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Micropaleontology of Lockhart Limestone (Paleocene), Nilawahan Gorge, Central Salt Range, Pakistan

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Abstract

The present study deals with the micropaleontological investigation of the Lockhart Limestone of Paleocene age from the Nilawahan Gorge, Salt Range, Pakistan. 21m thick section of the Lockhart Limestone was measured and sampled in the Nilawahan Gorge at an interval of 1m. The limestone has a faulted lower contact with the Sardhai Formation (Lower Permian) and conformable upper contact with the Patala Formation (Upper Paleocene) and is predominantly nodular-bedded with interbeds of marls.

On the basis of detailed petrographic analysis, eight species of diagnostic benthic foraminifers belonging to genera *Miscellanea, Operculina, Lockhartia, Assilina* and *Discocyclina*, are recorded. The rocks are entirely of shallow marine in origin with biotic assemblages confirming Paleocene age of the Lockhart Limestone.

Keywords: Lockhart; Nilawahan Gorge; Foraminifera; Paleocene

1. Introduction

The Salt Range marking the southern boundary of the Potwar Plateau lies between the River Indus in the west and River Jhelum in the east. Beyond the River Indus at Kalabagh, it takes a sharp turn running almost in north-south direction (Ghazi et al., 2004). The entire mountainous belt has, previously been differentiated into the Cis-Indus Salt Range and Trans-Indus salt Range now known as the Salt range and Trans-Indus Surghar Range, respectively (Sameeni, 2009). The Salt Range offers a classical locality for the Paleocene stratigraphy for both in terms of its lithological characteristics as well as its foraminiferal content (Ghazi et al., 2004).

2. Stratigraphy of the study area

The complete stratigraphic succession exposed in the Nilawahan Gorge is given in table 1. This sequence contains the Salt Range Formation of Pre-Cambrian age at the base and the Kamlial Formation of Late Miocene age at the top.

The present study only covers the paleontological and biostratigraphical study of the Lockhart Limestone of the Paleocene age, having Sardhai Formation (faulted contact) from base and Patala Formation (comformably) from top (Table 1).

The name Lockhart Limestone to the Paleocene limestone unit in Kohat area was given by Davies (1930) and later approved by the Stratigraphic Committee of Pakistan (Fatmi, 1973).

Table 1. Stratigraphy of Nilawahan Gorge, Modified by Gee (1989)

Era	Period	Age	Group	Formation	Lithology
		Late Miocene		Kamlial Formation	Greenish sandstone reddish claystone/mudstone, conglomeritic base
Major Unconformity					
Cenozoic	**Tertiary**	**Early Eocene**	**Chharat group**	Chorgali Formation	Olive green shale with bedded limestone
				Sakesar Limestone	Massive and nodular limestone with marl. Chert in upper part
				Nammal Formation	Light grey calcareous shale and limestone
		Paleocene	**Makarwal Group**	Patala Formation	Green shale with coal seams, thin bedded limestone and marl.
				Lockhart Limestone	Nodular limestone with minor marl
				Hangu Formation	Medium to thick bedded sandstone, laterite at base
Faulted Contact					
Paleozoic	**Permian**	**Early Permian**	**Nilawahan Group**	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 and early Cambrian**		Kussak Formation	Gray and purplish shale and glauconitic sandstone pebble bed at base
				Khewra Sandstone	Massive maroon fine textured shale and lags below
	Pre Cambrian	**Eocambrian**		Salt Range Formation	Red gypseous marl with rock salt, gypsum dolomite above occasional oil shale.

The pioneer work on the micropaleontology of Lockhart Limestone was carried out by Davies (1930) in the Samana Range where he described many Late Paleocene larger benthonic foraminifers. Davies and Pinfold (1937) described and illustrated the characteristic Paleocene benthonic larger foraminiferal species from Lockhart Limestone in the Salt Range. Haque (1956) described and illustrated the smaller foraminifera including few planktonic forams from the Patala Formation and the Nammal Formation from the Nammal Gorge. Ashraf and Bhatti (1991) worked on the nannofossils of the Patala and Nammal formations of the Khairabad area of the Western salt Range. Sameeni (1997) outlined the Alveolinid biostratigraphy of the Eocene succession of the Salt Range which was a valuable addition to the Salt Range biostratigraphy. Afzal and Butt (2000) have provided valuable information on the planktonic foraminiferal zonations from the Lower Tertiary of the western Salt Range.

