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**SURJ**

# Paleoecological and Biostratigraphic studies of Laki limestone member of Laki formation (ypresian) and tiyon formation (Late Ypresian-Lutetian), on the basis of smaller foraminifera,Thano Bula Khan, Sindh.

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**Abstract:**

Eocene succession of Lower Indus Basin; in terms of Laki Formation and Tiyon formation has remained an unsolved problem untill now; many of the geologists and Stratigraphic Committee of Pakistan believe Tiyon as a unit of Laki Formation. In this study an effort is made to prove the difference between both rock units on the basis of smaller foraminifera. Laki Formation and Tiyon formations are best exposed at Rehman Dhoro and Tiyon Nai sections respectively which are their type sections. For this study the area of Thano Bula Khan, District Jamshoro, Sindh was selected shown in top sheet no. 35 0/15.

The smaller foraminifera of Laki limestone member of the Laki Formation and Tiyon formation were identified and differentiated.

By the study of smaller foraminifera it is observed that the difference among both the formations is an enough biostratigraphic evidence for the recognition of Tiyon (late Ypresian-Early Lutetian) as a distinct formation.

Paleo-ecology on smaller foraminiferal basis was interpreted and the area of study is assigned shallow-deep marine depositional environment.

The aim of this paper is to assess and present the lithological and smaller foraminiferal difference between two rock units of Eocene age in the Southern Indus Basin. An attempt has been made to provide sufficient Biostratigraphic evidence to recognize the Tiyon (late Ypresian- Early Lutetian) as a formation, by studying the Paleo-ecology of the studied area.

**Keywords:** Eocene, Foraminifera, Laki, Tiyon, Sindh.

## 1. Introduction:

Study of foraminifera in Pakistan started as early as 1849 with larger foraminifera in Sindh and Kutch by Carter. The foraminifera of Laki Formation were first described to some extent by Nuttall (1925, 1926). However the study was restricted to the larger foraminifera. Studies on the smaller foraminifera as well as planktonic foraminifera were initiated by Haque (1965); who carried out a systematic study of foraminifera from the Paleocene-Eocene succession of Nammal Gorge section, Salt Range. However, these latest studies of smaller and planktonic foraminifera in Pakistan are few and far between left over voids in the systematic micropaleontology. There are numerous regions whose Cenozoic assemblages of smaller and planktonic foraminifera are virtually unknown. Sindh is one of these regions in Pakistan, where the bulk of outcrop consist of Cenozoic rocks of shallow marine origin with rich assemblage of foraminifera. The Centre for Pure and Applied Geology, University of

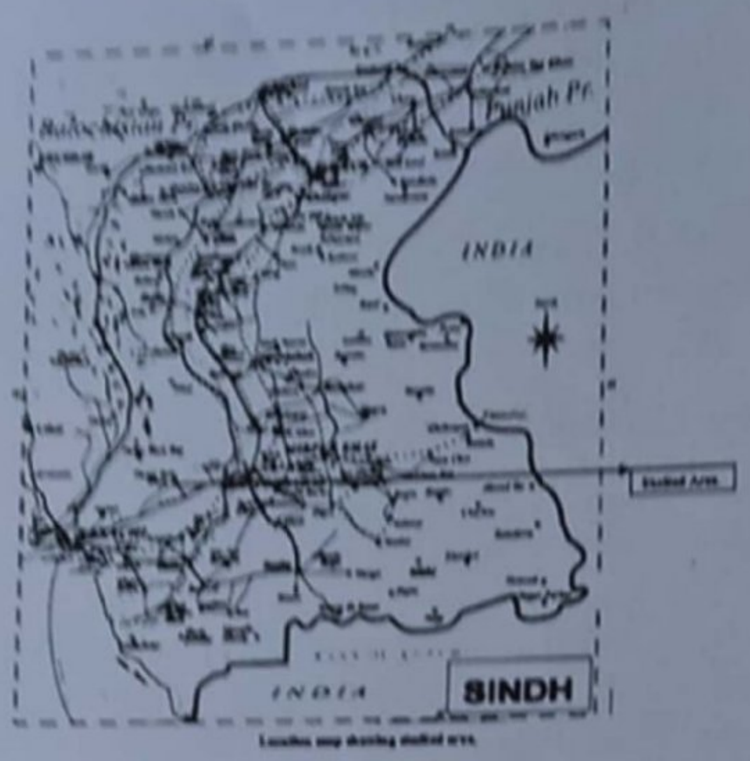
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Sindh took this situation into account and has worked on the Paleocene smaller foraminifera of Sindh.

