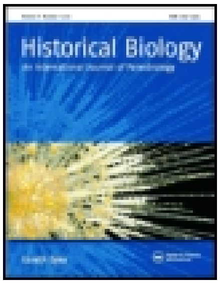

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Parataxonomic review of the Upper Cretaceous dinosaur eggshells belonging to the oofamily Megaloolithidae from India and Argentina

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The eggshell oospecies from India and Argentina are compared and reviewed in detail. These eggshells resemble each other in having a nodular outer surface ornamentation and clearly arched growth lines of the shell units. Microstructurally, the eggshell oospecies belonging to the oofamily Megaloolithidae shows fan-like shell units, which are sharply separated from each other throughout the thickness of the eggshell and can be traced up to the surface of the eggshell. Comparisons between four oospecies from India and Argentina reveal three groupings, which show similarities between megaloolithids of both countries: (1) *Megaloolithus jabalpurensis*, *M. matleyi* and *M. patagonicus*; (2) *M. cylindricus*, *M. rahioliensis* and Tipo 1d; and (3) *M. megadermus* and Tipo 1e. The other two types of eggshell oospecies from India and Argentina show partially fused external nodes and shell units. As a result, growth lines enter into the adjacent shell units with a marked concavity. A new oogenus *Fusioolithus* have been erected due to fusion between shell units and tubospherulitic morphotype, which include two new oospecies *F. baghensis* and *F. berthei*. Till date, morphostructurally, a total of 15 eggshell oospecies belonging to different oofamilies have been recorded from India and seven oospecies from Argentina.

Keywords: Indian; Argentinean; dinosaur eggshell oospecies; *Fusioolithus baghensis*; *Fusioolithus berthei*

Introduction

In India, most of the eggs have been related to sauropod and few eggs with theropods dinosaurs; to date, no embryos have yet been found in direct association with such eggs. The assignment of the eggshells to sauropods (the oofamiliy Megaloolithidae) is based on the skeletal material in the associated horizons and in the similarity of the eggshell structure found in megaloolithid eggs from the same oofamily from Argentina. Argentinean eggs have been related to a specific group of sauropod dinosaurs, the titanosaurs, and the discovery of embryonic remains in Auca Mahuevo eggs indicates that some of the megaloolithid eggs certainly belong to them (Chiappe et al. 1998, 2001; Salgado et al. 2005; García et al. 2010; Grellet-Tinner et al. 2011; Fernández 2013).

In Argentina, two eggshell oospecies were described belonging to the oofamily Megaloolithidae: *Patagoolithus salitralensis* Simón, 2006 and *M. patagonicus* Calvo, Engelland, Heredia and Salgado, 1997. Salgado et al. (2007, 2009) further described two megaloolithid eggshells: Type 2A and Type 2B. Recently, Fernández (2013) studied dinosaur eggshell from Salitral de Santa Rosa locality and Salitral Ojo de Agua, Allen Formation, Río Negro Province (Argentina), and described five types of eggshells belonging to the oofamily Megaloolithidae. Fernández (2013) assigned Tipo 1a and Tipo 1b of these eggshells to the oospecies *Patagoolithus salitralensis* and *M. patagonicus*, respectively, and also described three more types: Tipo 1c, Tipo 1d and Tipo 1e (see Fernández 2013), which, to date, has not been assigned to any oospecies. On the other hand, Indian researchers have described a large number of oospecies diversity (Khosla and Sahni 1995; Mohabey 1998). Seven eggshell oospecies that were erected by Khosla and Sahni (1995) belonging to the oogenus *Megaloolithus* were (1) *M. cylindricus*, (2) *M. jabalpurensis*, (3) *M. mohabeyi*, (4) *M. baghensis*, (5) *M. dholiyaensis*, (6) *M. padiyalensis* and (7) *M. walpurensis*. In addition, Mohabey (1998) also proposed eight eggshell oospecies belonging to the oogenus *Megaloolithus*: (1) *M. rahioliensis*, (2) *M. phensaniensis*, (3) *M. khempurensis*, (4) *M. dhoridungriensis*, (5) *M. matleyi*, (6) *M. megadermus*, (7) *M. balasinorensis* and (8) Problematica (? Megaloolithidae). Four out of eight eggshell oospecies proposed by Mohabey (1998), (1) *M. rahioliensis*, (2) *M. phensaniensis*, (3) *M. matleyi* and (4) *M. balasinorensis*, are nothing but repetition of the oospecies established already by Khosla and Sahni (1995) under different parataxonomic names (Vianey-Liaud et al. 2003). Vianey-Liaud et al. (2003) updated the synonymy of *Megaloolithus* oospecies and reveal a total of nine distinct oospecies from India: *M. cylindricus*, *M. mohabeyi*, *M. padiyalensis*, *M. jabalpurensis*, *M. dholiyaensis*, *M. dhoridungriensis*, *M. khempurensis*, *M. megadermus* and *M. baghensis*.

