

# Saddle-shaped reticulate *Nummulites* from Early Oligocene rocks of Khari area, SW Kutch, India

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Saddle-shaped reticulate *Nummulites* from the Early Oligocene rocks of Khari area, SW Kutch, India is reported here for the first time. Unusual shape of this *Nummulites* is due to the curved nature of the coiling plane, indicating space constrained postembryonic test growth. With regular development of chambers, septa and septal filaments, the saddle-shaped *Nummulites* constitutes the third morphotype of *N. cf. fichteli* Michelotti form A. Other morphotypes of the species reported earlier include inflated lenticular and conical tests. Multiple morphotypes of *N. cf. fichteli* form A indicates varied test growth in response to substrate conditions. Morphological variability exhibited by *N. cf. fichteli* form A from Kutch and some Early Oligocene reticulate *Nummulites* from the Far East are comparable. This faunal suite is morphologically distinct from the contemporary reticulate *Nummulites* of the European localities.

## 1. Introduction

The shallow marine Early Oligocene rocks of Kutch, western India are rich in larger foraminifera *Nummulites* Lamarck. The *Nummulites* fauna, constituting more than 85% of the total larger foraminifera assemblage, comprises a low diversity assemblage of reticulate and striate taxa (Nuttall 1925; Mohan 1965; Dasgupta 1970; Sengupta 2000, 2002, 2009; Sukla 2008). While reexamining the Early Oligocene larger foraminifera from parts of SW Kutch, the present researchers came across several saddle-shaped megalospheric tests of reticulate *Nummulites*. It appears that this taxon escaped the attention of previous researchers because of its unusual shape, which cannot be attributed to growth defect of the foraminifer as the specimens show regular development of chambers, septa, septal filaments and whorl wall. Detailed account of the saddle-shaped reticulate *Nummulites* from SW Kutch is presented in this

paper with a view to augment the systematics of reticulate *Nummulites* of Kutch in general and address the aspect of large morphological variability exhibited by some megalospheric tests in particular.

## 2. Materials and methods

Twentyeight megalospheric tests of saddle-shaped reticulate *Nummulites* were recovered from *in situ* rock samples collected at 1 m stratigraphic interval from 3.0–3.5 m thick, lithologically distinctive yellowish brown glauconitic marl of the Basal member, exposed along the flanks of Rakhdi, Berwali and Golay streams in Khari (23°28'N, 68°41'E) area of SW Kutch (figure 1). This lithostratigraphic unit is the lowermost part of the Maniyara Fort Formation of Early Oligocene age, which rests unconformably over the Middle Eocene Fulra Limestone (Biswas 1992). The Basal member rocks

