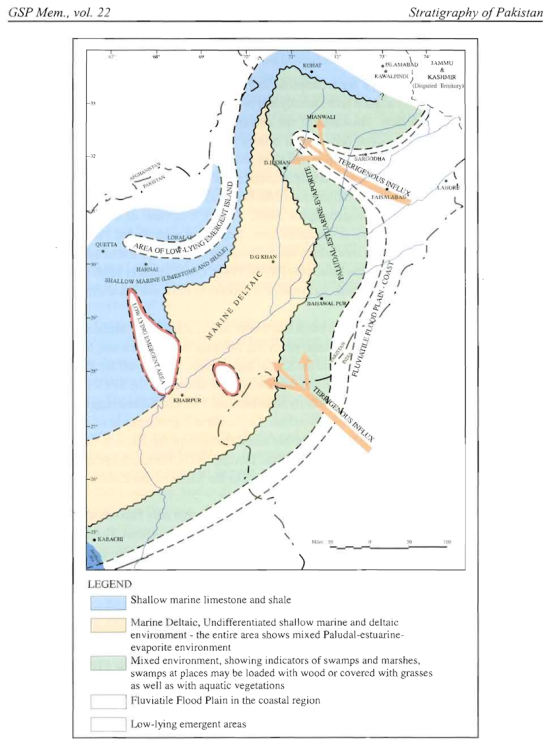

Figure 2: Paleogeographic sketch map of Paleocene-Eocene sequence (Modified after Shah, 2009). Asterisks show the distribution of Kuldana Formation of Middle Eocene in different areas.

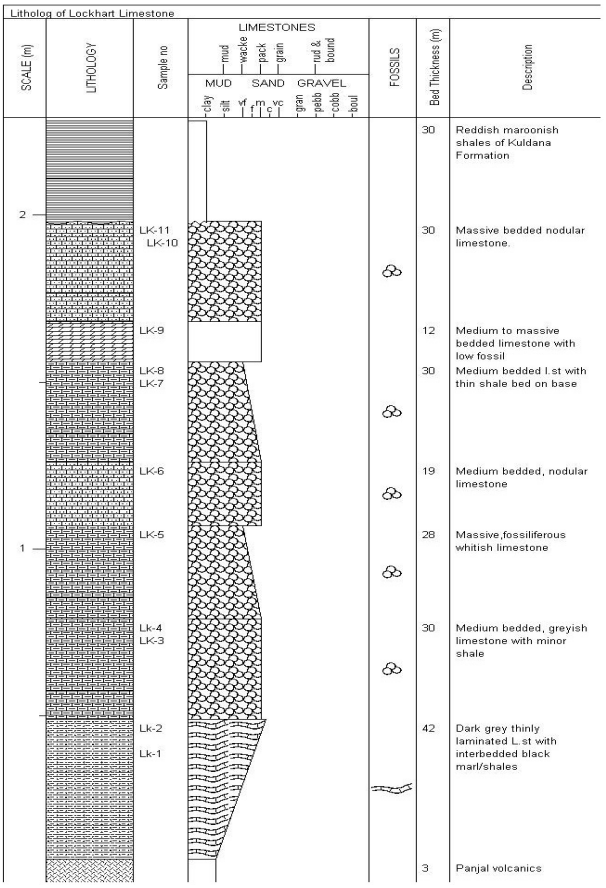

Figure 5: Measured section of Lockhart Limestone in Khursheedabad section, Kahuta area.

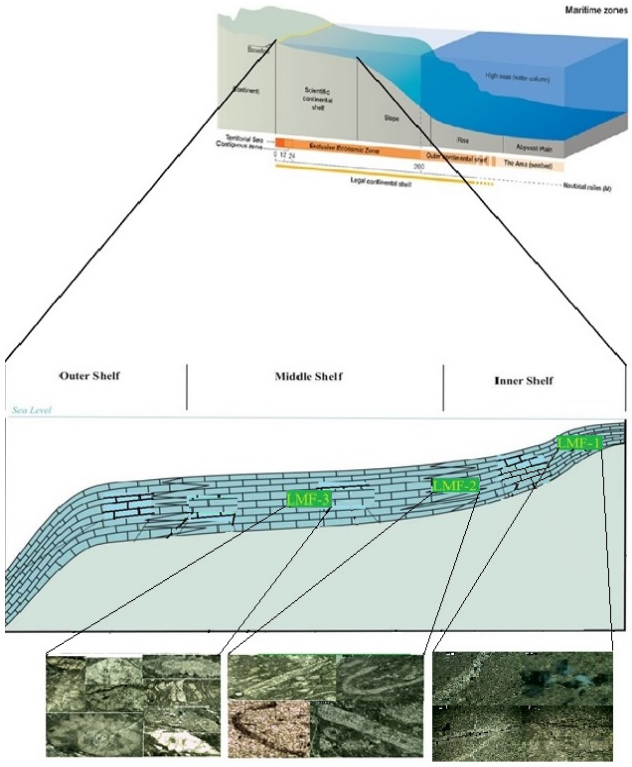

Figure 6: Depositional model of Lockhart Limestone based on both field sections in Kahuta area.