The Lockhart Limestone has been studied from the Nilawahan Gorge (lat 32 39 10 N; long 72 36 30 E), Central Salt Range (Fig. 1), and lies in the Survey of Pakistan Topo-Sheet No. 43 D/ 10. The thickness of Lockhart limestone in Nilawahan gorge is 21m and it is comprised of nodular limestone and marl.

3. Field observations

The Lockhart Limestone, measured in Nilawahan Gorge, is mainly comprised of medium to thick-bedded limestone having yellowish gray color on weathered surface and light grey to greenish gray color on fresh surface. The limestone is prominently nodular and fractured. The size of the nodules of limestone is 8 to11 cm in diameter and at places 14 to 16 cm. The rocks are fractured and most of the fractures are filled with calcite. The surrounding margins of the nodules are filled with fine grained material like clay and shale. Marl occurs as interbeds in limestone having grey to dark grey color, is of bituminous nature and gives off fetid odour. In total 21 samples (LL-1 to LL-21) were collected from bottom to top at different levels and thin sections were prepared for micropaleontological studies. The complete measured section of the studied formation along with locations and numbers of selected samples is given in Fig. 2.

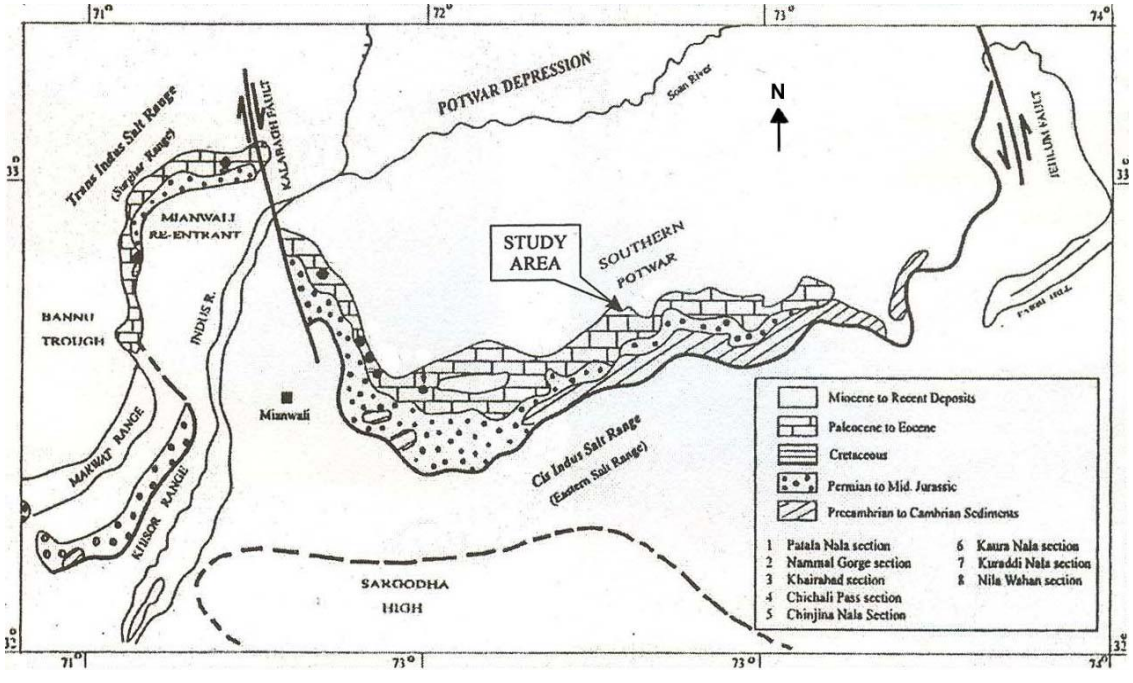

Fig. 1. Geological map showing location of study area (not according to the scale) in Salt Range, Pakistan (after Afzal and Butt, 2000)

