СТРАТИГРАФ БА ПАЛЕОНТОЛОГ

DINOSAUR NESTS AT THE NATURAL HISTORY MUSEUM, ULAANBAATAR

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Abstract

Eight dinosaur nests from Lower Cretaceous locality Algui Ulaan Tsav (Ulaanoosh Formation), Upper Cretaceous localities Bayan Zag, Tugrigiin Shiree, Numurt (Djadokhta Formation), Guriliin Tsav, Khulsan and Gilbent (Nemegt Formation) represent the following oospecies: *Spheroolithus* sp.; *Dictyoqlithus sp. nov*; *Prismatoolithus minimus* (Mikhailov, 1994); *Elongatoolithus sp. A.*; *Elongatoolithus sp. B*; *Elongatoolithus sp. C*; *Macroolithus rugustus* Young, 1965 and *Oblongotoolithus (?) sp. nov.*. Shown the difficulties in establishing of oospecies, because o lot of features (egg size, eggshell thicknees) are variabile

Introduction

During the last 75 years remarkably diverse dinosaurian nests, single eggs, and countless eggshell fragments have been collected from the Cretaceous localities of the Mongolian Gobi Desert [12]. Dinosaur nests were first discovered there in 1922 by the Third Central Asiatic Expedition of the American Museum of Natural History [1, 17]. Sochava [16] and Mikhailov [4, 5, 6, 7, 9, 10, 11] developed and applied morphological and parataxonomical nomenclature to abundant Mongolian Cretaceous egg and eggshell material, collected by the Joint Soviet-Mongolian Paleontological Expedition during the past 30 years. Several types of Upper Cretaceous fossil amniote eggs, clutches and eggshells, collected during the Polish-Mongolian Paleontological Expeditions (1963-1971) in some localities of the Gobi Desert were described by Sabath [15]. More fossil eggs found in the Gobi Desert by the Polish-Mongolian, Russian-Mongolian and Mongolian Paleontological Expeditions are housed in the Paleontological Department of the Natural History Museum at Ulaanbaatar. This collection of fossil eggs has never been described in detail, though its existence has been acknowledged by Mikhailov et al. [12]. Recently, expeditions of the American Museum of Natural History made interesting discoveries, including a theropod embryo [13] and a nesting oviraptor [14]. Since 1993, numerous eggshell fragments and nests have been collected by the Joint Paleontological Expedition of the Geological Institute (now Paleonological Center) of the Mongolian Academy of Sciences and the Hayashibara Museum of Natural Sciences, Japan [2, 18]. Several nests were also found by the Joint Mongolian-Chinese-Japanese Paleontological Expedition. These specimens still undergo preparation.

Fossil egg remains are known to date from 32 Cretaceous localities in Mongolia and further localities of similar stratigraphic setting are situated to the south, in the Inner Mongolia [23]. Nesting sites with preserved whole clutches or eggs containing identifiable embryonic remains are rare. Sites with only eggshell fragments are more common. Up to now, 24 dinosaurian and avian oospecies belonging to 13 oogenera and 10 oofamilies have been described from the Cretaceous of

Mongolian Gobi. Except the fossil bird eggs (*Laevisoolithus sochavai, Subtiliolithus microtuberculatus, Gobiolithus minor* and *G. major*) and two oospecies (*Oblongoolithus glaber* and *Parvoolithus tortuosus*) of problematic attribution, the remaing 18 oospecies are undoubtedly dinosaurian [8, 9 10].

Material and methods

The material studied herein is housed in the Paleontological Department of the Natural History Museum at Ulaanbaatar (abbreviated as NHMUB), and is on display there, except for two specimens, currently on the traveling exhibition 'Dinosaurs from Mongolia'; Tabl. 1). Nests are referred to using specimen numbers of the Geological Institute, Mongolian Academy of Sciences (abbreviated GIN), where they were catalogued before their transfer (with all fossil collections of GIN) to the newly established Paleontological Center, Mongolian Academy of Sciences.

Maximum and minimum measurements of egg size are given. The eggshell thickness is measured in separate eggshell fragments taken from each nest. From all nests small fragments of eggshell were also studied in radial and tangential thin section using polarizing light microscopy; some of the eggshells were additionally observed with a scanning electron microscope Philips XL in the Institute of Paleobiology, Polish Academy of Sciences.

