MICROFACIES ANALYSIS, PALEONTOLOGY AND BIOSTRATIGRAPHY OF PALEOCENE LOCKHART LIMESTONE FROM PAIL AREA, CENTRAL SALT RANG, PAKISTAN

BY

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Received: 6-7-2021 Accepted: 18-04-2022 Published: 10-10-2022

Abstract: *Paleocene and Eocene sedimentation is rich in foraminifera in entire Salt Range of Pakistan. Larger Foraminifera are abundant and contribute a major part of this period. They are regarded as useful tool for biostratigraphic dating of shallow marine sediments. This study is comprised of microfacies analysis paleontology and biostratigraphy of Lockhart Limestone. Thin sections of rock samples collected from measured section were observed under microscope. A number of microfossils from larger foraminifera and smaller foraminifera were clearly identified. Based on Dunham's textural classification and allochem counts three facies were established: Nummulitidae Mudstone, Nummulitidae Wackstone and Nummulitidae Packstone. Abundance of benthic foraminifera and scarcity of planktonic foraminifera in Lockhart Limestone indicates shallow, inner neritic, open-marine environments of deposition. Presence of larger foraminiferas species like; Lockhartia haimei, Lockhartia conditi indicates Upper Paleocene age of Lockhart Limestone.*

INTRODUCTION

The name "Lockhart Limestone" was given by Davies (1930a) to the Paleocene limestone unit in Kohat area. Afterwards the name was extended to the "Mari Limestone" of Latif (1970a) in Hazara area by the Stratigraphic Committee of Pakistan (Fatmi 1973). Waagen and Wynne (1872) were the pioneer workers in this area; they have explained stratigraphic succession and variety of important fossils in the Salt Range, Pakistan. Gee in 1948 mentioned the Paleocene coal of Dandot and Makarwal areas. Sameeni (1993) described micro-fauna of Lockhart Limestone of Nammal area Salt Range,Pakistan. Serra-Keil (1998) defined twenty Shallow Benthic Zones (SBZ) ranging from the base of Paleocence upto Eocence- Oligocence boundary. These SBZs are based on shallow benthic were derived from many lithostratigraphic sections in Europe, India and Salt Range, Pakistan.

The Salt Range is the southernmost edge of the Himalayan foreland fold-and-thrust belt, which is formed in the result of the collision of the Indo-Pakistan Plate with the Eurasian Plate starting from Paleocene Period. While travelling from Lahore to Islamabad on motorway (M2) after travelling 150 Km towards Islamabad, there is an abrupt change in the relief of the area that indicates the presence of a fault and this fault is known as Himalayan frontal thrust or Salt range thrust. The Salt Range is a feature of particular geological interest for its exposed rocks ranging from Pre Cambrian up to Recent. The Salt Range is located at the southern margin of Potwar plateau and extends from East (Jogi Tilla) to westward up to Kala Bagh where it crosses the Indus River and continues to Trans Indus Range. The average height is about 670 m but near Sakesar it rises up to 1422 m. The Salt range is considered to be the youngest and southern most compressional tectonic feature due to fact that, thrusting has progressively propagated to southward. This paper focuses on Biostratigraphy, Microfacies and the environment of deposition of Lockhart Limestone in the Pail Bhadrar area (Central Salt Range). The project area lies administratively in

Khushab district of Punjab province and located on the Chakwal–Khushab road. The exact bonds of the area are as; 32°34'00.02" N to 32°38'00.02" N and 72°27'00.55 E to 72°30'00.55 E.

The absolute relief of the area is moderate. The slopes of the ridges are generally moderate to gentle. The elevation ranges from 200m to 1017m above mean sea level. Various drainage patterns exist depending upon the host lithology and structure. Near Kattha Kalri different distributaries join to main nala (Kalar Wahan Nala) which finally drain in Jhelum River. The Nala drops its coarser load at the foothills in the form of boulders and pebbles, while fine material i.e., sand, silt and clay are carried to the depressions.

Stratigraphy ranging from Precambrian to recent is present in this area. There is no deposition during late Cambrian which is marked by uniformity. Permian strata is thrust against Tertiary strata, hence there is faulted contact between Permian and overlying Paleocene rock. Late Miocene Kamlial Formation is unconformable overlying on Early Chorgali Formation.

The Lockhart Limestone is exposed in some cliff and valleys in some parts but mostly it is covered by abundant coarse talus from the overlying steep cliffs of the Nammal Formation and Sakesar Limestone in this area. Mainly lithology is argillaceous and nodular limestone with intercalations of shale. It is conformably overlain by Patala Formation and underlain by Hangu Formation.

