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Planktonic zonation from the contact of Laki Formation (Early Eocene) and Tiyon Formation (Middle Eocene) Thana Bula Khan, Lower Indus Basin, Sindh, Pakistan

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Abstract

In terms of planktonic foraminiferal zonation, the Ypresian (Early Eocene) and Lutetian (Middle Eocene) boundary is drawn between Laki and Tiyon formations on the basis of reported species *Acarinina pentacamerata, Hantkenina liebusi, Hastigerina bolivariana, Globigerinattheka subconglobata subconglobata, Globigerina lozanoi colom* and *Turborotaia cerroazulensis possangoensis* adopting the zonation of Bolli, Subbotina, Shokina and Shutskaya.

Age confirmed on the basis of these species is Late Ypresian to Early Lutetian and thus can be correlated to the Lutetian of Paris Basin and Gulf coastal region.

Keywords: Laki Formation; Tiyon Formation; Middle Eocene (Ypresian–Lutetian)

1. Introduction

Study of foraminifera in Pakistan started as early as 1849 with larger foraminifera reported from 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 larger foraminifera. Studies on smaller foraminifera as well as planktonic foraminifera were initiated by Haque (1956); who carried out systematic study of foraminifera from the Paleocene-Eocene succession of Nammal gorge section, Salt Range. However, these studies of smaller and planktonic foraminifera in Pakistan are few and voids have been left in the systematic micropaleontology and stratigraphic correlation of the sequence with adjacent basin. There are numerous regions whose Cenozoic assemblages of smaller and planktonic foraminifera have not been studied systematically. 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 Sindh took this situation into account and worked on the Eocene smaller foraminifera of Sindh.

2. Geology of the studied area

The studied area is the western flank of Surjan anticline, located South East of Thano Bulla Khan Town, District Jamshoro, Sindh; and lies in Toposheet No.35 0/15 in between:
Longitude: $67^0\ 55'\ 20''$ to $67^0\ 55'\ 00''$ E
Latitude: $25^0\ 17'\ 40''$ to $25^0\ 20'\ 05''$ N

At the Chohar pass area of Surjan Anticline the Laki Limestone of Laki Formation, Tiyon Formation and Nari Formation are exposed.

2.1. Laki Formation

The term Laki Formation was introduced by Cheema et al. (1977) for the Laki group of the Jones (1960) and the Laki series of the Noetling (1903). Blanford (1879) included series of massive limestone containg *Alveolina spp.* An Early Eocene age was assigned to Laki Formation by Vredenbreg (1907), Nuttall (1925), Davies (1926), Haque (1962) and Jones (1960).

In the studied area the Laki Formation contains Laki Limestone member. Its basal part is massive and chalky, overlain by nodular

limestone which is interbedded with calcareous shale, nodules are hard and marly. Shale is highly fossiliferous. At the contact with Tiyon Formation the top of Laki Limestone is nodular containg chert nodules and is conformable. At the Chohar Pass along the road the thickness of Laki Limestone is 678 feet.

It dips (45^0-78^0) steeply on the eastern flank and dips (5^0-3.5^0) gently on the western flank of Surjan anticline.

2.2. Tiyon Formation

The Tiyon Formation is a thin, distinct rock unit between the Laki Limestone and Kirthar which was mapped as a separate unit and named as Tiyon Formation by the Jones (1960). Its name was derived from the Tiyon Nai or stream which flows from the western flank of the Laki Range, where type section of the formation is exposed.

The Tiyon Formation is exposed on the both flanks of the Surjan anticline mostly exposed on the western flank and has small exposure on the eastern flank. The maximum thickness of Tiyon Formation at the studied area is about 175 feet and dips (5^0 – 3.5^0 NW). The Tiyon Formation consists of shale, limestone and clay. The shale is greenish grey, yellowish brown, calcareous and gypsiferous. The limestone is nodular interbedded with few cm thick marl and massive limestone which is hard and highly fossiliferous. The Tiyon Formation has a conformable contact with the underlying Laki Formation and unconformable contact with overlying Nari Formation.

3. Material and Methods

25 samples from Laki Formation and 20 samples from Tiyon Formation were collected from contact upward at regular (5 ft) intervals. The samples were washed, sieved and picked under microscope for SEM study.