We follow the parataxonomical nomenclature of Mikhailov [5] with subsequent refinements [11].

The dinosaur nests in the collection of the Natural History Museum in Ulaanbaatar

Table 1.

No.	Cat. no. GIN	No. of eggs	Locality	Year	Collected by
1*	100/1001	23	Khermiin Tsav	1973	unknown
2	100/1002	12	Tugrigiin Shiree	1969	R. Barsbold
3*	100/1003	17	Algui Ulaan Tsav	1969	E. B. Kurochkin
4	100/1004	15	Khulsan	1971	Polish-Mongol. Pal. Exped.
5	100/1005	5	Guriliin Tsav	1975	Yu. I. Tsybin
6	100/1006	18	Numurt	1977	Student
7	100/1007	8?	Gilbent	1980	B. Namsrai
8	100/1008	23	Tugrigiin Shiree	1974	S. M. Kurzanov
9	100/1009	6	Bayan Zag	1970	D. Dashzeveg
10	100/1010	10?	Algui Ulaan Tsav	1987	Yo. Lkhagvasuren

* - currently at the travelling exhibition abroad and thus unavailable for study by the authors

Description

Veterovata

Eggs with dinosauroid-spherulitic basic shell type

Oofamily Spheroolithidae Zhao, 1979

Oogenus Spheroolithus Zhao, 1979

Oospecies Spheroolithus sp. A

GIN 100/1005 (Fig. 1A)

Description. Nest found in Guriliin Tsav by Russian paleontologist Yu. I. Tsybin in 1975. Clutch of five eggs arranged in one layer; four eggs are spherical, with diameters 75.4 - 92.7 mm, and one is slightly ellipsoid (91 x 110) mm. Eggshell thickness varies from 0.5 mm to 0.9 mm (average 0.7 mm). The outer surface is obscured by a thick layer of hardener applied during excavation mixed with sand, but is probably not ornamented, as evidenced by an exposed smooth fragment. Prolatospherulitic morphotype, prolatocanaliculate pore system.

Comparison. Paleontological Museum in Moscow displays a nest N 4216-440, also Spheroolithus from Guriliin Tsav. This differs from GIN 100/1005 in eggshell thickness and egg size (Mikhailov et al., 1994, fig. 7.7). *Spheroolithus irenensis*, *S. tenuicorticus, S. maiasauroides*, *S. chiangchiungtingensis* , and (?) *S. megadermus* are described from China and Mongolia. GIN 100/1005 differs from all known species in having thinner eggshell, and from *S. maiasauroides* by outer surface ornamentation.

Oofamily Dictyoolithidae Zhao, 1994
Oogenus Dictyoolithus Zhao, 1994
Oospecies *Dictyoolithus sp.nov.*
GIN 100/1010 (Fig. 1B)

Description. Eggnest was found in 1987 by Mongolian preparator Yo. Lkhagvasuren in locality Algui Ulaan Tsav. Ten large spherical eggs of 150-165 mm in diameter, arranged disorderly in one to three layers. Eggshell thickness varies from 1.8 to 2.6 mm. Smooth and slightly rough eggshell surface. Reticulate organization composed of superimposed shell units (in radial section a reticulated organization is seen), multicanaliculate branching pore system.

Comparison. From the Lower Cretaceous of China two oogenera were described: *Dictyoolithus* Zhao, 1994 and *Youngoolithus* Zhao, 1979. The former has relatively thin eggshells. The tangential section of the Mongolian specimens reveal greater similarity to the Chinese *Dictyoolithus*. Superimposed units are present. The eggshell thickness of Mongolian species is between two Chinese species of oogenus *Dictyoolithus*. Prof. Zhao Zikui (Zhao pers. comm. to A. Ya., 1999) suggested to establish a new oospecies.

