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ON THE FORAMINIFER *LOCKHARTIA ALVEOLATA* SILVESTRI

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ABSTRACT

This paper describes *Lockhartia alveolata* Silvestri from the Middle Eocene rocks of the Vinjhan-Miani area of Kutch, and discusses its stratigraphic and geographic distribution.

INTRODUCTION

Lockhartia alveolata Silvestri (1942) was erected on the material from the Middle Eocene of Somaliland, but the type specimens (seen only in thin sections of fine, compact, hard limestone) were, as Smout (1954) noted, insufficiently described and illustrated. Ovey (1947), unaware of the existance of *L. alveolata* when his paper went to press, erected a new species, *L. hunti*, which was reported subsequently from Turkey (Ten Dam, 1953) and Qatar (Smout, 1954). Samanta (1968) and Singh (1970) recorded *L. hunti* from the Middle Eocene of Assam, and the Lower Eocene of Kashmir respectively. *L. aleveolata* was reintroduced by Al-Hashimi (1974) who regarded it as a senior synonym of *L. hunti*. His description and figures were of specimens from the Middle Eocene of Iraq.

The purpose of this paper is to describe the species in detail and to determine its geographic distribution during the Eocene Epoch, in which the species is of biogeographical and geological interest for following reasons :

(a) *Lockhartia alveolata* is confined to the Eocene Epoch.

(b) The species is reported mostly from East Africa, India and the Middle East as an important member of typical carbonate nummulitic facies.

(c) It is, however, missing in the equivalent nummulitic facies of Europe.

Despite the fact that this is an important Eocene species occurring commonly in areas from the Middle East and East Africa to India, it has not yet been documented with proper description and illustration. The information pertaining to its stratigraphic and geographic distribution still remains to be recorded and discussed. In this paper, detailed description of this species aided by light photomicrographs is given, and an attempt made to discuss its stratigraphic and geographic range in the light of previously reported occurrences. As the type specimens and the topotype material are not available, this species is described from Kutch rather than from the type area.

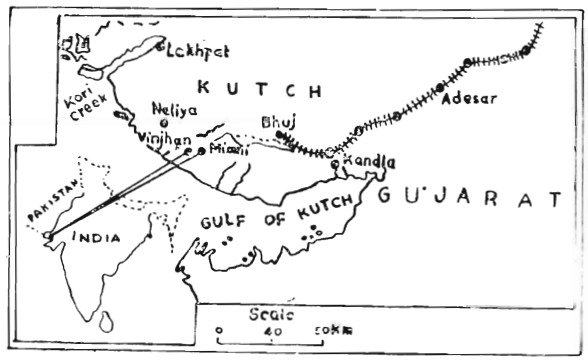

Figure 1. Location Map of the Area.

LOCATION AND STRATIGRAPHY OF THE AREA

The specimens here described are from samples collected from Middle Eocene outcrops in the neighbourhood of the villages Vinjhan and Miani. This locality lies about 82 kms SSW of Bhuj (Fig. 1). The beds, which are exposed in the Kankawati stream, dip at 3°-5° to the southwest, and unconformably overlie unfossiliferous Lower Eocene rocks (Fig. 2). The sequence has been measured as follows (Table 1, Fig. 3).

FAUNAL COMPOSITION AND BIOCHRONOLOGY

The larger foraminiferal fauna accompanying *L. alveolata* in the fossiliferous rock units of the Middle Eocene sequence in the above area includes *Nummulites acutus* (Somberby), *Nummulites obtusus* (Sowerby), *Nummulites stamineus* Nuttall, *Alveolina elliptica* (Sowerby),