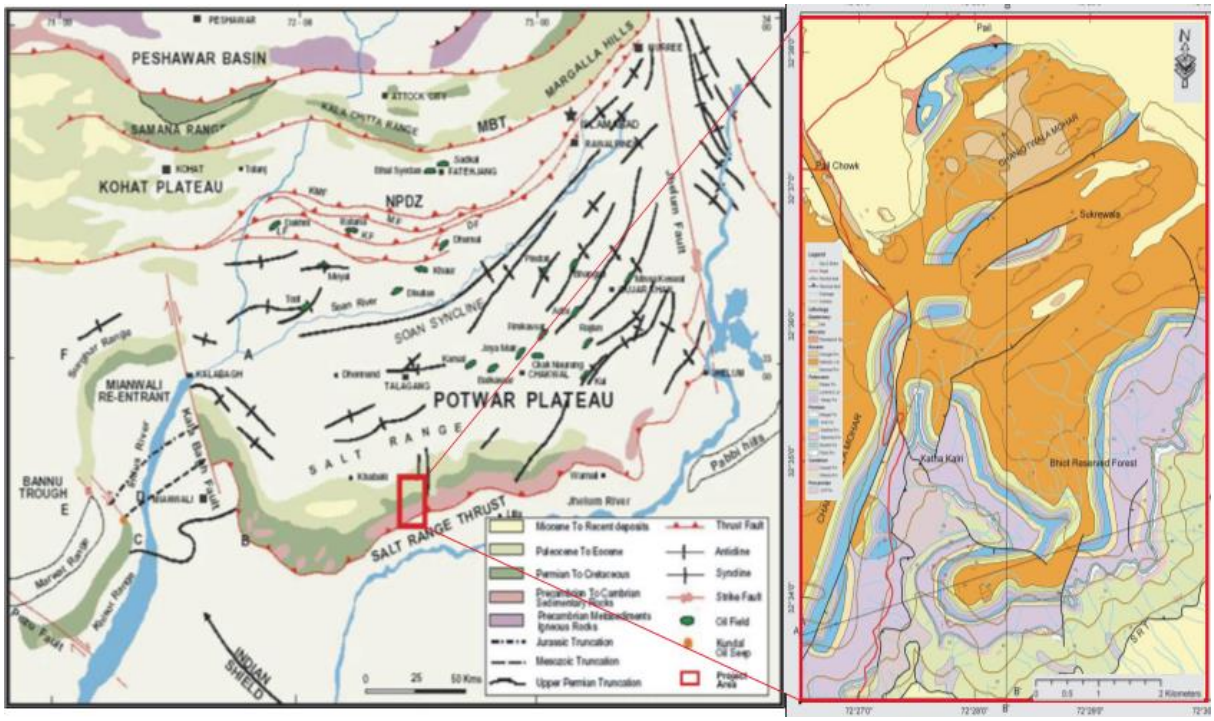

Fig. 1 Left side map is showing large scale tectonic features and location of project area while right side is a geological map map showing expose rock units in the study area.

Table 1. Stratigraphic table showing Formations their age and major unconformities existing in the study area.

Era	Period	Age	Formation	Lithology
		Late Miocene	Kamlial Formation	Greenish sandstone reddish claystone/mudstone, conglomerate at base.
Unconformity				
Cenozoic	Tertiary	Early Eocene	Chorgali Formation	Olive green shale with bedded limestone.
			Sakesar Limestone	Massive and nodular limestone with marl. Chert nodules are present near top.
			Nammal Formation	Light grey calcareous shale and thick bedded limestone.
		Paleocene	Patala Formation	Shale with coal seams, thin bedded limestone and marl.
			Lockhart Limestone	Light grey Nodular limestone with minor marl
			Hangu Formation	Medium to thick bedded sandstone, laterite at base
Faulted Contact				
Paleozoic	Permian	Early Permian	Sardhai Formation	Dark purple and lavender clays with subordinate sandstone
			Warchha Sandstone	Red and light colored sandstone and grits in part. Clay interbeds
			Dandot Formation	Olive green and gray sandstone. Shale occasionally carbonaceous
			Tobra Formation	Conglomeratic sandstone and shale boulders mainly igneous or metamorphic
Unconformity				
Paleozoic	Cambrian	Middle Cambrian	Kussak Formation	Gray shale and glauconitic sandstone pebble bed at base
		Early Cambrian	Khewra Sandstone	Massive maroon fine textured shale and lags below
	Pre Cambrian	Eocambrian	Salt Range Formation	Red marl with rock salt, gypsum dolomite above occasional oil shale

MATERIALS AND METHODS

We made traverses across the strike of rocks to mark the stratigraphic unit on base map. Dip, strike data and formation contacts were recorded with help of Brinton field observations. Formation contacts and geological features were capture in photographs. A thirty-meter lithological section with exposed base and top was measured. Eight samples were carefully collected from different lithofacies for thin section analysis. Rock samples were sliced and mounted on 1-2mm thick glass slide and then polished down to 0.03 thicknesses for thin section anaylysis. Thin sections were observed under optical microscope for paleontological and microfacies analysis. Photographs of thin sections were acquired by the digital camera attached with microscope.