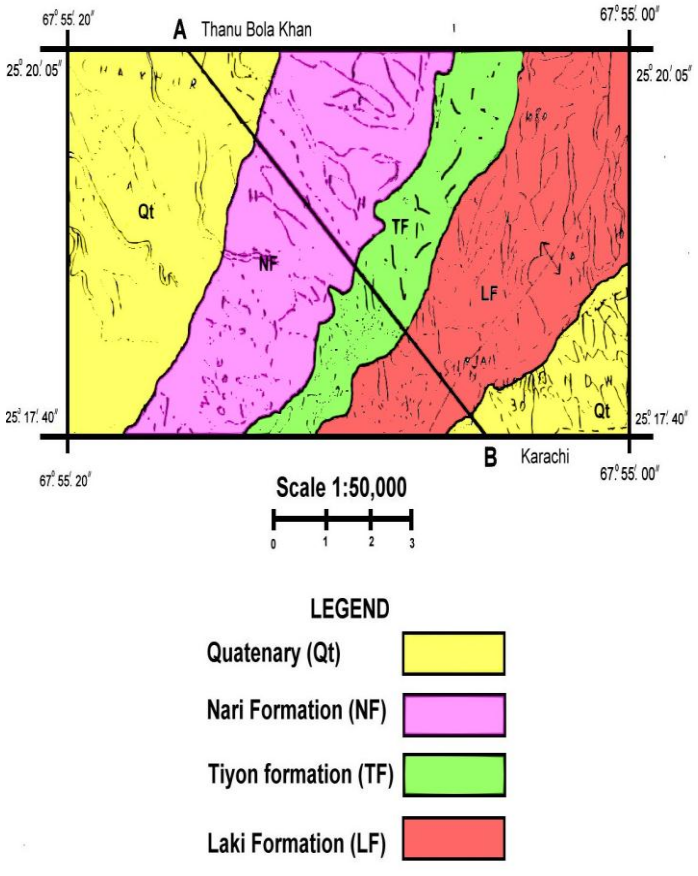

Fig. Geological Map of the studied area.

