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The Genus *Loftusia* in South Western Iran.

By Peter T. Cox, London.

With 5 plates (XXXIII—XXXVII) and 4 text figures.

Historical.

W. K. LOFTUS (1855)¹) during his travels in Iran between 1849 and 1852, collected specimens which he described as a "gigantic species of *Alveolina*".

PARKER and JONES (1860) again referred these specimens to D'ORBIGNY's genus *Alveolina*. BRADY (1869) after a close study of the material, in which he emphasized the difference in its wall structure from that of *Alveolina* D'ORB., proposed the genus *Loftusia* to accommodate LOFTUS' specimens; he included them all in the species *L. persica* and, on the evidence of small foraminifera included in the shell material of the specimens, referred them to the Eocene. This conclusion as to age of the specimens has been quoted frequently and is repeated in both the original German editions and in the English translation by EASTMAN of ZITTEL's "Grundzüge der Paläontologie" where *Loftusia* is included in the *Hydrozoa*.

G. M. DAWSON (1879) described certain poorly preserved forms from the Carboniferous of Marble Canyon, British Columbia as *Loftusia columbiana*. From his description and figures one cannot entirely dismiss the possibility that these forms should be referred to the genus *Loftusia* but, as suggested by GALLOWAY (1933, p. 198), they are more probably *Fusulinidae*.

V. VON MÖLLER (1880) referred some small, ovoid shells from the Carboniferous of Tschehardeh in northern Iran to a new species, *Loftusia carbonica*. It is probable that these specimens are also *Fusulinidae*.

H. DOUVILLÉ (1904) after examination of material collected in Persia by DE MORGAN, further described the structure of *L. persica* BRADY and distinguished from it the new species *L. morgani*. He

¹) Dates in brackets refer to literature listed at the end of this paper.

also showed that DE MORGAN collected both species from Upper Cretaceous beds and that none of his specimens had been obtained from the Eocene.

G. OSIMO (1909) referred *L. morgani* DOUV. to the genus *Alveolina* D'ORB., a procedure which has little to recommend it and which has not been followed by later writers.

H. DOUVILLÉ (1910) added further notes on the species *L. morgani* showing that it may attain a greater size than in the specimens he had originally described and amplifying his views on its structure.

A. SILVESTRI (1932) discussed the relationship of *Loftusia* with certain *Lituolidae*, transferred a species hitherto described by him (1925) as "*Lacazina*" *lamellifera* to the genus *Loftusia* and described a new species *L. bemmeleni*. Both *Loftusia lamellifera* and *L. bemmeleni* occur in pre-Tertiary, probably Lower Cretaceous, beds in Sumatra.

Classification.

There is no fundamental difference in structure between *Loftusia persica* BRADY and *Loftusia morgani* DOUVILLÉ. *L. morgani* is smaller and of more slender shape than *L. persica*; its whorls are slightly narrower, its septa less oblique and the agglutinated endoskeletal material is usually of relatively coarser grain in *L. morgani* than in *L. persica*. The nature of the spire, the arrangement of chambers and apertures and structure of the walls are similar in both species.

In the material examined in the present work, it has been found that specimens from certain localities are clearly identifiable with *L. morgani*; the slender, fusiform shape, the range in size and coarsely arenaceous shell correspond closely with DOUVILLÉ's type material.

From other localities or horizons groups of specimens have been collected ranging from 5.6 mm. to 35 mm. in diameter and from 12 mm. to 118 mm. in length. They vary in shape from ovoid to subcylindrical or fusiform. Many of the larger and more ovoid specimens agree closely with the type of material of *L. persica* BRADY; a few of the smaller ones differ but slightly from *L. morgani*. Since the great majority of these specimens are, in most of their structural characters, intermediate between typical *L. persica* and typical *L. morgani*; a third type has been distinguished and is here described as a separate species, *L. elongata* sp. nov.

In text-fig. 1, the external dimensions are shown graphically of the better preserved specimens of *L. persica*, *L. elongata* and *L. morgani*. The continuity of points representing *L. persica* and *L. elongata* at first suggests the presence of only one species but range in variation of specimens from any one locality or horizon is, in each case, relatively restricted. *L. elongata* is an elongated, thin form with a length: diameter ratio usually greater than 3.5:1; *L. persica* is relatively

thicker and shorter and its length:diameter ratio is generally less than 3.5:1. With two exceptions, in all the collections examined, over 90% of the specimens from any one horizon have a length:

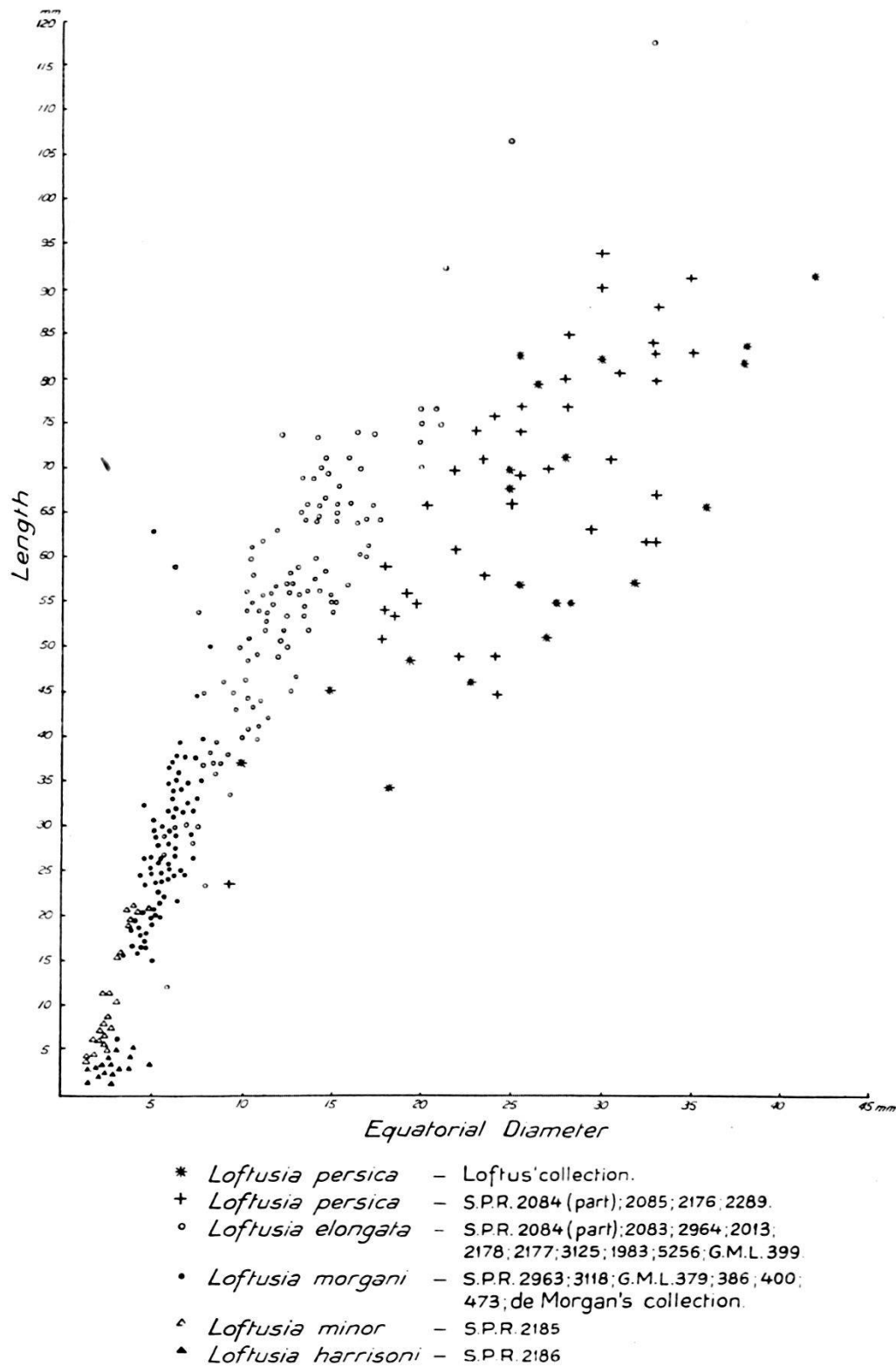


Fig. 1. Graph showing external dimensions of species of *Loftusia* BRADY.

diameter ratio either greater or less than 3.5:1. When a number of specimens have been collected from the same bed there is thus little difficulty in distinguishing between the two species. To include both *L. elongata* and *L. persica* in one species would not only imply