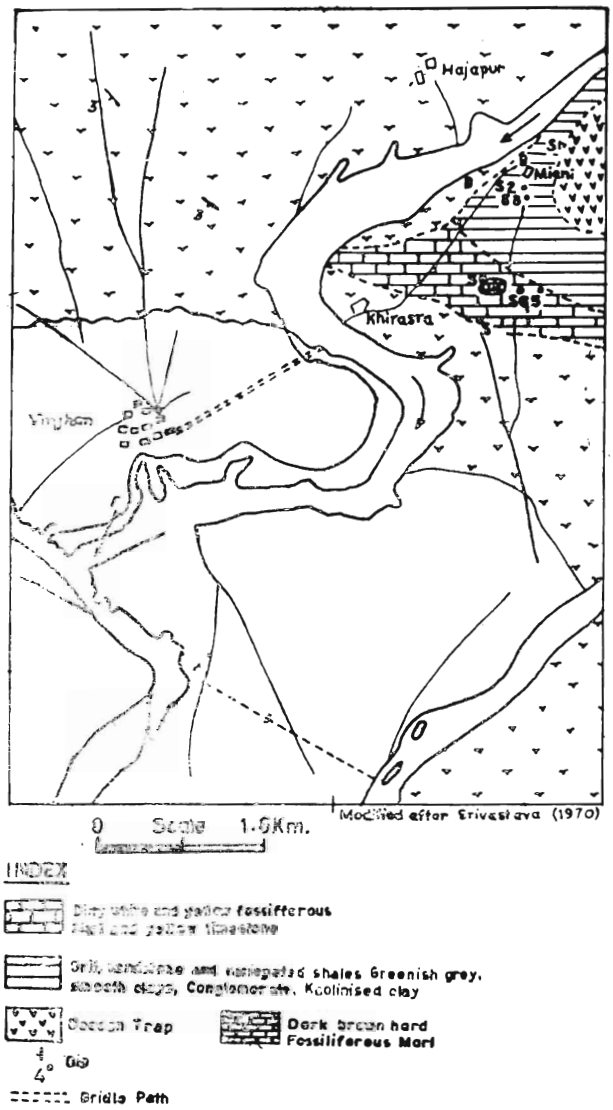

Figure 2. Geological Map of the Area.

Table 1. Sequence of Eocene rocks in the area

		Thickness in metres
	(7) Dirty white and yellow soft fossiliferous marl	2
Middle Eocene	(6) Yellow hard limestone	4
	(5) Khaki shales (unfossiliferous)	6
	(4) Grit sandstone and variegated shales	5
Lower Eocene	(3) Greenish grey smooth clay	3
	(2) Conglomerate	1
	(1) Kaolinised clay	1
	Deccan Trap	

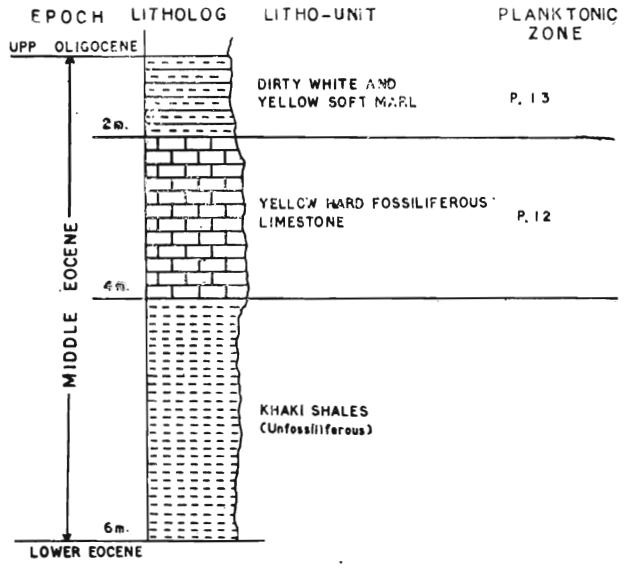

Figure 3. Stratigraphic column at the Area.

Assilina cancellata Nuttall, *Assilina exponens* (Sowerby), *Assislina subcancellata* Nuttall, *Discocyclina* (*D.*) *dispansa* (Sowerby), *D.* (*D.*) *jawana* (Verbeek), *D.* (*D*). *sowerbye* (Nuttall), *Dictyoconoides cooki* (Carter), etc. (Tewari, 1960). Tewari (1960) assigned a definite Middle Eocene (Lutetian) age to the fossiliferous units. Rich assemblages of smaller benthonic and planktonic foraminifera have also been recorded by the writer (Jauhri, 1974, 1976, 1981) and Jauhri and Vimal (1978) from these rock units. Planktonic forminifera indicate that the sixth and seventh lithounits of the aforesaid sequence correspond to Bolli's (1957) *Globorotalia lehneri* Zone and *Porticulasphaera mexicana* (=*Orbulinoides beckmanni*) Zone respectively. These zones are equivalent to zones P. 12 and P. 13 of Blow's (1969) planktonic zonation.

