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Integrated microfacies analysis of lower Paleogene carbonate rocks of Kasanwala area, Western Salt Range, North Western Himalayas, Pakistan

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Key words: Integrated microfacies analysis, North Western Himalayas, Biostratigraphy.

Abstract

The main purpose of this study is to analyze the microfacies and biostratigraphy of lower Paleogene carbonate rocks (Lockhart Limestone, Nammal Formation and Sakesar Limestone) from the Kasanwala section in Western Salt Range. Several samples were collected during field work to prepare the thin sections for rock identification and to identify the microfacies of above mentioned formations. The results depicts that Lockhart Limestone is composed of nodular limestone with intercalated shale and is dominated by larger benthonic foraminifera. The measured thickness of Lockhart Limestone in study area was 37m. Four microfacies of Lockhart Limestone have been observed after thin section analysis namely; Bioclastic Mudstone, Lockhartia Wackestone, Miscellanea Packstone and Lockhartia Packstone microfacies. The Nammal Formation consists of alternating beds of medium to dark grey limestone with some clay and shale and is highly fossiliferous in some parts. In this section, Nammal Formation was 56m thick. Five microfacies of Nammal Formation have been identified, namely ; Bioclastic Mudstone, Nummulitic Wackestone, Bioclastic Wackestone, Peloidal Wackestone and Nummulitic Packstone microfacies. The Sakesar Limestone is composed of cream to light grey nodular massive limestone with chert nodules in upper part. The observed thickness was 36m. Three microfacies of Sakesar Limestone have been proposed after comprehensive microscopic analysis namely; Algal Mudstone, Bioclastic Mudstone and Assilina Wackestone microfacies. On the basis of observed fauna, its bathymetry and the microfacies framework, it can safely be concluded that these lower Paleogene rocks were deposited in shallow marine, open shelf environment with free circulation of water.

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Introduction

This work is unified approach to the sedimentology and microfacies analysis of lower Paleogene rocks of Kasanwala area (Western Salt Range), Punjab Pakistan. Various microfacies of Lockhart Limestone, Nammal Formation and Sakesar Limestone have been established using Dunham classification scheme (1962). The Project area is situated in the western part of the Salt Range, Punjab Pakistan.

The Salt Range is restricted between the latitude values of 32˚ 18′ to 33˚ 06′ and longitude values of 71˚ 50′ to 73˚ and it form sequence of hills system in the Punjab province, forming the southernmost extension of Himalayas. It is approximately 175 km long forming an east west trending thrust front. The Salt Range is created due to the collision of the Indo-Pakistani plate with Eurasian plate since Eocene making up the southernmost border of the Himalayan foreland fold and thrust belt (James' and Lillie, 1998). The stratigraphic succession of Paleocene-Eocene age is well exposed throughout the Indus Basin of Pakistan (Gee, 1989; Sameeni and Butt, 1992).

The detailed microfacies and biostratigraphy were analysed from Paleocene-Eocene strata which include Sakesar Limestone, Nammal Formation and Lockhart Limestone formations.

The study area is situated in the Western Salt Range, Punjab, Pakistan, which is reachable from Mianwali-Talagang Road (Fig. 1). The study area is present in district Mianwali, which is about 222 km south west of Islamabad.

The section of Kasanwala area was selected for this study because of good and accessible Paleogene rock exposures. The study area is situated 53.3km North East of Mianwali near Dhurnaka Village. The aim of present research is to determine the microfacies and to evaluate the biostratigraphy of the lower Paleogene rocks of the studied area.

Materials and methods

Following modern techniques have been adopted for both in field and laboratory study.