We used textural classification by Dunham (1972), frequency and distribution of larger foraminiferas in Lockhart Limestone for classification of microfacies.

RESULTS AND DISCUSSION

Microfacies Analysis

Thin sections of eight rock samples collected from a measured section were observed under microscope for microfacies analysis. A number of microfossils from larger foraminifera and smaller foraminifera belonging to the *Family Nummulitidea*, *Family Rotaliidae*, *Family Miliolidae* and *Family Textulariidae* were clearly identified. They are from different genus; *Family Nummulitidea* includes *Operculina* and *Assilina*, *Family Rotaliidae* includes *Lockhartia*, *Family Milliolidae* includes different *Milliolids* and *Family Textulariidae* include only genus is *Bigenerina*. Based on Dunham's textural classification and allochem counts each sample was assigned with a facie name. In whole sections of rock three facies were established: Nummulitidae Mudstone, Nummulitidae Wackstone and Nummulitidae Packstone. Below are the microscopic observations for each sample.

Sample-1

Nummulitidae Packstone

The ground mass is micrite and is approximately 35% of rock unit. Bioclasts are comprised of; *Miscellanea*, *Operculinids*, *Ranikothia*, *Eoannularia*, *Discocyclinids*, *Lockhartia*, *Milliolids*, *Bigenrina* and few *algae*. Which are approximately 65% of rock unit. Some clastic fragments such as calcite and quartz are also present. Calcite veins are also observed.

Sample-2

Nummulitidae Wackstone

The ground mass is micrite and is approximately 65% of rock unit. Bioclasts are comprised of; *Lockhartia*, *Miscellanea*,*Operculinids* and some Uniserials, which are approximately 35% of rock unit. Some shell fragments are replaced by sparite.

Sample-3

Nummulitidae Packstone

The ground mass is micrite and is approximately 43% of rock unit. Bioclasts are comprised of; *Discocylinids*, *Lockhartia*, *Assilinids*, *Miscellanea*, *Operculinids*, *Milliolids* and *Bigenerina*, which are approximately 57 % of rock unit. Primary veins are present.

Sample-4

The ground mass is micrite and is approximately 40% of rock unit. Bioclasts are comprised of; *Miscellanea*, *Operculinids*, *Assilinids*, *Discocyclinids*, *Lockhartia*, *Milliolids*, Uniserials and some *algae* are also observed which are approximately 60% of rock unit. Fossils are composed of non-ferron calcite whereas 15-20 % Ferron calcite is also present.

Sample-5

Nummulitidae Packstone

The ground mass is micrite and is approximately 30-32% of rock unit. Bioclasts are comprised of; Miscellanea, Operculinids, Ranikothia, Eoannularia, Discocyclinids, Assilinds, Lockhartia, Milliolids, Uniserial, Biserial and some algae are also observed which are approximately 68-70% of rock unit. Primary and secondary calcite veins are also observed. Pyritized Brachiopod shells are also found

Sample-6

Nummulitidae Mudstone

The ground mass is mixture of micrite and sparite and is approximately 95% of rock unit. Bioclasts are comprised of; Ranikothia, Assilinds, Discocyclinids and Miscellanea which are approximately 5% of rock unit. Calcite veins are present.

Sample-7

Nummulitidae Wackstone

The ground mass is micrite and is approximately 85% of rock unit. Bioclasts are comprised of; Lockhartia, Eoannularia, Operculinids and Uniserial, Biserial which are approximately 15% of rock unit. Non-ferron calcite has replaced fossil shells.

Sample-8

Nummulitidae Wackstone

The ground mass is micrite and is approximately 85% of rock unit. Bioclasts are comprised of; Lockhartia, Operculinids Ranikothia, Assilinds and Uniserial, Biserial which are approximately 15% of rock unit. Highly dolomitized limestone vein and fossil shell are replced by non-ferron calcite. Some stalolites are also present.