Remarks: The eggs found in the Lower Cretaceous locality Algui Ulaan Tsav were identified by Mikhailov [7] as a *Faveoloolithus ningxiaensis* Zhao & Ding, 1976, originally described from the Upper Cretaceous of China. Localities Algui Ulaan Tsav and Nogoon Tsav were dated by Mongolian geologists [3] as Lower Cretaceous. The alleged presence of *F. nigxianensis* cast doubt on this age of locality became questionable, because all known eggshell fragments of this type previously found came from Upper Cretaceous sediments [7]. Recently a new oofamily and oogenus *Dictyoolithus* Zhao, 1994 with two oospecies were described from the Lower Cretaceous Sigou and Gaogou Formations of China [24]. Detailed study of eggshells and nests from Algui Ulaan Tsav and Nogoon Tsav shows that they cannot be identified as *F. ningxianensis*. The holotype of *F. ningxianensis* consists of subspherical eggs (126-142 mm x 111-138 mm) with eggshells 1.12-1.68 mm thick [25]. The specimens from Algui Ulaan Tsav identified by Mikhailov as *F. ningxianensis* are subspherical, but 150-165 mm in diameter, and the eggshell thickness is 1.8-2.6 mm. Thus, neither egg size nor eggshell thickness measurments overlap. The radial and tangential thin sections reveal multicanaliculate pore system. In the Ulaanbaatar collection we have not thin section with clear filispherulitic images, the structure of eggshell usually consists from

superimposed shell units with a reticulate organization (Fig.2), which are characteristic feature of the genus *Dictyoolithus*.

Species with real images of Faveoolithidae in Chinese understanding were published by Sabath [15], but the specimens were broken eggshells from Khermiin Tsav - the Upper Cretaceous locality. The taxonomical position of Chinese oogenera *Dictyoolithus* and *Shixingoolithus* is disputable. Mikhailov [11] argues that both are very similar to the oogenus *Dendroolithus* and it would be reasonable to consider *Dictyoolithus* as a separate oogenus of the oofamily Dendroolithidae. Based on our material of *Dictyoolithus* described from Lower Cretaceous deposits we are suggesting to leave the oofamily Dyctyoolithidae as a separate oofamily.

Eggs with dinosauroid-prismatic basic shell type

Oofamily Prismatoolithidae Hirsch, 1994

Oogenus *Prismatoolithus* Zhao et Li, 1993

(= *Protoceratopsidovum* Mikhailov, 1994)

Oospecies *Prismatoolithus minimus* (Mikhailov, 1994)

GIN 100/1002 (Fig. 1C)

Description. The nest, found by Dr. R.Barsbold in Tugrigiin Shiree at first field season of the Joint Russian-Mongolian Paleontological Expedition (1969). Eggs elongated (10 x 4 cm), slightly asymmetrical, outer surface is smooth.

Remarks: The nest as displayed in the NHMUB contains 12 eggs. There is no accurate field documentation of the clutch arrangement. Moreover, some of the eggs reportedly belong to another nest of the same type, so that GIN 100/1002 is actually a composite display specimen, completed from separate eggs (Bataa personal communication to A.Ya, 1997). Thus, the positioning of the eggs within the nest is conjectural. In the NHMUB there is also a clutch of eggs from Shiljust Uul (not yet catalogued), which consists of 18 separated single eggs, also resulting from the formerly common practice of complete matrix removal from around the eggs. Such preparation practices are to be discouraged in case of nests because they cause irreversible loss of taphonomical data.

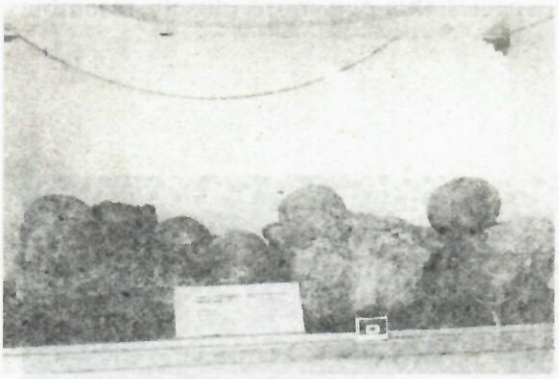
The locality Tugrigiin Shiree yielded eggshell remains of *Spheroolithus irenensis, Protoceratopsidovum sincerum, P. minimum, Elongatoolithus frustrabilis* and *E. Sigillarius* [5, 11, 12, 15]. Characteristics of GIN 100/1002 indicate their protoceratopsid affinity. Distinguishing between *P. minimum* and *P. sincerum* is of lesser importance, given their high variability (up to 20 mm in length and up to 10 mm in diameter within a single clutch, Mikhailov 1997). Mikhailov [11] also suggested that some differences between oospecies with smooth-surface eggshells might reflect only temporal changes within the population of *Protoceratops andrewsi*.