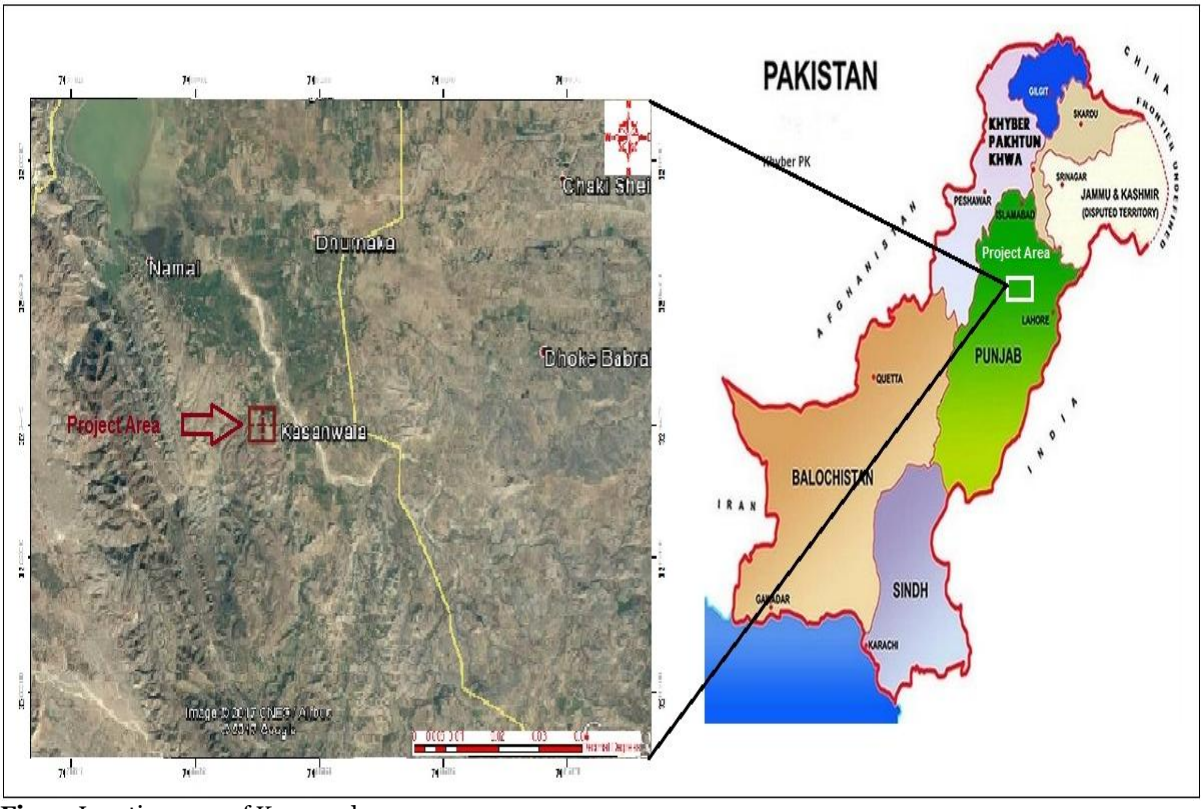

Fig. 1. Location map of Kasanwala area.

Field work

The project work was arranged in the western Salt Range and one stratigraphic section was measured, logged and sampled. The name of that section is Kasan Kasanwala area (32° 38' 39" N and 71° 50' 23" E). GPS is used to mark the exact location of this section on the globe. During our field work, variations in lithological behavior and many other megascopic features such as, colour, nodularity, texture, fossil contents and bedding style were observed and noted. Samples from hard lithologies such as limestone were collected on the basis of facies change and bed to bed variations. The data such as sample locations, lithologies, field photographs, was logged to record the estimated thickness of these above mentioned formations.

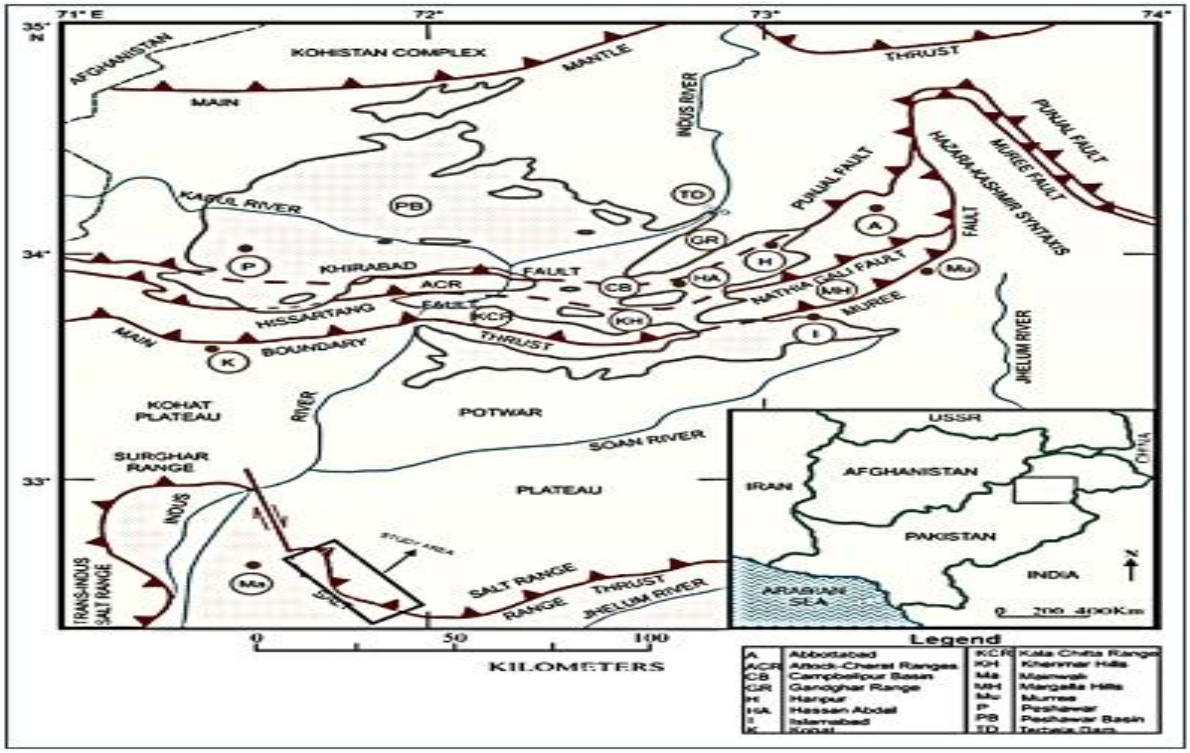

Fig. 2. Tectonic map of northern Pakistan showing major structural boundaries of the location of study area (Modified after Halland *et al.*, 1988). The enclosed block in Potwar plateau marks the location of study area.

Laboratory work

For sedimentology and bio stratigraphic investigations, preparation of thin sections is the main laboratory work. Thin sections were carefully prepared in Petrographic Thin Section Laboratory. The polarizing microscope was used to study the prepared thin sections. Thin section investigation was used to determine the various constituents of the lower Paleogene rocks and to construct the biostratigraphy and microfacies of the Lockhart Limestone, Nammal Formation and Sakesar Limestone. With a digital camera attached to the microscope, microphotographs were taken at preferred locations from thin sections.

Microfacies analysis

Microscopic data such as percentages of cement, matrix and grains was generated, based on such petrographic data the limestone of these mentioned formations are classified by using the Dunham classification scheme (1962).

Geological Settings

In Geographic point of view, Pakistan is present between the Longitude 60°E to 78°E and Latitude 24°N to 37°N. In Geological prospective, its location is on Indian Plate. The area where three plates i.e Indian, Eurasian and Arabian, were intersected, its

structure has dominantly been affected by their previous and current inter-relationships.