SYSTEMATIC PALAEONOTLOGY

Subfamily Rotaliinae EHRENBERG, 1839

Genus *Lockhartia* DAVIES, 1932

Type species *Lockhartia haimei* (DAVIES)

Lockhartia aleveolata SILVESTRI

(Plate II—1-7)

Lockhartia alveolata Silvestri, 1942, *Palaeontogr. Italica.* Sienna, Italy, vol. 32, suppl. 3, pp. 49-89, pl. II (9), fig. 4; also Silvestri, 1939, *Ibid.*, Suppl. 4, pl. 8 (18), fig. 8.

Lockhartia hunti Ovey, 1947. *Ann. Mag. Nat. Hist.*, London Ser. II vol. 13, pp. 571-576, pl. 10, figs. 1-5, pl. 11, fig. 1.-Ten Dam 1953. *Bull. Geol. Soc.*, Turkey, vol. 4, no. 1, pl. 1, fig. 3.-Smout, 1954, *Brit. Mus. Nat. Hist.*, p. 54, pl. IV, fig. 7.-Singh, 1970, *Jour. Geol. Soc.* India, vol. II, no. 1, p. 38, pl. 5, figs, 2a-e.

Lokhartia hunti Ovey var. *pustulosa* Smout, 1954, *Brit. Mus. Nat.Hist.*, pp. 54-55, pl. IV, figs. 8-10.-Singh, 1970, *Jour. Geol. Soc.* India, vol. II, no. 1, 38, pl. 5, figss 3a-b.-Rahaghi, 1976, *Publ. N.I.O.C.*, No. 6, p. 55, pl. 1, fig. 5 (non pl. 1, fig. 6).-Govindan, 1983 (for 1981).

Himal. Geol. vol. II (Palaeont. and Strat.) pp. 156-159, pl. 1, fig. 6, pl. 2, fig. 7, pl. 3, figs. 1-8.
Lockhartia alveolata Silvestri var. *pustulosa* Smout, Al-Hashimi, 1974, *Jour. Geol. Soc.* Iraq, vol. VII, pp. 67-68, pl. 2, figs. 12-13. *Dictyoconoides kohatica* (Davies), form A, Sander, 1962 *Rev. Micropalaeont.* vol. 5, no. 1, p. 26, pl. 4, figs. 22-24. *Lockhartia alveolata* Silvestri-Al-Hashimi, 1974, *Jour. Geol. Soc.* Iraq. vol. VII, pp. 66-67, pl. 2, figs. 9-11,-Pandey and Dwarikanath, 1977, *Proc. 4th Colloq. Indian Micropal.* and *Startigraph.*, p. 51, pl. 1, figs. 1-3.

Material : A total of fourteen specimens, all from the lithounit 7 of Table 1, was examined.

Description

External characters : Test conical to lenticular, trochospiral, spiral side convex, evolute, umbilical side flattened to slightly convex, involute, equatorial profile circular, equatorial periphery slightly lobulate, axial profile ellipsoidal, axial periphery rounded, with thin, imperforate rim at the margins of the apertural face and latter portion of the test. Umbilical region crowded with tubercles and meandrine slits. Chambers numerous, arranged in $2\frac{1}{2}$ to 3 whorls, last whorl with 5 to 8 chambers, rectangular on spiral side and uniformly traingular on umbilical side ; sutures on spiral side flush with the surface except in the last whorl where they appear to be depressed; intercameral sutures perpendicular to spiral suture, at least in the final whorl; sutures on the umbilical side radial, slightly curved, depressed, later becoming deeply excavated. Wall thick, calcareous, perforate, built of laminated, radially fibrous calcite. Surface strongly tuberculate on umbilical side and very mildly pustulate on spiral side. Aperture an interiomarginal slit extending towards the umbilicus.

The diameter of the test varies from 0.35 mm to 0.75 mm; height of the test varies from 0.25 mm to 0.55 mm; H/D ratio ranges from 0.55 to 0.73 (Fig. 4).