## 2. Geology of the studied area:




The studied area is the western flank of Surjan anticline, located SE of Thano Bula Khan town, District Jamshoro, Sindh; and lies in Toposheet No. 35 0/15 in between:

Longitude: 67° 50' 10" to 67° 57' 18" E.
Latitude: 25° 15' 00" to 25° 9' 16" N.

The studied section comprises of Laki limestone member of Laki Formation and Tiyon formation.

**Laki Formation:**

Vredenberg (1909) included in the Laki series of Sindh; the Laki limestone and Meting shale, which is underlain by the upper Ranikot group. Nuttall's (1925) subdivision for Laki series has been widely accepted; he classified these beds in descending order as under:

Laki limestone.
Meting Shale.
Meting limestone.
Basal Laki laterite.

An early Eocene age was assigned to it by Vredenberg (1906, 1921), Nuttall (1925), Davis (1926), Cox (1931), Noetling (1905), Haque (1962), Hunting Survey Corporation (1960) and Iqbal (1973).

At the Chohar Pass area of Surjan anticline the Laki limestone member of Laki Formation is exposed consisting mostly limestone with minor amount of shale, sandstone and marl. The nodular limestone is mostly hard, compact and massive. The basal part of the Laki limestone is chalky. In the studied area Laki limestone dips steeply on the eastern flank and dips gently on the western flank of Surjan anticline. The amount of dip on the western flank is 3.5° to 8° NW. The base of the Laki Formation is not exposed in the studied area but its upper contact is conformable with overlying Tiyon formation.

**Tiyon formation:**

The unit named as Tiyon formation is a thin, distinct rock unit between the Laki limestone and Kirthar Formation.

This was mapped as a separate unit and named as Tiyon formation by the Hunting Survey Corporation (1960). Its name was derived from the Tiyon Nai or Stream which flows from the western flank of the Laki Range, where a type section for the formation is exposed.

Tiyon formation is exposed in a narrow strip in western Sindh and is part of the Southern Mountain front assemblage. At the north end the formation appears in the anticlines of the Laki and Badhra ranges and in smaller structure immediately to the south. Further south it is exposed in the hills flanking the valley of Thano Bula Khan and in the Rojh Watwaro range, west of Kalu Khuhar.

The Tiyon formation is exposed on the both flanks of the Surjan anticline, mostly exposed on the western flank and have small exposure on the eastern flank. The maximum thickness of Tiyon formation at the studied area is about 175 feet.

The Tiyon formation consists of shale, limestone and clay. It is further divided into two units (Shale unit and Limestone unit). In the studied area the Tiyon formation dips at 4° NW. The Tiyon formation has a conformable contact with the underlying Laki Formation and upper contact in the studied

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area is unconformable with the Nari Formation.

**Systematic classification of Smaller Foraminifera:**

In this work Cushman (1959) classification of foraminifera; including their recent revision of the classification of foraminifera (Cushman foraminiferal research institute) has been adopted. The smaller foraminifera were identified at the generic level.

**Smaller foraminifera of Laki limestone member of Laki Formation:**

**Family: ROTALIDAE.**
**Sub Family: ROTALLINAE.**
**Genus: EPONIDES Montfort, (1808).**



**Description:**

Test trochoid, usually biconvex, umblical area closed but not typically with a plug, wall calcareous, perforate, aperture a low opening between periphery and umblical area, usually well away from the peripheral margin.

**Remarks:**

Rare specimen, characterized by small umblicus, a low opening between the periphery and umblical area.

**State of preservation:**

Moderately preserved, chambers and sutures are not fully shown.

**Family: ROTALIDAE.**
**Sub Family: DISCORBINAE.**
**Genus: VALVULINERIA Cushman, (1926).**



**Description:**

Test trochoid, close coiled, ventrally umblicate, chambers numerous, wall calcareous, finely perforate, aperture ventral, large extending from the umblicus toward the periphery, often with a thin plate filling the umblical area, sometimes extending into the face of the chamber, becoming tripartite.

**Remarks:**

Moderately preserved. Chambers and umbilicus are moderately shown.

**State of preservation:**

Moderately preserved with distinct rips.