In the west, Salt Range Thrust has broad lobe geometry, where it is shortened by the Kalabagh Strike Slip Fault (Gee, 1980; Leathers, 1987; McDougall and Khan, 1990). In a western part of the Salt Range, the frontal ramp is farthest in the south (Qayyum, 1991). All the faults dip very steeply in the Western Salt Range (Fig. 2). This proposes that these faults were established after the roof sequence had prevailed the ramp. The Salt Range is taking a NW curve nearby Warchha in the west. Its structure remains the same and it is disconnected from the Trans-Indus Ranges by the Kalabagh. Kasanwala Area (Study area) lies particularly in Western Salt Range, Punjab-Pakistan. The formations exposed in Kasanwala area are presented in Table 1.

Results and discussion

Microfacies analysis of lower Paleogene rocks

For microfacies analysis total 52 samples were collected from the Lower Paleogene rocks of the Kassanwala section. Out of these 52 samples, 19 samples of Lockhart Limestone, 24 samples of Nammal Formation and 9 samples of Sakesar Limestone were collected. But only 27 samples were prepared for sedimentology and biostratigraphic studies.

Table 1. Stratigraphic column of Kasanwala area.

Age	Formations	Description
Pliestocene	Kalabagh conglomerates	Course Boulder and pebble conglomerates
	Kamlial Formation	Purple to dark brick red sandstone with hard purple shale
Miocene	Murree Formation	Greenish grey sandstone with subordinate intraformational conglomerates
Eocene	Sakesar Limestone	Creamish, nodular, massive limestone and shale having chert in upper part
	Nammal Formation	Light to medium grey argillaceous limestone with olive green shales
Paleocene	Patala Formation	Shale & marl with subordinate limestone and Sandstone
	Lockhart Limestone	Light grey to brown limestone having calcite veins
	Hangu Formation	Variegated sandstone, shale and carbonaceous shale
	Datta Formation	Greenish grey sandstone with shale
Jurassic	Kingrĺali	Light grey dolomite & dolomitic limestone
Triassic	Tredán Formation	Sandstone & shale
	Mànwalí	Marl, Limestone, sandstone and dolomite
	Chiddru Formation	Medium to fine Grained sandstone with subordinate shale
Upper Permian	Wargal Limestone	Limestone & dolomite having light to medium grey colour
	Warchha Sandstone	Sandstone & shales with conglomerates in some places
	Dandtot Formation	Yellowish sandstone with dark grey shales
Lower Permian	Tobra Formation	Sandstone & conglomerates with pink Granite

The microfacies analysis is constructed on the basis of microscopic investigations of thin sections. The microfacies analysis describes the percentage of allochems, matrix, textural features, fossil contents, and diagenetic fabric. Abundance, type and size of the invertebrate fauna (Brachiopods, Bivalves, echinoids, gastropods and ostracods), flora (Algae) and non-skeletal components (Peloids and intraclasts) gives valuable information for the interpretation of depositional environments.

Table 2. Summary of petrographic analysis of Lockhart Limestone of Kasanwala section.

Lockhart Limestone																																
Slide Number	Sample Interval (m)	Miscellanea miscella	Miscellanea sp.	Lockhartia conditi	Lochartia tipperi	Discocyclina	Discocylina sp.	Algae	Milliolids	Ranikothalia sahnii	Eoannularia eocenica	Assilina Sp.	Davisina sp.	Bioclast	Bivalves	Pellets	Ranikothalia sindensis	Ranikothalia sp.	Dentalina	Echinoids	Lockhartia haimei	Assilina laminosa	Peloids	Ostracods	Brachiopods	Intraclasts	Micrite %	Sparite %	Grains %	Rock classification
LK 7	33.6	4						10	11					19	12				2				3	4		15	88	4	6	Bioclastic Mudstone
LK 6	18.3	12			2			6	6					22							12			6		14	92	2	8	Bioclastic Mudstone
LK 5	16.6	49		20	5	9	8	43	4		8	13		40	8			10	4		16		5	35	3		35	5	60	Miscellanea Packstone
LK 4	12.6	39		11		8		12		5		19		20	11	2		13		12	4	20		13			35	5	60	Miscellanea Packstone
LK 3	11.2	20		6	22	17		14	2			5							1					13			40	5	55	Lockhartia Packstone
LK 2	4.1		48	7	14	13		19	1	8	1	11		15	3	5	6	10						10			35	5	60	Miscellanea Packstone
LK 1	1.6	32		16	17	10		19			2	5	2	28										7			35	15	50	Lockhartia Wackestone

Microfacies analysis of Lockhart Limestone

In Kasanwala area, it consists of yellowish grey to creamish colour nodular limestone and is highly fossiliferous (Fig. 3). Its upper and lower contacts are conformable with Patala Formation (upper contact) and Hangu Formation (lower contact).

The observed thickness of Lockhart Limestone in the project is 37m. It is full of larger benthic foraminifera, bivalves and other invertebrate fossils. On the basis of reported fauna, Late Paleocene age is assigned to the Lockhart Limestone (Shah, 1977).

The detailed petrographic analysis is given in Table 2. Four microfacies of Lockhart Limestone have been identified after detailed thin section study. In below description LKF1-4 stands for L=Lockhart Limestone, K=Kasanwala area, F=Microfacies and 1-4 shows a various number of facies. These four microfacies are given below:

Miscellanea Packstone Microfacies (LKF1): This facies constitutes the 42% of the total section. This is the most abundant facies of this section (Fig. 4).

This facies contains 60% allochems, 35% micrite and approximately 5% sparite. Miscellanea is the major constituent of these fossil grains by making 22% of this facies. One genus of Miscellanea species is very common in this facies namely, Miscellanea miscella.