Currently, the record of oofamily Megaloolithidae is wide; here we try to update the synonymy, morphostructural diversity and paleobiogeographic implications of

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the Indian and Argentinean Late Cretaceous dinosaur eggshell oospecies. The eggshells belonging to the oofamily Megaloolithidae from Argentina are similar to India, France and Spain materials, and all eggshells studied have presented similar microstructural and megascopic characters. Furthermore, Vianey-Liaud et al. (2003) tentatively compared *M. patagonicus* with the Indian oospecies *M. jabalpurensis*. After that, no serious attempt has been made till date to compare the Indian eggshells with the Argentinean eggshells.

In this article, we try to unravel the underlying relationships between materials from Argentina with eggs and eggshells from India. In view of latest publications and findings (Calvo et al. 1997; Vianey-Liaud et al. 2003; Simón 2006; Fernández 2013), the synonymy of the Indian and Argentinean Upper Cretaceous dinosaur eggshell oospecies has been revised and described under systematic classification.

In this article, we reviewed all materials from India and Argentina and we found that Tipo 1c eggshells from Salitral de Santa Rosa (see Fernández 2013) have significant differences with all the eggshells that we have reviewed, therefore we consider it appropriate to create a new oospecies.

Geological setting

The Lameta Formation containing dinosaur eggs is a widely distributed sequence of fluviatile deposits extending over 10,000 km (Sahni and Khosla 1994a). The Lameta Formation generally occurs in discontinuous outcrops in different localities of Gujarat, Madhya Pradesh, Maharashtra and Andhra Pradesh and rests unconformably on a different supergroup, i.e. Precambrian basement, Gondwana Supergroup, and is further overlain by Deccan basalts. The Lameta Formation at Jabalpur consists of a well-preserved sequence of sandstone, calcrete and paleosols of freshwater origin, and has the same stratigraphic position (i.e. infratrappean) as the Lameta Formation at Bagh in the Lower Narbada valley. In the Jabalpur sub-region, the Lameta Formation is 50 m thick (Tandon et al. 1995), whereas in Jhira Ghat (west of Jabalpur) they attain a thickness of about 75 m (Lunkad 1990). The Lameta Formation of Nand-Dongargaon Basin exposed in parts of Chandrapur and Nagpur Districts, Maharashtra, and Kheda-Panchmahal Districts, Gujarat, attains a thickness of about 20 m (Mohabey 1996). But, in general, the overall thickness of the Lameta Formation varies from 0.5 to 50 m (Khosla and Sahni 1995). The dinosaur-bearing Lameta Formation has been deposited in an alluvial environment, comprising overbank, channel and back-swamp environments and under semi-arid conditions, which has been further corroborated by the presence of ostracods and charophytes (Sahni and Khosla 1994a, 1994b; Khosla and Sahni 2000, 2003).

Eggs, nests and eggshells from Río Negro Province appear in Allen Formation, whose age has been estimated by Ballent (1980), based on ostracods, as middle Campanian to lower Maastrichtian. This formation lies in the area of Lago Pellegrini, Río Negro Province, and is about 260 km to the northwest of Salitral de Santa Rosa and 36 km to the northeast of Neuquén city. Allen Formation has been divided into three members (Andreis et al. 1974). Leanza and Hugo (2001) suggested that the paleoenvironment in this formation was characterised by fluvial deposits of moderate energy (the lower member) followed by lacustrine and fluvial deposits of low energy (the middle member), and finally shallow lacustrine deposits with evaporitic facies (the upper member). In the area of Salitral de Santa Rosa-Salinas de Trapalcó, the Allen Formation is widely exposed (Leanza and Hugo 2001). Salgado et al. (2007) differentiated two subunits of the Allen Formation: (1) a lower subunit composed of fine-grained sandy deposits with subordinate muddy layers and thin evaporitic levels and (2) an upper thick succession of siltstone and mudstone deposits with thin intercalations of ostracod-rich limestones and sandy levels. On the basis of sedimentological and lithofacial features, the lower subunit (which bears vertebrate fossils, including dinosaur eggs) is interpreted as a brackish lagoonal and supratidal environment, associated with aeolian sands (dunes) and deposits of ephemeral rivers (Salgado et al. 2007). Abundant rhizoturbation and caliche in the egg-bearing deposits indicate the presence of paleosols, which presumably developed in a coastal, more probably supratidal environment. The facies and environmental conditions of these deposits suggest that the lower subunit is related to the middle member of the Allen Formation *sensu* Andreis et al. (1974). In the area of Salitral de Santa Rosa-Salinas de Trapalcó, five egg-bearing levels have been recognised in the middle and upper parts of the lower subunit. In addition, these layers have yielded other varieties of megaloolithid eggs.