The eggshells and nests from Ulaan Nuur Basin of Mongolia served Mikhailov [6] to establish a new oogenus *Protoceratopsidovum* with three species: *P. sincerum, P. minimum* and *P. fluxuosum*. However, a very similar oogenus *Prismatoolithus* with a single oospecies *P. gobiensis* Zhao & Li, 1993 [26] has been described from a Chinese locality Bayan Mandahu in the Inner Mongolia. The strata exposed at Bayan Mandahu and Tugrigiin Shiree belong to the same formation. The Chinese species is actually indistinguishable from *Protoceratopsidovum sincerum* Mikhailov, 1994. As the paper of Zhao and Li was published earlier, *Prismatoolithus* becomes the valid generic name also for other Mongolian species described as *Protoceratopsidovum* by Mikhailov [6].

Eggs with ornithoid basic shell type

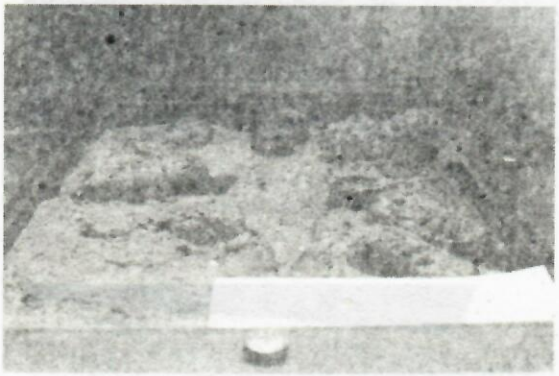
Fig.1. Nests of dinozaurs. 1A-Spheroolithus sp.A

1D - Elongatoolithus sp.A



1B - Dictgoolithus sp.nov

1E - Elongatoolithus sp.B



1C - Prismatoolithus minimus (Mikhailov, 1994)

1F - Elongatoolithus sp.C

Oofamily Elongatoolithidae Zhao, 1975
Oogenus Elongatoolithus Zhao, 1975
Oospecies *Elongatoolithus* sp. A
GIN 100/1004 (Fig 1D)

Description. The nest, found during the last field season of the Polish-Mongolian Paleontological Expeditions (1971), has been left in Mongolia and prepared by the exquisite Mongolian preparator B.Namsrai. The nest comprises 15 elongated, 14 cm long

eggs with linearituberculate ornamentation in equatorial part and dispersituberculate on poles. Width of eggs are range between 42.5-56.6 mm. Eggshell thickness is 0.8-1.5 mm. Ratite morphotype, angusticanaliculate pore system.

Comparison. Seven oospecies *of Elongatoolithus* have been formally named: *E.andrewsi*, *E.elongatus*, *E.magnus*, *E.sigillarius*, *E.excellens*, *E.frustrabilis*, and *E.subtitectorius*; more forms of this genus await formal description. The oospecies differ in egg size, eggshell thickness and details of surface ornamentation. Elongatoolithid eggs since the early discoveries by the AMNH expeditions have been attributed to *Protoceratops*, and only recently their ultrastructure resembling that of eggshells of ratite birds pointed to their theropod affinities [5,15], a hypothesis verified by the subsequent discovery of a theropod embryo associated with such an egg (GIN 100/972) from Ukhaa Tolgod. That egg is incomplete, and its estimated size was approximately 12 cm by 6 cm; the thickness of the eggshell varies between 0.50 and 0.95 mm [13]. Among known Mongolian oospecies this egg more closely resemble

1G-Macroolithus rugustus (Young, 1965)

