

***Loftusia persica*: an Eocene Lazarus occurrence?**

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Abstract

A specimen of *Loftusia persica* Brady is described that contains as a part of its inner test a specimen of *Turborotalia pomeroli* (Toumarkine and Bolli), which is a very distinctive Middle to Late Eocene planktonic foraminifera. Although originally described as a “Tertiary” form, more recently *Loftusia persica* has been considered to be restricted to the Maastrichtian. A number of scenarios that could have led to the inclusion of an Eocene planktonic foraminifera deep within the test of a specimen of *Loftusia* are discussed, and it is concluded that the most probable interpretation is that *Loftusia persica* reappeared as a “Lazarus” species in the Eocene having survived the Cretaceous-Paleocene mass extinction, but was eventually driven to extinction by the orogeny that led to the formation of the Zagros Mountains.

Introduction

Loftusia, a well-known genus among larger benthic foraminifera, has been reported from various Maastrichtian strata in the Mediterranean and the Middle East. *Loftusia* was first described as coming from the “Tertiary” of Iran by Carpenter and Brady (1869), who included all Iranian specimens collected by Loftus under *Loftusia persica*. Subsequent to Carpenter and Brady (1869), all loftusias were assigned to the Maastrichtian, and post-Maastrichtian assemblages were recorded as being reworked in younger sediments (e.g. Meriç and Görmüs, 2001). *Loftusia persica*, an agglutinated foraminifera, seems to have built its test by cementing fine arenaceous grains acquired from the ambient environment. Occasionally, as noted in Carpenter and Brady (1869), these grains included the tests of dead smaller foraminifera. While recently re-analysing the foraminifera found in the test of the genosyntypes specimens of Carpenter and Brady (1869), deposited in the Natural History Museum (NHM), London, we have found that the specimens appear to belong to two different provenances; those which have tests that contain small benthic foraminifera of Late Cretaceous age, and another that has a distinctive Eocene planktonic foraminifera bound into the test. Below, we discuss the significance and possible explanations of these observations.

Description of *Loftusia*

Loftusia is irregularly fusiform or cylindrical in shape, and may have either rounded or pointed ends. It is comprised of a series of chambers that are planispirally coiled around an elongate axis. The front of each chamber slopes gently downwards to meet the previous whorl; the portion behind the frontal slope is gently inclined (see Fig. 1); the

portion behind the frontal slope is carried backward at a constant elevation. There is, thus, no part of the exterior wall possessing a configuration that would define an apertural face in the normal sense, although there are a number of pores in the surface of the chamber adjacent to the previous whorl. If a test constructed in this fashion is viewed in cross-section, it will be seen that the net effect is the production of a continuous and smoothly spiralling wall enclosing a series of low chambers, that are bounded by smoothly curved and highly oblique septa. The interior of the chambers are partially filled by networks of irregular projections that cover the inner surface of the exterior walls; some of the projections reach the surface of the preceding whorl and thus form pillars or partial septa, depending on their shape. The spiral wall of *Loftusia* is made up of a thin outer calcareous layer and a thick arenaceous layer; the forward extension of the latter forms the gently-inclined frontal slope of each chamber. *Loftusia* attained an immense size, some individuals having a diameter of over 30mm and a length of more than 10cm.

>>>>Fig. 1 here

Loftusia, like all agglutinated foraminifera, built its shell by accreting components from the ambient environment. It bound them with organic or biomineralized cements produced by the cell. According to Meriç and Görmüs (2001), *Loftusia* seem to have included fragments of the lithology of the ambient platform, and in many Tethyan forms they report tiny ophiolitic rock fragments within the loftusian tests, reflecting ophiolite formation, associated with this region in the Maastrichtian.

Loftus had originally assigned the specimens to the Palaeogene *Alveolina* (Carpenter and Brady, 1869). However, after a detailed study of the wall structure of the test, Brady (in Carpenter and Brady, 1869) proposed a new genus *Loftusia*, referring to Loftus, and included all specimens under *Loftusia persica*, which was the first species of the genus. Brady illustrated his specimens with excellent drawings, showing inclusions within the tests of smaller foraminifera, such as small miliolids. He gave its age as “Lower Tertiary”.