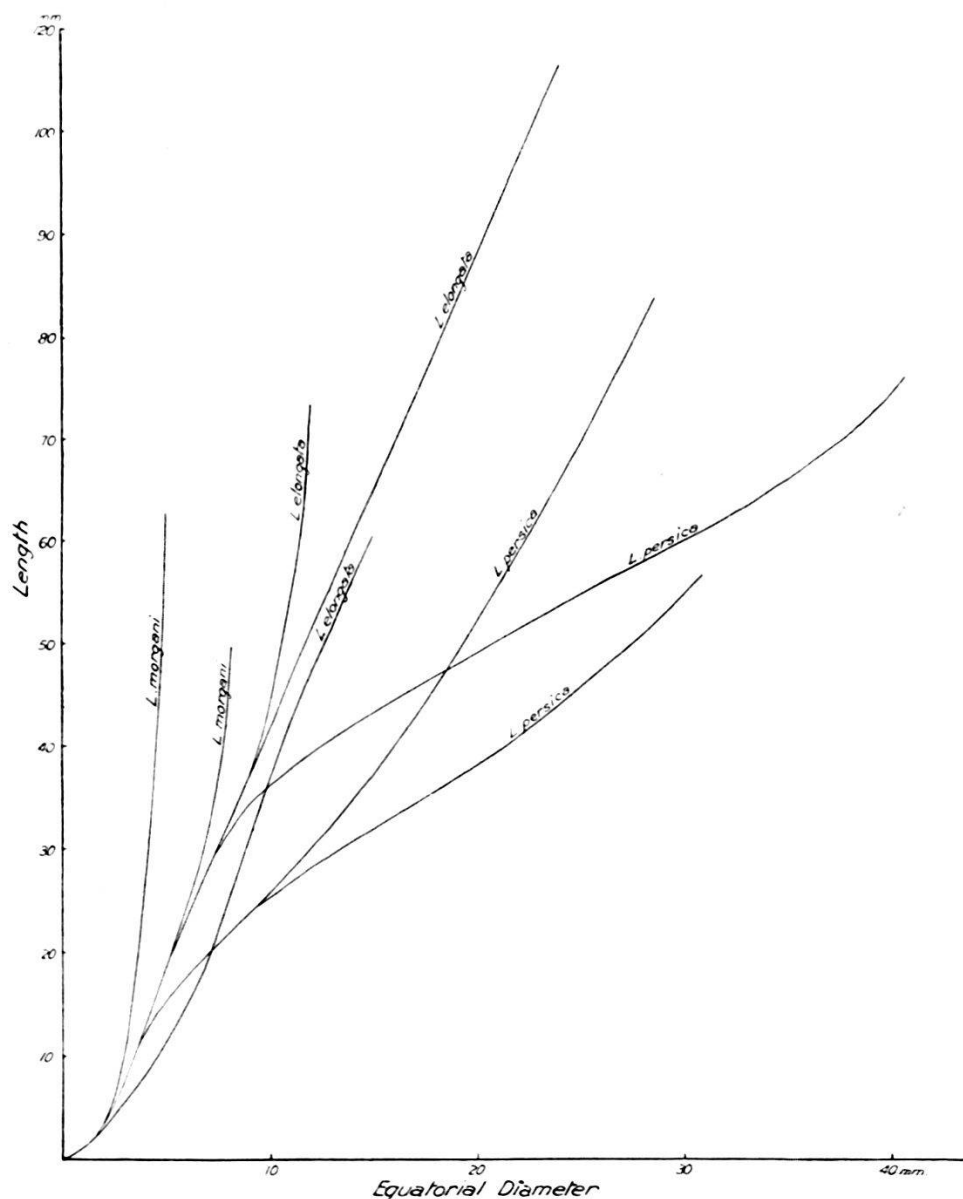


Fig. 2. Diagram to illustrate development of different varieties of *Loftusia persica*, *L. elongata* and *L. morgani*.

a greater variability in shape than is usually admitted within one foraminiferal species but would obscure an available distinction which may be of stratigraphic significance.

None of the specimens referred to *L. persica*, *L. elongata* or *L. morgani* has been found to possess a megaspheric nucleoconch. In one collection from Kuh-i-Sarab (S.P.R. 2185), both microspheric

and megaspheric forms occur. The former resemble small specimens of *L. morgani*; the latter are still smaller but are also of elongate, fusiform shape. Though it is possible that these specimens may, ultimately, have to be included in the species *L. morgani* Douv., it seems more probable, with the evidence now available, that they belong to a separate and earlier species. They are here described as *Loftusia minor* sp. nov.

Specimens of *Loftusia* which differ widely from any of the above mentioned species were collected by Dr. HARRISON, also from Kuh-i-Sarab, in beds of approximately the same horizon as those containing *L. minor*. They are of small, globose shape and all the specimens examined internally are megaspheric forms. Since there is doubt whether they are megaspheric forms related to *L. persica* or *L. elongata* or are associated with microspheric forms distinct from either, they are here described as a new species, *Loftusia harrisoni* sp. nov.

The several species of the genus *Loftusia* which occur in Persia are shown, with their external dimensions, in the following table.

Length:Diameter Ratio	Max. Diameter greater than 8 mm.	Max. Diameter less than 8 mm.	
	Microspheric Forms	Microspheric Forms	Megaspheric Forms
Less than 3.5 : 1	<i>L. persica</i> (Type: 76 × 41 mm.)		<i>L. harrisoni</i> (Type: 4.2 × 2.7 mm.)
Between 2.5 : 1 and 3.5 : 1			<i>L. minor</i> (A-form) (Type: 7.2 × 2.8 mm.)
Greater than 3.5 : 1	<i>L. elongata</i> (Type: 73 × 12 mm.)	<i>L. morgani</i> (Type: 42 × 6 mm.)	
		<i>L. minor</i> (B-form) (Type: 22 × 4 mm.)	

Stratigraphical Distribution.

BRADY (1869, p. 750) referred *Loftusia persica* to the Lower Tertiary on the evidence of smaller foraminifera, including a supposed "*Nummulina*", imbedded in the arenaceous endoskeleton of LOFTUS' specimens. DE MORGAN later collected specimens of *Loftusia* from near LOFTUS' locality (Kellapstun Pass, near Do Pulan) where they

were associated with a Maestrichtian fauna; the Mollusca and Foraminifera are described by DOUVILLÉ (1904). J. V. HARRISON, A. H. TAITT and N. L. FALCON have more recently examined the area and obtained many collections of *Loftusia*, including *L. persica* BRADY, but no specimen of the genus was found in the Eocene. In fact, of all the material under examination, wherever specimens of *Loftusia* have been collected with an associated fauna, the assemblage is one of Maestrichtian character. It can therefore be safely assumed that the type specimens collected by LOFTUS were also obtained from Maestrichtian beds.

In Iran, species of *Loftusia* frequently occur associated with *Omphalocyclus macropora* LAM. and *Siderolites calcitrapoides* LAM.; in certain localities *Orbitoides* cf. *media* (D'ARCH.) and *O. apiculata* SCHLUMB. have been found in the same or near horizons. In the Bakhtiari Country, HARRISON²) has recorded the following macrofossils from the flysch and rubbly limestone group in which the *Loftusiae* occur:

Cyclolites arabica KÜHN
C. regularis LEYM.
Terebratula toucasi D'ORB.
Polyptychus cf. *morgani* DOUV.
Hippuritella cornucopiae DOUV.

Catopygus morgani COTT. et GAUTH.
Pyrina orientalis COTT. et GAUTH.
Hemipneustes compressus NOET.
Echinoconus gigas COTT.

At Jabal al Abyadh, near Yanqul, in the Oman Peninsula, G. M. LEES (1928, p. 608) and K. WASHINGTON GRAY found *Loftusia* sp. in beds with:

Ostrea unguolata SCHLOTH.
O. overwegi L. VON BUCH
Pecten (Vola) alpinus (D'ORB.)
P. (V.) cf. *quadricostatus* (SOW.)

Plicatula hirsuta COQ.
Cardium productum SOW.
C. loralaiense NOET.
 "Echinanthus" *pumilus* DUNCAN &
 SLADEN, var. *abiadensis* LEES

and the foraminifera *Omphalocyclus macropora* LAM. and *Siderolites* sp.

Though there is little doubt, in the great majority of cases, that the specimens of *Loftusia* so far collected in Iran, Arabia or Iraq were found in Maestrichtian or possibly Danian beds, distribution of the several species within these stages is less clearly established. Most of the specimens were obtained from different sections and, since the Maestrichtian in Iran has not been zoned by other fossils, there is no reliable datum by which to make detailed correlation.

At Gavara, in the Province of Kirmanshah, LEES observed 4,282 ft. of sands, conglomerates and marls overlying about 200 ft. of Upper Cretaceous limestone and below massive Eocene limestones. Between 800 ft. and 2,230 ft. below the top of the arenaceous group,

²) Report to Anglo-Iranian Oil Co. Ltd.

L. morgani occurs associated with *Omphalocyclus macropora* and *Orbitoides apiculata* SCHLUMB. From 2,690 ft. to 3,040 ft. below the top of this group, *Loftusia elongata* occurs with *O. macropora* and *Orbitoides* cf. *media* (D'ARCH.).

On the north-eastern slope of the Kuh-i-Sarab anticline, Bakhtiari Country, HARRISON found *Loftusia persica* (S.P.R. 2176) at the top of an Upper Cretaceous limestone and marl group. On the southern slope of the same structure he obtained *L. elongata* (S.P.R. 2177) some 400 ft. below the top of this group and *L. minor* a further 150 ft. down in the sequence. *L. harrisoni* was obtained in this locality from about the same horizon as *L. minor*.