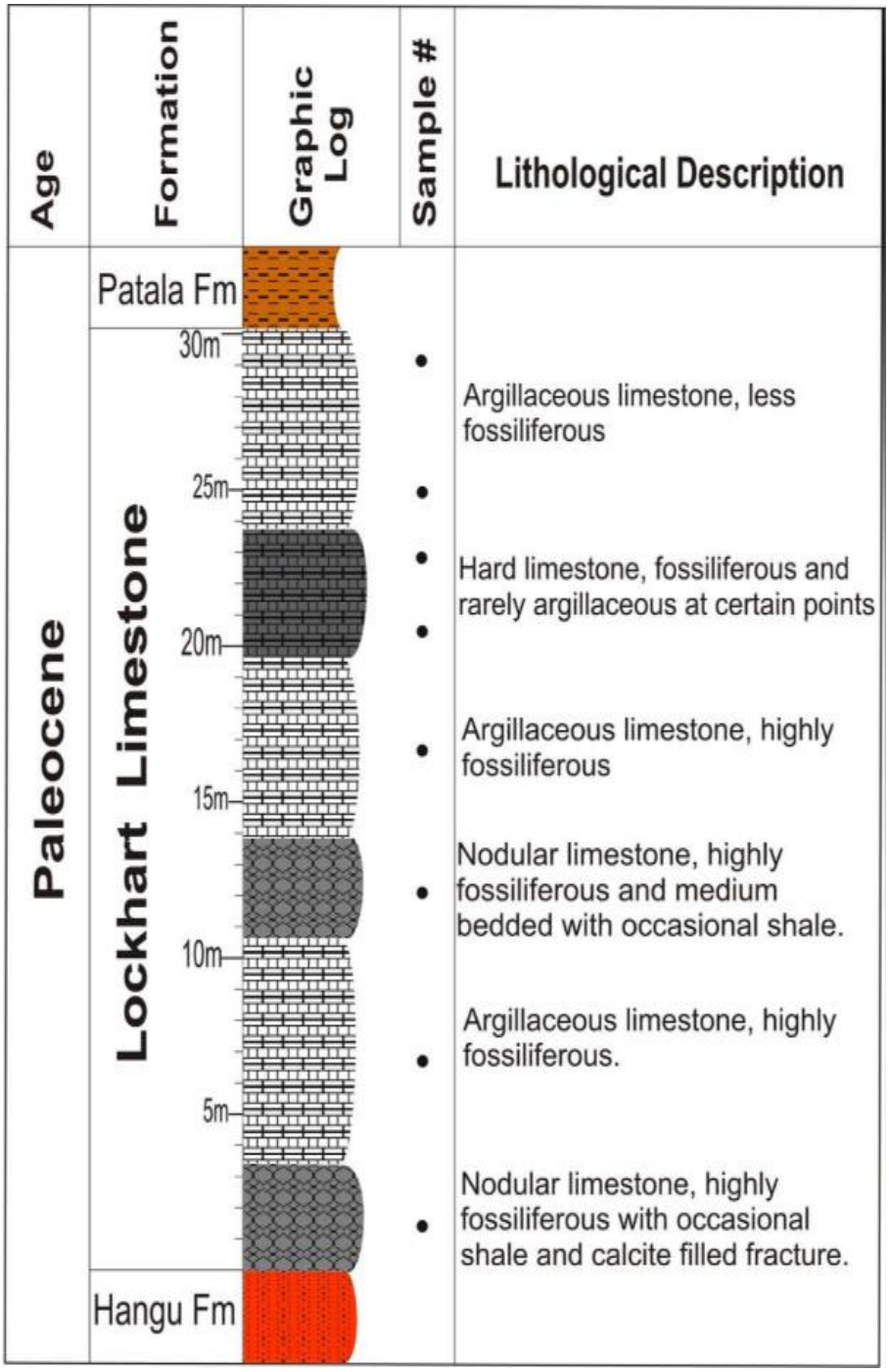

Fig. 2 Lithographic section of Lockhart Limestone, Central Salt Range, Pakistan.

Table 2. Microfacies analysis of Lockhart Limestone, Central Salt Range, Pakistan.