Cox (1937) made the next major contribution on the genus *Loftusia*, and described four species, *Loftusia harrisoni* nov. sp., *Loftusia elongata* nov. sp., *Loftusia minor* (B and A) nov. sp. and *Loftusia persica* Brady, from the Upper Cretaceous of southwestern Iran. Loftusiids became larger and more tightly coiled during the middle and late Maastrichtian (Al-Omari and Sadek, 1976), with species such as *L. elongata* and *L. morgani* becoming dominant during this time (Al-Omari and Sadek, 1976).

In contrast to other species, *Loftusia persica* seem to have been restricted to the Arabian plate (Meriç *et al.*, 2001), as in addition to its occurrence in SW Iran (Zagros), it is also found in the Late Cretaceous of Oman (Kühn, 1929) and the middle to upper Maastrichtian sediments of northern Iraq (Van Bellen *et al.*, 1958; Al-Omari and Sadek, 1976). All occurrences of *Loftusia* in post-Maastrichtian strata are now interpreted as being the result of reworking (Meriç and Görmüs, 2001).

As *Loftusia persica* is an agglutinated, fusiform-shaped, larger foraminifera, its biofabric and imbricating features are important in studying the ambient environment where it lived. The large specimens of *L. persica* seem to be restricted to very shallow-water reef, while in fore-reef areas they were rare.

***Loftusia persica* Brady from the Natural History Museum collection**

The specimens described in this paper are some of the samples collected by Loftus, during his archaeological and geological researches near the line of the Turko-Iranian frontier in the mid-19th century, and subsequently sectioned and deposited by Brady in the Natural History Museum, London. They are described (Carpenter and Brady, 1869) as coming from a “blue marly limestone” in the Kellapstun Pass, near the Dú Púlún Bakhtiyari Mountains.

Brady had described all of his thin sections as “Lower Tertiary”, however they were subsequently relegated to the Late Cretaceous by later workers. However, while studying the small tests of foraminifera that were embedded within the *Loftusia* samples from the NHM, we inferred that the samples of *Loftusia persica* of Brady were possibly of two types.

The first type included specimens of *Loftusia* with inclusions of small benthic foraminifera, such as *Textularia* (Plate 3, figs 1, 3), and miliolids (Plate 3, fig. 4). Many tests of *Loftusia* were oxidised, with oxide grains produced during diagenesis filling the tests of many of the included forms (e.g. Plate 2, fig. 6). These grains were falsely called “red spherules” by Brady. Some fragments of larger benthic foraminifera enmeshed in the structure of the test (Plate 2, figs 2, 4) are also present. These embedded foraminifera seem to have originated from the ambient platform, as some were also found *in situ* in the micritic matrix of the host rock (e.g. Plate 2, figs 2, 3). They are mainly Late Cretaceous agglutinated foraminifera, such as *Cuneolina* cf. *parva* Henson (Plate 2, figs 2-4). On the other hand, reworked Cenomanian forms such as *Mayncina* sp. (see Plate 3, fig. 2) were also present throughout the tests. These observations are perfectly compatible with the accepted notion that *Loftusia* accreted the tests of dead, smaller benthic as grains used to build its test. From the embedded forms, we conclude that this set of *Loftusia* lived in Upper Cretaceous shallow water platform environments.

We found, however, a second set of inclusions in another example of *Loftusia persica* that were of a planktonic foraminifera. The test shown in Plate 1 (figs 1-3) is of *Turborotalia pomeroli* (Toumarkine and Bolli), which is a very distinctive Middle to Late Eocene planktonic foraminifera. As seen in Plate 1 (figs 2, 3A), *Turborotalia* is embedded within the test of *Loftusia* and, we suggest, together with other benthic foraminifera (Plate 1, fig. 3B), was acquired as the test of the *Loftusia* grew. The mode of occurrence of the *Turborotalia* is identical with other embedded forms, and does not appear to be contamination. It is our inference, therefore that *Loftusia* is *in situ* in an Eocene strata.

Discussion

There are three possibilities that might explain the presence of *Turborotalia* within the *Loftusia* test.