Materials and methods

In the present work, we studied the rich Upper Cretaceous dinosaur localities from India and Argentina. These localities have produced hundreds of eggs and eggshell fragments. The specimens are housed at Vertebrate Paleontology Laboratory, Panjab University, Chandigarh; Paleontology Division, Geological Survey of India, Nagpur, Maharashtra; and Geological Survey of India, Gandhinagar, Gujarat, India. In Argentina, specimens are housed in Museo Municipal de Lamarque, in Paleovertebrate and Paleohistology Collection, Lamarque City, Río Negro Province, Argentina (MML-Pv, MML-PH).

Collected eggshells were observed with binocular loupe Nikon SMZ 645 for macrocharacters. Microcharacters were observed in radial thin section using a polarising microscope LabKlass, JPL-1350. The eggshells were photographed with a digital camera. Prior to analysis, the eggshells were submitted to a process of cleaning using ultrasound and etched with 4% dilute hydrochloric acid for about 4–5 seconds. This process brings out the relief of the specimen and also leads to the removal of any matrix or calcareous material on the eggshell fragment. The eggshell fragments were then mounted on the aluminium stubs with the help of a double-sticky tape or with silver paint in the case of larger specimens. The stubs with the mounted specimens were then sputtered with gold in a JEOL FC-1100 Ion Sputtering Device. This was done to ensure emission of a sufficient number of secondary electrons for imaging. The samples were then studied under scanning electron microscope (SEM) (JEOL JSM-25S and Nova Nano 230 FEI). Radial and tangential thin sections of eggshells of about 30 μm were made following methods proposed by Chinsamy and Raath (1992). Measures were taken using a scale inside the ocular of the binocular loupe and the polarised microscope.

Examined materials from India include more than 180 eggshell fragments of *M. cylindricus*. They are as follows: 15 thin sections from Chui Hill (VPL/KH/ 201-204, 224-235) and 10 thin sections from Pat Baba Mandir (VPL/KH/ 212-221), Jabalpur, Madhya Pradesh; 20 thin sections from Dholiya (VPL/KH/101-120), Dhar District, Madhya Pradesh; 5 thin sections from Walpur (VPL/ KH/ 241-245), Jhabua District, Madhya Pradesh; 2 thin sections from Rahioli (VPL / KH/161-162), Kheda District, Gujarat; a nest containing four eggs; 3 nearly complete silicified eggs; 1 fragmentary egg and more than 500 eggshell fragments of *M. jabalpurensis*. Twenty thin sections from Bara Simla Hill (VPL/KH/ 250-270); 2 thin sections from Lameta Ghat section (VPL/ KH/271-272), Jabalpur, Madhya Pradesh; 5 thin sections from Dholiya (VPL/KH/351-355); 5 thin sections from Bagh Cave section (VPL/KH/401-405) and 3 thin sections from Padiyal (VPL/KH/300-303), Dhar District, Madhya Pradesh. Thirty eggshell fragments of *M. mohabeyi*; 30 eggshell fragments of *M. dholiyaensis*. Three fragmented eggs and more than 50 eggshell fragments of *M. baghensis*, four thin sections from Bagh Cave section (VPL/KH/ 550-553); seven eggshell fragments from Pisdura (VPL/KH/572-577), Chandrapur District, Maharashtra; five thin sections from Balasinor Quarry in Kheda (VPL/KH/ 563-567), Gujarat; two thin sections from Anjar (Kachchh, VPL/AS/SB/560-561), Gujarat and two thin sections from Lameta Ghat (VPL/ KH/570, 571), Jabalpur, Madhya Pradesh. Eight eggshell fragments of *M. padiyalensis*; a near-complete egg and partial eggs from the numerous clutches of *M. khempurensis*; a nearly complete egg, broken eggs and eggshell debris of *M. dhoridungriensis*; two complete eggs and numerous eggshell fragments of *M. megadermus.* Ten eggshell fragments from Jhabua, Madhya Pradesh; partial eggs and eggshell debris of problematica (? Megaloolithidae); a single clutch containing five incomplete oval eggs of Incertae sedis; more than 500 eggshell fragments of *Subtiliolithus kachchhensis*; nests containing 13 eggs and more than 200 eggs in total of *Ellipsoolithus khedaensis* and fragmentary eggshells of ? *Spheroolithus.*

Most of Argentinean material has been collected at the surface of two sites (Mansilla I and Mansilla II); materials from other sites were collected *in situ*, these eggs were not complete and were found in unconsolidated sandstones of Berthe II, Berthe III, Berthe IV, Berthe V, Berthe VI, García I, Santos II B, Arriagada I and Arriagada II. All Argentinean materials studied here were collected in Salitral de Santa Rosa and Salitral Ojo de Agua, Río Negro Province.