**Family: ROTALIDAE.**
**Sub Family: DISCORBINAE.**
**Genus: GYROIDINA depressa d'Orbigny.**



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**Description:**

Test trochoid, ventral side usually convex, umblicus small and deep, spiral suture with a depressed channel, chambers numerous, wall calcareous, finely perforate, aperture a low arched opening on the ventral side toward the umbilical area.

**Remarks:**

Rare specimen, characterized by large opening umblicus, shows clear affinity with G. Girardana, because of its biconvex shape, it resembles with Eponides.

**State of preservation:**

Well preserved specimen exhibiting the sutures clearly.

**Family: LAGENIDAE.**
**Sub Family: NODOSARIINAE**
**Genus: ROBULUS Montfort, (1808).**



**Description:**

Test calcareous-arenaceous, bilaterally symmetrical, typically close coiled and involute, chambers numerous, triangular in side view; aperture spherical glassy, the median slit enlarged in the middle of the end of the apertural face.

**Remarks:**

Well preserved specimen, characterized by small umblicus.

**State of preservation:**

Moderately preserved, chambers and sutures are shown.

**Family: MILIOLIDAE.**
**Genus: MASSILINA secans, Schlumberger, (1893).**



**Description:**

Test with the early chambers Quinqueloculina, later ones added on opposite sides in a single plane, Quinqueloculina stage is present in both megalospheric and microspheric forms; wall often with a arenaceous layer, aperture simple; typically with a bifid tooth.

**Remarks:**

Rare specimen found in Laki limestone member of Laki Formation.

**State of preservation:**

Rare preserved, chambers and apertures are not clearly shown.

**Family: MILIOLIDAE.**
**Genus: QUINQUELOCULINA d'Orbigny.**



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**Description:**

Test with the coiling in five planes, the chamber a half coil in length, five chambers completing a cycle of two turns about the axis in section but two and a half coil lengthwise, wall calcareous imperforate layer, in some species with in outer layer of sand grain, aperture at the end of the chamber, rounded, typically with a simple tooth.

**Remarks:**

Moderate specimen found in Laki limestone member of Laki Formation.

**State of preservation:**

Moderately preserved, chambers and apertures are shown.

**Family: ANOMALINIDAE.**
**Sub Family: CIBICIDINAE.**
**Genus: CIBICIDOIDES Brotzen, (1936).**



**Description:**

Test trochoid, biconvex, both dorsal and ventral sides nearly involute, aperture near the peripheral margin of the last formed chamber and extending along the inner border of the chamber on the dorsal side.

**Remarks:**

Rare specimen found in Laki limestone member of Laki Formation.

**State of preservation:**

Rare preserved, chambers and sutures are not clearly shown.

**Family: ANOMALINIDAE.**
**Sub Family: CIBICIDINAE.**
**Genus: CIBICIDES Montfort, (1808).**



**Description:**

Test Plano-convex, trochoid, usually attached by the flattened dorsal side, wall calcareous, coarsely perforate, aperture peripheral at the base of the chambers, sometimes extending ventrally but typically with a long silt like extension. Dorsally between the inner margin of the chamber and the previous whorl; nearly at the length of chamber.

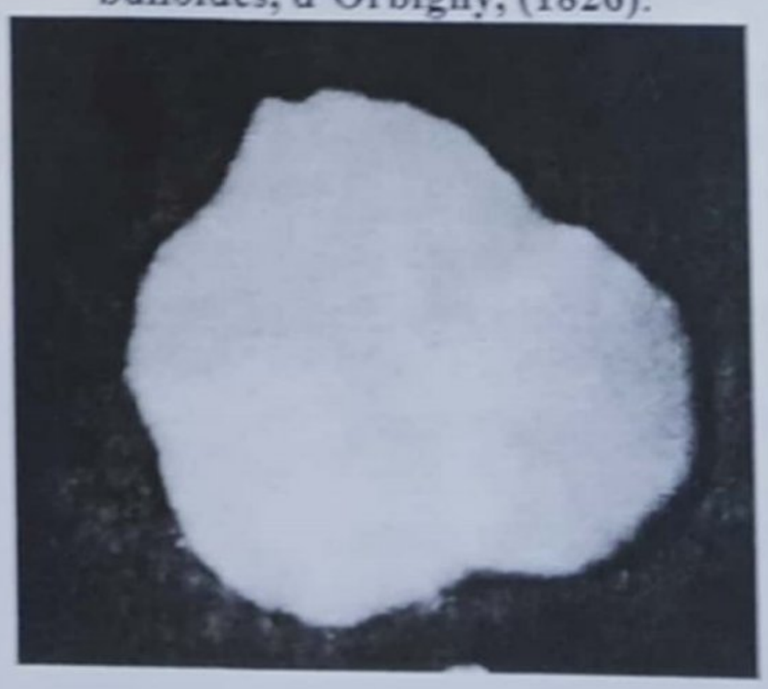
**Remarks:**

Rare specimen characterized by large opening of the umblicus.