The least likely is that *Turborotalia* (a planktonic form), either burrowed or was swept deep into the test of a dead, reworked Maastrichtian *Loftusia* sometime in the Eocene, and that *Turborotalia* was in fact not entrained within the loftusian test during the growth of this larger form. From the textural evidence shown in Plate 1, however, there is no apparent way in which this could have occurred, and we dismiss this possibility.

The second possibility is that *Loftusia persica* survived the end Cretaceous extinction event as a species and remained hidden, possibly in a geographically restricted environment or refugia (which was indeed possibly present in the end Maastrichtian in this region, see Fig. 2), before returning as a “Lazarus” species (i.e. a species that disappears from one period of the fossil record, only to appear again later). Although such “resurrections” are improbable, one must always recall the finding of the Coelacanth, a lobefinned fish also thought to have gone extinct at the end Maastrichtian, but discovered in the last century alive and well in the waters around Madagascar.

>>>> Fig. 2 here

Finally, *Turborotalia*-containing *Loftusia* may be a so-called “Elvis species” (Erwin and Droser, 1993), which evolved after the end-Maastrichtian, but filled a similar niche to the Cretaceous forms. In which case these “*Loftusia*” although almost identical in form, are not actually a descendant of the original *L. persica*, but developed a similar morphology through convergent evolution. This implies that the extinction of *Loftusia* at the end of the Cretaceous is real, and the two taxa are polyphyletic.

Loftusia belongs to the superfamily Loftusioidea Brady, 1884, and the main morphological trend in this superfamily is the development of labyrinthic structures along a number of separate lineages (see BouDagher-Fadel, 2008). The Cretaceous litiolids had their ancestor in the Jurassic, but in the Late Cretaceous, they became large and internally very complex. *Loftusia*, with interseptal pillars, appeared in the Maastrichtian and attained immense sizes, while also acquiring an increased tightness of coiling leading to fusiform tests. However, the end of the Cretaceous saw the extinction of most of the litiolids. The Late Cretaceous specimens (see Plates 1, figs 5-6; Plate 2, figs 1-6 and Plate 3, figs 1-6) and that of the suggested Eocene taxon (see Plate 1, figs 1-4) are very similar and very internally complicated. The appearance of an Elvis species of such complexity might be difficult to explain in the terms of evolutionary processes, and so in our opinion it is most plausible that the Eocene specimen from Iran is a Lazarus form of *L. persica*.

Finally, we offer possible answers to two pertinent questions arising from our hypothesis:

(i) Having survived the end Cretaceous mass extinction event, what would have caused *Loftusia* to become extinct in the Eocene? One possibility is the tectonic induced obliteration of its refugia. The closure of Tethys along the Zagros suture (see Fig. 2) at the end of the Eocene (Mohajjel *et al.*, 2003) caused an orogeny that destroyed its limited habitat thus leading to its demise.

(ii) Why should Cretaceous and Eocene samples be found in the same collection? In the Zagros Mountain of Southern Iran, Middle Eocene strata rest unconformably on Cretaceous strata (Falcon, 1974), and this might explain how loose specimens from the Middle Eocene strata might be mixed with the Late Cretaceous forms and so collected together by Loftus in his journey of regional exploration.

We acknowledge the controversial nature of our hypothesis, but believe that our identification of *Turborotalia* and our inference of how it became embedded deep within test of a *Loftusia* specimen is robust. To test our hypothesis further, more work needs to be done to confirm the occurrence of *Loftusia* in the Eocene of Iran, which will involve more detailed field work and more detailed studies of the inclusions within the tests of all of the *Loftusia* samples which have been described up to now as being from reworked post Maastrichtian sediments (Meriç and Görmüş, 2001).

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Figure Captions

Fig. 1. Schematic drawing of an equatorial section of *Loftusia*.

Fig. 2. Palaeogeographic and tectonic reconstructions of the Late Cretaceous and Eocene of the western Tethyan realm (by R. Blakey, <http://jan.ucc.nau.edu/~rcb7/paleogeographic.html>).