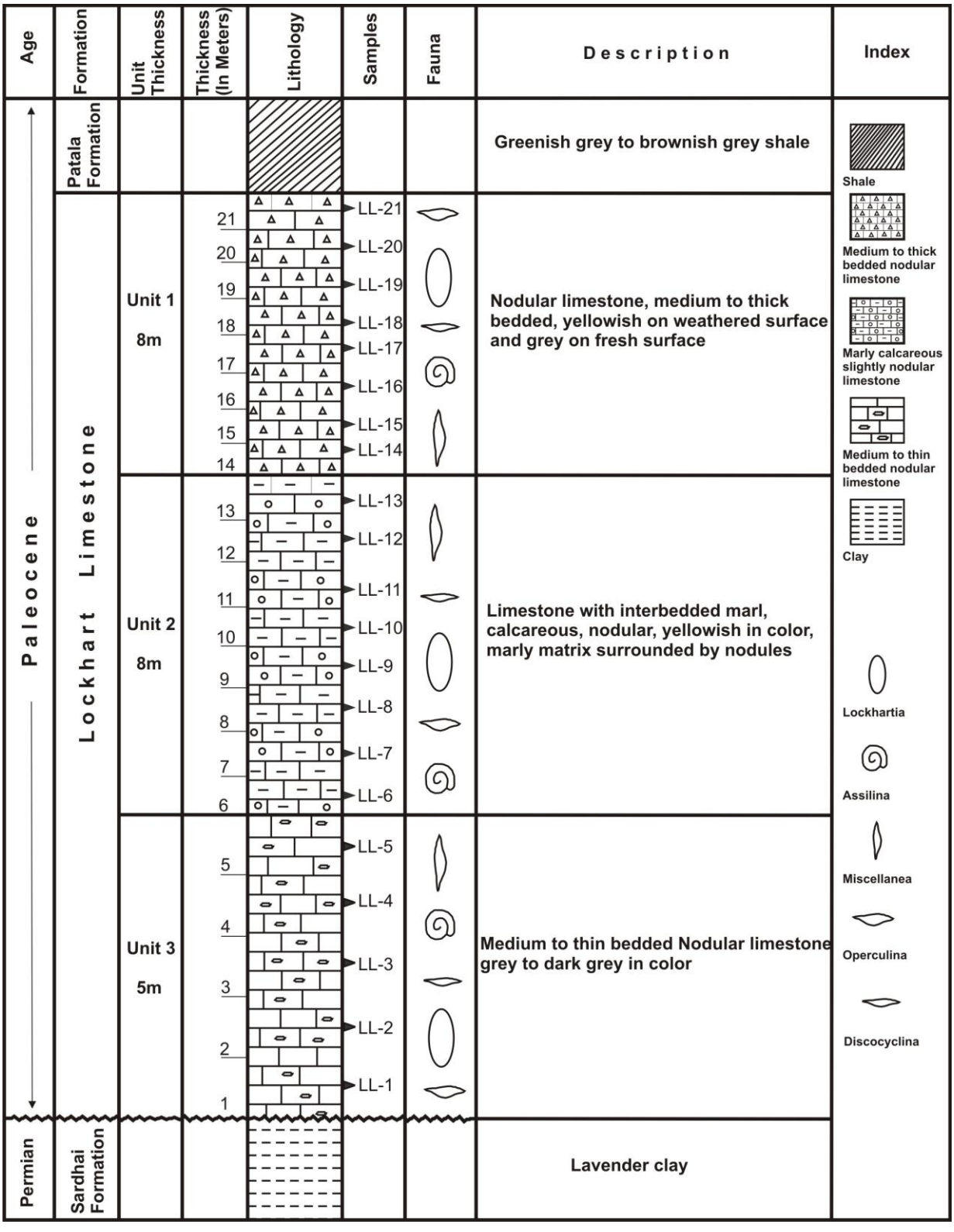

Fig. 2. Lithological log of the measured section of Lockhart Limestone in the Nilawahan Gorge, Central Salt Range.

The recorded species of foraminifera are as follows:

1. *Miscellanea miscella* (d' Archiac and Haime)
2. *Operculina salsa* (Davies and Pinfold)
3. *Operculina patalensis* (Davies and Pinfold)
4. *Lockhartia haimei* (Davies)
5. *Assilina subspinosa* (Davies and Pinfold)
6. *Lockhartia conditi* (Nuttall)
7. *Discocyclina ranikotensis* (Davies)
8. *Lockhartia tipperi* (Davies)