3.3 Diagenetic Fabric of The Lockhart Limestone: Carbonate rocks are susceptible to diagenesis and alteration processes [9]. The older carbonate rock exhibit dissolution and re-precipitation in response to change in chemical environment [10]. The limestone are subjected to a variety of physical and chemical changes during deposition. The allochemical constituents of the carbonate rocks are changed into micrite or lime mud through boring activity of endolithic algae [11]. In the Lockhart Limestone, the micritized fabric is formed by activity of benthic organisms specifically dasycladacean algae and larger foraminifera of inner and subtidal distal shelf facies. The formation of microspar has been attributed to aggrading neomorphism [12]. In the Lockhart Limestone, conversion of micrite to microspar is a common phenomenon and is characterized by the development of isolated, patches of granular microspar selectively converting micrite into sparite. The Lockhart Limestone is texturaly wacke to packstone with large amount of lime mud matrix. The allochem constituents consists of a wide assemblage of large foraminifers. The abrasion and fracturing of allochems due to lithostatic pressure results formation of micrite in the rock. The compaction refers to changes in original texture of the rocks as a result of overburden pressures in shallow to deep burial conditions. During compaction bioclasts are fractured and under deep burial conditions styolites were developed (Plate 1, A). They vary in width up to several centimeter. The fractures in the limestone are noted in the field and in the thin sections. These fractures are formed by lithostatic pressure and tectonic activity related with Himalayan orogeny. These fractures are later filled with coarse spary calcite and are termed as calcite veins. A wide variety of calcite veins and veinlets are present in almost all micorfacies of Lockhart Limestone. The Lockhart Limestone exhibits nodular bedding in the area. The individual nodules are highly irregular and are attributed to chemical compaction. The stylolites and solution seams are parallel to bedding in the Lockhart limestone indicate a diagenetic change. The presence of several diagenetic features indicate that the Lockhart Limestone of the studied area has been subjected to post-depositional low grade diagenesis. These diagenetic changes includes micritization, neomorphism (microspar, aragonite calcite transformation), dolomitization, compaction (disorientation of biocalst, pressure dissolution fabric), nature and origin of calcite filled micro fractures.

4. Discussion:
Transgression of sea water occurred in Paleocene on the northwestern margins of the Indian plate [13]. The Paleocene Lockhart Limestone and Patala Formation were deposited in shallow marine sea in the area. The limestone of Lockhart Limestone is greyish to blue in color. Limestone is hard and compacted. Weathering and dissolution features are clearly found on surface. Large pot holes are common in the formation. The formation forms cliffy topography in the area. Limestone is highly folded, faulted and fractured. Shales and marls are interbedded near the base of the formation. Nodularity decreases towards the middle part of the formation. In the middle part of the Lockhart Limestone the recrystallized fossils on weathered surface are abundant. As a result of recrystallization calcite completely replaced internal structure of the fossils. Fossils are less common on base and top of the formation. Micrite is the dominant constituent in most of the rock samples. Sparite is also present abundantly in the rock samples. Three microfacie zones were identified on the basis of fossils. In the first zone (LMF-1) fossils are absent. Micrite is the dominant constituent of the rock samples. In the second zone (LMF-2) dasycladacean algae and variety of Algaes were found in this part which mark shallow shelf depth. Third zone (LMF-3) is marked by mixed bioclast which are abundant in middle part of the formation. They are large Foraminifera which includes species of Assilina, Lockhartia, Nimmulites, Ranikothalia, Massilina, Texularia and Milliolids. These fossils indicate shallow marine shelf depositional environment for Lockhart Limestone.

5. Conclusion
On the basis of field and petrographical studies these conclusions are drawn:

- Paleocene Lockhart Limestone is exposed in Kalamula and Khursheedabad area which lies on the Eastern limb of Hazara Kashmir Syntaxis.
- Lower contact of Lockhart Limestone is unconformable with Panjal volcanics and the upper contact is conformable with Patala Formation.
- The Lockhart Limestone in Folk's classification is classified as bio-micrite while in Dunham's classification it is termed as wackstone to packstone.
- The petrographic study of the Limestone showed that the rock is composed of allochems, micrite and sparite.
- The fossils are recrystallized fossils are algae, opperculina, assilina sp, nimmulites, ranikothalia sp, masselena, millioid and lokhartia sp.
- The large Foraminifera's and dasycladacean algae in the rocks indicate shallow marine shelf environment. Three shallow shelf facies LMF-1, LMF-2 and LMF-3 were identified from bottom to top on the basis of fossils.
- The deposition of Lockhart Limestone with larger benthic foraminifer took place during the Upper Paleocene after the transgression of the sea water.

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