Other allochemical grains, Lokhartia sp. 12%, algae 11%, bioclasts 11%, Assilina sp. 10%, Ranikothalia sp. 9%, Echinoids 8%, Ostracods 8%, Discocyclina sp. 6%, bivalves 5% and Eoannularia eocenica 1-2% are present in this facies.

Bioclastic Mudstone Microfacies (LKF2):This facies comprises 28% of the studied section. This is the second most abundant facies of this section (Fig. 5).

It contains 7% allochems, approximately 90% micrite and 3% sparite. Bioclasts are the major constituents of this facies by making 26% of the total section. These bioclasts are highly broken and lost their internal structure probably due to high energy or transportation. Other allochems like, Miscellanea sp. 11%, Lokhartia sp. 15%, algae 10%, Milliolids 11%, Ostracods 6%, biovalves 15% and intraclasts 18% are present in this facies.

Table 3. Summary of petrographic analysis of Nammal Formation of Kasanwala section.

Nammal Formation																																	
Slide Number	Sample Interval (m)	Nummulites mamilatus	Nummulites sp.	Nummulites atacicus	Discocyclina sp.	Operculina jiwani	Operculina subsalsa	Operculina sp.	Assilina subspinosa	Assilina granulosa	Discocylina dispansa	Discocyclina ranikotensis	Algae	Milliolids	Smaller forams	Ooids	Assilina Sp.	Textularia	Bioclast	Bivalves	Ranikothalia sindensis	Dentalina	Lockhartia conditi	Enthothyracids	Assilina laminosa	Peloids	Ostracods	Brachiopods	Micrite %	Sparite %	Grains %	Rock Classification
NK13	59	30	12			4				5	18		22	8			20		28				9	23	20	14		2	40	5	55	Nummulitic packstone
NK12	41		3	3				3					11	19			2		22	4				15			26		70	10	20	Bioclastic Wackestone
NK11	38	20	33	4			1		3		24		7	5			24	1			28		2		8				42	8	50	Nummulitic Wackestone
NK10	38														5				11	3							10		12	82	8	Bioclastic Mudstone
NK9	25														6				3								3		91	8	1	Bioclastic Mudstone
NK8	22														5				2	7							7		93	4	3	Bioclastic Mudstone
NK7	18		22								12		29	14		4	3		28	20		4		24		26	16		40	10	50	Nummulitic Wackestone
NK6	12													3					8	4							13		91	6	3	Bioclastic Mudstone
NK5	7.5				2								16	18			4		30	4				12		30	22		60	10	30	Bioclastic Wackestone
NK4	4.6		6			2					5		5	5			4		13								6		40	55	5	Bioclastic Mudstone
NK3	2.5				1														10			1					23		92	3	5	Bioclastic Mudstone
NK2	1.6												5						8			2					11		90	5	5	Bioclastic Mudstone
NK1	0.8		5			2					8	3					9		12	6					2	23	24	4	45	10	45	Peloidal Wackestone

Lokhartia Wackestone Microfacies (LKF3): It comprises the 14% of the total section. This is the least abundant facies of this section (Fig. 6).

It contains 50% fossils grains, 35% micrite and 13-15% sparite. Lokhartia sp. are the major fossils grains by making 24% of this facies. Two different genera of Lokhartia sp. are identified namely, Lokhartia tipper and Lokhartia conditi.

In other fossil grains, Miscellanea miscella 23%, Discocyclina sp. 8%, algae 13%, bioclasts 20% and ostracods 5% are present in this facies. Lokhartia Packstone Microfacies (LKF4): Lokhartia packstone comprises 14% of the total section. This is also the least abundant facies of this section (Fig. 7).

It contains 55% allochems, 40% micrite and approximately 3-4% sparite. Lokhartia sp. are the major constituents of this facies by making 28% of this section.

In this species, Lokhartia tipper and Lokhartia conditi genera are very common. Rest of the allochems like, Miscellanea sp. 20%, Discocyclina sp. 17%, algae 14% and Ostracods 13% are also present in this facies.

Table 4. Summary of petrographic analysis of Sakesar Limestone of Kasanwala section.

Sakesar Limestone																							
Slide Number	Sample Interval (m)	Nummulites mamilatus	Nummulites sp.	Discocyclina sp.	Operculina jiwani	Operculina sp.	Discocylina dispansa	Algae	Milliolids	Smaller forams	Assilina Sp.	Bioclast	Bivalves	Ranikothalia sindensis	Dentalina	Lokhartia sp	Assilina laminosa	Peloids	Ostracods	Micrite %	Sparite %	Grains %	Rock classification
SK7	36.6							16				9	2					7	4	94	5	1	Algal Mudstone
SK6	29.3	30	10		8		10	30	12		22	26		4	2	10	22	36		50		50	Assilina Wackestone
SK5	20.7		5					4				8							11	95	3	2	Bioclastic Mudstone
SK4	14.2							19	2	4	2	8						9	4	95	3	2	Algal Mudstone
SK3	13.2					4		14	3	4		10							9	93	5	2	Algal Mudstone
SK2	12.2							12	3	9									7	94	5	1	Algal Mudstone
SK1	4.5			4				3	4	7		15	3			1			7	95	3	2	Bioclastic Mudstone

Microfacies analysis of nammal formation

It consists of medium to dark greyish limestone with clay & shale in the project area (Fig. 8) and is highly fossiliferous in some parts. These rocks occur as alternations. Shales are creamish in colour and limestone of medium to dark grey colour has been observed. The formation is also well exposed in the Salt Range. In the project area, the Nammal Formation is 56m thick.

Fig. 3. Lockhart Limestone in Kasanwala area.