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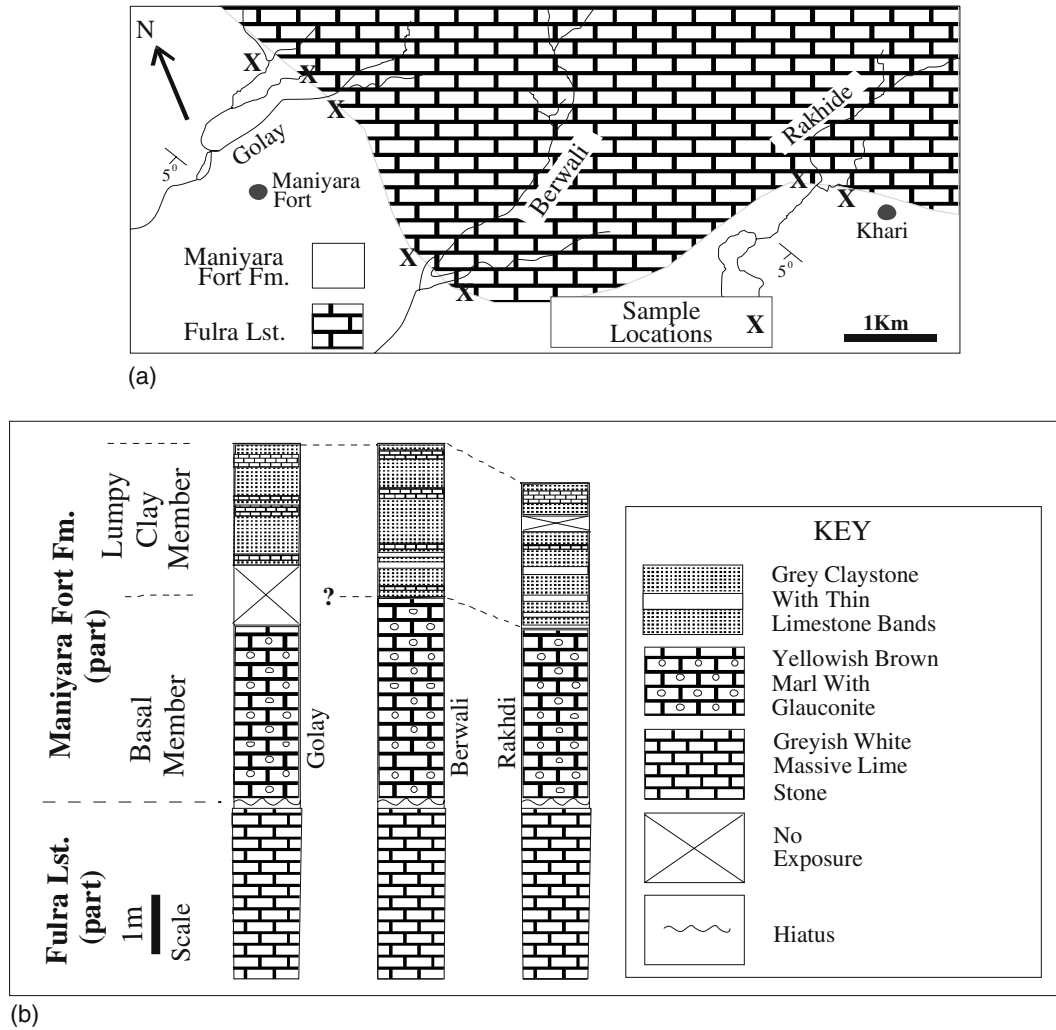


Figure 1. Geological map of Khari area, SW Kutch and portions of Palaeogene rocks exposed in traverses along Golay, Berwali and Rakhdi streams (after Sengupta 2009, figures 1–2). (a) Sample locations. (b) Lithocolumns along traverses showing Basal member and Lumpy Clay member rocks (Early Oligocene) of the lower part of Maniyara Fort Formation resting unconformably over the upper part of Fulra Limestone (Middle Eocene). Rock samples were collected from the Basal member at 1 m stratigraphic interval.

contain high abundance of reticulate *Nummulites* (table 1).

All tests were externally examined under the stereo microscope. Internal features were observed in oriented sections of matrix free tests and centered tests encountered in thin sections of rocks. Equatorial and axial sections were prepared parallel and perpendicular to the crest of the saddle-shaped tests respectively (figure 2). Four equatorial and six axial sections were examined. Specimens illustrated in this work are deposited in the Geology Department of Calcutta University.

### 3. Systematic palaeontology

Order: Foraminiferida  
 Family: Nummulitidae de Blainville, 1825  
 Genus: *Nummulites* Lamarck, 1801

#### *Nummulites* cf. *fichteli* Michelotti

Pl. 1, figures 1–8

2000 *Nummulites* cf. *fichteli* Michelotti; Sengupta; p. 673–677, Pl. 1, figures 1–14

2002 *Nummulites* cf. *fichteli* Michelotti; Sengupta; p. 223–224, figure 1

**Megalospheric form:** Test small (D 2.6–3.5 mm), saddle-shaped and asymmetric. Surface smooth. Septal filaments show reticulate pattern.

Equatorial section is elliptical in outline. Large elliptical embryonic apparatus (maximum dimension 480–650  $\mu$ ) consists of subcircular protoconch (maximum dimension 450–500  $\mu$ ), and crescentic deuteroconch. Spire short, comprising 3–4 whorls. Portion of the spire along the saddle crest shows longer than high chambers and short inclined septa. Peripheral chambers may be nearly two times longer than high. Marginal cord thickens

Table 1. Classification of A form reticulate 'Nummulites' from Oligocene rocks of Kutch.