In Kuh-i-Abbagh, Bakhtiari Country, A. H. TAITT found *L. elongata* at the top of an Upper Cretaceous limestone group about 1,000 ft. thick. From a slightly lower horizon he collected both *L. persica* and *L. elongata*. Near the base of this limestone group *Omphalocyclus macropora*, *Siderolites calcitrapoides* and *Orbitoides* cf. *media* occur.

DOUVILLÉ (1910, p. 76) concluded, after his examination of DE MORGAN's material, that *L. persica* is characteristic of the lower part of the Maestrichtian and *L. morgani* of the upper part of the same stage and of the Danian. The evidence subsequently obtained does not conflict with this conclusion though it is not possible to cite any further case in which both these species occur in the same section nor specific evidence of the Danian age of any specimen. In the Gavara section, *L. morgani* is associated with *Orbitoides apiculata*, a species which in Europe is characteristic of middle or upper Maestrichtian horizons. In the same section *L. elongata* occurs with a species of *Orbitoides* which is closely similar to if not identical with *O. media* a species characteristic of lower Maestrichtian beds in western Europe. In the other sections mentioned, *L. elongata* occurs either below or at about the same horizon as *L. persica*.

L. minor and *L. harrisoni* in Kuh-i-Sarab occur in the lowest *Loftusia*-bearing horizons. A megaspheric specimen of *Loftusia* was also collected by K. W. GRAY and R. C. JENNINGS from Ausuna Sar Gach, Khurramabad in Luristan, in limestones containing *L. elongata*. This specimen which occurs as a longitudinal section in a rock slide is probably identical with *L. harrisoni*.

The possibility has been mentioned of *L. minor* ultimately proving to be indistinguishable from *L. morgani*. Should this be the case, DOUVILLÉ's contention that *L. morgani* occurs only in upper Maestrichtian or Danian beds and that *L. persica* is confined to the lower Maestrichtian breaks down in the light of the Kuh-i-Sarab section.

Affinities.

The closely related species by which the genus *Loftusia* is represented in south-western Iran, resemble, in shape and structure of the spiral wall, many of the *Fusulinidae* but differ from them in their endoskeletal development. This superficial similarity was no doubt due to structural convergence in adaption to similar modes of life rather than to genetic affinity. The *Fusulinidae* attained their maximum development in the late Palaeozoic and it is very improbable that their stock should have persisted, without intermediate record being found, to flourish again in the Cretaceous.

The shape, mode of coiling and arrangement of septa and apertures in *Loftusia* resemble these features in *Praealveolina* REICHEL (1933). In this case also the similarity is probably due to convergence rather than affinity. Arenaceous foraminifera may, in some cases, have been derived from porcellaneous ancestors, as for example certain *Miliolidae*, but it is improbable that *Loftusia* could be derived directly from *Praealveolina* which is itself a highly evolved form.

CHAPMAN (1902, p. 136) indicated a probable relationship between *Cyclamina* and *Loftusia*. SILVESTRI (1932) has recently brought forward further evidence in support of this view and described two species, *Loftusia lamellifera* and *L. bemmelini* which appear to occupy positions morphologically intermediate between *Pseudocyclamina* and the Maestrichtian *Loftusiae*.

The initial microspheric spire of *Loftusiae* from Persia, in equatorial section, closely resembles the spire of *Choffatella decipiens* SCHLUMB. In axial section it is less compressed and approximates more nearly to the shape of *Cyclamina*. That *Loftusia* was derived from a Lituolid ancestry seems most probable and it is perhaps significant that species of both *Pseudocyclamina* and *Choffatella* occur in the Lower Cretaceous of south-western Iran.

Descriptive Palaeontology.

Genus **Loftusia** W. B. BRADY, 1869.

Test fusiform, ovoid, globose or nautiloid. Planispiral. Whorls regular, tightly coiled and gradually increasing in thickness from centre to periphery, Spiral wall imperforate, calcaerous, alveolar; endoskeleton arenaceous. Whorls divided into chambers by primary, longitudinal, oblique septa; chambers with labyrinthic, endoskeletal structure, composed of pillars, set radially, which may fuse together to form transverse, secondary septa or partial septa. Apertures numerous, arranged in transverse rows across the primary septa.

The nature of the spiral wall in *Loftusia persica* and *L. morgani* has been described by DOUVILLÉ (1904, 1906); in other species of

Loftusia it is similarly constructed. The development of an alveolar, supporting structure beneath a thin, outer, imperforate layer, as pointed out by DOUVILLÉ (1906), is common in many of the more highly organized, arenaceous foraminifera. DAVIES (1930, pp. 491 to 493) gives a clear description of this structure as developed in *Dictyoconus* BLANCKENHORN and traces its evolution through the allied genera *Lituonella* SCHLUMB. & DOUV. and *Coskinolina* STACHE. In *Loftusia* the minute cells of the alveolar layer (Pl. XXXVII, *alb*) are similarly arranged but are polygonal in plan and not rectangular as shown diagrammatically by DAVIES (loc. cit. text-fig. 5, p. 492).

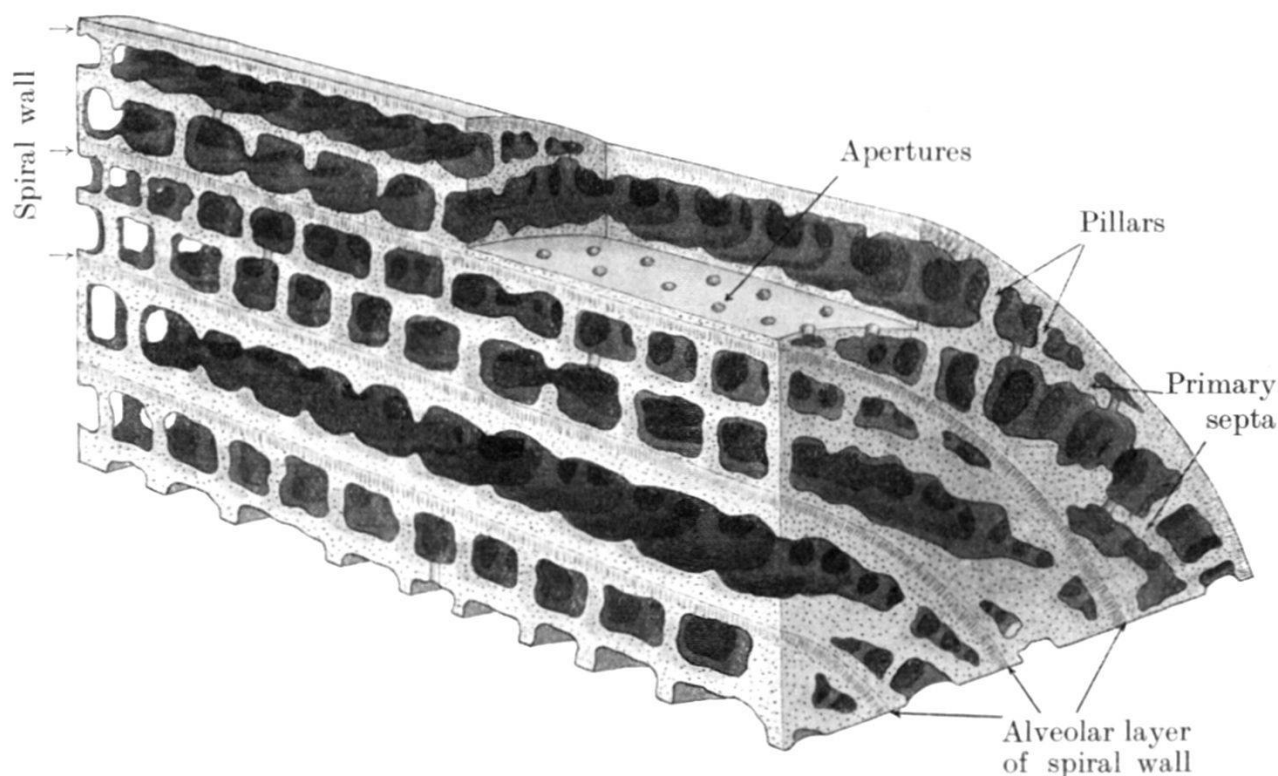


Fig. 3. Block-diagram of a segment of *Loftusia persica* BRADY.

There is a marked difference in shell substance between the spiral wall and the endoskeleton: the spiral wall, which includes the outer imperforate layer and the "plates" (DAVIES) or "poutrelles" (DOUVILLÉ) which form the alveolar mesh, is composed only of finegrained calcareous matter; the endoskeleton is built up of a heterogenous accumulation of siliceous and calcareous sand grains, tests of minute foraminifera and other organismes and a variable amount of fine-grained calcareous cement. The primary septa are a part of the endoskeletal structure.