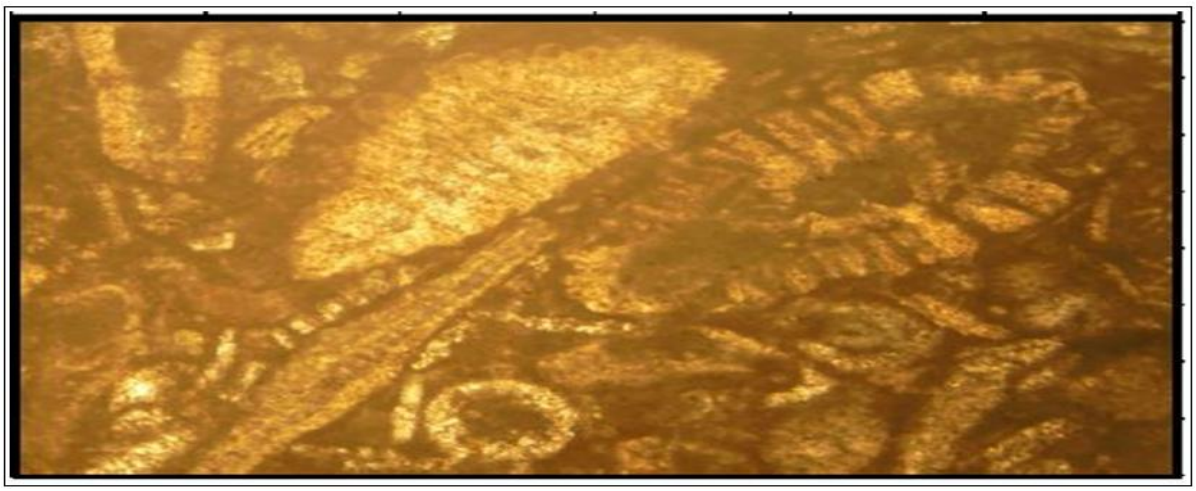

Fig. 4. Microphotograph showing Miscellanea Packstone microfacies (Resolution: X10x).

The upper conformable contact of the Nammal Formation has been observed with Sakesar Limestone, while the lower contact is not observed. Faunal contents suggest the Eocene age Nammal Formation. The detailed petrographic analysis is given in Table 3.Five microfacies of Nammal Formation have been identified after detailed analysis of thin sections. In below description, NKF1-5 stands for N=Nammal Formation, K=Kasanwala area, F=Micrfacies and 1-5 shows various number of facies. These five microfacies are given below:

Bioclastic Mudstone Microfacies (NKF1): In all observed samples of Nammal Formation, this facies constitutes 53% of the total section. This is the most abundant facies of this section (Fig. 9). It contains 4-5% allochems, 73% micrite and nearly 23% sparite. Biosclats are the most abundant allochems forming 27% of the total allochems. These bioclasts are showing no internal structure might be due to high energy and transportation.

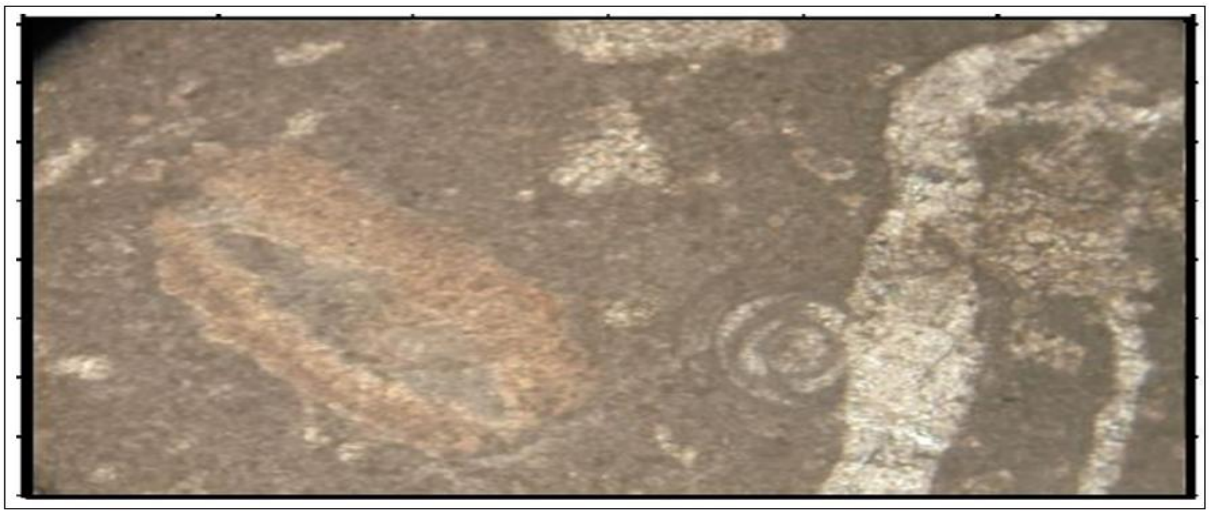

Fig. 5. Microphotograph showing Bioclastic mudstone microfacies (Resolution: X10x).

Fig. 6. Microphotograph showing Lockhartia Wackestone microfacies (Resolution: X10x).

In other allochems, Ostracods 30%, Operculina sp. 4%, Assilina sp. 8%, bioclasts 27%, bivalves 15%, Discocyclina sp. 8%, Nummulites sp, 12%, and nearly 15% algae are present in this facies. Some iron minerals are also present. Nummulitic Wackestone Microfacies (NKF2): It comprises the 15% of the total

section. This is the second most abundant facies of this section (Fig. 10). It contains 50% fossils grains, 21-23% micrite and 8% sparite. Nummulites sp. are the major contributing species of this facies by making 23% of the total section. In other fossil grains, Assilina sp. 3%, Discocyclina sp. 10%, algae 14%, Ranikothalia sp. 15%, bioclasts 10%, bivalves 8%, Enthothyracids 8%, peloids 10% and Ostracods 5% are also present in this facies.

