TWO SPECIES OF *LEPIDOCYCLINA* FROM THE AGATE-CONGLOMERATES (BURDIGALIAN) OF THE SURAT-BROACH REGION, WESTERN INDIA

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ABSTRACT—Two species, *Lepidocyclina* (*Nephrolepidina*) *sumatrensis* (Brady) var. *taptiensis* var. nov. and *L.* (*N.*) *tournoueri* (Lem. et Douv.) have been described from the L. Miocene (Burdigalian) which is transgressive in this region.

IN the alluvial country between Surat and Broach, Tertiary strata are exposed in small patches along Tapti, Kim, Amraoti and Kaveri rivers. A great thickness of agate-conglomerates and yellow sandstones with small agates, gravels and sandy clay overlie the nummulitics, at places overlapping the latter and resting on the denuded edges of the Deccan Traps. The Tertiary outcrops in this region are shown in the accompanying map.

W. T. Blanford, (1867), classified them together as 'older tertiary' and regarded them as unquestionably Lower Eocene and equivalent to 'nummulitics of Sind and Kutch and to the beds of the Paris basin'.

One of the present authors (Rao, 1939, 1941) investigated the Tapti exposures during 1937–41 and came to the following conclusions :—

1. Blanford's 'nummulitics' consist of (a) limestone with *Pellatispira*, *Discocyclina*, and *Nummulites* of Upper Eocene (Post Kirthar) age, and (b) agate-conglomerates and sandstones with *Lepidocyclina*, *Miogypsina* and *Austrotrillina howchini* of Burdigalian (Lower Miocene) age.
2. North of Wagalkhod no outcrops of the Eocene limestones are met with. Here the agate-conglomerates are prominently developed and are resting directly on the denuded traps.

The name Tapti series has been recently proposed by Eames (1952) to the *Pellatispira*-bed of Surat-Broach region. Similar beds have been described by him from Western Pakistan, Assam (Kopili beds) and Burma (Yaw stage and the upper part of Pondaung sandstones). He states that the difference between the faunas of the Tapti series and the Kirthar series is fundamental and he also assigns an Upper Eocene age (post-Kirthar) to this series.

The Miocene sequence is fossiliferous and contains *Ostrea*, *Pecten* and *Balanus*, bryozoans, echinoid spines, corals, calcareous algae and foraminifera which include *Lepidocyclina* (*Nephrolepidina*) *sumatrensis* var. *taptiensis* var. nov., *L.* (*N*) *tournoueri*, *Miogypsina irregularis*, *M. thecidaeformis*, *Austrotrillina howchini*, *Nonion* sp., *Elphidium* sp. and *Rotalia* sp.