**State of preservation:**

Well preserved, chambers and sutures are shown.

**Family: GLOBIGERINIDAE.**
**Sub Family: GLOBIGERININAE.**
**Genus: GLOBIGERINA**
**bulloides, d'Orbigny, (1826).**



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**Description:**

Test trochoid throughout umblicate, chambers in the young stage especially of the microscopic form in a flattened trochoid form like Discorbis, usually smooth and the wall thin, later globular, wall calcareous, thick and cancellated in well preserved, aperture small opening into the umblicus.

**Remarks:**

Moderately specimen characterized by small aperture and resembles with Discorbis.

**State of preservation:**

Well preserved, aperture and globes are clearly shown.

**Family: GLOBIGERINIDAE.**
**Sub Family: GLOBIGERININAE.**
**Genus: GLOBIGERINELLA acquilateralis, Cushman, (1927).**



**Description:**

Test trochoid at least in the microscopic form later planispiral, aperture single, small opening into umblical side, fine spines covering the test in well preserved specimen.

**Remarks:**

Moderately specimen characterized by umblicus, small opening.

**State of preservation:**

Well preserved, aperture and globes are clearly shown.

**Family: NONIONIDAE.**
**Genus: ASTRONONION, Cushman and Edwards, (1937).**



**Description:**

Test free, planispiral, coiled, bilaterally symmetrical, periphery broadly rounded, chambers numerous, distinct, usually somewhat inflated, wall calcareous perforate, the aperture elongate along the peripheral posterior margin.

**Remarks:**

Rare specimen found in Laki limestone member of Laki Formation.

**State of preservation:**

Rare preserved, aperture and chambers are not clearly shown.

**Family: NONIONIDAE.**
**Genus: NONION, Montfort, (1808).**



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**Description:**

Test free, more or less involute, bilaterally symmetrical, periphery broadly rounded to acute, chambers numerous, wall calcareous finely-coarsely perforate, aperture median an arched, usually low opening between the base of the apertural face and the preceding coil.

**Remarks:**

Moderately specimen characterized by rounded or sub rounded chambers.

**State of preservation:**

Moderately preserved, sutures and chambers are clearly shown.

**Family: NONIONIDAE.**
**Genus: NONIONELLA, Cushman, (1926).**



**Description:**

Test free, trochoid, dorsal side only partially involute, ventral side completely so close coiled, inequilateral, ventral side developing a distinct elongate lose at umblical end covering the umblicus, wall calcareous finely perforate, ventral side is V-shaped, aperture is median.