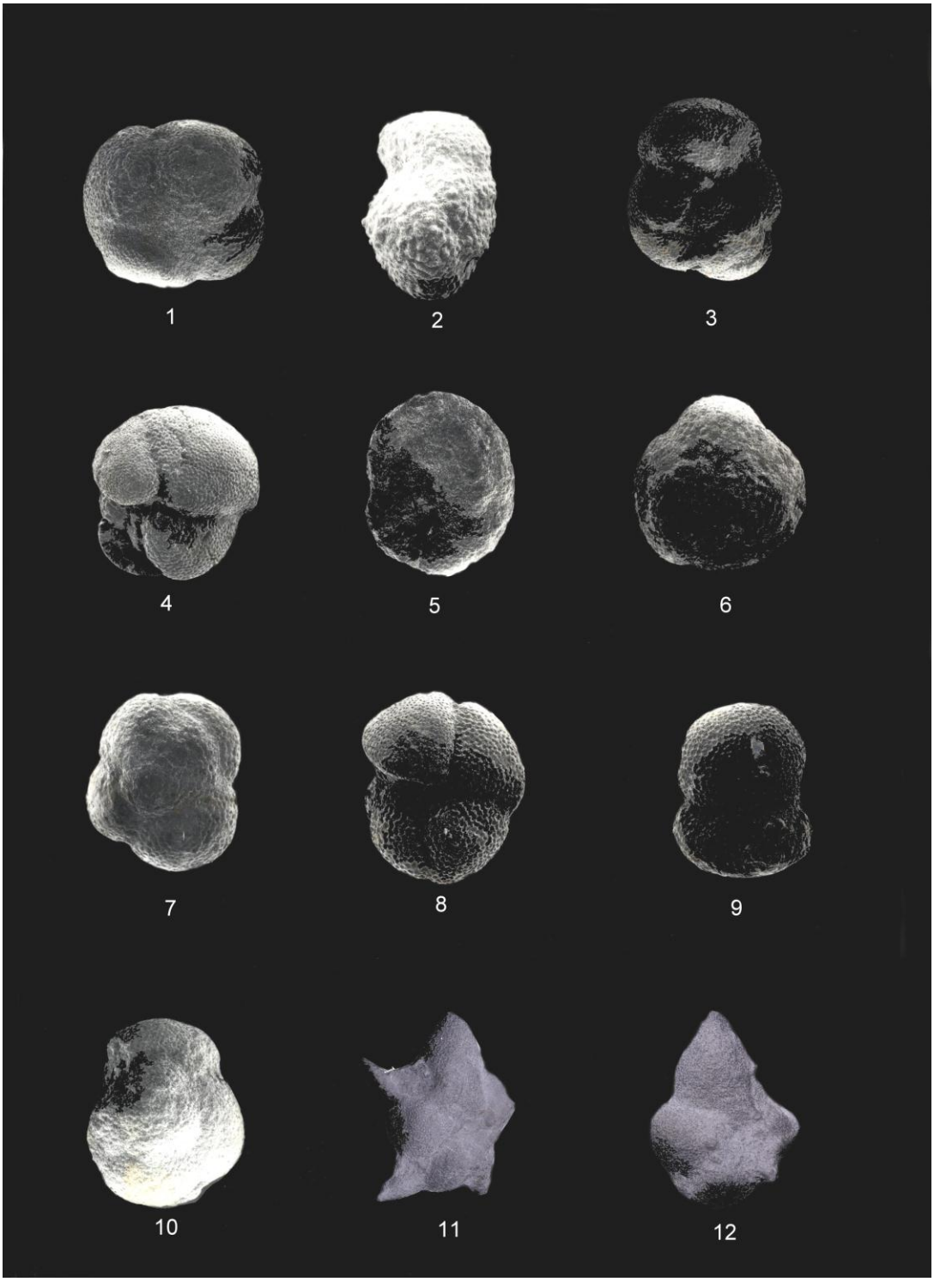

Fig. 1. ***Globigerina theka subconglobata euganea Proto Decima and Bolli***
Lateral view from the sample Tyt-4, Tyt-6
Occurrences Lutetian

Fig. 2. ***Acarinina pentacamerata Subbotina 1947***
Dorsal view from the sample Lkt-9, Lkt-12,Tyt-2
Occurrence: Late Ypresian to early Lutetian

Fig. 3. ***Globigerina higginsi Bolli 1957***
Lateral view from the sample Lkt-4, Lkt-8, Tyt-5,Tyt-6

Fig. 4. ***Hastigerina.cf.bolivariana***
Dorsal view from the sample Lkt-4, Tyt-2

Fig. 5. ***Turborotalia cerroazulensis pomeroli***
Dorsal view from the sample Tyt-7, Tyt-4

Fig. 6. ***Globigerina theka subconglobata subconglobata***
Ventral view from the sample Tyt-4, Tyt-9

Fig. 7. ***Globigerina lozanai* Colom**
Dorsal view from the sample Lkt-5, Tyt-2

Fig. 8. ***Globigerina spinuloinflata***
Ventral view from the sample Tyt-6

Fig. 9. ***Hastigerina bolivariana***
Dorsal view from the sample Lkt-14, Tyt-6

Fig. 10. ***Turborotalia cerroazulensis possangoensis***
Dorsal view from the sample Tyt-4

Fig. 11. ***Hantkenina dumblei***
Ventral view from the sample Lkt-25, Tyt-1 at contact

Fig. 12. ***Hantkenina liebusi***
Ventral view from the sample Tyt-5

4. Systematic Paleontology

***Globigerinatheka subconglobata euganea* (Shutskaya, 1958)**
(Plate No.1, Fig. 1)
Globigerinoides subconglobates Chalilov var.
Subconglobeta chalilov in Shutskaya, 1958, pp. 86-87, pl.1, figs. 4-11.
Stratigraphic Range: The stratigraphic age of recorded species is typical Middle Eocene.

***Acarinina pentacamerata* (Subbotina)**
(Plate No.1, Fig. 2)
Globorotalia pentacamerata Subbotina, 1947, pp. 128-9, pl.7, fig. 12, pl. 9, figs. 24-26.
Stratigraphic Range: Stratgraphic age of figured specimen is Early–Middle Eocene
(Acarinina pentacamerata zone)

Globigerina higginsi
(Plate No.1, Fig. 3)
Globigerinoides higginsi Bolli, 1957c, pp. 164, pl. 36, figs. 11-13.
Globigerina (Globigerina) higginsi (Bolli), Kenkins, 1971, pp. 149, pl. 16, figs. 469-470.
Stratigraphic Range: Globorotalia pentacamerata zone. Stratigraphic age of recorded species is Early–Middle Eocene.

Hastigerina cf. H. bolivariana
(Plate No.1, Fig. 4)
Bolli (1957), pl. 37, figs. 14a-16.
Stratigraphic Range: This form differs from *Hastigerina bolivariana* by its smaller size less planispiralcoiling and a less globular last chamber. This species is very abundant during the Orbulinoides beckmani zone of Bolli (1957). Stratigraphic age of recorded species is Middle Eocene.

***Turborotalia cerroazulensis pomeroli* (Toumarkine and Bolli)**
(Plate No.1, Fig. 5)
Turborotalia cerroazulensis pomeroli Toumarkine and Bolli, 1970, pp. 140, pl.1, fig. 13.
Stratigraphic Range: Stratgraphic age of figured specimen is Middle Eocene.

Globigerinathheka subconglobata subconglobata
(Plate No.1, Fig. 6)
Subconglobeta chalilove (ms) in Shutskaya, 1958, pp.86-7, pl.1, figs. 4-11
Bolli (1972) designated the specimen figured by Shutskaya (1958) on pl.1, fig.8
Stratigraphic Range: Globigerapsis kugleri zone by Bolli (1957) but Proto Decima andBolli (1970) named it Globigerapsis subconglobata *curryi*. Bolli(1972) renamed the zone as Globigerinathheka subconglobata subconglobata zones.Stratigraphic age of given specimen is Middle Eocene.