Sample No.	Allochems %age	Allochems included	Mud stone	Wacke stone	Pack stone
8	15%	Lockhartia 8% Assilinids 33% Operculinids 17% Ranikothalia 25% Uniserial/Biserial 17%		■	
7	15%	Lockhartia 11% Operculinids 22% Eoanularia 11% Echinoderm 22% Uniserial/Biserial 33%		■	
6	5%	Miscellanea 9% Assilinids 27% Operculinids 9% Ranikothalia 27% Discocyclina 27%	■		
5	70%	Lockhartia 18% Miscellanea 15% Assilinids 3% Operculinids 3% Discocyclina 9% Eoanularia 6% Echinoderms 9% Milliolids 12% Uniserial/Biserial 21 Algae 3%			■
4	60%	Lockhartia 18% Miscellanea 7% Assilinids 10% Operculinids 7% Discocyclina 7% Eoanularia 10% Echinoderm 7% Uniserial/Biserial 15% Milliolids 7% Algae 7%			■
3	57%	Lockhartia 24% Miscellanea 20% Assilinids 3% Operculinids 3% Discocyclina 10% Eoanularia 14% Milliolid 10% Bigenerina 7% Echinoderm 7%			■
2	35%	Lockhartia 6% Uniserial/Biserial 17% Miscellanea 47% Operculinids 29%		■	
1	65%	Lockhartia 4% Miscellanea 12% Operculinids 4% Ranikothalia4% Discocyclina 8% Eoanularia 24% Echinoderm 20% Milliolid 12% Uniserial/Biserial 8% Algae 4%			■

Paleontology and Biostratigraphy

There are number of microfossils that are found in microfacies analysis of samples of Lockhart Limestone, some of them are clearly identifiable even upto specie level. Fossils belong to the Family Nummulitidea, Family Rotaliidae, Family Miliolidae and Family Textulariidae.

The fossils of different genus found as per shown in figures of Family Nummulitidea includes Operculina and Assilina. Family Rotaliidae includes Lockhartia. Family Milliolidae includes different Milliolids with no clear insight to even genus level whereas the Family Textulariidae include only genus is Bigenerina.

Genus: Assilina
Species: Assilina subspinosa (Davies & Pinfold)

Synonymy
Nummulities granulose (D'Arch, 1879)

Assilina miscella (D'Arch, Haime, 1906)

Assilina miscella (D'Arch, Haime, 1909)

Assilina ranikoti (Davies, Pinfold, 1926)

Assilina ranikotensis (Nuttall, 1931)

Description
Test is discoidal with sharp periphery and evolute. These tests have megalospheric generation; ornamentations are in the form of large granules closely massed over the central parts of the test, meridian section shows the central granules standing out like spines whose roots extend inward to form pillars. This specie is found in Paleocene and Eocene age rocks.

Genus: Operculina

Species: Operculina salsa (Davies &Pinfold)

Synonymy
Operculina salsa (DaviesPinfold, 1937)

Description
It has megalospheric proloculus. Marginal cord is thick. The septa are finally granulated and there is a small cluster of granules at the poles. From center it is thick and the whorls loose moderately. The test is relatively rugged. The septa are being externally visible over a large portion of spire.

Fig. 3 (a) and (b) are cross-sectional view of Assilina subspinosa, (c) is plane and (d)is cross-sectional view of Operculina salsa.

Genus: Lockhartia

Species: Lockhartia conditi (Nuttal)

Synonymy

Lockhartia conditi (Nutall, 1926)

Lockhartia conditi (Davies, 1927)

Lockhartia (Davies, Ovey, 1947)

Lockhartia sp. (Dam, 1953)

Lockhartia Conditi (Smout, 1954)

Description

Test biconvex, trochospiral, calcareous perforate, spire is close, umbilical boss is present, knobs are also arranged. Suture lines on evolute side not visible, straight suture present on involute side, not reaching the center, few knobs on involute side. Aprture interiomarginal, long, umbilical. Periphery rounded, keelate. Involute side shows umbilical boss, thick suture visible on involute side, which is not reaching up to the center, aperture interiomarginal in its position. This specie is found in Paleocene Eocene age rocks.

Species: Lockhartia tipperi (Smout)

Synonymy

Lockhartia tipperi (Davies, 1926)

Lockhartia tipperi (Nuttal, Berighton, 1931)

Lockhartia (Davies,Ovey, 1947)

Lockhartia tipperi (Smout, 1954)

Lockhartia tipperi (Sander, 1962)

Description

Test bilaterally ornamented, biconvex, compressed, calcareous perforate, coarsely perforate. Suture line not visible. Aperture interiomarginal on umbilical side. Periphery rounded, thick keel present.

Diagnosis

Test biconvex compressed, numerous knobs present on the proloculous, thick keel present on the periphery, umbilical boss present, umbilical side is having numerous knobs.

Species: Lockhartia haimei (Davies)

Synonymy

Lockhartia haimei (Davies, 1927)

Lockhartia haimei (Silvestri, 1938)

Lockhartia haimei (Dam, 1953)

Lockhartia haimei Smout, 1954)

Lockhartia haimei (Sander, 1962)

Description

Test calcareous perforate, planoconvex, evolute side is convex, proloculous is covered by the knobs. Suture lines thick on spiral side, oblique, only the chambers of last whirl are visible. Aperture inter-marginal, umbilical in position. Periphery rounded, bilaterally ornamented with knobs, keelate.