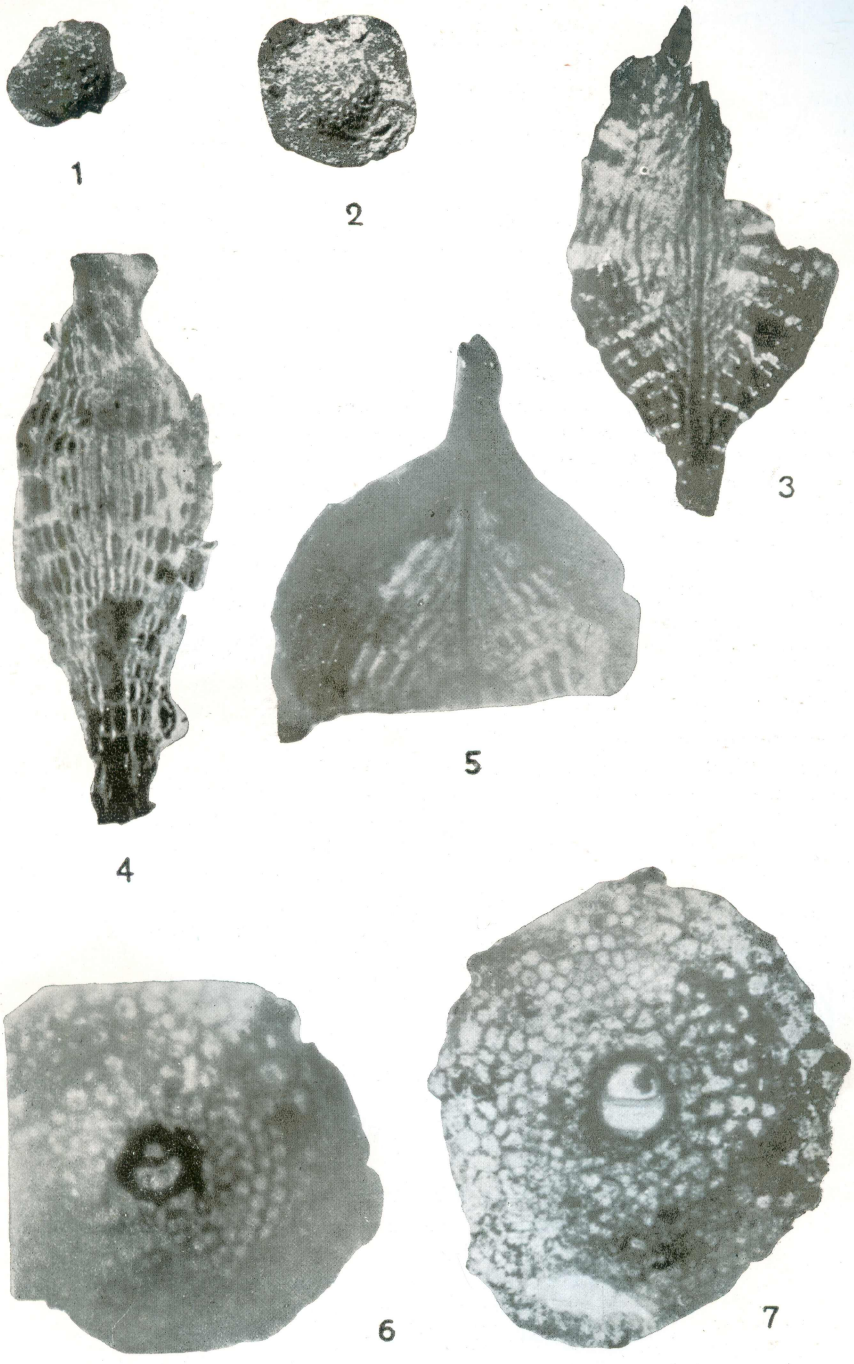
Cushman (1919) refers *Lepidocyclina sumatrensis* to the Aquitanian age. David-Sylvain (1937) gives the range of *L.* (*N*) *tournoueri* from Aquitanian to Burdigalian. Brönnimann (1940) following Senn (1935) gives the following stratigraphic range of larger foraminifera in the Upper Oligocene and Lower Miocene of N. W. Morocco :

Lower Miocene—Burdigalian—*Miogypsina* s.s., *Lepidocyclina* s.l.

Oligocene—Aquitanian — *Miogypsina* s.s., *Lepidocyclina* s.l., *Miogypsinoides*.

EXPLANATION OF PLATE 5

FIG. 1—*L.* (*N*) *tournoueri* (Lem. et Douv.) Megaspheric test. ×5.6.
2—*L.* (*N*) *sumatrensis* (Brady) var. *taptiensis* Megaspheric test. ×5.6.
3—*L.* (*N*) *sumatrensis* (Brady) var. *taptiensis* Axial section of megaspheric form. ×37.5.
4—*L.* (*N*) *tournoueri* (Lem. et Douv.) Axial section of megaspheric form. ×37.5.
5—*L.* (*N*) *sumatrensis* (Brady) var. *taptiensis* Axial section of megaspiric form. ×37.5.
6—*L.* (*N*) *sumatrensis* (Brady) var. *taptiensis* Equatorial section of megaspheric form. ×37.5.
7—*L.* (*N*) *tournoueri* (Lem. et Douv.) Equatorial section of megaspheric form. ×37.5.