Author	Taxa	Test D (mm)	Test shape	Protoconch	Whorls
Nuttall (1925)	<i>N. fichteli</i>	3.3–4.5	Biconvex	Subcircular; 290–370 $\mu$	Nearly 6 whorls in a radius of 1.5 mm in both
	<i>N. clypeus</i>	5.5 (av.)	Biconvex with apical mamelon	Subcircular; 250–360 $\mu$	
Mohan (1965)	<i>N. fichteli</i>	3.0–5.6	Biconvex; apical mamelon variable	Subcircular; similar to Nuttall's (1925) taxa	5–5
Dasgupta (1970)	<i>N. fichteli</i>	2.5–6.0	Biconvex; includes feeble apical mamelon	Circular; 450 $\mu$ (av.)	5–10
	<i>N. clypeus</i>	3.0–5.5	Biconvex with strong apical mamelon	Subcircular; 350 $\mu$ (av.)	6–8
Sengupta (2000, 2002)	<i>N. cf. fichteli</i>	3.0–4.6	Both biconvex and conical	Subcircular – irregular; 600–800 $\mu$	5.5
Sukla (2008)	<i>N. fichteli</i> forma <i>fichteli</i>	4.25–6.00	Biconvex	Circular – subcircular; 400–750 $\mu$	5–7
	<i>N. fichteli</i> forma <i>clypeus</i>	2.10–6.25	Biconvex with strong apical mamelon	Subcircular; 350–800 $\mu$	2–7
Sengupta (this paper)	<i>N. fichteli</i> forma <i>granulata</i>	2.15–5.75	Biconvex	Subcircular; 400–600 $\mu$	4–7
	<i>N. cf. fichteli</i>	2.6–3.5	Saddle-shaped	Subcircular; 450–510 $\mu$	3–4

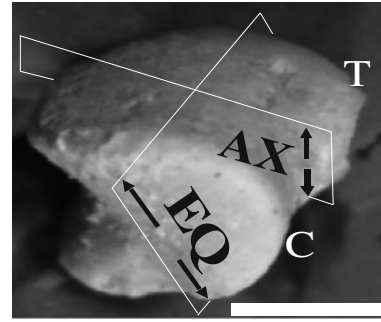


Figure 2. *N. cf. fichteli* form A from Pl. 1, figure 1 showing saddle crest (CT), plane of equatorial section (EQ) and plane of axial section (AX). Test attains maximum dimension equal to its diameter along CT. Test dimension is minimum across CT. Bar scale 1 mm.

with ontogeny from about one third the chamber height in early whorls to nearly half the chamber height in peripheral whorls.

Axial section is triangular in outline. Test asymmetric in the coiling plane. Large elliptical embryonic apparatus (maximum dimension 480–932  $\mu$ ) is followed by few whorls ( $\sim 3$ ). Vary in outline; crescentic chambers may be nearly two times wider than high, while triangular chambers are slightly higher than wide. Curved alignment of chambers on either side of the embryonic apparatus indicates the curved nature of the plane of coiling. The degree to which the equatorial plane is curved strongly varies between individuals. Marginal cord thinner than chamber height. Spiral laminae thicker than alar prolongation. Wide alar prolongation extends up to the pole. Pillars are uniformly distributed from periphery to pole and do not extend to the outside of test.

**Remarks:** Nuttall (1925) classified the Oligocene reticulate *Nummulites* of Kutch as *N. fichteli* – the omnipresent European taxon and a new endemic taxon – *N. clypeus* (table 1). However, majority of subsequent researchers like Sastri *et al* (1964); Mohan (1965); Chatterji and Mathur (1966); Mohan and Gupta (1968); Raju *et al* (1970); Mohan and Pandey (1971); Mohan (1982); Samanta *et al* (1985); Samanta (1988); Biswas (1992); Saraswati (1995), Sarkar *et al* (1996); Saraswati *et al* (1993, 1997) and Sarangi *et al* (1998) referred the Kutch reticulate *Nummulites* as *N. fichteli*. Sukla (2008) recognized *N. fichteli* forma *fichteli* forms A and B, *N. fichteli* forma *clypeus* forms A and B and *N. fichteli* forma *granulata* forms A in materials from Berwali stream section, SW Kutch. Tewari (1956, 1957); Tewari and Singh (1969); Dasgupta (1970, 1977) and Tandon (1976) followed Nuttall's (1925) two-fold classification of the reticulate *Nummulites*. Sen Gupta (1959) first accepted the Nuttall's (*op. cit.*)

classification but subsequently (Sen Gupta 1964) abandoned it in favour of *N. fichteli*.