Diagnosis

Test planoconvex, spiral side is having knobs, calcareous perforate, suture of the last spire on evolute side is visible, coarsely porous.

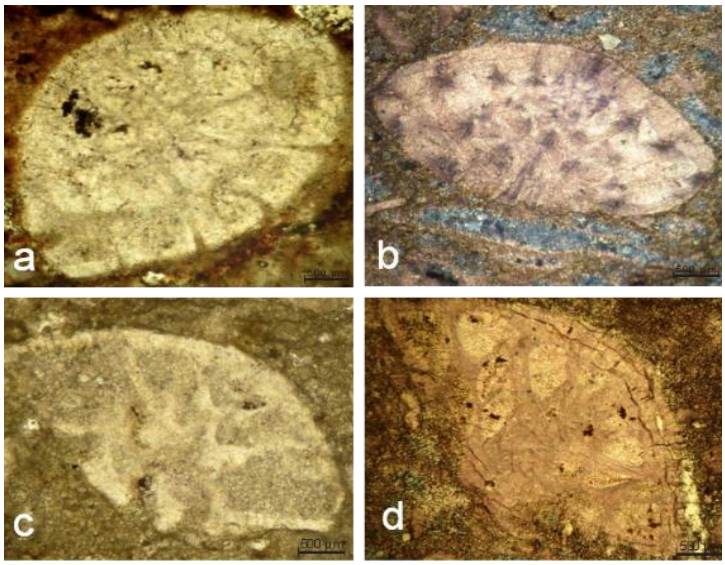

Fig. 4 (a)is Lockhartia conditi (b) is Lockhartia tipperi (c) and (d) are Lockhartia haimei.

Genus: Miscellanea

Species: Miscellanea miscella (D' Arch, Haime)

Synonymy

Siderolites miscella (D'Arch, Haime, 1916)

Siderolites miscella (Nutall, 1926)

Siderolites miscella (Nutall, 1927)

Miscellanea miscella (Pfender, 1934)

Miscellanea miscella (Davies, Pinfold, 1937)

Description

Test planispiral involute, biconvex test like Nummulites, but it is bilaterally ornamented with knobs, with a coarsely perforated spiral sheet composed of closely spaced pillars. Suture lines not visible. Aperture not visible, at base of last formed chamber. This specie is found in Paleocene age rocks.

Genus: Ranikothalia (Caudri)

Species: Ranikothalia sahnai (Davies)

Synonymy

Operculina sahnai (Davies, 1927)

Nummulites sahnai (Davies, Pinfold, 1937)

Description

Test planispiral evolute, flattened, with no septal filaments, with thick fan shaped marginal cord, having both, operculinoidal and nummulitic growth.

Diagnosis

Test like Operculina, planispiral evolute, flattened, fan shaped thick marginal cord is the characteristic feature of this species.

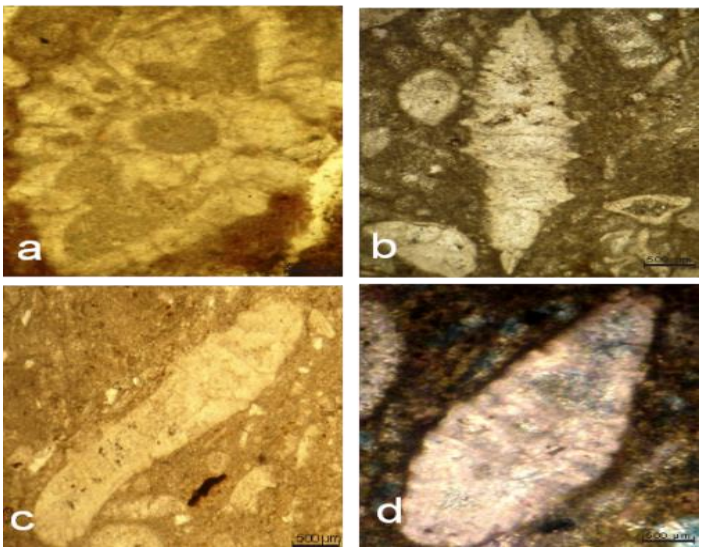

Fig. 5 (a), (b) and (d) are Miscellanea miscella (c) is Ranikothalia sahnai.

Genus: Discocyclina Gumbel

Species: Discocyclina ranikotensis (Davies)

Synonymy

Discocyclina ranikotensis (Davies, 1927)

Description

Test large, planispiral, flattened, rounded plate like.