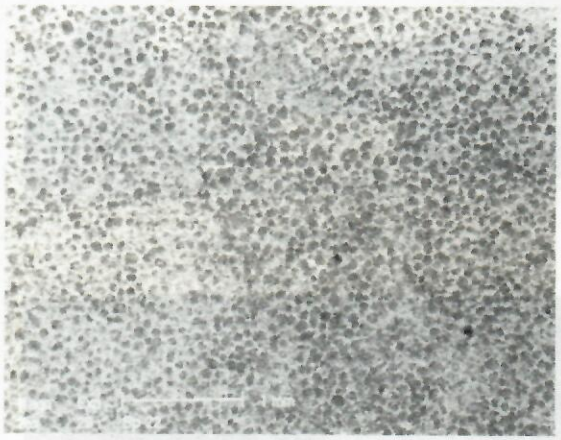
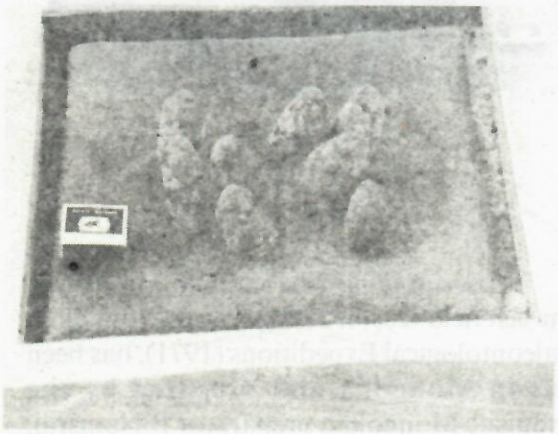
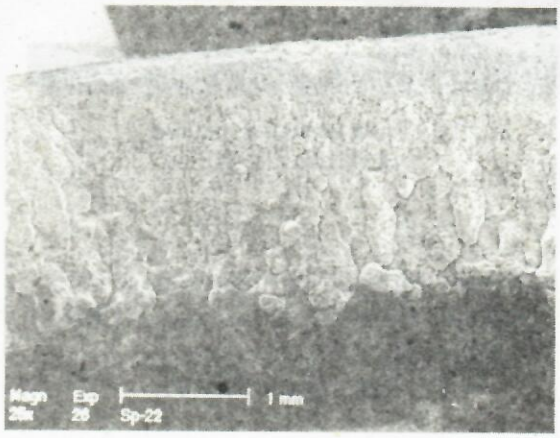


Fig 2. Eggshell structure in SEM.
A-transverse section



1 I-oblohgoolithus (?) sp. nov



B-radial section

Elongatoolithus frustrabilis. *E. sigillarius* differs from the latter only in some peculiarites in the surface ornamentation. In 1995, a team of Mongolian-Polish paleontologists, including one of us (K.S.), visited the locality Ukhaa Tolgod and collected egg samples, deposited in Ulaanbaatar. In our collections (ZPAL MgOv-II/25) we have fragments with the different surface ornamentation referred to *Elongatoolithus frustrabilis* as well as to *E. sigillarius*. So, at present it seems most reasonable to assume that as a *Elongatoolithus sp. A*.

Oospecies *Elongatoolithus sp. B*
GIN 100/1006 (Fig. 1E)

Description. This nest was found by a student in Numurt, a locality near Zamyn Khond in Ulaan Nuur Basin in 1977. It comprises 18 elongated eggs arranged in a circle. Egg diameter is 5 cm, length is 15 cm. The eggshell thickness is 1.4 mm. Ratite morphotype of ornitoid basic shell structure, angusticanaliculate pore system.

Oospecies *Elongatoolithus* sp. C
GIN 100/1008 (Fig. 1F)

Description. Nest found in Tugrigiin Shiree by S.M. Kurzanov in 1974. Consists of 23 nearly complete elongated, symmetrical eggs arranged in circles in three layers. Egg length is 176.5-187.3 and diameter is 61.1- 68.8 mm. Eggshell thickness is 0.8-1.3 mm. Outer surface with lineartuberculate ornamentation with □normal□ (longitudinal) orientation in the equatorial part of egg and smooth or with dispersituberculate ornamentation on poles. Eggshell with ornithoid basic shell structure, ratite morphotype; angusticanaliculate pore system.

Comparison. Elongatoolithus frustrabilis and *E. sigillarius* with this type of eggshell were described earlier from Tugrigiin Shiree [6]. Both oospecies in the original description were discerned by eggshell thickness. Later measuments have shown, however, that one has thickness of 0.3-1.2 mm (Mikhailov, 1997: text-fig.14) while the other - 0.3-1.1 mm (Mikhailov 1994: p. 91). Now they are separated only by minor peculiarities in the surface ornamentation. GIN 100/1008 is smooth-shelled on some parts of pole.

The clutch is arranged in a typical elongatoolithid manner: the eggs seem to have been laid spirally pair by pair. The pairs of eggs (possibly held together by mucus when excreted simultaneously from both oviducts) were not separated by later manipulation nor taphonomical processes. There is an empty space in the middle of the clutch.