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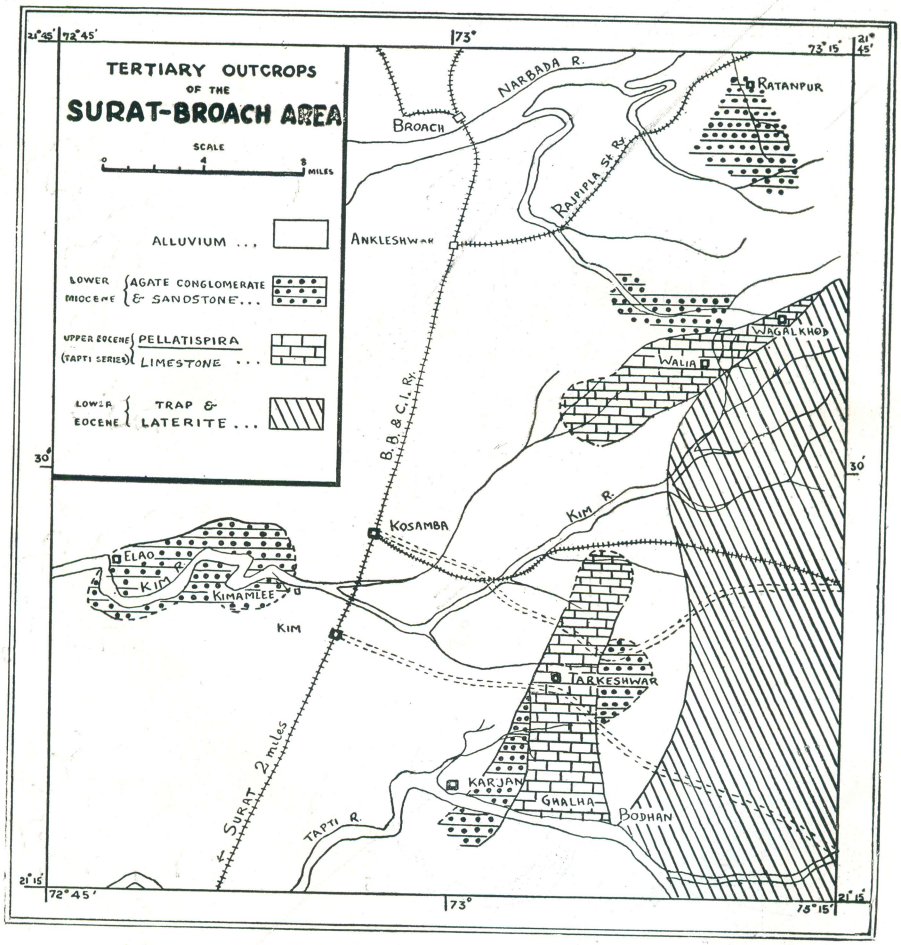
He records *L.* (*N*) *tournoueri* from strata ranging from Sannoisian (Lattorfian) to Burdigalian. Eames (1953) restricts the term Aquitanian to 'beds and faunas known to be of basal Miocene age' and suggests that Aquitanian of Senn and Brönnimann be shifted to Lower Miocene. Hanzawa (1940) confines *Austrotrillina howchini* (*Trillina howchini*) to Aquitanian.

Cole (1945) recording *L.* (*N*) *sumatrensis inornata* Rutten from Lau, Fiji, states,

Crespin (1947) recognises the following index genera for Tertiary 'f_1'-'f_2' and 'e' in Australia :

Middle Miocene 'f_1'–'f_2' *Nephrolepidina, Flosculina, Miogypsina, Cycloclypeus,*

Lower Miocene 'e' *Eulepidina, Neoalveolina, Spiroclypeus, Miogypsinoides, Cycloclypeus.*



"The stratum which contains satisfactory specimens for identification are all referred to the Upper portions of Lower Miocene or according to divisions of the Tertiary formations of the Orient by Van der Vlerk and Umbgrove, they would be assigned to the Tertiary 'f'."

She restricts *Austrotrillina howchini* to another facies of 'f_2' characterised by absence of *Lepidocyclina.*

Jacob and Sastri (1952) have described *L.* (*N*) *sumatrensis* from the Burdigalian of Quilon, Travancore coast.

The Surat-Broach agate-conglomerates contain Nephrolepidines, Miogypsines and *Austrotrillina howchini*. The absence of *Eulepidina* and *Miogypsinoides* indicates a Burdigalian age for these beds, equivalent to Upper Gaj of Sind and Baluchistan, Upper Pegu of Burma and Tertiary 'f_1' 'f_2' of East Indies.

One of the present authors (S.S., 1953) has recently investigated the thin-bedded grits, conglomerates and sandstones exposed near Gogha, Eastern Kathiawar. These beds are agatiferous and contain a few fossils including *Miogypsina* cf. *antillea*. These beds appear to be of the same age as the agate-conglomerates of the Surat-Broach area.

Lepidocyclina and *Miogypsina* have recently been discovered by Chatterji, Krishna Mohan, Rao and Sah in parts of Kathiawar (1952). Beds containing a fauna similar to that now being described have been recorded in these areas.

In the present paper a description of the two species of *Lepidocyclina*, previously recorded by Rao (1939), is given.