***Globigerina lozanoi* (Colom)**
(Plate No.1, Fig. 7)
Globigerina lozanoi Colom, 1954, 1979, pp. 855, specimenfigured by Colom, pl. 2, fig. 45.

Globigerina yeguaensis Weinzierl and Applin, 1929, pp. 498, pl.43, figs. 1a-b
Stratigraphic Range: Hantkenina nutalli zone of Bolli.The stratigraphic age of figured specimen is Early to Middle Eocene.

***Globigerina spinuloinflata* (Bandy)**
(Plate No.1, Fig 8)
Globigerina spinuloinflata Bandy, Bull. Amer. Paleontol., vol. 32, No.131, pp.122, pl.23, figs.1
Globorotalia spinuloinflata (Bandy)-Bolli, 1957, p.168, pl.38, figs. 8a-c
Stratigraphic Range: Hantkenina aragonensis zone to Porticulasphaera Mexicana zone,Navet Formation.Stratigraphic age of recorded specimen is Middle Eocene.

Hastigerina bolivariana
(Plate No.1, Fig 9)
Globigerina wilsoni bolivariana Petters, 1954, pp. 39
Stratigraphic Range: Orbulinoid beckmanni Zone of Bolli (1957). Stratigraphic age of figured specimen is Middle to Late Eocene.

***Turborotalia cerroazulensis possagnoensis* (Toumarkine and Bolli)**
(Plate No.1, Fig. 10)
Turborotalia cerroazulensis possagnoensis Toumarkin and Bolli, 1970, pp. 139, pl.1, fig. 4
Stratigraphic Range: Morozovella lehneri zone.The stratigraphic age of figured specimen is Middle Eocene.

Hantkenina dumbeli
(Plate No.1, Fig. 11)
Globorotalia broedermani Cushman and Bermudez, 1949
Globorotalia broedermani Cushman and Bermudez – Bolli, 1957, US. Nat. Mus. Bull.
Stratigraphic Range: *Hantkenina dumbeli* was reported by Weinzierl and Applin, 1929 from the Middle Eocene, G. yeguaensis zone to the base of C. unicavus zone, Texas. Stratigraphic age of figured specimen is Middle – Late Eocene.

***Hantkenina liebusi* (Shokina)**
(Plate No.1, Fig. 12)
figs. 24, 6a, 7 foraminiferal beds, iiskaya, Neaucasus, US
Stratigraphic Range: Hantkenina nutalli zone of Bolli. The stratigraphic range of figured species is Middle to Early Eocene.

5. Conclusion

The Eocene period is characterized by having abundant fauna throughout the world. In the present paper association of rich and well preserved planktonic foraminiferal assemblage along with the abundantly occurring larger foraminiferal genera including Alveolina, Assilina, Orbitoides, Dictyoconoides, Discocylina and Nummulities has been found in the study area. In this paper twelve Early–Middle Eocene zone marker species have been reported from Tiyon Formation e.g. *Acarinina pentacamerata* (Subbotina, 1947), *Globigerinatheka subconglobeta euganea* (Proto Decima and Bolli, 1970), *Hantkenina liebusi* (Subbotina, 1953), *Hastigerina.c.f. bolivariana* (Bolli, 1957*)* and *Turborotalia cerroazulensis pomeroli* (Toumarkine and Bolli, 1970*)* are present at the contact of Laki and Tiyon formations at Chuhar Pass, Thana Bola Khan, Lower Indus Basin, Sindh. On the basis of the reported species the age of Laki Formation is confirmed as Early Eocene and the age of Tiyon Formation is confirmed as Middle Eocene which can be correlated to the Lutetian of Paris Basin and Gulf coastal region.

Table 1. Zonation of Planktonic foraminifera of Tiyon Formation (Late Early to Middle Eocene)

Eocene Early Laki Formation	Middle Tiyon formation	Lower Kirthar Formation	Planktonic Foraminifera	Author
			Acarinina pentacamerata	Subbotina 1947,
			Globigerinatheka subconglobata euganea	Proto Decima and Bolli, 1970
			Globigerinatheka subconglobata subconglobata	Shutskaya, 1958
			G. lozanoi	Colom, 1954
			G. spinuloinflata	Bolli, 1957
			G. higginsi	Bolli, 1957
			Hantkenina dumblei	Cushman and Bermudez, 1949
			Hantkenina liebusi	Subbotina, 1953
			Hastigerina bolivariana	Petters, 1954
			Hastigerina. cf. H. bolivariana	Bolli, 1957
			Turborotalia cerroazulensis pomeroli	Toumarkine and Bolli, 1970
			Turborotalia cerroazulensis possangoensis	Tumarkine and Bolli, 1970

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