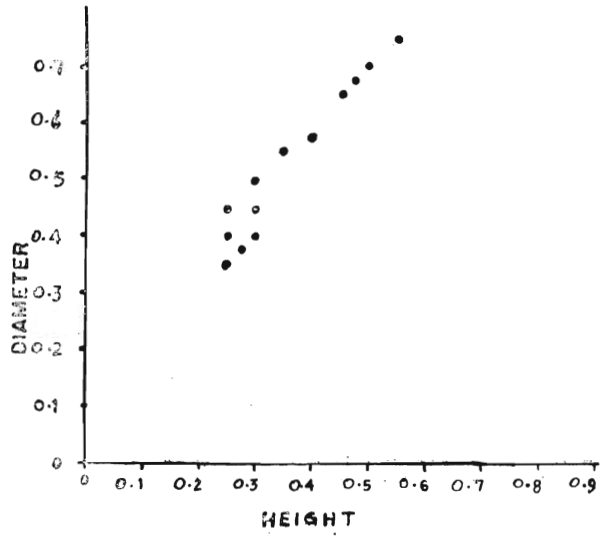

Figure 4. H/D Plot.

Internal characters (*Axial section*) : The chambers are evolute on the spiral side and somewhat crescent shaped. They increase rapidly in size from one whorl to the next ; length of the chamber shows size increase from 0.125 mm to 0.275 mm: their width increases from 0.075 mm to 0.15 mm; and the diameter of proloculus ranges from 0.15 mm to 0.175 mm. The umbilical cavity is large and deep, covering two-thirds of the total thickness of the test, filled with 6-7 vertical pillars of varying thickness; the pillars together assume a fan-like shape having a narrow proximal and broad distal end; the thin, horizontal plates lying across the vertical pillars are indistinct; thickness of the wall is between 0.025 mm and 0.075 mm; apical angle varies from 98° to 107°.

Equatorial section : Megalospheric forms: proloculus rounded, large, followed by three whorls which increase rapidly in size; chambers separated by curved, double-walled septa which are thickned near the base: chambers in earlier portion are square shaped: those of later stages are elongate, rectangular.

Remarks : *Lockhartia alveolata* is common in the Kutch material. It shows variation in the size and shape of the test, the number of chambers in the last whorl, and in the development of tubercles on the umbilical side. The imperforate rim developed around the borders of apertural face and the latter part of the test near the aperture is seen only in a few specimens and is not a constant feature. Internal characters are more or less uniform. Except for the size of proloculus and the number and thickness of pillars, the overall test morphology is rather uniform.

Pandey and Dwarikanath (1977 recorded *L. alveolata* from the Middle to Upper Eocene of the Cambay Basin. One of their specimens has been examined and found to be quite similar to those from Kutch, although their figured axial section has fewer, and rather more thickened pillars.

Lockhartia hunti has been regarded as a junior synonym of *L. alveolata* on account of its similarity to the latter. Smout (op. cit.) pointed to the similarity of the high cone seen in both Silvestri's and Ovey's forms, although the two were regarded as separate species. Al-Hashimi (op. cit.) examined the characters of Ovey's *L. hunti* and those of Silvestri's *L. alveolata* and found considerable similarity between them; even the values for the height/diameter ratio were found to be very close. Consequently, he placed *L. hunti* in synonymy with *L. alveolata.*

Lockhartia alveolata is a distinct species and is distinguishable from other related species. The related species are *Lockhartia haimei* (Davies), *Lockhartia conditi* (Nuttall), and *Lockhartia tipperi* (Davies). *L. haimei* can be distinguished from *L. alveolata* by dorsally conical

test, subacute periphery, higher spiral angle,and lack of an obvious aperture on umbilical side. *L. conditi* differs in having the smooth spiral surface, subacute periphery and characteristic striations along the length of the pillars. *L. tipperi* is characterized by larger test, very flat spire, wide umbilical cavity and relatively narrow pillars.

Horizon : Dirty white and yellow soft marl (7) ; and yellow hard limestone (6).

Locality : ENE of Khirasra village of the Vinjhan-Miani area, southwestern Kutch, Gujarat.