Text-fig. 3 illustrates diagrammatically the structure of the endoskeleton in *Loftusia*. Irregular pillars extend radially between successive longitudinal septa or between the septa and the spiral

wall. There is a greater accumulation of these supporting pillars in the acute angles between septa and spiral walls than in the centre of each chamber. The central parts of the chambers are usually filled with an undivided mass of crystalline calcite.

In his first description of *L. morgani*, DOUVILLÉ (1904, p. 368) said that there appeared to be only one row of apertures placed at the base of the apertural face whereas in *L. persica* there were many rows. Later (1910, p. 77), he said that there seemed to be other apertures aligned transversely. In the specimens examined during the present work, the apertures in all species of *Loftusia* appear to be similarly arranged: there are numerous small rounded openings in the primary septa set in transverse rows to correspond with spaces between the rows of pillars.

DOUVILLÉ (1904, Pl. L. fig. 36, explanation) drew attention to certain transverse ridges on the worn surfaces of some of DE MORGAN'S specimens of *L. morgani* and compared them with the surface striae of the Alveolines. Such ridges are also visible on the worn surfaces of other species of *Loftusia* and are remains of the endoskeleton of an outer whorl which has been eroded away. The surface of the living shell was probably smooth except for faint longitudinal furrows along the lines of junction between the spiral wall and underlying primary septa.

BRADY (1869, p. 742) noted the presence of several flattened specimens in LOFTUS' collection but concluded, with some hesitation, that their shape was due to distortion after death of the animal. In many of the later collections similar squashed specimens occur. In spite of the massive supporting endoskeleton secreted by *Loftusia* the shell must have been relatively fragile; not only are there many cases, especially in marly, less competent sediments, of the shells having been crushed after death but, in several specimens, the earlier whorls show fractures which have healed and have been covered by latter whorls, with more or less distortion of the external shape of the test.

***Loftusia persica* W. B. BRADY, 1869.**

(Pl. XXXIII, fig. 1.)

- 1855. *Alveolina* sp. W. K. LOFTUS. Q.J.G.S. Vol. XI, p. 285, footnote.
- 1860. *Alveolina* sp. W. K. PARKER & T. R. JONES. Ann. Nat. Hist. 3rd Ser. Vol. VIII, p. 161.
- 1869. *Loftusia persica* W. B. BRADY. Phil. Trans. Vol. GLIX, pp. 739—754; Pls. LXXVII—LXXX.
- 1904. *Loftusia persica* (pars) H. DOUVILLÉ. Miss. sc. en Perse, Vol. III, Pt. IV, pp. 367.

LOFTUS' collection of *L. persica* is now preserved, partly in the British Museum (Natural History) and partly in the Hancock Museum, Newcastle-upon-Tyne. The former group consists of thin sections

and specimens, some of which have been cut and polished to show different planes. Measurements of these specimens are:

<i>Length</i>	<i>Equatorial Diameter</i>	<i>Number of Whorls</i>
55 mm.	28.3 mm.	—
68 „	25 „	—
—	ca. 25 „	—
76 „	41 „	32
55 „	27.5 „	19
ca. 83 „	38 „	26
ca. 70 „	ca. 25 „	15
—	24 „	16
51 „	27 „	22
—	37 „	25
—	25 „	21

The writer has not seen the material in the Hancock Museum but the Curator, MR. T. RUSSEL GODDARD, kindly sent him measurements of the twelve specimens of *L. persica* there preserved. Their dimensions are:

<i>Length</i>	<i>Diameter</i>	<i>Length</i>	<i>Diameter</i>
91.5 mm.	42.0 mm.	57.0 mm.	25.5 mm.
82.0 „	38.0 „	48.0 „	19.5 „
79.5 „	26.5 „	46.0 „	23.0 „
82.0 „	30.0 „	45.0 „	15.0 „
71.0 „	28.0 „	37.5 „	10.0 „
65.5 „	36.0 „	34.5 „	18.5 „

Since BRADY did not indicate a holotype, the specimen cut in three pieces, numbered 9088, 9089 and 9090 respectively, in the British Museum (Natural History), is selected as lectotype for the species. This specimen is 76 mm. long and 41 mm. in diameter; it is of ovoid shape and has 32 whorls. It is cut in half transversely and one of the halves is again bisected longitudinally. This specimen may have been the model from which BRADY's figure shown on Plate LXXVIII was drawn (BRADY 1869) though the figure only shows 17 whorls.

Specimens from four other localities are identified with BRADY's species. They vary in equatorial diameter from 9.2 mm. to 35 mm. and from 23.7 mm. to 80 mm. in length. The average dimensions of 40 specimens are: 68 mm. in length by 25.5 mm. in diameter. Ratio of length to diameter varies between 3.3:1 and 1.8:1 with an average of 2.7:1. As shown in text-fig. 1, there is wide variation in size and shape and no great preponderance of specimens near the

average figures. The number of whorls varies with the diameter of the specimen. There is little variation in different specimens, between the whorl thickness at corresponding distances from the centre. The following development in a specimen 32.4 mm. in diameter is typical of the species:

Diameter of microspheric nucleoconch	0.04 mm.
Thickness in equatorial section of 1st whorl	0.25 „
„ „ „ „ „ 5th „	0.35 „
„ „ „ „ „ 10th „	0.50 „
„ „ „ „ „ 15th „	0.50 „
„ „ „ „ „ 20th „	0.55 „
„ „ „ „ „ 25th „	0.63 „
„ „ „ „ „ 30th „	0.82 „
Total number of whorls: 31 in a radius of	16 „

The number of chambers per whorl usually increases slightly from the earlier to the later whorls but the individual chambers increase greatly in width with growth of the shell. The inner whorls have from 12 to 15 chambers per whorl and in larger specimens the outer whorls usually contain 18 to 25 chambers. There is similarly a slight increase in distance apart of the endoskeletal pillars from the inner to the outer whorls. The worn outer surfaces of larger specimens show from 18 to 25 transverse ridges per centimetre corresponding to so many rows of pillars.

The apertures are subcircular and about 0.03 mm. in diameter. The longest series of plates forming the alveolar layer of the spiral wall form polygonal cells about 0.02 mm. across, and 0.06 mm. long in the outer whorls. These cells are further subdivided in their outer parts by secondary plates about half as long as the primary ones. The endoskeletal material is composed of sand grains varying in diameter up to about 0.15 mm. set in a calcareous cement. The proportion of cement to arenaceous matter is usually greater in this species than in other *Loftusiae* and consequently the internal structure is more clearly seen. It must be noted however that the apparently greater clearness of the endoskeletal structures in sections of *L. persica* is partly due to the fact that, at least in the outer whorls, the scale of development is greater than in other species and the apparent fineness in texture is to some extent relative.

Wherever sections have been seen passing through the centre of the shell a minute initial microspheric coil can be distinguished. It is less than 0.05 mm. in diameter and, though difficult to make out the precise form of this nucleoconch owing to the irregularity of the arenaceous material, it appears to be either nautiloid or globose in shape and to expand rapidly like the spire of *Choffatella*. The septa are closely set together and strongly recurved. It is not possible to see clearly in any of the specimens examined whether or not the chambers are further subdivided by transverse structures such as develop in later whorls.

Examination of longitudinal sections of adult specimens shows the successive shapes through which the shell has passed in its younger stages. It is found that there is a good deal of irregularity in the course followed by different specimens but, in each case seen, there is progression from a globose or ovoid shape in the first few whorls to a more elongate form in which the length:diameter ratio is greater than 3.5 : 1. The elongate phase is then followed by a relative shortening of succeeding whorls so that the shell assumes a more ovoid shape. In text-fig. 2 the successive changes in shape throughout the development of three specimens of *L. persica* are shown.

L. persica is distinguished from *L. elongata* by the more ovoid shape of adult specimens. Young specimens, as indicated in text-fig. 2, may be indistinguishable from small varieties or young specimens of *L. elongata*.

Localities:

S.P.R. 2289 — Tang-i-Mehmud, Kuh-i-Garreh, Bakhtiari Country, Iran.

S.P.R. 2084, 2085 — Kuh-i-Abbagh, Bakhtiari Country, Iran.

S.P.R. 2176 — N.E. Slope of Kuh-i-Sarab, Bakhtiari Country, Iran.

S.P.R. 5234 — Yezd-i-Khast, Laristan, Iran.

Loftusia elongata sp. nov.

Pl. XXXIII, fig. 2; Pl. XXXV, fig. 1 & 2.

1904 *Loftusia persica* (pars) H. DOUVILLÉ. Miss. sc. en Perse, Vol. III, Pt. IV.