Plate Captions

Plate 1

Figs 1-4. *Loftusia persica* Brady ?Eocene Persia, 1) White rectangle shows region enlarged in Fig. 3, X8; 2-3) Enlargement of a chamber to show an Eocene planktonic foraminifera, *Turborotalia pomeroli* (Toumarkine and Bolli) enmeshed in the test 2) X93; 3) X56; 4) an enlargement of the same part of the test showing A) *Turborotalia pomeroli*, B) a benthic foraminifera, *Textularia* spp., X37, NHM coll.

Figs 5-6. *Loftusia persica* Brady, Late Cretaceous, Dú Púlún Bakhtiyari Mountains, Kellapstun Pass, Iran, genosyntypes, ex Loftus coll, P177 and P178, NHM Brady coll.; 5) X9; 6) X25.

Plate 2

Figs 1-2. *Loftusia persica* Brady, transverse section, Dú Púlún Bakhtiyari Mointains, Kellapstum Pass, Iran, NHM P3959, 1) showing oxide crystals produced by diagenesis, 2) horizontal section of *Cuneolina* cf. *parva* Henson, a Late Cretaceous species, enmeshed in the test of Fig. 1, X28.

Figs 3-4. Fragments of *Cuneolina* cf. *parva* Henson in the micritic matrix of the host rock in which *Loftusia persica* of Fig. 5 was embedded, 3) X55; 4) X61.

Fig. 5. *Loftusia persica* Brady with the micritic matrix showing the fossils in the ambient environment of deposition, X11.

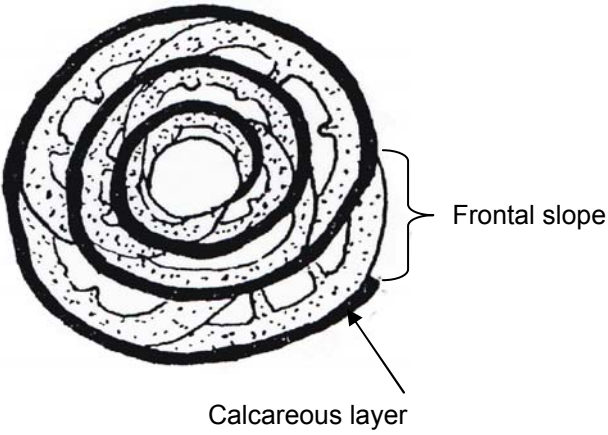
Fig. 6. A rotaliid test with oxide grains produced on diagenesis filling its test. The rotaliid foraminifera is embedded in the test of *Loftusia persica* Brady, axial section, Dú Púlún Bakhtiyari Mointains, Kellapstum Pass, Iran, NHM P3959, X30.

Plate 3

Figs 1-3, 6. *Loftusia persica* Brady, axial section, Dú Púlún Bakhtiyari Mointains, Kellapstum Pass, Iran, NHM P3959, with benthic inclusions, 1,3,6) *Textularia* spp. embedded in the *Loftusia* test, X40; 2) *Mayncina* sp., a reworked Cenomanian form enmeshed in the same *Loftusia* test, X60;

Fig. 4. *Loftusia persica* Brady with a small miliolid enmeshed in the test, UCL coll., X50.

Fig. 6. *Loftusia persica* Brady Dú Púlún Bakhtiyari Mointains, Kellapstum Pass, Iran, genosytype, ex Loftus coll, P177 and P178, NHM Brady coll, X10.