Sengupta (2000, 2002) observed that *N. fichteli* Michelotti and *N. clipeus* Nuttall are difficult to

distinguish and opined that the Kutch reticulate *Nummulites* may be classified as *N. fichteli-clipeus* Group and *N. cf. fichteli* (table 1). The taxon *N. cf. fichteli* includes moderately large B form tests with

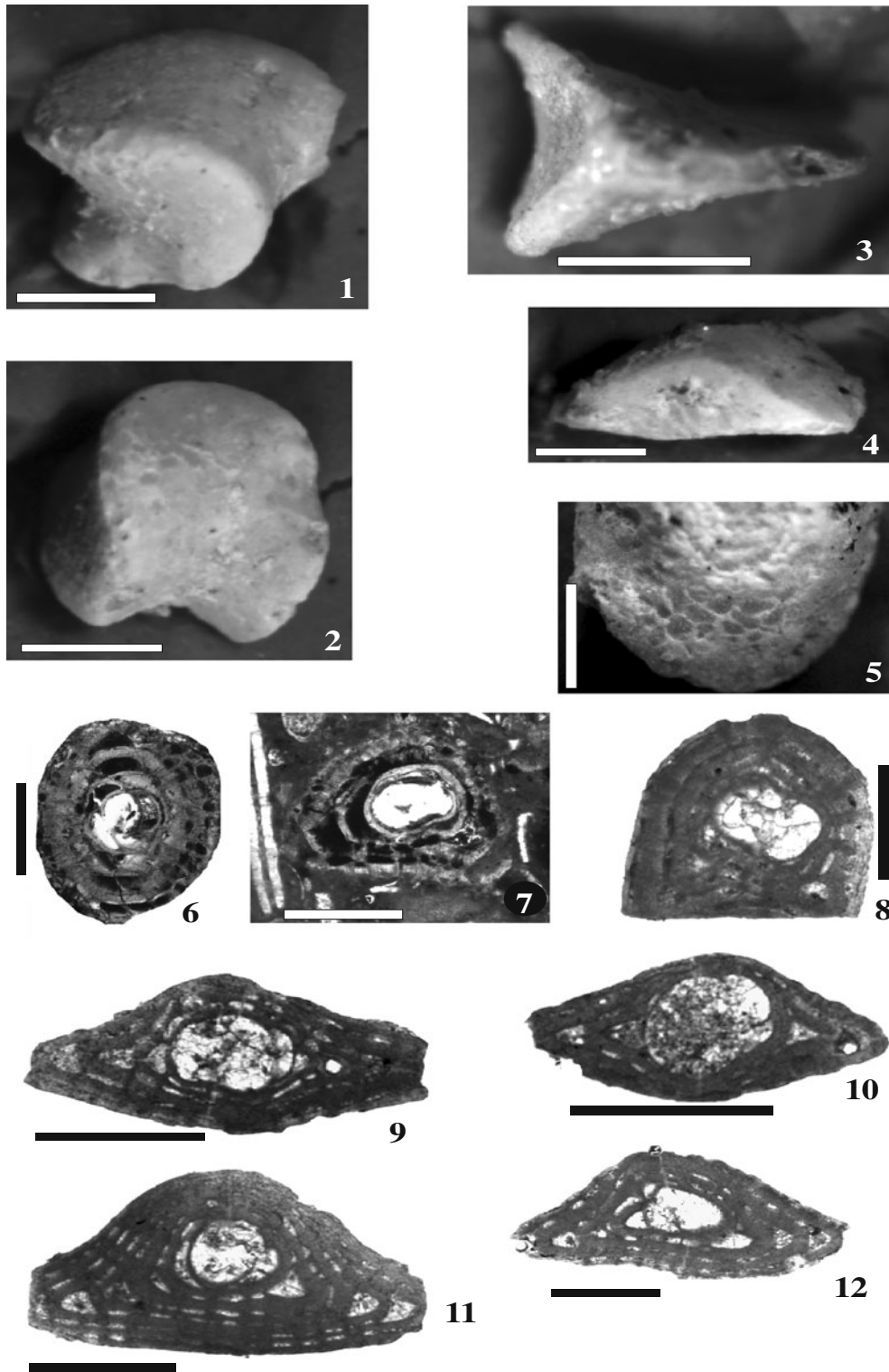


Plate 1. Morphotypes of *Nummulites* cf. *fichteli* Michelotti form A, Early Oligocene, Basal member, Maniyara Fort Formation, Khari area, SW Kutch. (1–8) Saddle-shaped morphotype; (9–10) lenticular morphotype, and (11–12) conical morphotype. 1–4: External views; 1 and 2 are different views of same test; 5: decorticated surface showing septal filaments; 6: equatorial section; and 7–12: axial sections. All bar scales 1 mm.

multiple spire and small A form tests with short spire, large embryonic apparatus and multiple morphotypes. Multiple morphotypes include inflated lenticular and conical tests (see, Pl. 1, Figs. 9–12). The saddle-shaped *Nummulites* are presently identified as a new morphovariant of *N. cf. fichteli*. The size range of this morphotype (D 2.6–3.5 mm) is slightly less than that recorded earlier in *N. cf. fichteli* form A (D 3.0–4.6 mm; Sengupta 2000). No new microspheric form was found associated with the saddle-shaped *Nummulites*. *N. cf. fichteli* occurs in association with *N. fichteli-clipeus* Group in the Basal member of Maniyara Fort Formation.

There are reports of wide variation of megalospheric test shape in some Lower Oligocene reticulate *Nummulites* from the Far East, viz., *N. fichteli* Michelotti s.l. of Brunei (Adams 1965) and *N. absurdus* (Doornink) of Java (in Roveda 1970). These taxa have large embryonic apparatus, long chambers and reticulate septal filaments. These reticulate *Nummulites* of Far East and *N. cf. fichteli* of Kutch are not known to occur in the Lower Oligocene localities of Europe like Priabona and Biarritz (see Adams 1965) and the Middle East (see Racey 1995; Boukhary *et al* 2010).