This species is fusiform or sub-cylindrical in shape; it may be either rounded or pointed at the ends and shows considerable variation in size. Its length varies from 12 mm. to 118 mm. and diameter from 5.6 mm. to 33 mm. The average length of 102 specimens is 55.5 mm. and average diameter 12.3 mm. The ratio of length to diameter varies between 3.5 : 1 and 9.2 : 1 with an average of 4.5 : 1. Maximum, minimum and average dimensions of several groups of specimens collected from different localities are shown in the following table:—

Specimen No.	Number of Specimens	Length			Diameter			Length:Diameter		
		Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.
SPR. 2083	14	74	60	45	17.7	13.6	8.9	6.0	4.45	3.6
SPR. 2013	19	56	47	30	15.2	10.0	5.7	7.0	4.7	3.7
SPR. 2177	19	66	47.5	27	13.5	9.8	5.7	9.2	4.85	3.95
SPR. 2178	5	107	74.6	44	25.0	17.9	11.0	4.75	4.19	3.65
SPR. 1983	30	74	59.4	40	16.5	12.7	7.9	5.8	4.7	3.63
SPR. 5256	8	73	61.3	43	20.0	15.0	9.5	5.2	4.1	3.5
GML. 399	4	60	56.9	54	17.0	15.4	14.5	4.0	3.7	3.53

The internal structure of *L. elongata* closely resembles that of *L. persica*. The alveolar layer of the spiral wall is of approximately the same sized mesh as that of *L. persica*. The thickness of whorls, measured in equatorial section is also of the same order, at corresponding distances from the centre, but in *L. elongata* successive whorls increase greatly in length. As shown graphically in text-fig. 2, this results in but little change of length:diameter ratio throughout growth of the shell. In *L. elongata* there are usually 7 or 8 whorls in the first 2.5 mm. of radius and specimens of 15 mm. diameter have 16 to 18 whorls, of which the outer ones are about 0.55 mm. in thickness in the equatorial plane. There are from 15 to 20 chambers in the outer whorls which, in larger specimens, are about 2.5 mm. broad in their widest part.



Fig. 4. *Loftusia elongata* nov. sp.

Transverse section of fine grained variety. S. P. R. 2013. Kuh-i-Dalun, Bakhtiari Country, Iran. $\times 5$.

There is wide variation in grain of the endoskeletal deposit. The specimen figured in Pl. XXXV, fig. 1 contains a relatively small amount of coarse-grained material and in this respect resembles most of the specimens examined of *L. persica*. On the other hand, the specimens shown in Pl. XXXV, fig. 2 contain much more coarse arenaceous material in proportion to the amount of fine grained calcareous cement present.

The apertures in this species are similarly arranged to those of *L. persica* and are of the order of 0.03 mm. in diameter in the outer whorls.

No megaspheric nucleoconch has been found in any of the specimens referred to *L. elongata* though a single megaspheric form similar in shape and size to *L. harrisoni* has been seen in rocks from Ausuna Sar Gach, where *L. elongata* also occurs. The microspheric nucleoconch of *L. elongata* is, so far as it is possible to see the details, similar to that of *L. persica*.

Holotype: The specimen from near Darab, Laristan, figured Pl. XXXIII, fig. 2 is selected as holotype for this species.

Localities:

- S.P.R. 5256, 5257 — ca. 2 miles W. of Darab, Laristan, Iran (Type Locality).
- S.P.R. 2083 — Kuh-i-Abbagh, Bakhtiari Country, Iran.
- S.P.R. 2013 — Kuh-i-Dalun, Bakhtiari Country, Iran.
- S.P.R. 2177 — S. slope of Kuh-i-Sarab, Bakhtiari Country, Iran.
- S.P.R. 2178 — N.E. slope of Kuh-i-Sarab, Bakhtiari Country, Iran.
- S.P.R. 1983 — Kuh-i-Sirwah, Bakhtiari Country, Iran.
- S.P.R. 3125 — Asanbid, Bakhtiari Country, Iran.
- S.P.R. 2964 — Chalau, Bakhtiari Country, Iran.
- G.M.L. 399 — Gavara, Province of Kirmanshah, Iran.

Loftusia morgani H. DOUVILLÉ, 1904.

Pl. XXXIII, fig. 3; Pl. XXXIV, figs. 1 & 2.

- 1904 — *Loftusia morgani*, H. DOUVILLÉ. Miss. sc. en Perse Vol. III, Pt. IV.
- 1910 — *Loftusia morgani*, H. DOUVILLÉ. Mém. Soc. Géol. Fr. Vol. XVIII, fasc. 1, pp. 76—78.
- 1909 — *Alveolina morgani*, G. OSIMO. Pal. Ital. Vol. XV.

Specimens identified with this species vary from 6 mm. to 44.5 mm. in length and 3 mm. to 8 mm. in diameter. Their ratio of length to diameter varies from 2:1 to 7.2:1. The average dimensions of 88 specimens are: length 27 mm.; diameter 5.8 mm.; ratio length: diameter 4.6:1. There is relatively little fine-grained calcareous cement in the endoskeleton which is composed of sand grains and other fragments varying up to 0.18 mm. in diameter. The coarseness of this material greatly obscures structural details of the shell but it is evident that the mode of coiling and arrangement of septa are similar to these features in other species of *Loftusia*. Similarly it is believed that the apertures are disposed in rows across the primary septa.

Localities:

- S.P.R. 2963 — ca. 2 miles N. of Sar Qaleh Qayad, Bakhtiari Country, Iran.
- S.P.R. 3118 — Sar-i-Kul, Bakhtiari Country, Iran.
- G.M.L. 386, 400 — Gavara, Province of Kirmanshah, Iran.
- G.M.L. 437 — Darkhwar, Province of Kirmanshah, Iran.

Loftusia minor sp. nov.

Pl. XXXIII, fig. 5; Pl. XXXVI, figs. 1, 2 & 3.

The specimens referred to this species are small and fusiform. The microspheric forms externally resemble small specimens of *L. morgani* but in thin sections the agglutinated material is seen to be of finer grain. Of the several collections of *Loftusia* examined in this work, this species includes the only group of specimens in which both micro- and megaspheric forms occur in close association and bearing an obvious relation one to the other.

The microspheric forms vary, in eleven specimens, from 10.3 mm. to 21.28 mm. in length and from 2.15 mm. to 4.9 mm. in diameter. Length:diameter ratio varies from 3.38:1 to 5.41:1. The average dimensions are: length 15.08 mm.; diameter 3.63 mm.; length:diameter ratio 4.66:1. There are from 7 to 9 whorls in larger specimens. The inner whorls, following on the initial microspheric spire, are from 0.15 mm. to 0.25 mm. in thickness and the outer whorls vary from 0.25 mm. to 0.4 mm. in different specimens examined. The average whorl thickness in three specimens is 0.26 mm.

Details of the microspheric nucleoconch are not clear in any of the specimens sectioned but there appears to be an initial, rapidly expanding spire similar to that of *L. persica*. This nucleoconch does not exceed 0.1 mm. in diameter and is globular in shape. The first succeeding whorl is ovoid and by the 3rd or 4th whorl the shell has assumed the elongate form which continues with little change in length:diameter ratio until the adult stage.

The number of chambers increases from about 12 in the second whorl to 18 in the 6th whorl and 20 in the 9th. The spiral wall, endoskeleton and apertures are similarly constructed to those of other species of *Loftusia*.

The megaspheric forms vary in shape from blunt fusiform to sub-cylindrical with rounded ends. In 13 specimens they vary from 3.72 mm. to 7.45 mm. in length and 1.42 mm. to 2.9 in diameter with an average length of 5.96 mm. and diameter of 2.15 mm. The ratio of length to diameter varies from 2.16:1 to 3.44:1 with an average of 2.79:1. The nucleoconch is about 0.7 mm. in diameter; it is approximately spherical and probably consists of an inner rounded chamber of about 0.5 mm. diameter which is completely surrounded by a second chamber. The interior dividing wall is not well preserved in any of the specimens examined but traces of it are visible in each case. The nucleoconch is followed by three or four whorls which increase slightly in thickness from centre to periphery. The first whorl varies in thickness in different specimens from 0.15 mm. to 0.39 mm., the last whorl from 0.25 mm. to 0.41 mm.

L. minor differs from *L. morgani* by its somewhat smaller range in size, its generally more finely arenaceous wall material and the presence of a characteristic megaspheric form.

Holotype: Microspheric form — specimen illustrated in Pl. XXXIII, fig. 5+.

Megaspheric paratype — specimen illustrated in Pl. XXXVI, fig. 1.

Locality: The type material for this species was collected by Dr. J. V. HARRISON on the southern slope of Kuh-i-Sarab, Bakhtiari Country, Iran (S.P.R. 2185); he has referred to the species in private reports as *Loftusia persica* var. *minor*.

***Loftusia harrisoni* sp. nov.**

Pl. XXXIII, fig. 4; Pl. XXXVI, figs. 4, 5 & 6.

This species includes certain small, globose megaspheric forms. They vary in shape from subspherical to ovoid. The ratio of length to diameter varies, in 17 specimens, from 1.92:1 to 0.7:1 with an average of 1.2:1. The length varies from 1.6 mm. to 5.5 mm. with an average of 3.2 mm. Diameter varies from 1.53 mm. to 5 mm. with an average of 2.68 mm.

The megaspheric nucleoconch is from 1.7 mm. to 2.0 mm. in diameter. Traces of internal subdivision are visible, as in the nucleoconch of *L. minor*, but recrystallization has, in each specimen examined, destroyed details of this structure.