The examined materials from Argentina include more than 810 eggshell fragments of *Patagoolithus salitralensis*, which were studied under binocular loupe; the numbers mentioned here belong to the specimens photographed (MML-Pv 125/960–979/981/984/987/1010/1012/1013/1022). Nine thin sections were made: García I (MML-Pv 164/165); Berthe III (MML-PH 1125/1129); Mansilla I (MML-PH 1281/1282); Mansilla II (MNL-PH 1133/1134) and Cerro Bonaparte (MML-PH 1151). One nest was studied with 14 eggs (MML-PV 41). More than 421 fragments of *M. patagonicus* were studied under binocular loupe; the numbers which are mentioned here belong to the photographed specimens (MML-Pv 966/980/982/983/985/986/1009/1011/1018/1020). Two thin sections were made from locality Mansilla I (MML-PH 1281-1282). Four eggshells fragments of Tipo 1c from Santos II B (MML-Pv 947-948) (see Fernández 2013) were made three thin sections: Berthe V (MML-PH 1145) and García I (MML-Pv 1269–1270); four eggshell fragments of Tipo 1d (see Fernández 2013) were imaged under binocular loupe from Berthe V (MML-Pv 931/932/1023/1024), and were made eight thin sections: Berthe V (MML-PH 1261/1262), Berthe IV (MML-PH 1131/1138), García I (MML-PH 1271/1272) and Sitio Alberto (MML-PH 1279/1280). Finally, one nearly complete egg and three eggshell fragments of Tipo 1e (see Fernández 2013) were studied under binocular loupe from Berthe II (MML-Pv 912/914/921) and were made four thin sections: Berthe II (MML-PH 1143), Berthe V (MML-PH 1154) and Berthe VI (MML-PH 1285/1286).

Abbreviations. MML-Pv, Museo Municipal de Lamarque Paleovertebrate Collection; PLM, polarised light microscope; MML-PH, Museo Municipal de Lamarque, Paleohistology Collection; P, pore; PPL; plane polarised light; VPL/KH, Vertebrate Palaeontology Laboratory, Khosla; VPL-AS/SB, Vertebrate Palaeontology Laboratory, Ashok Sahni and Sunil Bajpai.

Results

Review and comparison of the different eggshell oospecies and oofamily Megaloolithidae from India and Argentina

Four of Megaloolithidae eggs from India (*M. jabalpurensis*, *M. matleyi*, *M. cylindricus* and *M. megadermus*) resemble those from Argentina in having a spherical shape of eggs, nodular outer surface ornamentation and clearly arched growth lines of the shell units. A new oofamily Fusioolithidae has been erected due to the presence of fused shell units noticed in eggshell specimens from the Lameta Formation of Bagh Caves (Dhar District, Madhya Pradesh), Kheda (Gujarat, India) and Upper Cretaceous deposits of Salitral Moreno and Salitral de Santa Rosa, Río Negro, Argentina.

Oofamily **MEGALOOLITHIDAE** Zhao, 1975 (emend. 1979)

Megaloolithus jabalpurensis Khosla and Sahni, 1995: 90–91

Megaloolithus matleyi (Mohabey, 1996: 188–191)

(*Type locality*. Pavna, Chandrapur District)

Megaloolithus patagonicus (Calvo, Engelland, Heredia and Salgado, 1997: 27–30)

(*Type locality*. Gran Neuquén neighbourhood, Neuquén city, Neuquén Group, Patagonia, Argentina)

Figure 1(a)–(d)

Type locality. Bara Simla Hill (Jabalpur, Madhya Pradesh, India).

Type horizon and age. Sandy carbonate (= limestone) bed; Late Cretaceous, Lameta Formation.