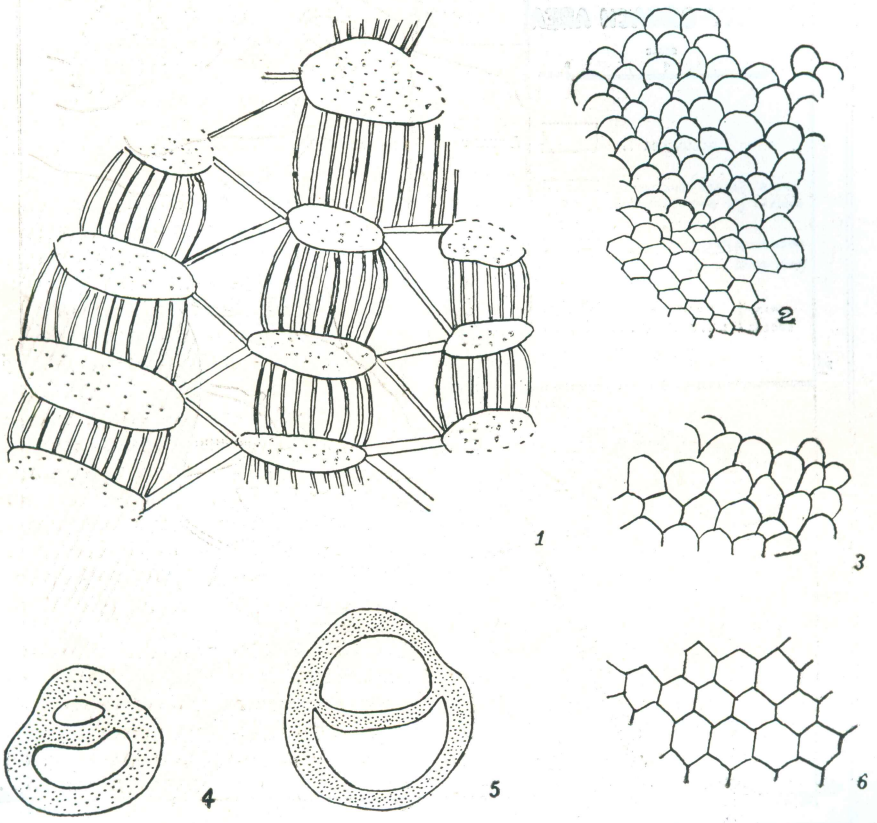


FIG. 1—Axial section of *L.* (*N*) *sumatrensis* (Brady) var. *taptiensis* to show stolon passages between lateral chambers. ×384.
2—Equatorial chambers of microspheric form of *L.* (*N*) *tournoueri* (Lem. et Douv.) to show gradation from hexagonal chambers near centre of ogival chambers towards periphery. ×88.
3—Equatorial chambers of the megaspheric form of *L.* (*N*) *tournoueri* (Lem. et Douv.). ×88.
4—Nucleoconch of *L.* (*N*) *sumatrensis* (Brady) var. *taptiensis*. ×88.
5—Nucleoconch of *L.* (*N*) *tournoueri* (Lem. et Douv.). ×88.
6—Equatorial chambers of megaspheric form of *L.* (*N*) *sumatrensis* (Brady) var. *taptiensis*. ×88.

LEPIDOCYCLINA (NEPHROLEPIDINA) SUMATRENSIS (Brady) var. TAPTIENSIS var. nov.

Pl. 5, figs. 2, 3, 5 & 6; Text figs. 1, 4 & 6

L. (*N*) *sumatrensis* (Brady) RAO, S.R.N., 1939, *Curr. Sci.*, *8*, No. 4, fig. 1, *c* and *d*

Megaspheric form, test small, average diameter 2 mm. and average thickness 1.2 mm. semi-globose, with a prominent central boss with a diameter of 1.2 mm. and a sharply defined flange. Ratio of diameter to thickness 1.75 : 1. Ornamentation consisting of pillars developed all over, those over the central boss being larger than those over the peripheral flange.

Tangential and radial diameters of the equatorial chambers, which are spatulate to haxagonal in shape, $\pm 65\mu$ and $\pm 55\mu$ respectively. Equatorial chambers arranged in tiers. Second chamber of the nucleoconch partially enveloping the inital chamber and separated from it by a thin, slightly convex septum with its convexity directed away from the initial chamber. Internal diameter of the initial and the second chambers $70\mu \times 85\mu$ and $65\mu \times 170\mu$ respectively. Internal length across both the chambers of the nucleoconch 160μ. Thickness of the bounding wall of the nucleoconch 40μ and that of the septum separating the first and the second chambers 25μ.

Number of lateral chambers on each side of the equatorial layer $\pm 10\mu$ in megaspheric form, ± 15 in microspheric form. Height of the equatorial layer variable, minimum in the centre and gradually increasing towards the periphery. Inclusive of roof and floor, it measures 40μ and 70μ in the centre and at the peripheries respectively. Lateral chambers somewhat rectangular, variable in size, those just over the nucleoconch 140μ in length and 30μ in height. Thickness of floor and roof of the lateral chambers $\pm 15\mu$. Columns present.