The nucleoconch is followed by two or three whorls which are from 0.35 mm. to 0.7 mm. thick in different specimens. The whorls are subdivided into 12 to 18 chambers by septa which are somewhat more oblique than those of *L. minor*. The arenaceous endoskeletal material is of relatively fine grain; structure of the spiral wall and arrangement of apertures are similar to these features in other species of *Loftusia*.

L. harrisoni is readily distinguished from any of the above described species of *Loftusia* by its shape and size. Its nucleoconch is more than twice the size of the megaspheric nucleoconch of *L. minor*. The species bears some resemblance to *L. bemmeleni* described by SILVESTRI (1932) from the Lower Cretaceous of Sumatra but differs by the greater size of its nucleoconch and its smaller number of whorls.

Holotype: Specimen illustrated in Pl. XXXIII, fig. 4+.

Locality: S.P.R. 2186 — S. slope of Kuh-i-Sarab, Bakhtiari Country, Iran. A thin section of a single specimen, J-G/ZE/331, from Ausuna Sar Gach, Khurramabad, Luristan, Iran, is probably of this species.

The species is named after Dr. J. V. HARRISON, who collected the type specimens.

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Explanation of Plates.

Plate XXXIII.

- Fig. 1: *Loftusia persica* BRADY. Exterior view.
Specimen S.P.R. 2084. Kuh-i-Abbagh, Bakhtiari Country, Iran.
Specimen S.P.R. 2176. NE slope, Kuh-i-Sarab, Bakhtiari Country, Iran.
- Fig. 2: *Loftusia elongata* sp. nov. Exterior view.
Specimen S.P.R. 2013, Kuh-i-Dalun, Bakhtiari Country, Iran.
Specimen S.P.R. 5256, ca. 2 miles W of Darab, Laristan, Iran. H = holotype.
- Fig. 3: *Loftusia morgani* DOUVILLÉ. Exterior view.
Specimen S.P.R. 2963. 2 miles N of Sar Qaleh Qayad, Bakhtiari Country, Iran.
- Fig. 4: *Loftusia harrisoni* sp. nov. Exterior view.
S.P.R. 2186. Kuh-i-Sarab, Bakhtiari Country, Iran. + = holotype.
- Fig. 5: *Loftusia minor* sp. nov. Exterior view.
S.P.R. 2185, Kuh-i-Sarab, Bakhtiari Country, Iran. + = holotype.
- All figures natural size.

Plate XXXIV.

- Fig. 1 & 2: *Loftusia morgani* DOUVILLÉ.
S.P.R. 2963. 2 miles N of Sar Qaleh Qayad, Bakhtiari Country, Iran.
Fig. 1: longitudinal section, $\times 8,7$. Fig. 2: transverse section, $\times 9,6$.
- Fig. 3: *Loftusia elongata* sp. nov. Part of longitudinal section, $\times 17,6$.
S.P.R. 5256, ca. 2 miles W of Darab, Laristan, Iran.

Plate XXXV.

- Fig. 1: *Loftusia elongata* sp. nov. Fine grained variety. Part of transverse section, $\times 17,6$.
S.P.R. 2013, Kuh-i-Dalun, Bakhtiari Country, Iran.
- Fig. 2: *Loftusia elongata* sp. nov. Coarse grained variety. Part of transverse section, $\times 17,6$. Ca. 2 miles W of Darab, Laristan, Iran.

Plate XXXVI.

Fig. 1: Fig. 1—3. *Loftusia minor* sp. nov.

S.P.R. 2185, Kuh-i-Sarab, Bakhtiari Country, Iran, $\times 9,6$.

Fig. 1: megaspheric form, longitudinal section.

Fig. 2: microspheric form, longitudinal section.

Fig. 3: microspheric form, transverse section.

Fig. 4—6: *Loftusia harrisoni* sp. nov.

S.P.R. 2186, Kuh-i-Sarab, Bakhtiari Country, Iran. $\times 9,6$ (megaspheric form).

Fig. 4: longitudinal section.

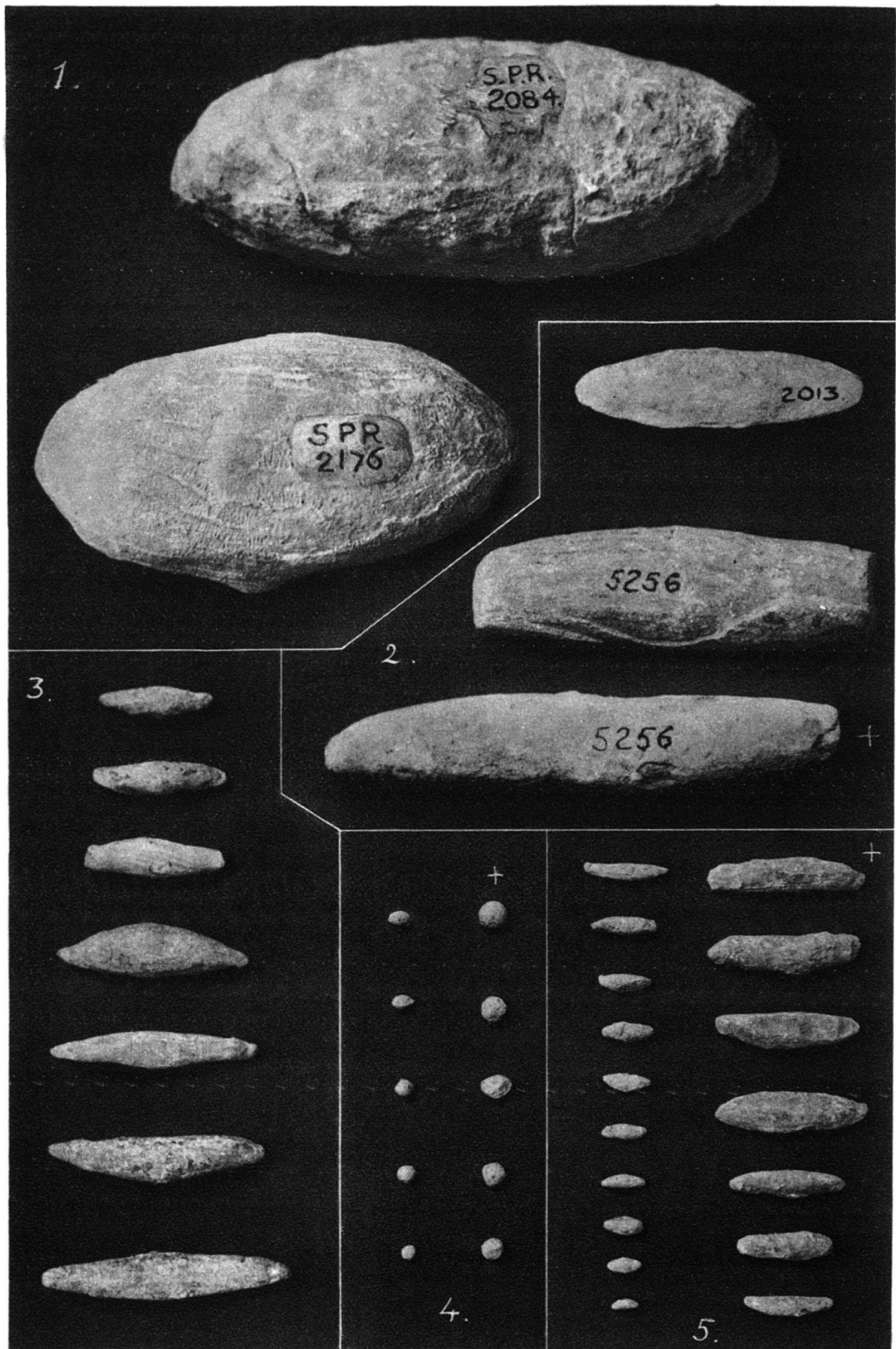
Fig. 5: oblique section.

Fig. 6: nearly transverse section.

Plate XXXVII.

Loftusia elongata sp. nov. Fine grained variety. Part of tangential thin section, in reflected light, on black back ground, $\times 32$.

alv = alveolar layer of the spiral wall; p = pillars; s = septum with apertures.