Diagnosis

Test planispiral, flattened, can be identified easily in cross section as thin median layer in the center and two lateral layers are observed, rectangular chamberlets.

Genus: Miliolid

Description

The specimen exhibit sections from almost all slides, the test shows changing pattern of development of chambers, it has three to four chambers, walls calcareous and are imperforate and their presence marks meteoric or brackish water conditions. It ranges in age from Paleocene to Eocene.

Genus: Bigenerina

Description

It has two walled chambers that join one another in coiled form.

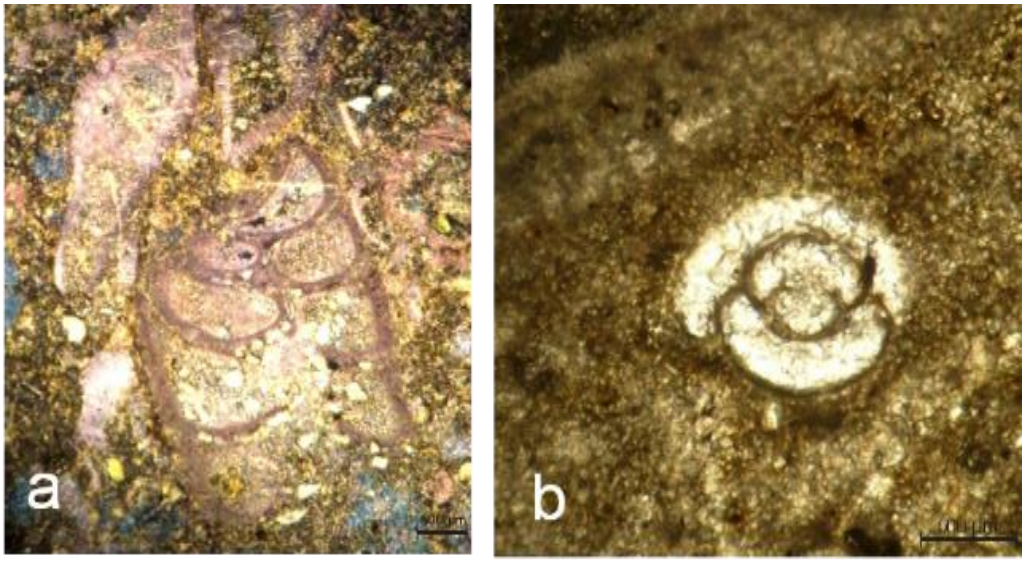

Fig. 6 (a) is Bigenerina (b)is Milliolid.

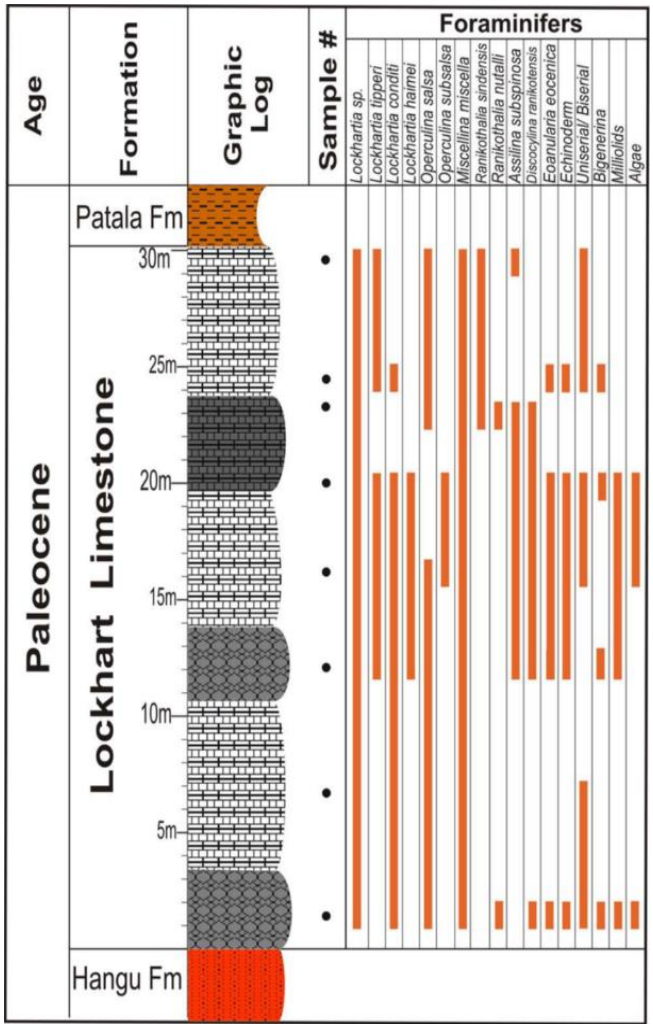

Fig. 7 Section showing vertical distribution of various foraminifera.