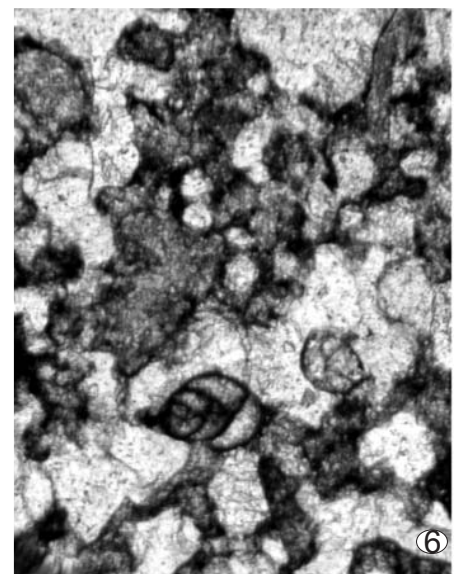
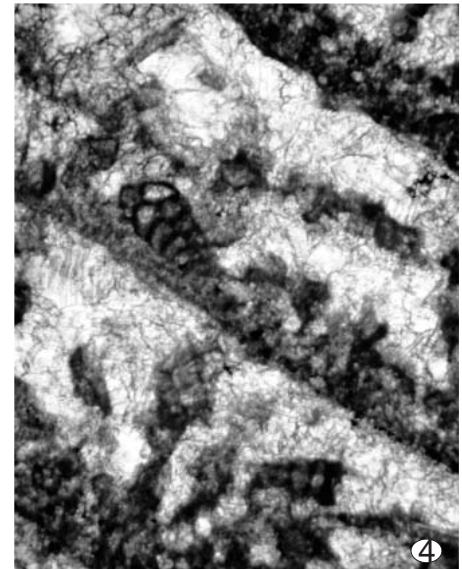
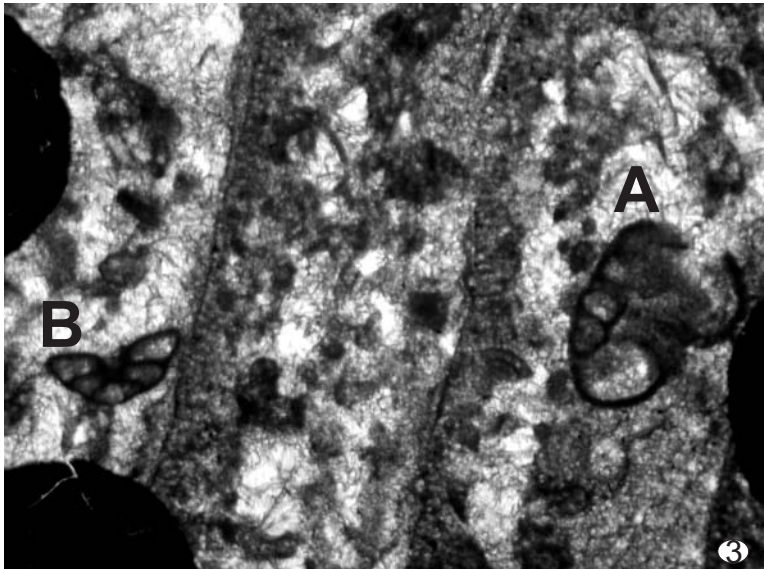
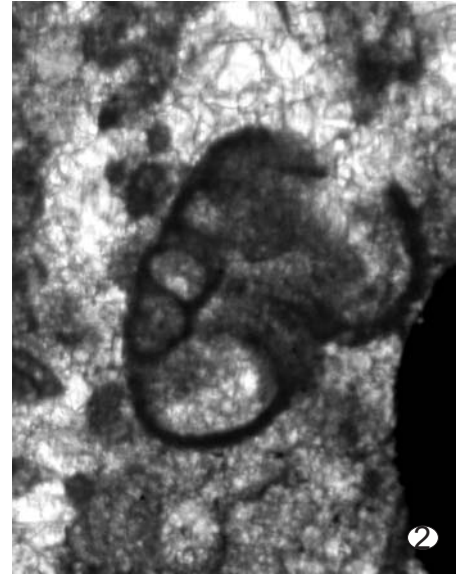
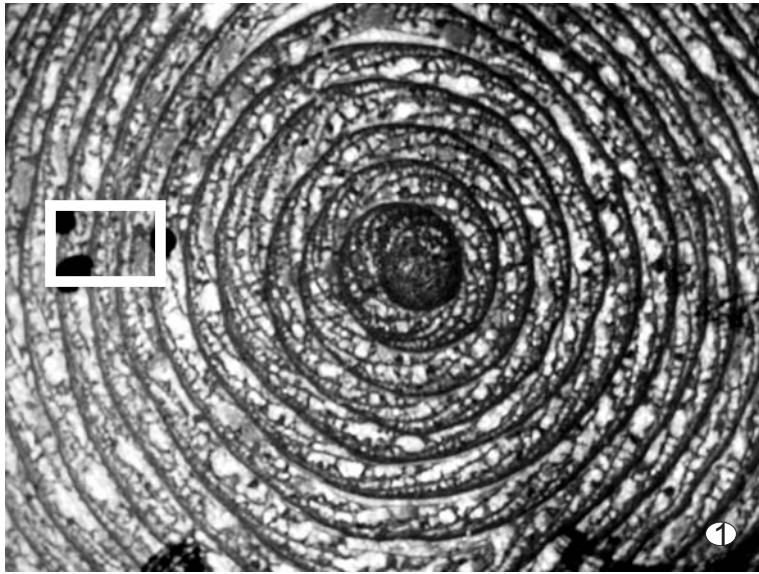