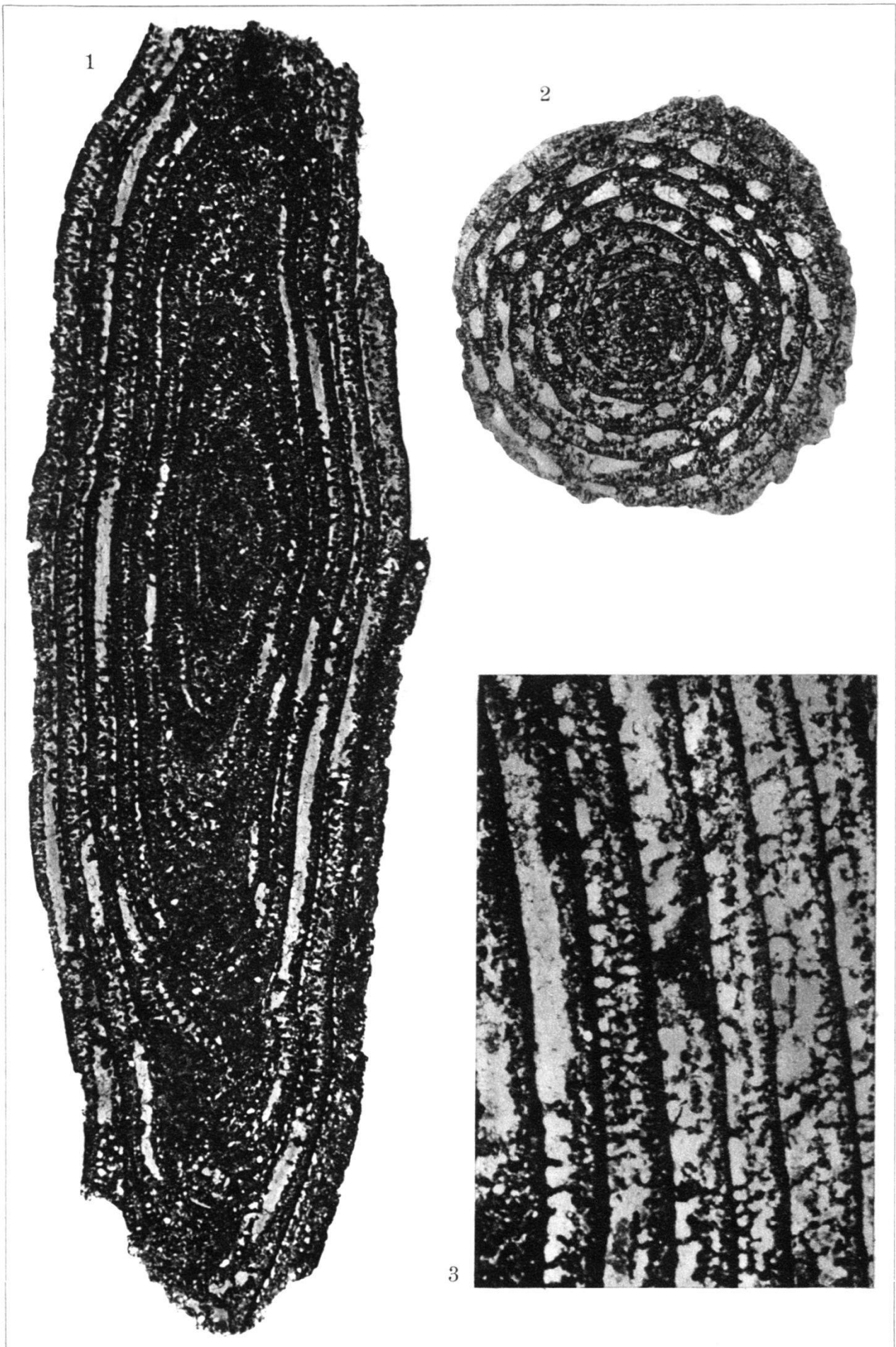


Exterior view, natural size.

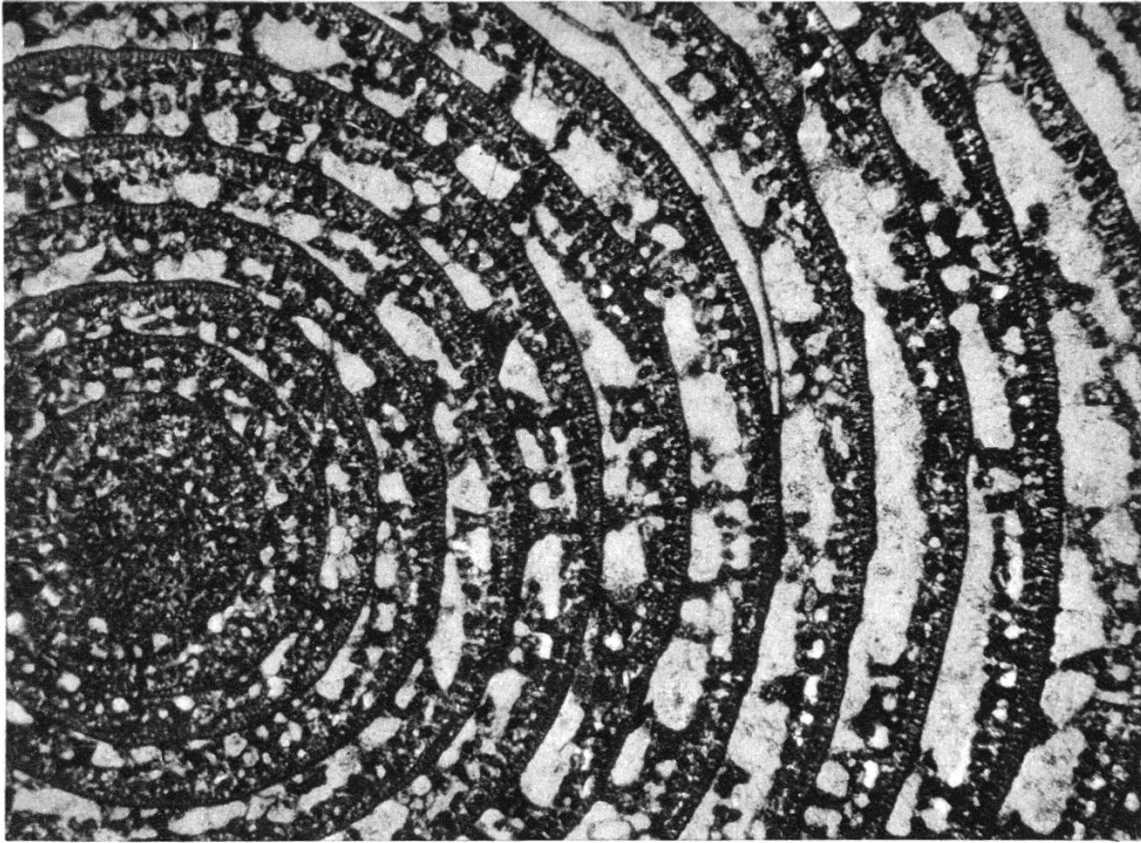
1: *Loftusia persica* BRADY. 2: *L. elongata* n. sp. 3: *L. morgani* DOUVILLÉ.

4: *L. harrisoni* n. sp. 5: *L. minor* n. sp.

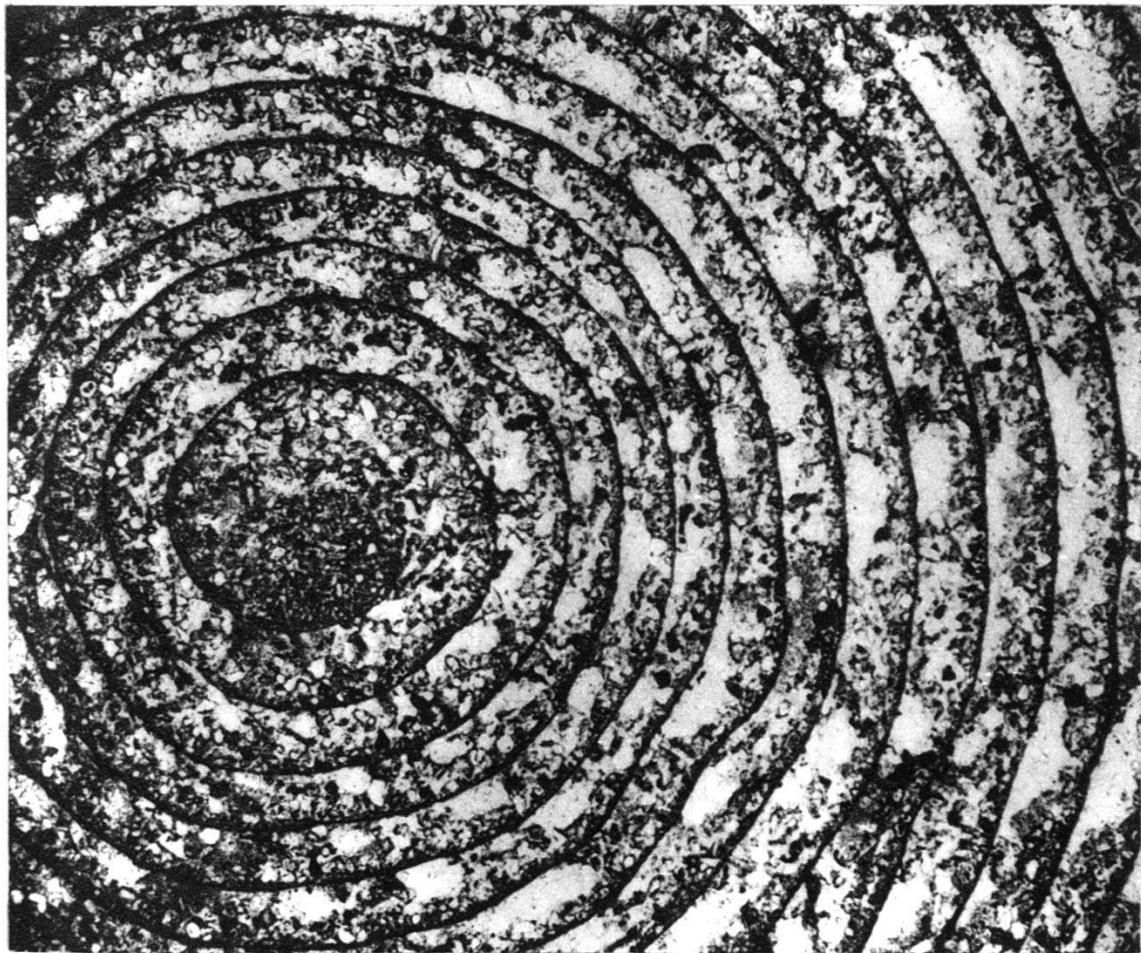
Explanation of plates in full see p. 449—450.