PLATE I

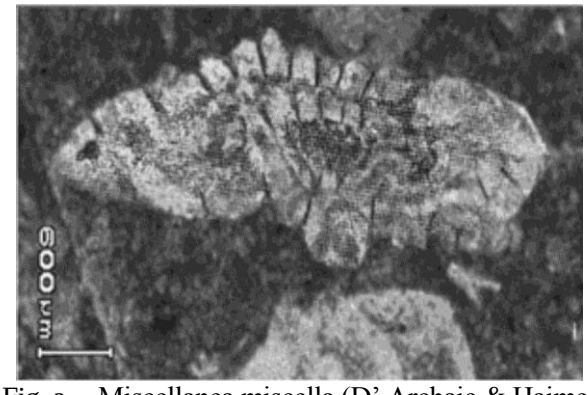

Fig. a. Miscellanea miscella (D' Archaic & Haime) Sample No. 15 (Nilawahan Gorge)

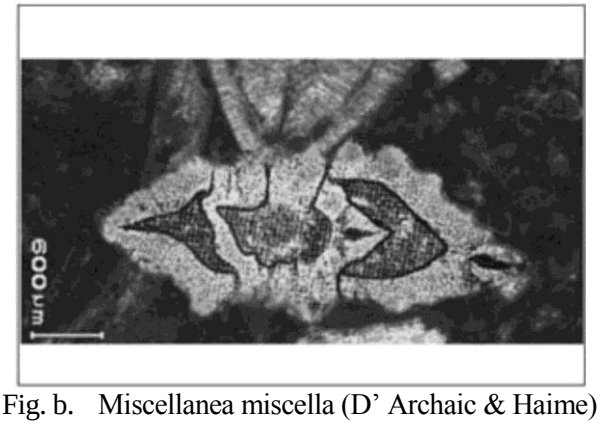

Fig. b. Miscellanea miscella (D' Archaic & Haime) Sample No. 15 (Nilawahan Gorge)

4. Systematic Paleontology

4.1. Miscellanea miscella **(**d' Archiac and Haime) (Plate I, Figs. a, b)

Miscellanea miscella This is the most common species present throughout the formation. The diagnostic character of this species is the presence of a compressed or biconvex shell which is planispiral involute without marginal cord. Interseptal canals are present. The chambers are simple, involute and equitant, the filaments being nearly straight.

4.2. Operculina salsa (Davies and Pinfold) (Plate II, Figs. a, b)

Operculina salsa is characterized by the umbonal boss and the coils are adjacently depressed by virtue of which it is distinct from *Operculina subsalsa*

PLATE II

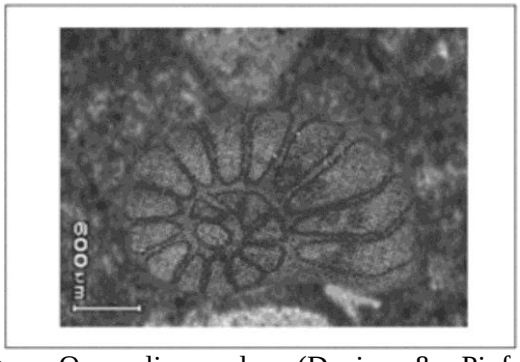

Fig. a. Operculina salsa (Davies & Pinfold) Sample No. 12 (Nilawahan Gorge)

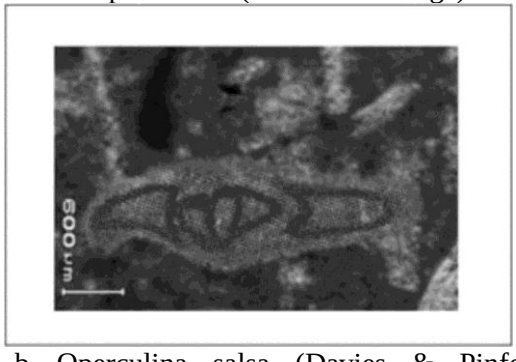

Fig. b. Operculina salsa (Davies & Pinfold) Sample No. 12 (Nilawahan Gorge)

4.3. Operculina patalensis **(**Davies and Pinfold) (Plate III, Fig. a)

Operculina patalensis is characterized by less opening coiling, abrupt shell growth and the presence of rim around the outermost whorl formed by marginal cord. The marginal cord is smooth and the septa are curved.