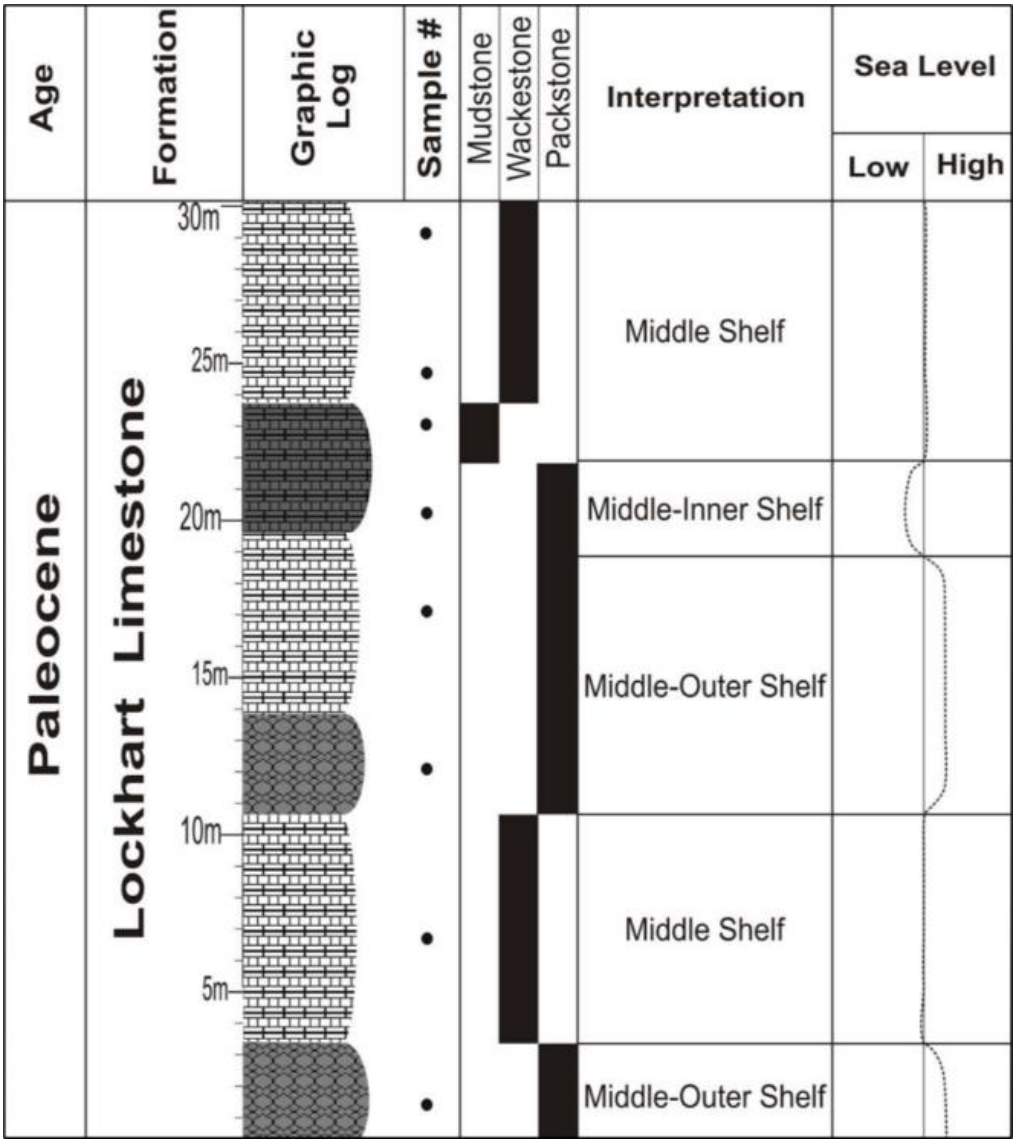

Fig. 8 Environments of deposition infered from microfacies and Foraminiferal assemblage.

CONCLUSIONS

This section shows abundance of benthic foraminifera and scarcity of planktonic foraminifera, that indicates shallow, inner neritic, open-marine environments of deposition at water depths probably less than 100 ft. Presence of larger foraminiferas species like; Lockhartia haimei, Lockhartia conditi indicates Upper Paleocene age of Lockhart Limestone.

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