#### 4. Morphotypes of *N. cf. fichteli* form A

*N. cf. fichteli* form A includes inflated lenticular, conical and saddle-shaped tests (Pl. 1, figures 1–12). In India, no other *Nummulites* species is known to exhibit morphological variation of the megalospheric form as large as *N. cf. fichteli*. Sengupta (2002) observed that relative position of the coiling plane plays a crucial role in determining test shape and symmetry in *N. cf. fichteli* form A. Median or polar position of the coiling plane with respect to the large embryonic apparatus results in the development of symmetric inflated lenticular and asymmetric conical tests, respectively. In the saddle-shaped morphotype, the plane of coiling remains more or less straight except at the saddle crest where it bends sharply.

On the basis of very high faunal abundance, extensive bioerosion (Sengupta 1999) and profusion of glauconite, Sengupta (2002) and Sengupta and Nielsen (2009) inferred a regime of low sedimentation during the deposition of the Basal member rocks of SW Kutch. Faunal abundance and high residence time of bioclasts at the sediment–water interface favour shell accumulation in low sedimentation regime (Kidwell 1985). It was suggested (Sengupta 2002) that lenticular and conical morphotypes of *N. cf. fichteli* form A thrived on micritic and shelly substrates, respectively. The saddle-shaped morphotype appears to reflect space

constrained growth between large bioclasts following chance settling of the embryonic individuals therein. Unable to escape from within the space enclosed by the bioclasts, the saddle-shaped foraminifera achieved growth within the limited space, sans morphological irregularity, by bending the plane of coiling. This mode of growth reduced the test dimension in the direction perpendicular to the saddle crest.

#### 5. Conclusion

*N. cf. fichteli* form A is represented by three morphotypes with saddle-shaped, lenticular and conical tests. Saddle-shaped tests show curved plane of coiling but regular development of chambers, septa, septal filaments and the whorl wall. The curved nature of the coiling plane seems to have favoured post-embryonic space-constrained test growth between large bioclasts. Morphological variability of *N. cf. fichteli* from Kutch is comparable with that of Early Oligocene reticulate *Nummulites* of the Indonesian region. Contemporary reticulate *Nummulites* are morphologically more conservative in the European localities.

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