STRATIGRAPHIC RANGE AND GEOGRAPHIC DISTRIBUTION

Originally recorded from the Middle Eocene of nothern Somaliland, *Lockhartia alveolata* is now known to have ranged from India to the Middle East. Following Silvestri's (op. cit.) first record from the Middle Eocene of Somaliland, this species has been reported (mostly as *Lockhartia hunti*) from the Lower Eocene of Somaliland (Ovey, op. cit.), the Lower Eocene of Turkey (Ten Dam, op. cit), the Lower Eocene of the Qatar Peninsula (Smout, op. cit.), the Middle Eocene of Saudi Arabia (Sander, 1962), the Middle Eocene of Iraq (Al-Hashimi, op. cit.), and the Lower Eocene of Iran (Rahaghi, 1976).

In India, this species is known from several areas. Its occurrence has been recorded from the Middle Eocene of Assam (Samanta, 1968). In Kashmir, the species occurs in the Lower Eocene part of Subathu Group (Singh, 1970). Its presence has been noticed in the Lower Eocene of Rajasthan (Sigal *et al.*, 1971), although the report was not supported by any illustration or description. It is a common species in the Middle Eocene of the present area. Its occurrence has been reported from the Cambay Basin where it extends from the Middle Eocene to the Late Eocene (Pandey and Dwarikanath, 1977); in this context, the doubts raised by Govindan (1981) on the validity of this species in the Cambay Basin material of the above workers are not convincing. The writer has examined one of their specimens which seems to be a true representative of *L. alveolata*. Thus, the species, previously regarded as restricted in the Middle Eocene, is now known to range from the Early Eocene to Late Eocene. See Table 2.

Lockhartia alveolata seems to have been restricted to India, Qatar, Turkey, Iran, Iraq, Somaliland and Saudi Arabia (Fig. 5). The above distribution suggests that *L. alveolata* was distributed from the Middle East to Assam where it clearly lived in areas of warm, shallow-water, carbonate deposition. There are no records of this species in areas beyond Turkey. No report of its occurrence in the Western Pacific has been made either. This absence may be due either to lack of data from these regions or to rare development of sediments of suitable facies, especially in the region from Borneo to the Marshall Isles. However, in Europe where sediments of right age and facies are well developed, its absence is striking. A definitive statement on dispersal of this species is not possible with the currently available information. From the known geographic distribution, it could, however, be suggested that *L. alveolata* probably evolved in the warm, shallow waters of the Indian Ocean and remained restricted to the region between the Middle East and India. Yet however restricted this species may have been in its geographic range, it is a distinct species and could be considered for broad age correlation.

Table 2. Stratigraphic Range of *Lockhartia alveolata* in the localities between the Middle East and Assam

COUNTRIES / EPOCH	SOMALILAND	TURKEY	QATAR	SAUDI ARABIA	IRAQ	IRAN	INDIA				
							KUTCH	RAJASTHAN	KASHMIR	CAMBAY BASIN	ASSAM
LATE EOCENE											
MIDDLE EOCENE											
EARLY EOCENE											

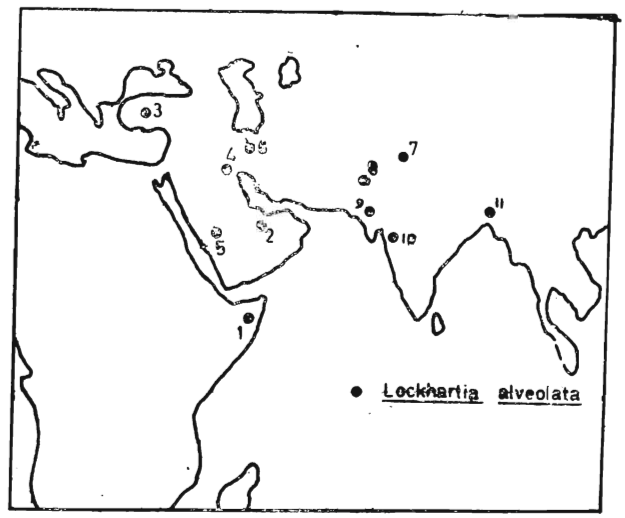

Figure 5. Distribution of *Lockhartia alveolata* in the Middle East, northeast Africa and India (Locations appoximate) :
1, Somaliland; 2, Qatar; 3, Turkey;
4, Iraq; 5, Saudi Arabia; 6, Iran;
7, Kashmir; 8, Rajasthan; 9, Kutch;
10, Cambay Basin; and 11, Assam.