Description. These eggshells have a discretispherulitic morphotype, eggs are spherical to sub-spherical in shape with diameter variable from 140 to 160 mm. The eggshell thickness ranges from 1.0 to 2.38 mm and shows compactituberculate ornamentation (subcircular nodes). The average node diameter is about 0.675 mm with diameter ranging from 0.35 to 1 mm (Figure 1(a),(b)). The spheroliths are fan shaped and of variable width and shape (Figure 1(c),(d)). The lateral margins of spheroliths are non-parallel. The average height/width ratio is 2.45:1 (Figure 1(c),(d)). The growth lines are moderately arched upwards and follow the contour of the external profile (Figure 1(c),(d)). The pores are circular in shape, with tubocanaliculate pore system (pore canals are straight). The basal cap is subcircular in shape and smaller (0.1–0.5 mm in diameter) than in *M. cylindricus*.

Remarks. *Megaloolithus jabalpurensis* is distinguished from *M. cylindricus* in being thinner and in having small and large, fan-shaped spheroliths of variable width and shapes (Figure 1). The pores are circular to elongate as compared to subcircular shape in *M. cylindricus*. The pore canals studied in radial sections are small, narrow and

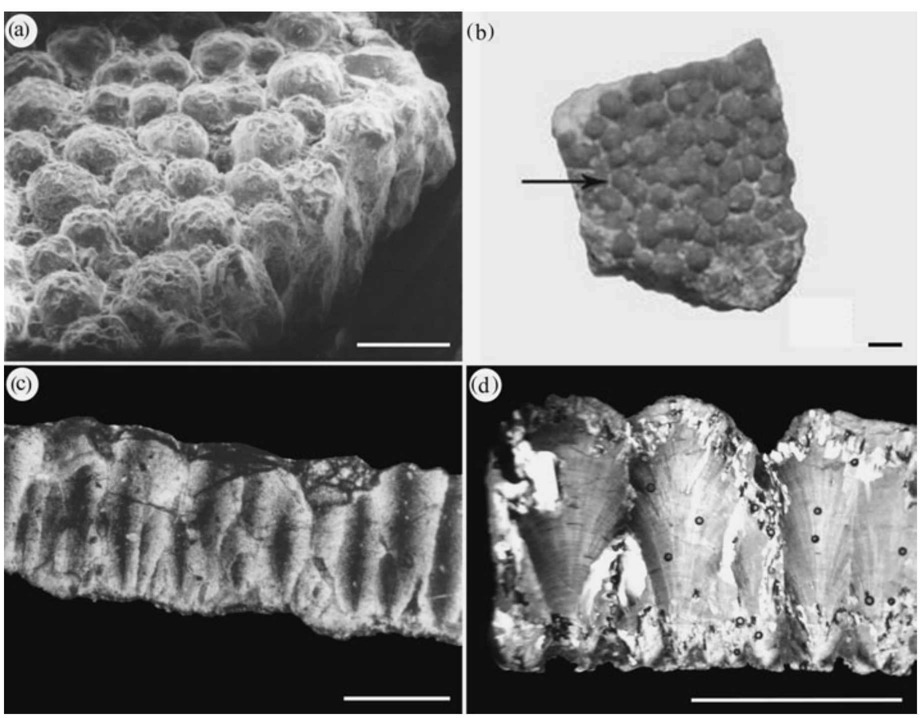


Figure 1. (a) Tangential thin section of outer surface of *M. jabalpurensis*, PPL, Bara Simla Hill (VPL/KH/251), Jabalpur, Madhya Pradesh; note discrete and coalesced circular to subcircular nodes. Bar length = 500 μm. (b) External surface of *M. jabalpurensis*, under Binocular Loupe (BL), Mansilla I, egg level 3, Bajos de Santa Rosa, Río Negro (MML-Pv 980); note discrete and circular to subcircular nodes. Bar length = 1 mm. (c) Radial thin section (*M. jabalpurensis*), Bara Simla Hill (VPL/KH/250), Jabalpur, Madhya Pradesh; note spheroliths under cross-nicols showing sweeping extinction pattern. Bar length = 500 μm. (d) Radial thin section (*M. jabalpurensis*), under PLM (MML-PH 1283). Mansilla II, egg level 3, Bajos de Santa Rosa. Río Negro, Argentina; note the shell units are sharply separated. Bar length = 1 mm.

subvertical in shape as compared to the straight pore canals in *M. cylindricus*. The additional eggshell specimens from the Lameta Formation of Jabalpur were described earlier by Vianey-Liaud et al. (1987). Later, the eggshells from the same locality were also described as '(?) Titanosaurid Type-II' by various authors (Sahni et al. 1994; Tandon et al. 1995).