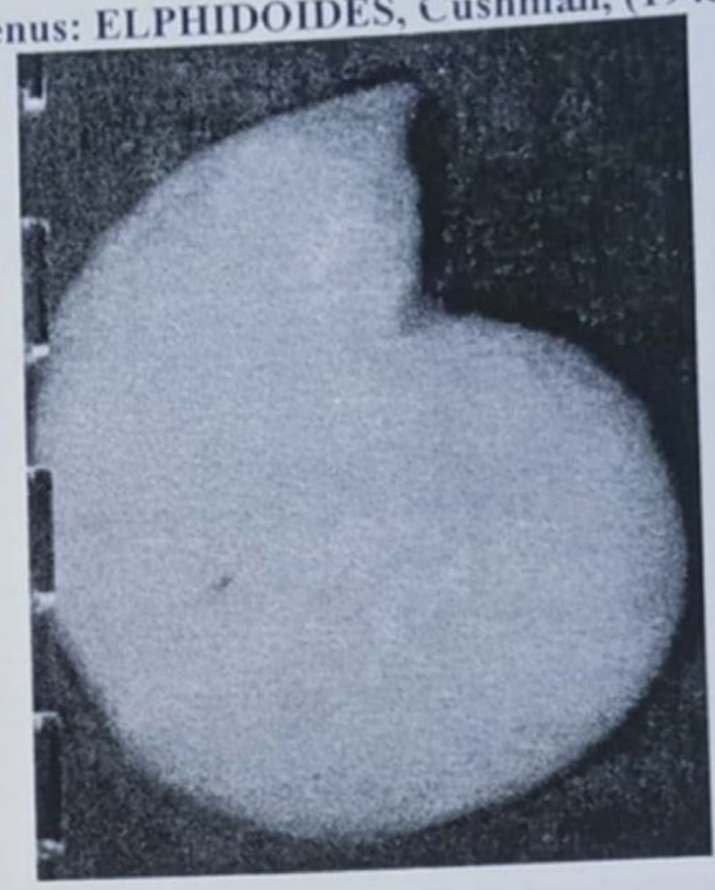
**Remarks:**

The specimen is characterized by umblicus.

**State of preservation:**

Moderately preserved, sutures and chambers are shown.

**Family: NONIONIDAE.**
**Genus: ELPHIDOIDES, Cushman, (1945).**



**Description:**

Test trochoid, dorsal side showing the early coils, ventral side involute, sutures with semi circular openings and retral processes, wall calcareous perforate, aperture consisting of a low opening on the ventral side at the base of the test formed chamber with a supplementary opening, irregularly V-shaped toward the base of the apertural face.

**Remarks:**

The specimen is characterized by large umblicus.

**State of preservation:**

Well preserved, sutures and chambers are shown.

**Smaller foraminifera of Tiyon formation:**

**Family: ROTALIDAE.**
**Sub Family: DISCORBINAE.**
**Genus: DISCORBIS, Lamarck, (1804).**



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**Description:**

Test typically Plano-convex, the ventral side flattened, chambers often produced to partially cover the umblical area, wall calcareous perforate, aperture at the base of the umblical margin on the ventral side of the chamber.

**Remarks:**

Rare specimen found and characterized by large umblicus.

**State of preservation:**

Moderately preserved, chambers and sutures are not fully shown.

**Family: ANOMALINIDAE.**
**Sub Family: ANOMALININAE.**
**Genus: ANOMALINA d'Orbigny, (1826).**



**Description:**

Test nearly involute; dorsally as well as ventrally, chambers added nearly in a planispiral manner, the inner coils of the dorsal side often appearing as a central raised boss, wall calcareous, perforate, aperture becoming peripheral at the base of the last formed chamber in the median line, sometimes with boss of clear material over the umblical region.

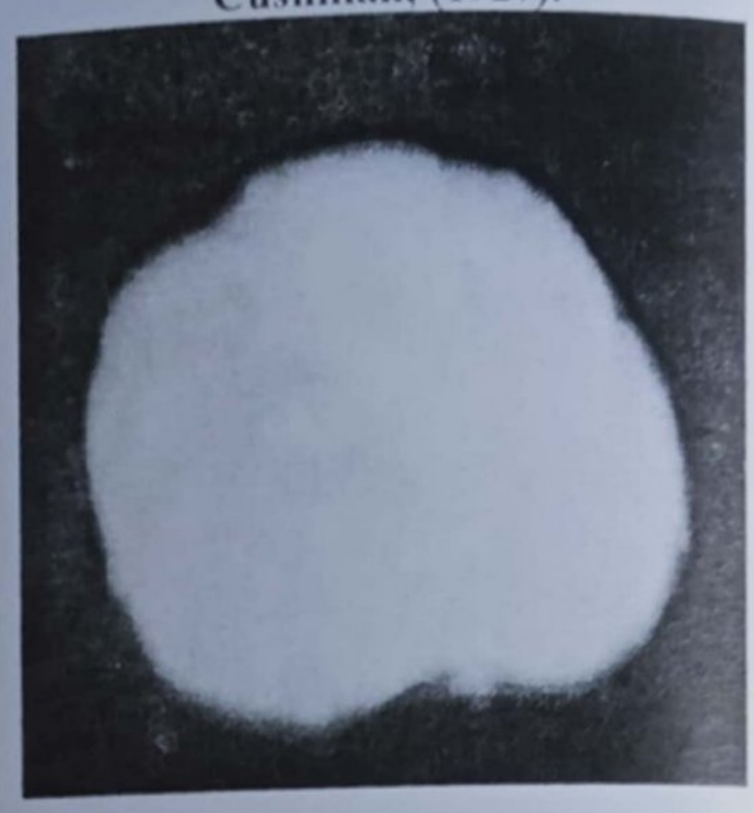
**Remarks:**

Moderately specimen characterized by large umblicus.