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EXPLANATION OF PLATE

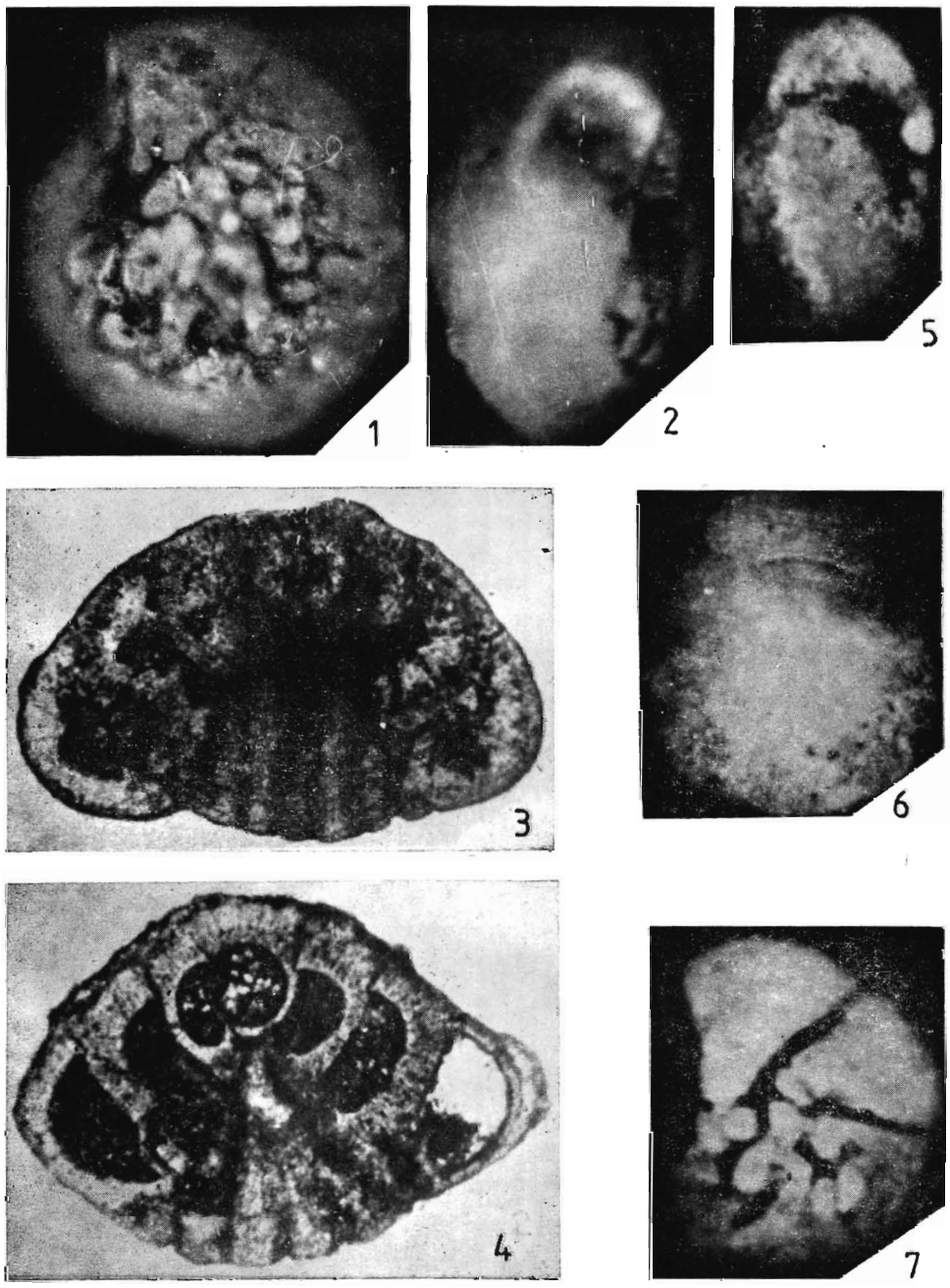
PLATE I

Lockhartia alveolata Silvestri

1—2; 1, umbilical view, 2, peripheral view ×80

5—7; 5, peripheral view, 6, spiral view; 7 umbilical view ×75

3—4, orientated axial sections; 3 ×100, 4 ×100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