PLATE III

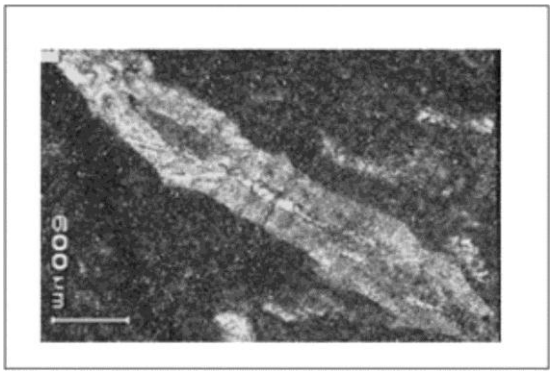

Fig. a. Opercullina patalensis (Davies & Pinfold) Sample No. 5 (Kalawahan Gorge)

4.4. Assilina subspinosa **(**Davies and Pinfold)
(Plate IV, Figs. a, b)

Assilina subspinosa has strongly ornamented shell with thick granules on the surface giving a spinose appearance. The granules are transversing the interior part of the shell in the form of pillars.

PLATE IV

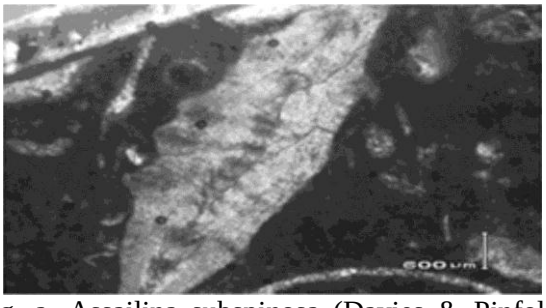

Fig. a. Assailina subspinosa (Davies & Pinfold) Sample No. 14

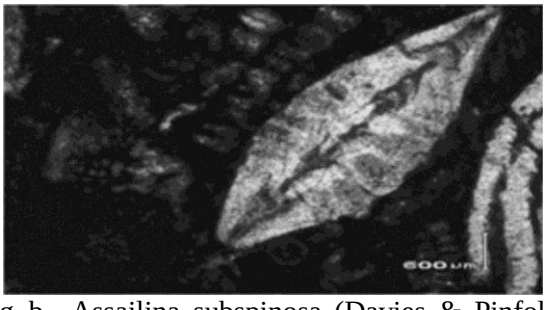

Fig. b. Assailina subspinosa (Davies & Pinfold) Sample No. 14

4.5. Lockhartia haimei **(**Davies)
(Plate V, Figs. a, b)

Lockhartia haimei is a guide fossil for Paleocene rocks. This specie has a low trochospiral keeled shell. The umbilical side is filled with pillars. Wall is calcareous and perforate. The spiral side is coarsely perforate and shows the presence of spiral bars or pustules. The ventral side is almost covered with numerous pustules extending to the inner structure of the shell as pillars.

4.6. Lockhartia tipperi **(**Davies)
(Plate VI, Figs. a, b)

Lockhartia tipperi is characterized by a low trochospiral shell with rounded peripheral margin with thicker pustules on the umbilical side. The pillars are regular but very distinct and the umbilical plates are well developed.

PLATE V

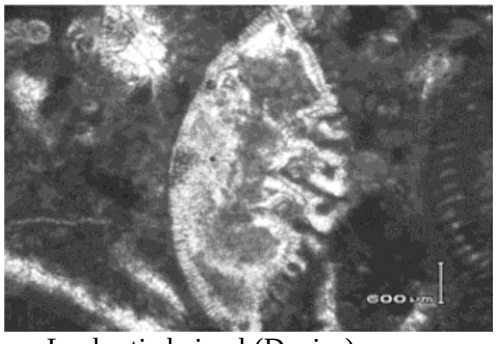

Fig. a. Lochartia haimel (Davies) Sample No. 10 (Nilawahan Gorge)

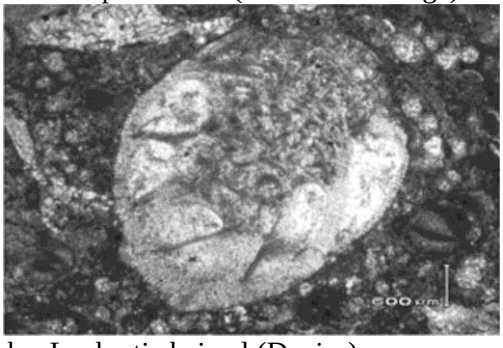

Fig. b. Lochartia haimel (Davies) Sample No. 10 (Nilawahan Gorge)