Remarks. Emended diagnosis of oogenus *Elongatoolithus* [11] said that long diameter of eggs less than 170 mm. Some eggs of this nest riched in diameter of 187 mm.

Oogenus Macroolithus Zhao, 1975
Oospecies Macroolithus rugustus
(Young,1965)
GIN 100/1009 (Fig. 1G)

Description. Nine elongated, symmetrical (some slightly asymmetrical) eggs (66-74 mm x 152- 207 mm). Smooth on poles, sometimes dotted. Thickness of eggshells from equatorial part is 1.2 mm. Shell structure is ornithoid.

Remarks: According to the NHMUB catalogue, this nest was found by D. Dashzeveg in Bayan Zag, in 1970. However, no eggshell fragments attributable to *Macroolithus* were ever reported from this locality, despite this is the earliest discovered and most extensively studied egg-bearing locality in the Gobi. This oogenus in not only unknown from this extensively studied site, but also it is stratigraphically younger (typical for Maastichtian strata) than the Djadokhta Formation at Bayan Zag.

However, the large size of eggs, and symmetry of poles clearly substantiate assignment of GIN 100/1009 to *Macroolithus*. Thus we suspect a labelling error may have led to wrong attribution of locality to this specimen.

In spite of thin eggshells and variable egg size the identification was done but clearly merits further investigation. *Macroolithus rugustus* and *M. yaotunensis* were described by Zhao [20]. The surface ornamentation, shell thickness, and pore shape are similar in those oospecies. They differ in boundary between mammillary layer and columnar layer. It is straight in the *M. rugustus* and wavy in the *M. yaotunensis*. The observation of more than twenty thin sections of eggshells of *M. mutabilis* Mikhailov 1994, described from the Nemegt Formation of Mongolia, shows that this feature is highly variable and can not be used as diagnostic for this oospecies. Another character differentiating the oospecies is egg size: for *M. rugustus* range is 85-75x165-181 mm, for *M. yaotunensis* range is 94-67x176-208 mm. GIN 100/1009 seems to be a part of nest and range of eggs is (66-74) x (152- 207) mm, and very thin eggshells. In this case it is very difficult to make identification. Index and mean is better for comparison.

Oofamily Oblongoolithidae Mikhailov, 1994

Oogenus Oblongoolithus Mikhailov, 1996

Oospecies Oblongoolithus (?) sp. nov.

GIN 100/1007 (Fig. 1 I)

Description. Nest found by a GIN preparator B. Namsrai in the locality Gilbent in 1980. Consists of remains of vertically positioned 8 eggs. The estimated length of eggs is 11 cm. Widths are 36.3 mm, 36.4 mm, 35.7 mm, 32.9 mm, 38.7 mm, 37.2 mm, 37.0 mm, 35.4 mm. The thickness of eggshells in the equatorial part is 1.6 mm, and in the upper, pointed pole became thin. Surface is smooth.

Comparison. Two kinds of eggs with ornithoid basic shell structure and smooth surface are known from the Gobi. One is *Nanhsiungoolithus chuetienensis,* typified by larger eggs and thicker eggshells than the GIN 100/1007 [19, 27]. The other species is *Oblongoolithus glaber*.

Remarks: The oogenus *Nanhsiungoolithus* of the oofamily Elongatoolithidae with type species *N. chuetienensis* has been established upon the material from a locality situated about 2 km south of Nanhsiung, Guangdong Province, China. Mikhailov [11] discussing the oofamily Elongatoolithidae wrote that □rare eggs of *Nanhsiungoolithus chuetienensis* from the Upper Cretaceous of China have not been illustrated□. Actually, the holotype (V.2782) was illustrated, as a *Oolithus cf. elongatus,* by Young (1965: pl. XII, XIII A) and described only in 1998 [27]. Typical for this species is the barely discernible linear ornamentation and proportion of thickness of mammilary to spongy layer (1:1). Mikhailov [11] established a new oofamily for the oogenus *Oblongoolithus* with type oospecies *O. glaber* Mikhailov, 1996, mentioning the lack of ornamentation as a principal diagnostic character differing Oblongoolithidae from Elongatoolithidae. Such a diagnosis needs emending, because not all species of the oofamily Elongatoolithidae have ornamented outer surface. Also among the protoceratopsian eggs (Prismatoolithidae) there are species with smooth or ornamented outer surface, so this feature seems to be fairly variable well below the family level.

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