The new variety *taptiensis* now described has a smaller and flatter test than *L.* (*N*) *sumatrensis* described by Van der Vlerk from the Indonesian region. The presence of columns distinguishes *L.* (*N*) *sumatrensis* var. *taptiensis* from *L.* (*N*) *sumatrensis* var. *inornata* Rutten and *L.* (*N*) *sumatrensis* var. *minor* Rutten.

LEPIDOCYCLINA (NEPHROLEPIDINA) TOURNOUERI (Lem. et Douv.)

Pl. 5, figs. 1, 4 & 7 ; Text figs. 2, 3 & 5

L. Tournoueri: Lemoine et Douvillé, 1904, *Mém. Soc. Géol. Fr., Paléont.* t. XII, *Mém.* 32, p. 19, pl. 1, fig. 5; pl. 2, figs. 2, 14; pl. 3, fig. 1.

L. (*N*) *Tournoueri* (Lem. et Douv.): Vaughan, T. W. 1933, *Smith. Misc. Coll.*, Vol. 89, No. 10, pp. 25-26, pl. 13, figs. 1, 2.

L. (*N*) *Tournoueri* (Lem. et Douv.): David-Sylvain, E., 1937, *Mém. Soc. Géol. Fr. Nouv. Serie, t.* XV, *Fasc.* 1, Feulles 1 a 6, *Mém.* 33, p. 18, pl. 2, fig. 5.

L. (*L*) sp. nov. : Rao, S. R. N., 1939, *Curr. Sci.*,Vol. 8, No. 4, p. 167-8, fig. 1*a* and *b*.

L. (*N*) *Tournoueri* (Lem. et Douv.) : Hanzawa, S., 1940, *Jub. Pub. Comm.*, Yabe's 60th Birthday, pp. 787-789, pl. 41, figs. 1-6.

L. (*N*) *Tournoueri* (Lem. et Douv.) : Brönnimann, P., 1940, *Mem. Suisses de Paléont.* Vol. 63, pp. 47-50, Taf. 3, fig. 3, Taf. 5, figs. 3, 11, 12, 14.

Megaspheric forms much more abundant. Megaspheric test small, diameter 2–4 mm., thickness 1.4 mm., semi-globose, ratio diameter : thickness 1.9 : 1, with a pronounced central boss and a conspicuous flange. Microspheric test 4.6 mm., in diameter and 1.7 mm. in thickness, lenticular, ratio diameter : thickness 2.7 : 1, with clearly differentiated central boss and peripheral flange. Ornamentation in megaspheric form consists of 12–14 pustules arranged around a centrally positioned granule over the central boss, surface diameter of the pustules 100μ–120μ; in microspheric form variable, central boss strongly papillated but with papillae feebly developed over the peripheral flange.

Equatorial section shows hexagonal chambers, equidimensional with diameter of $\pm 45\mu$ near the centre but towards the periphery the radial diameter gradually increases to $\pm 70\mu$ and the chambers become ogival. Initial chamber partially enclosed by the second chamber of the nucleoconch and separated from it by a thin partition either straight or bent slightly towards the second chamber. Internal diameter of the initial chamber $100\mu \times 150\mu$ and that of the second chamber $75\mu \times 200\mu$. Internal length across both the chambers 200μ. Average width of the wall bounding the nucleoconch $\pm 30\mu$, maximum 45μ. Width of the wall separating the initial chamber from the second chamber 20μ.

Axial section shows ±10 lateral chambers on each side of the equatorial layer, with or without pillars. Height of the equatorial layer 45μ in the centre but gradually increasing to 85μ in the peripheral region, inclusive of roof and floor. Lateral chambers elongated, rectangular, variable in size, measuring 145μ×125μ just above the nucleoconch. Thickness of floor and roof of the lateral chambers ±15μ.

Lepidocyclina (*Nephrolepidina*) *tournoueri* (Lem. et Douv.) generally agrees with the original description given by Lemoine and Douvillé but the latter do not give detailed measurements and hence an exact comparison is not possible. The Surat species resembles *L.* (*N*) *tournoueri* described by Brönnimann (1940) from N.W. Morocco and that described by Vaughan (1933) from Mexico, only differing from these two in the smaller size of the nucleoconch. It comes very close to the Japanese species described by Hanzawa (1940), differing only in ornamentation.

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