PLATE VI

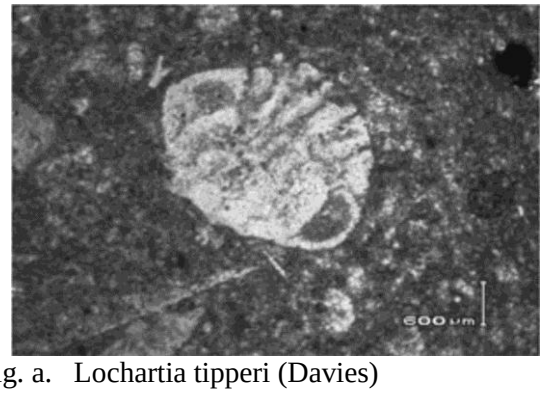

Fig. a. Lochartia tipperi (Davies) Sample No. 3 (Nilawahan Gorge)

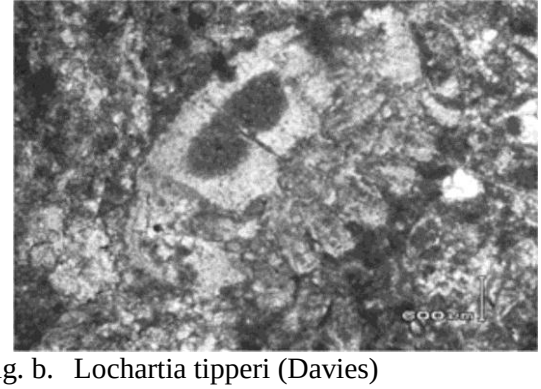

Fig. b. Lochartia tipperi (Davies) Sample No. 3 (Nilawahan Gorge)

4.7. Lockhartia conditi **(**Nuttall)
(Plate VII, Fig. a)
Lockhartia conditi has a high spired shell with few thick pillars filling the umbilical portion. It is distinguished from the species of Lockhartia by its high trochospiral shell with few thick pustules on the umbilical side.

PLATE VII

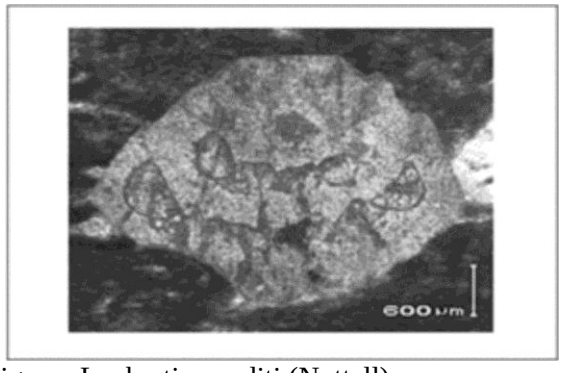

Fig. a. Lochartia conditi (Nuttall)
Sample No. 13

4.8. Discocyclina ranikotensis **(**Davies)
(Plate VIII, Fig. a)

Discocyclina ranikotensis is characterized by having a thin and elongated shell. Numerous chamberlets are also prominent and visible.

PLATE VIII

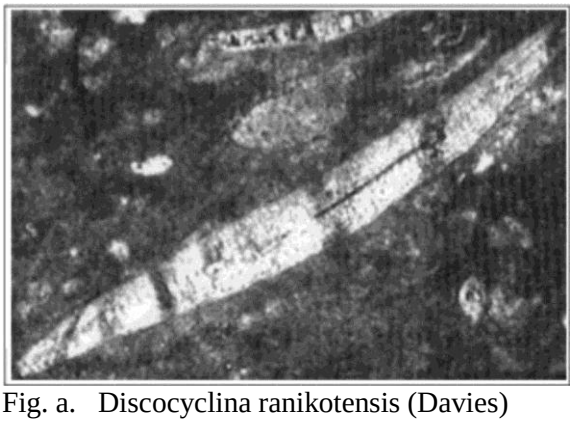

Fig. a. Discocyclina ranikotensis (Davies)
Sample No. 8 (Kalarwahan Gorge)

5. Conclusions

The bioclasts observed in the formation are larger foraminifera identified as *Miscellanea miscella* (d' Archiac and Haime), *Operculina salsa* (Davies and Pinfold), *Operculina patalensis* (Davies and Pinfold), *Lockhartia haimei* (Davies), *Assilina subspinosa* (Davies and Pinfold), *Lockhartia conditi* (Nuttall), *Discocyclina ranikotensis* (Davies) and *Lockhartia tipperi* (Davies).

The Lockhart Limestone is a carbonate sequence almost entirely of marine origin with minor amount of clay and calcareous shale containing diagnostic larger foraminifera that confirms the Paleocene age of the formation.

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