Fig. 7. Shows Lockhartia Packstone microfacies (Resolution: X10x).

Fig. 8. Nammal Formation in Kasanwala area.

Bioclastic Wackestone Microfacies (NKF3): This facies comprises the 15% of the total section. It contains 40%% fossils grains, 65% micrite and 10% sparite (Fig. 11). Biosclats are the most abundant allochems forming 21% of the total allochems. These bioclasts are showing no internal structure might be due to high energy and transportation. In other allochems, Ostracods 9%, Assilina sp. 1%, bioclasts 21%, Nummulites sp. 4%, Miliolids 15%, Peloids 5%, and nearly 10% algae are present in this facies.

Nummulitic Packstone Microfacies (NKF4): It comprises the 8% of the total section. This is the least abundant facies of this section. It contains 55% fossils grains, 40% micrite and 5% sparite (Fig. 12). Nummulites sp. are the major contributing species of

this facies by making 22% of the total section. Nummulites mamilatus is the most common genus found in this section. In other fossil grains, Assilina sp. 13%, Discocyclina sp. 9%, algae 11%, bioclasts 14%, Operculina sp. 2%, Lokhartia sp. 4%, Enthothyracids 11%, peloids 7% and Miliolids 4% are also present in this facies.

Fig. 9. Microphotograph showing Bioclastic Mudstone microfacies (Resolution: X10x).

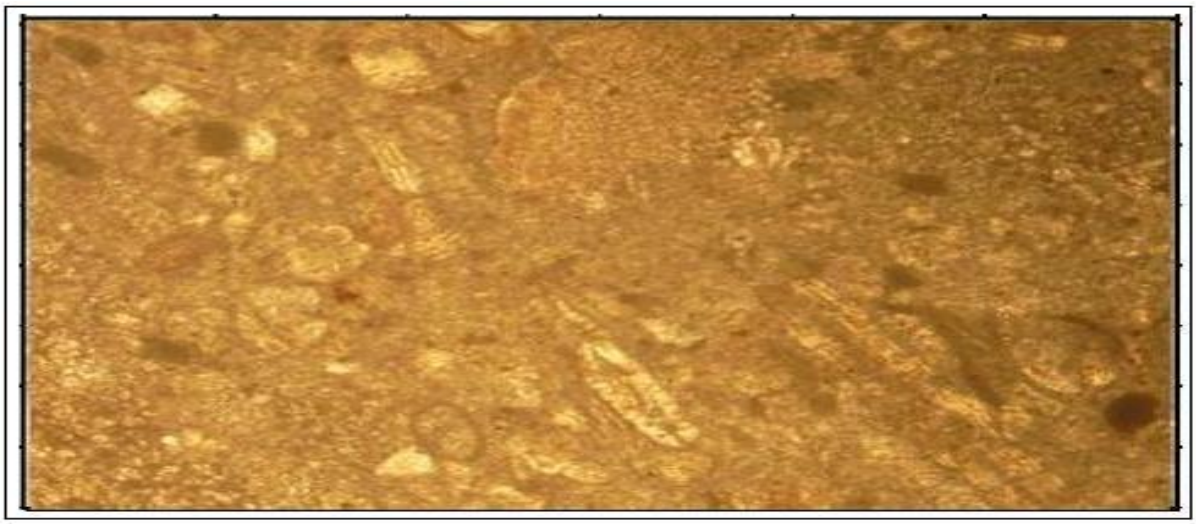

Fig. 10. Microphotograph showing Nummulitic Wackestone microfacies (Resolution: X10x).

Peloidal Wackestone Microfacies (NKF5): This facies comprises the 8% of the total section. This is the least abundant facies of this section. It contains 45%% fossils grains, 45% micrite and 10% sparite (Fig. 13). Peloids are the most abundant allochems forming 48% of the total allochems. In other allochems, Assilina sp. 11%, bioclasts 12%, Nummulites sp. 5%, bivalves 6%, and Discocyclina sp. 11% are present in this facies.

Microfacies analysis of Sakesar limestone

During our fieldwork in Kasanwala area, it has been observed that the formation is composed of creamish to light grey massive bedded limestone with nodules of chert in the top most part of the formation (Fig. 14). It is widely distributed in our project area i.e Kasanwala area. Its thickness varies between 70 m and 150 m in the Salt Range (Shah, 1977). The observed estimated thickness of the Sakesar

Limestone in the project area is 36m. The lower conformable contact of the Sakesar Limestone has been observed with Nammal Formation at Kasanwala area while the upper contact has not been observed. The detailed petrographic analysis is given in Table 4. Three microfacies of Sakesar Limestone have been identified after detailed thin section study. In below description SKF1-3 stands for L=Sakesar Limestone, K=Kasanwala area, F=Micrfacies and 1-3 shows a various number of facies. These three microfacies are given below:

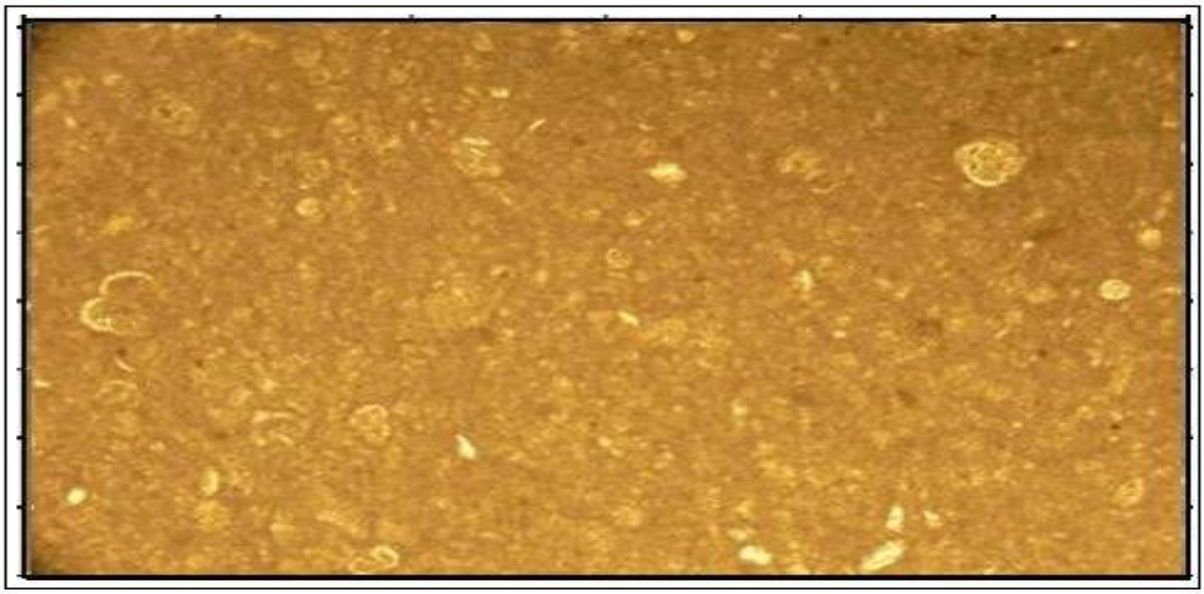

Fig. 11. Microphotograph showing Bioclastic Wackestone microfacies (Resolution: X10x).

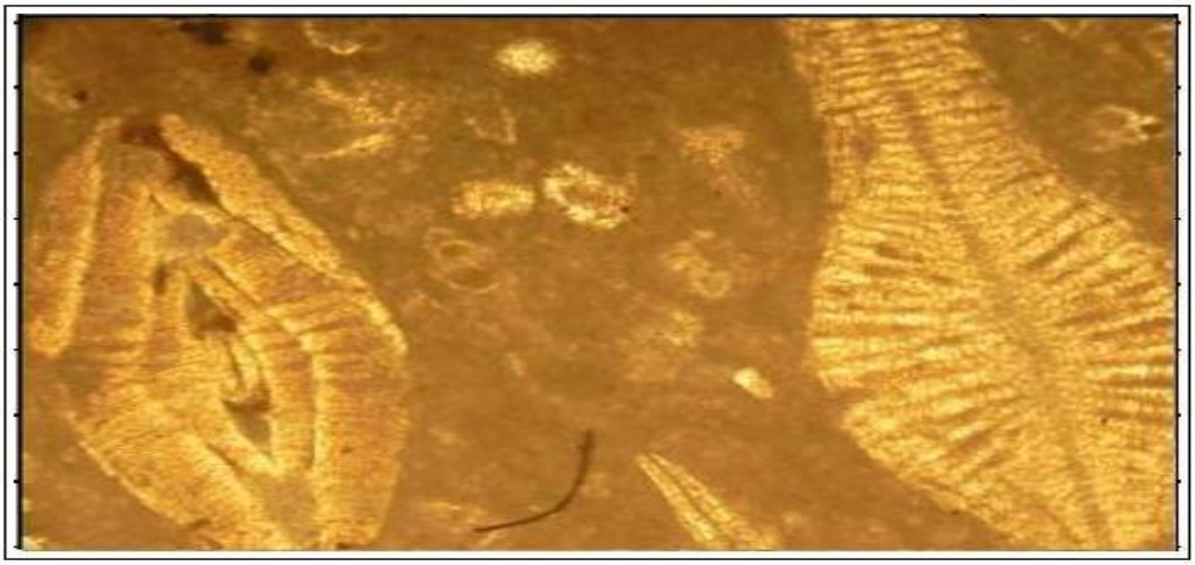

Fig. 12. Microphotograph showing Nummulitic Packstone microfacies (Resolution: X10x).

Algal Mudstone Microfacies (SKF1): This facies constitutes the 57% of the studied section. This is the most abundant facies of this section (Fig. 15). This facies contains 2-3% allochems, >93% micrite and approximately 5% sparite. Algae is the major constituent of these allochems by making 35-38%. Two different genera of algae are identified namely, Cymopolia and Konincopora. In other allochems, smaller forams make 25%, Miliolids make 8-10% and Ostracods forms 18-20% of the total allochems.

Bioclasts ranging from 4-5% are also present but these clasts lost their identity probably due to the higher energy or transportation.

Bioclastic Mudstone Microfacies (SKF2): In all observed samples of Sakesar Limestone, this facies constitutes 26% of the total section. This is the second most abundant facies of the Sakesar Limestone. It contains 2-4% allochems, >94% micrite and nearly 3-5% sparite (Fig. 16). Biosclats are the most abundant allochems forming 26% of the total allochems. These bioclasts are showing no internal structure might be due to high energy and transportation. In other allochems, Ostracods 15%, 3-4% smaller forams, 2-3% Discocyclina sp. and Nummulites species and nearly 4% algae are present in this facies.