At present, this eggshell oospecies is also being recorded from two additional localities, namely Dholiya and Padiyal (Dhar District, Madhya Pradesh). Eggshells of about 2.38 mm in thickness have been noticed in Dholiya. Crushed, fragmented and nearly three complete silicified eggs belonging to this oospecies (140–160 mm in diameter) have been found at Padalya, Dhar District in Madhya Pradesh (Vianey-Liaud et al. 2003). The megascopic characteristics of the spherical-shaped dinosaur eggs having a diameter of 140–160 mm recorded earlier from the Waniawao village near Dohad (Panchmahal District, Gujarat) are similar to *M. jabalpurensis* reported from Jabalpur (Vianey-Liaud et al. 2003). The eggshell from Gujarat attains a thickness of about 1.0–1.5 mm, the thickness that is conspecific with Jabalpur eggshells. *Megaloolithus jabalpurensis* is closely similar in micro- and ultrastructural characters to *M. matleyi* (Mohabey 1996, 1998) recovered from Pavna village, Chandrapur District, Maharashtra, and Pat Baba Mandir, Jabalpur, Madhya Pradesh (Vianey-Liaud et al. 2003) (Table 1). Vianey-Liaud et al. (2003) compared two oospecies *M. jabalpurensis* and *M. matleyi* and commented that *M. jabalpurensis* (Khosla and Sahni, 1995) is the same as *M. matleyi* (Mohabey, 1996). They also compared *M. patagonicus* with *M. jabalpurensis* and found both oospecies have similar mega- and microstructural characteristics (Vianey-Liaud et al. 2003; Table 1, Figure 1).

Therefore, the oospecie *M. jabalpurensis* Khosla and Sahni (1995) has publication priority over *M. matleyi* Mohabey (1996) and *M. patagonicus* Calvo, Engelland, Heredia and Salgado (1997) and these two oospecies were considered as junior synonyms of *M. jabalpurensis*.

The three oospecies listed in Table 1 shows a lot of variation in shape and width of spheroliths. The eggshell fragments recovered from Bara Simla Hill, Padiyal and Bagh Cave sections are similar in thickness to the eggshells collected by Mohabey (1998) from Pavna and Patbaba ridge (Jabalpur). The eggshells from Dholiya are somewhat thick (2.38 mm). As a result, the height/width ratio is variable in different localities. But otherwise both the oospecies shows similar micro- and ultrastructural features.

Elsewhere in the world, the eggshells are known from the Upper Maastrichtian of Aix-en-Provence Basin, France (Penner Type 3, Penner 1985). Williams et al. (1984) reported similar eggshell microstructure as that of *M. jabalpurensis* from Upper Maastrichtian of France. The Indian eggshell oospecies is similar in some characters to *Megaloolithus mamillare* known from the Rousset-Erben locality of Maastrichtian age near LaBégude (Aix-en-Provence Basin) above the Rognac Limestone, France (Vianey-Liaud et al. 1994) and Abella and Bastus localities of Late Cretaceous age in the Tremp Basin, southern Pyrenees, Lleida, Spain (Vianey-Liaud and Martinez 1997). Both oospecies show fan-shaped shell units but megascopically French eggs are bigger (190–230 mm) in size than the Indian eggs (Vianey-Liaud et al. 2003). Calvo et al. (1997) described an oospecies *M. patagonicus* (160 mm) from Bajo de la Carpa Formation, Neuquen Group, Patagonia of Upper Cretaceous age (Coniacian–Santonian), Argentina. Micro- and megascopically *M. jabalpurensis* is similar to the oospecies *M. patagonicus* in shape and size of egg, eggshell thickness, external ornamentation, nodal diameter, pattern of growth lines and pore system, and shape of eggshell units (Vianey-Liaud et al. 2003, Figure 1). Recently, Fernández (2013) described a Type 1b eggshell from Salitral de Santa Rosa, Río Negro, Argentina, referred to *M. patagonicus* from Neuquén city (Calvo et al. 1997). These kinds of eggshells have been reported from two different localities (Mansilla I and Mansilla II), both in the egg level 3 of Salitral de Santa Rosa, Allen Formation, Río Negro Province (see Salgado et al. 2007; Fernández 2013). Therefore, the listing of these Indian eggshells extends their register to Río Negro province and Neuquén province from Argentina, because we considered *M. patagonicus* as a junior synonymous of *M. jabalpurensis*.