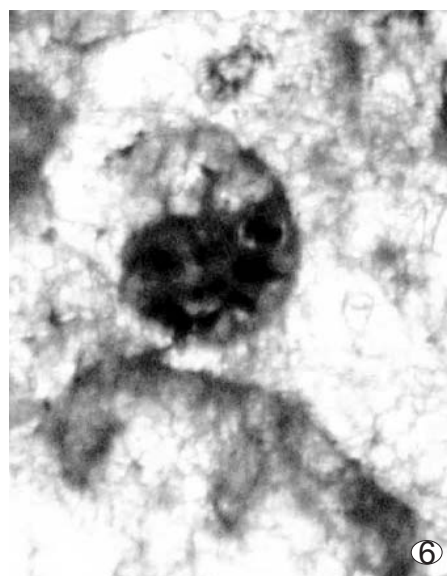
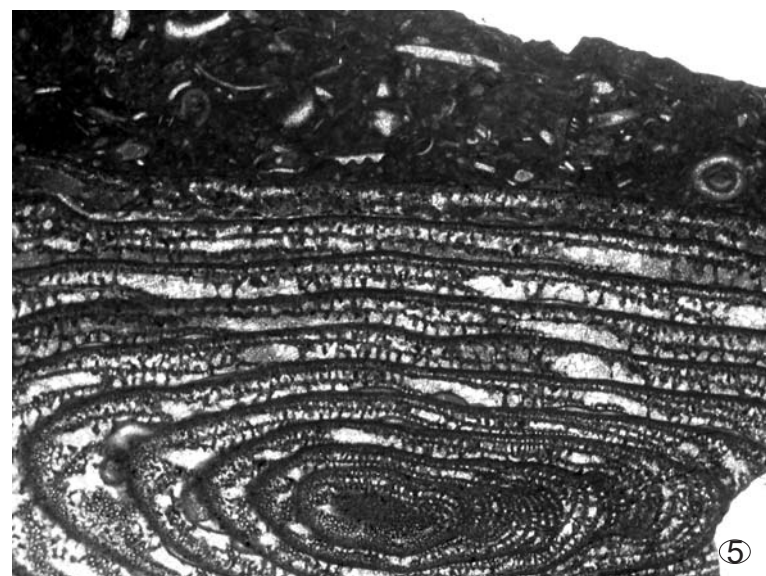
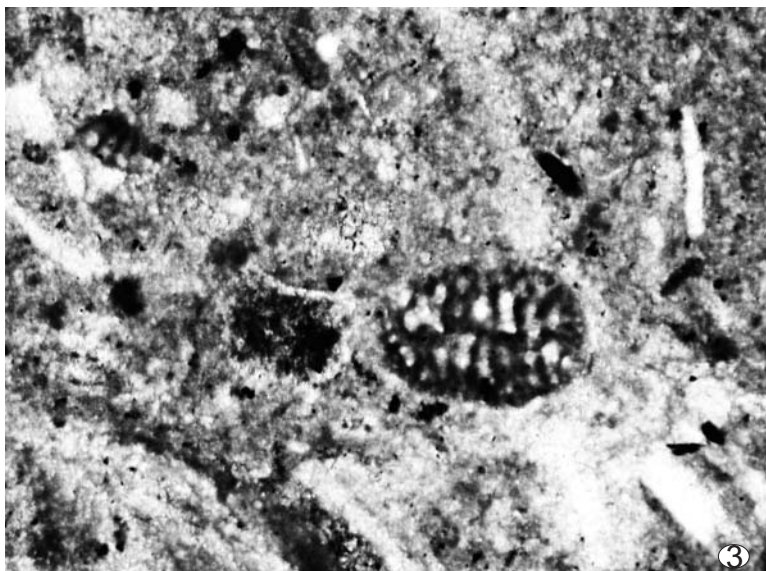
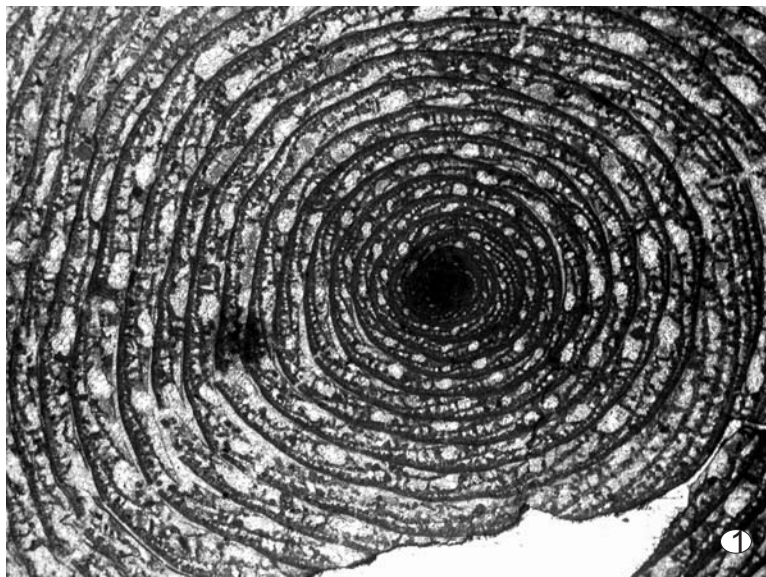