**State of preservation:**

Well preserved, chambers and sutures are clearly shown.

**Family: GLOBOROTALIDAE.**
**Genus: GLOBOROTALIA tumida, Cushman, (1927).**



**Description:**

Test trochoid, chambers often like globigerina, with rough cancellated exterior, biconvex, dorsal side more or less flattened, ventral side strongly convex, wall calcareous perforate, frequently spinose in whole or in restricted areas, aperture opening into the umblicus which is either open or partially covered by a lip.

**Remarks:**

Moderately specimen characterized by large aperture opening into the umblicus or partially covered by a lip.

**State of preservation:**

Well preserved, aperture and globes are clearly shown.

**Family: GLOBOROTALIDAE.**
**Genus: GLOBOROTALIA faimbriata, Cushman, (1927).**



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**Description:**

Test trochoid, chambers often like globigerina, with rough cancellated exterior, biconvex, dorsal side more or less flattened, ventral side strongly convex, wall calcareous perforate, frequently spinose in whole or in restricted areas, aperture opening into the umblicus which is either open or partially covered by a lip.

**Remarks:**

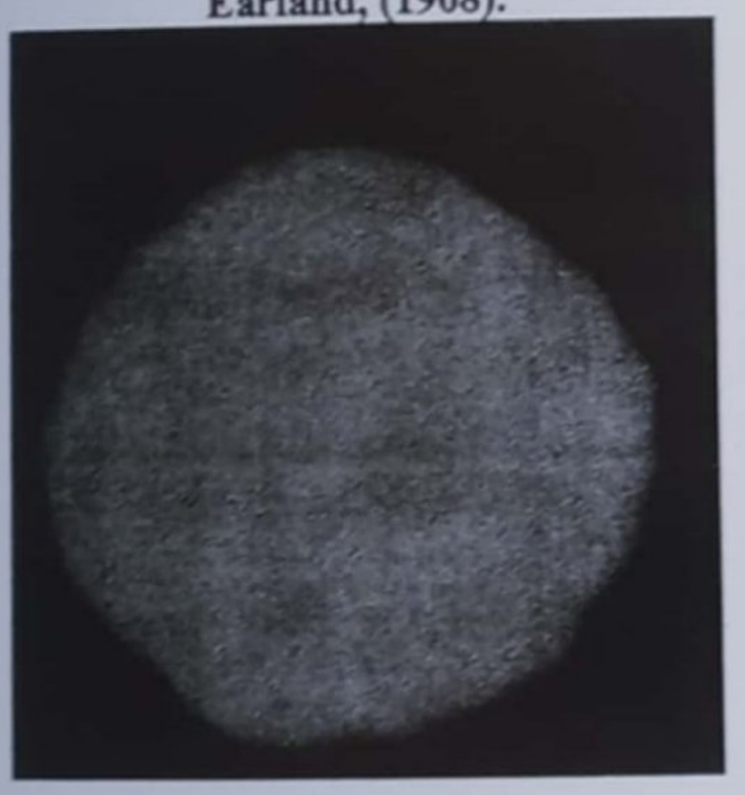
Moderately specimen characterized by large aperture opening into the umblicus or partially covered by a lip.

**State of preservation:**

Well preserved, aperture and globes are clearly shown.

**Family: GLOBOROTALIDAE.**

**Genus: CYCLOLOCULINA, Heron-Allen and Earland, (1908).**



**Description:**

Test with the chambers in a low trochoid spire, chambers elongate, periphery somewhat spinose, later chambers still more elongate, finally becoming annular, wall calcareous, coarsely perforate, no general aperture, the large coarse perforations serving as aperture.

**Remarks:**

Rare specimen characterized by elongated chambers, the large coarse perforations serve as aperture.

**State of preservation:**

Rare preserved, chambers and sutures are not fully shown.

## 3. Paleoecology:

In the present investigation, Paleoecology of the area on the basis of Smaller foraminifera is determi. d and the area is assigned following three assemblage zones:

[1] Brackish water zone: By the presence of Eponides and Quinqueloculina. These fossils are capable of tolerating a low percentage of salinity.

[2] Shallow water zone: By the presence of Cibicides and Cibicidoides.

[3] Deep water zone: This zone is characterized by the presence of Gyroidina.

Some fossils are found to live both in Shallow as well as Deep water conditions, therefore, they are not good indicators of Paleoecology; they include: Valvulineria, Robulus and Nonionella.

## 4. Acknowledgement:

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