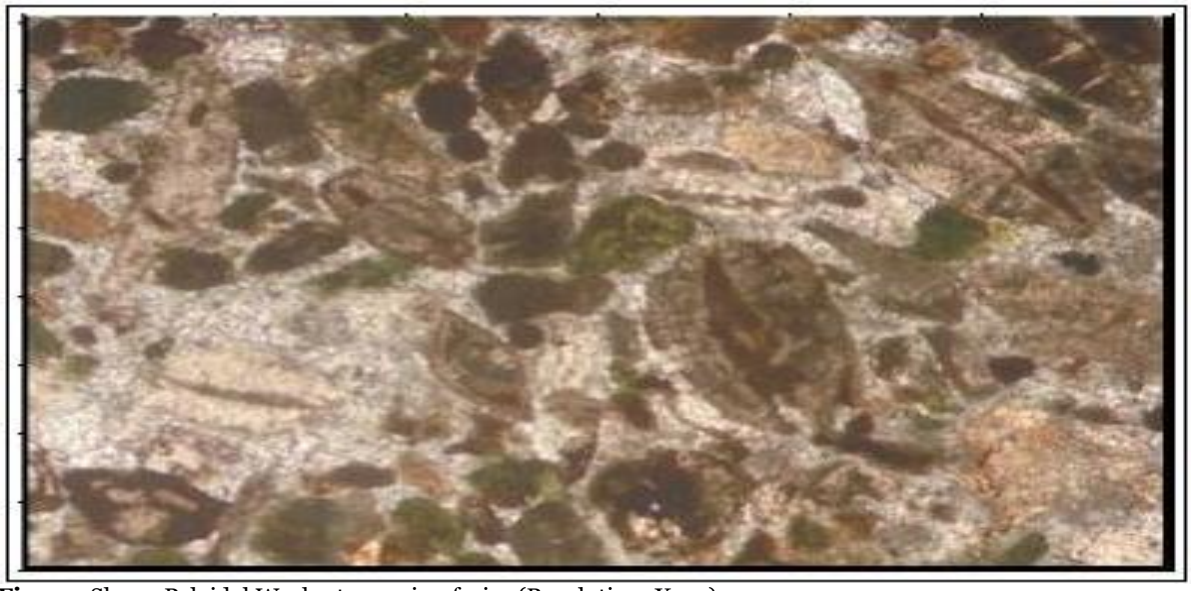

Fig. 13. Shows Peloidal Wackestone microfacies (Resolution: X10x).

Fig. 14. Sakesar Limestone in Kasanwala area (Resolution: X10x).

Assilina Wackestone Microfacies (SKF3): This facies constitutes the 14% of the total section. This is the least abundant facies of the Sakesar Limestone. It has >50% fossil grains and approximately 48-50% micrite (Fig. 17). No evidence of sparite has been identified but only few shells are filled with microsparite.

Fig. 15. Microphotograph showing Algal Mudstone microfacies (Resolution: X10x).

Fig. 16. Microphotograph showing Bioclastic Mudstone microfacies (Resolution: X10x).

Fig. 17. Shows Assilina Wackestone microfacies (Resolution: X10x).

Most dominant allochemical grains are Assilina forming approximately 22% of the total. In this species, Assilina laminosa is the most abundant. Rest of the allochems are Nummulites species 20%, 14% Peloids, 1% Lockhartia and Discocyclina species, 2% bioclasts, 2% algae and few percentages of Operculina, Ranikothalia and Dentalina are present in the observed facies.

Conclusion

In the study area (Kasanwala area) Permian to Eocene succession is exposed. The Paleocene and Eocene succession particularly Lockhart Limestone, Nammal Formation and Sakesar limestone in Kasanwala area of Western Salt Range was measured, logged and sampled. The present studies deals with the biostratigraphy and microfacies analysis of the Lockhart Limestone, Nammal Formation and Sakesar Limestone. In field, good outcrops of the Lockhart Limestone of Paleocene age are exposed for field observation and generally it is composed of nodular limestone with intercalated shale having larger benthic foraminifera. The observed thickness of Lockhart Limestone in the project area is 37m. The Larger benthonic Foraminifera contain: *Miscellanea miscella,Lockhartia conica, Lockhartia haimei, Lockhatia conditi, Lockhartia tipperi, Ranikothalia sindensis, Ranikothalia sahnii, Discocyclina ranikotensis, and Operculina salsa*. After detailed thin section analysis of the samples of Lockhart Limestone, four microfacies of the Lockhart Limestone have been identified namely, Miscellanea Packstone, Bioclastic Mudstone, Lokhartia Wackestone and Lokhartia Packstone microfacies. Similarly, Nammal Formation of Eocene age is also exposed in the Kasanwala area with best exposures. In the project area, it consists of medium to dark grey limestone with the alternations of clay & shale and is highly fossiliferous in some parts. Shales are creamish in colour and limestone of medium to dark grey colour has been observed. In kasanwala area, Nammal Formation is 56m thick. In Nammal Formation, the larger benthic foraminifera includes: *Discocyclina dispansa, Discocyclina ranikotensis, Assilina laminose, Operculina sp., Nummulites sp*. After detailed thin section analysis of Nammal Formation, five microfacies of this formation have been identified namely, Bioclastic Mudstone, Nummulitic Wackestone, Bioclastic Wackestone, Nummulitic Packstone and Peloidal Wackestone microfacies. During the fieldwork in Kasanwala area, it has been observed that the Sakesar Limestone is composed of creamish to light grey massive limestone with chert nodules in the top most part of the formation. It is widely dispersed in our project area i.e Kasanwala area. The observed estimated thickness of the Sakesar Limestone in the project area is 36m.In Sakesar Limestone, the larger benthonic foraminifera include: *Operculina sp., Assilina sp., Nummulites sp., Ranikothalia sp., and Discocyclina sp*. After detailed analysis of Sakesar Limestone, three microfacies of this formation have been identified namely, Algal Mudstone, Bioclastic Mudstone and Assilina Wackestone.

On the basis of observed fauna, its bathymetry and the microfacies framework, it can safely be concluded that these lower Paleogene rocks were deposited in shallow marine, open shelf environment with free circulation of water.

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