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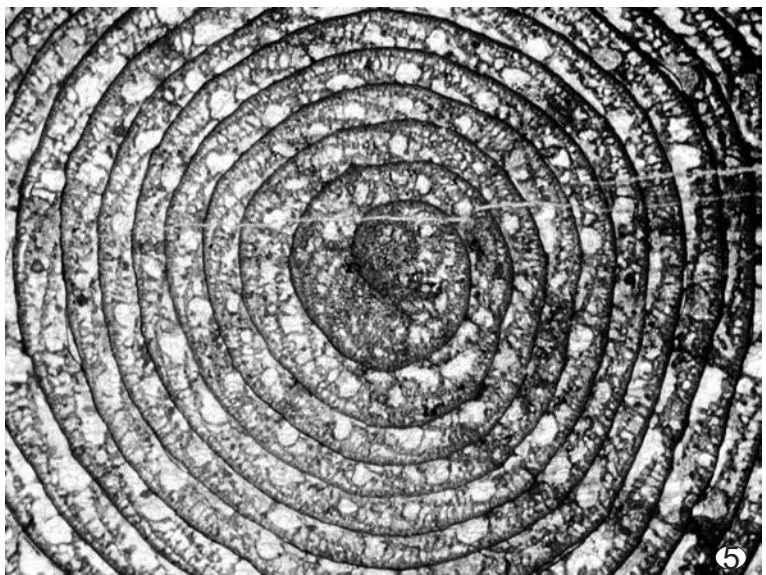
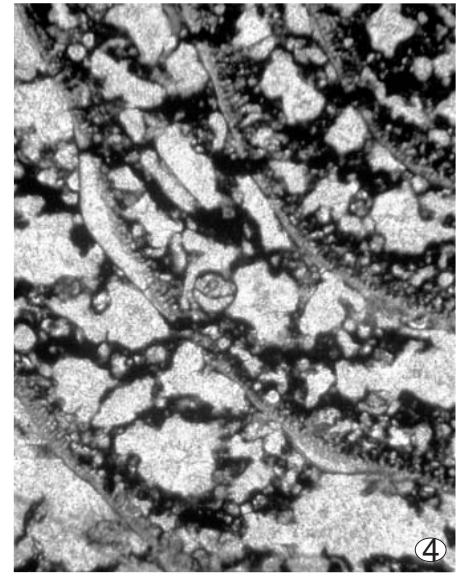