Megaloolithus cylindricus Khosla and Sahni, 1995: 89–90

Megaloolithus rahioliensis (Mohabey, 1998: 349)

(Type locality: Rahioli, Gujarat, India)

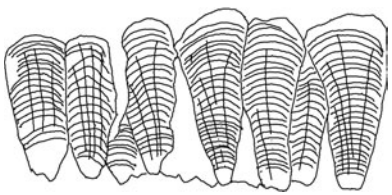
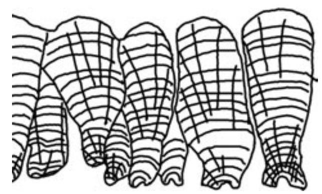
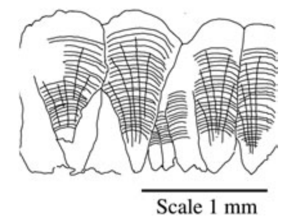
Figure 2(a)–(h)

Type locality. Chui Hill (Jabalpur, Madhya Pradesh, India).

Type horizon and age. Sandy carbonate (= limestone) bed; Late Cretaceous, Lameta Formation.

Description. Eggs are spherical in shape with diameter variable from 120 to 200 mm. The eggshell thickness ranges from 1.7 to 3.5 mm (Figure 2(a),(c),(e)). The eggshell exhibits compactituberculate ornamentation (mostly discrete nodes seen). The nodes are circular to subcircular in shape and are well separated from each other. The nodal diameter ranges between 0.4 and 1.4 mm with an average of about 0.8–1.0 mm (Figure 2(d),(f)). The tall spheroliths are slender, elongated, straight and cylindrical in shape (Figure 2(a),(c),(e)). The lateral margins of spheroliths are straight, parallel and vertical above mammillae (basal caps) (Figure 2(e)). The average height/width ratio is 4:1. The growth lines are highly arched (Figure 2(a),(e),(g),(h)). The pores are subcircular and belong to tubocanaliculate pore system (Figure 2(b),(c)). The pore canals are long, narrow and straight. The basal caps are of medium sized and subcircular in shape (0.2–0.5 mm in diameter).

Table 1. The three oospecies showing similar microstructural characteristics.

M. jabalpurensis (Khosla and Sahni, 1995) 	*M. matleyi* (Mohabey, 1998) 	*M. patagonicus* (Calvo, Engelland, Heredia and Salgado, 1997) 
1. **Shape of egg**		
Spherical	Spherical	Probably spherical
2. **Egg diameter**		
140–160 mm	160–180 mm	160 mm
3. **Eggshell thickness**		
Range: 1.0–1.75 mm (Bara Simla Hill, Patbaba); Ridge: 1.0–1.50 mm (Jabalpur, Madhya Pradesh); Padiyal: 1.20–1.66 mm (Dhar District, Madhya Pradesh); Bagh Cave: 1.33–1.75 mm (Dhar District, Madhya Pradesh); Dholiya: up to 2.38 mm (Dhar District, Madhya Pradesh)	Pavna: 1.50–1.80 mm (Chandrapur District, Maharashtra) and Patbaba Ridge (Jabalpur, Madhya Pradesh).	Bajo de la Carpa Formation: 1.70–2.1 mm (Neuquén City, Argentina); Allen Formation: 1.8–2.6 mm (Mansilla I y II, Bajos de Santa Rosa, Río Negro)
4. **Height/width ratio**		
2.45:1	3:1	3.66: 1