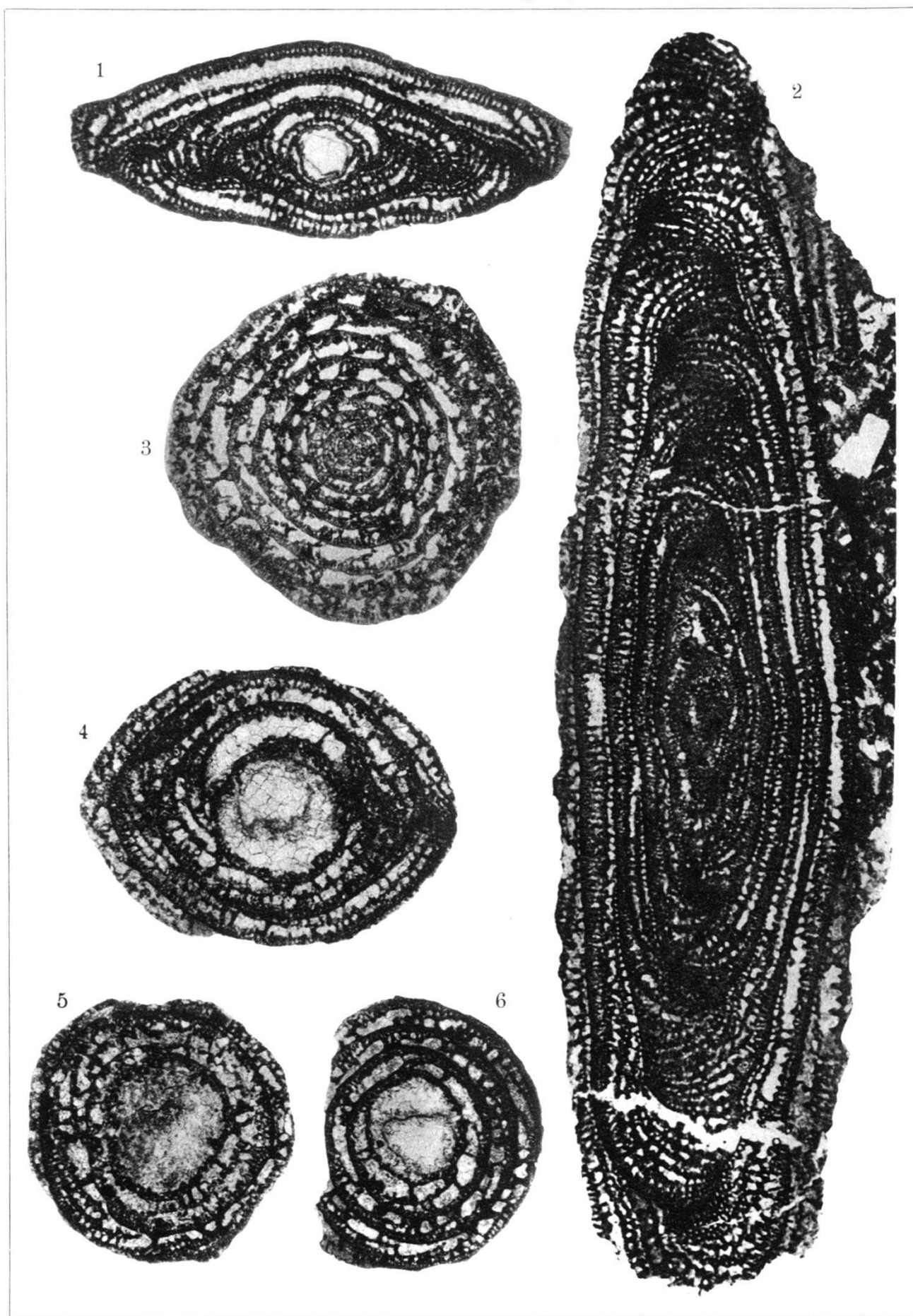
1 & 2: *Loftusia morgani* Douv. 3: *L. elongata* n. sp.



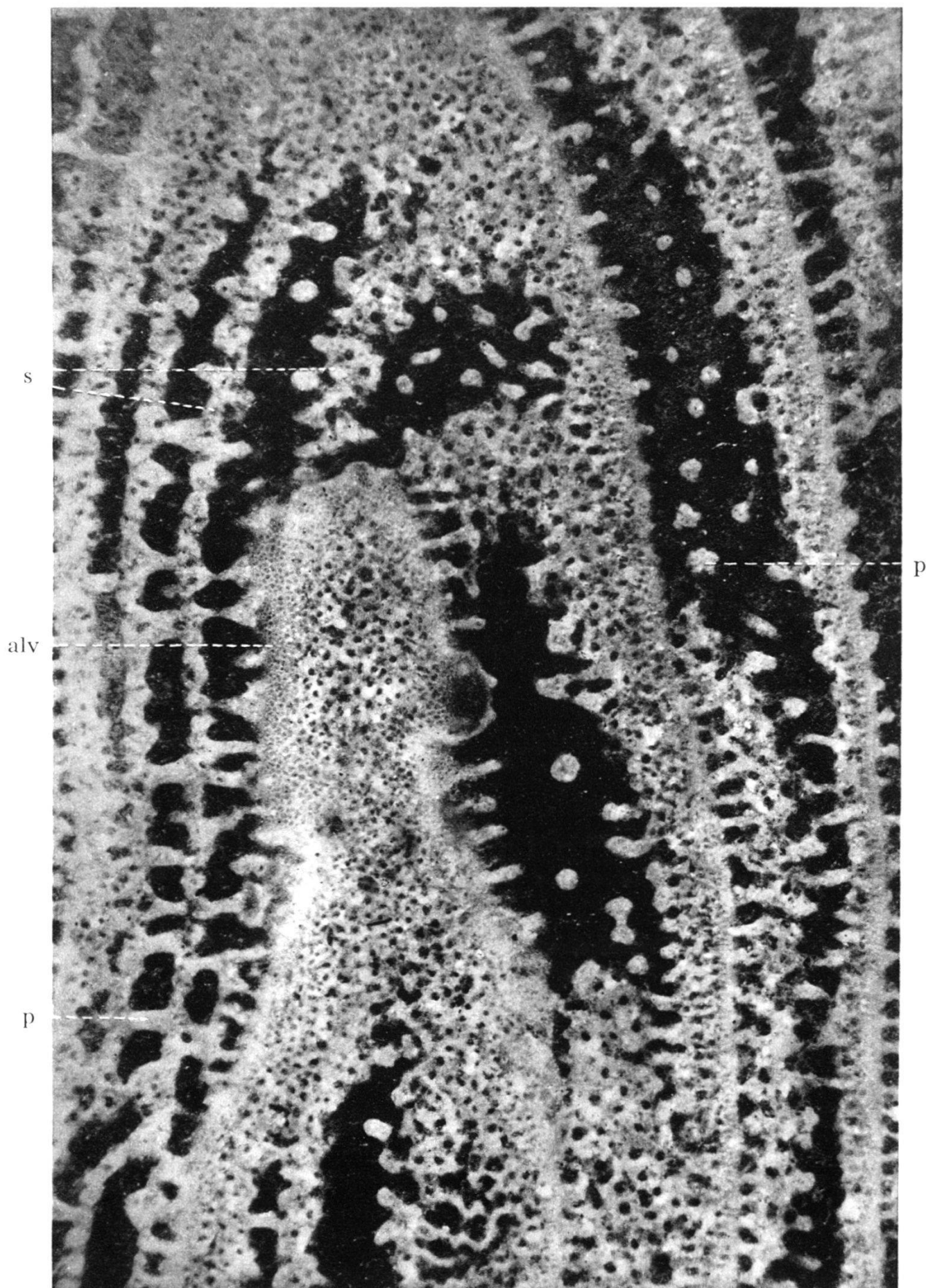
1: *Loftusia elongata* n. sp. Fine grained variety.



2. *Loftusia elongata* n. sp. Coarse grained variety.



1-3: *Loftusia minor* n. sp. 4-6: *Loftusia harrisoni* n. sp.



Tangential section of *Loftusia elongata* n. sp.
in reflected light, on black back ground. $\times 32$.

alv = alveolar layer of the spiral wall; p = pillars; s = septum with apertures.

M. REICHEL phot.

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