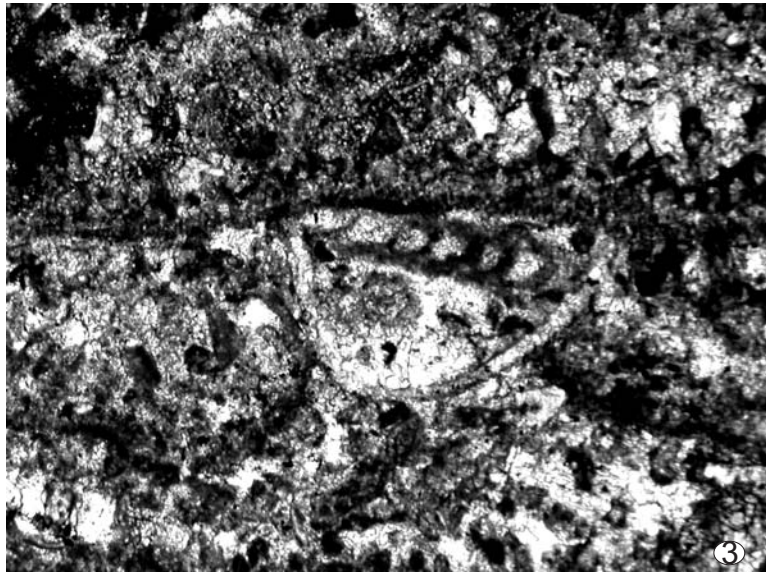
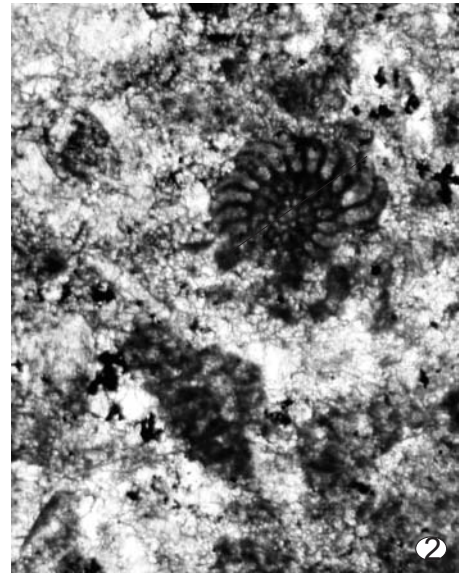
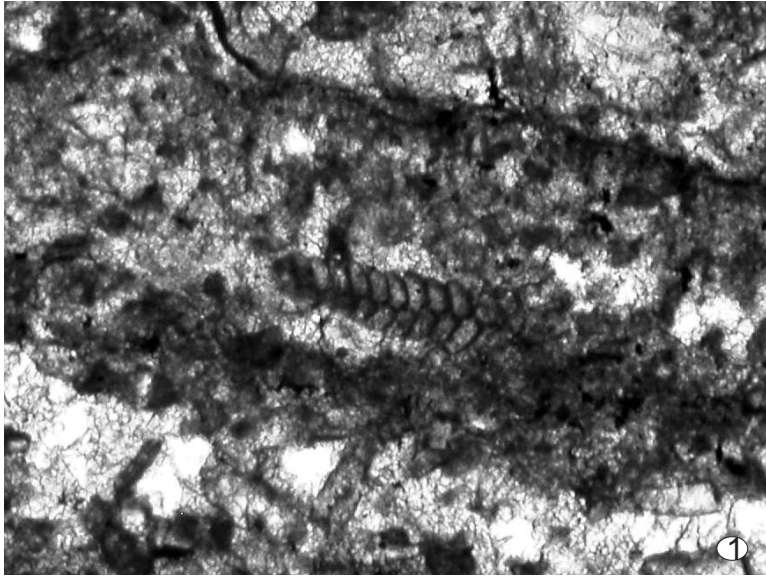


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