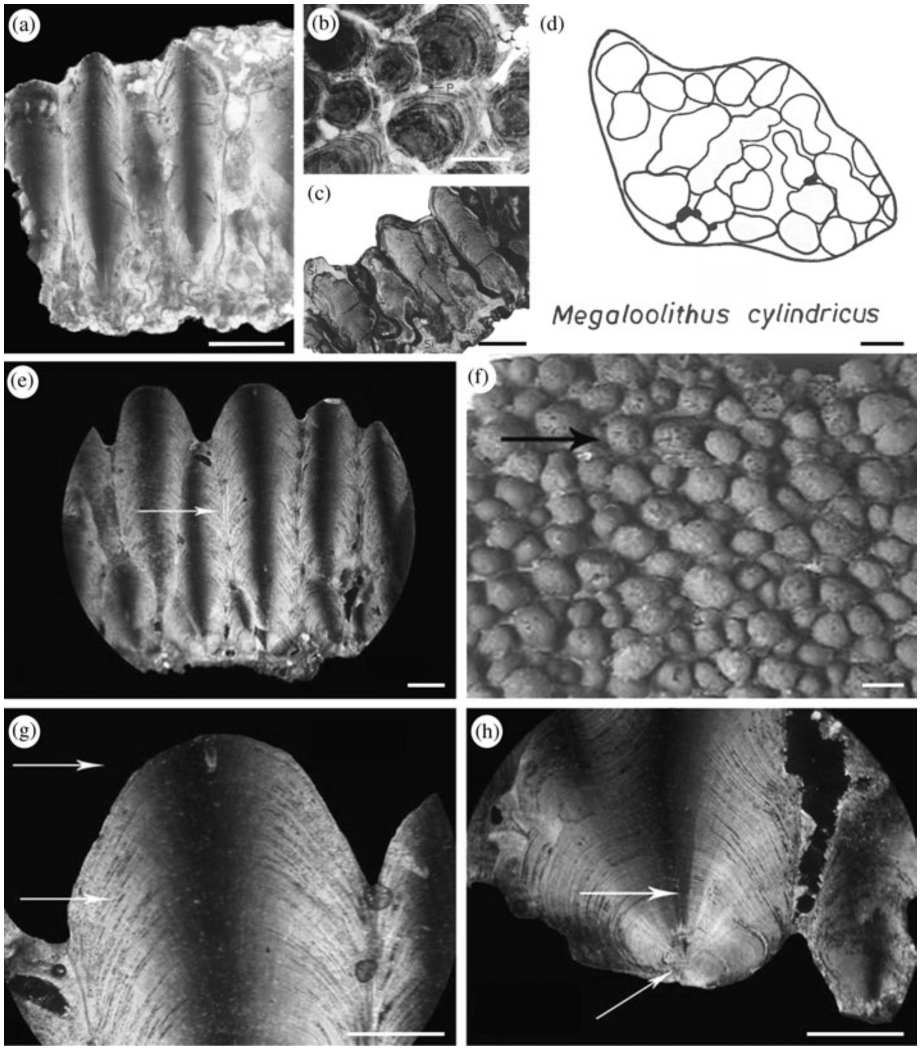


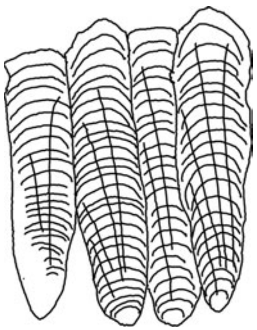
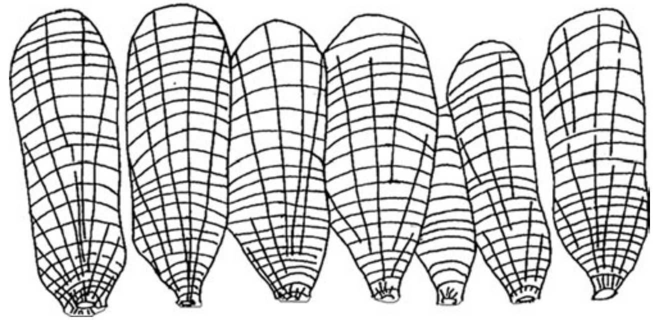
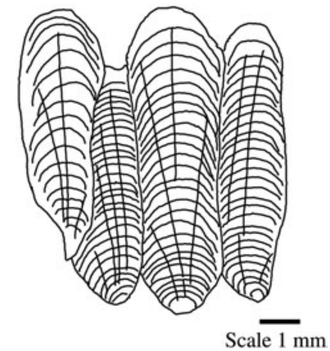
Figure 2. (a) Radial thin section of *M. cylindricus*, Pat Baba Mandir (VPL/KH/214), Jabalpur, Madhya Pradesh; note cylindrical-shaped spheroliths under cross-nicols showing sweeping extinction pattern. Bar length = 500 μm. (b) Tangential thin section (*M. cylindricus*) of outer surface of eggshell, PPL, Dholiya (VPL/KH/102), Dhar District, Madhya Pradesh; note subcircular pores, subcircular nodes with concentric growth lines. Bar length = 500 μm. (c) Radial thin section, *M. cylindricus* PPL, Pat Baba Mandir (VPL/KH/212), Jabalpur, Madhya Pradesh; note discrete cylindrical-shaped spheroliths that are highly replaced by silica. Bar length = 500 μm. (d) Schematic diagram showing the outer surface of eggshell (*M. cylindricus*), note subcircular pores and subcircular nodes. Bar length = 1 mm. (e) Radial thin section of *M. cylindricus*, PLM (MML-PH 1131), Berthe V, egg level 4, Bajos de Santa Rosa, Río Negro, Argentina; note the arrow showing the limit between shell units. Bar length = 1 mm. (f) View of the outer surface of *M. cylindricus*, under binocular microscope (MML-Pv 931), Berthe V, egg level 4, Bajos de Santa Rosa, Río Negro, Argentina. Bar length = 1 mm. (g) Radial thin section of *M. cylindricus*, Berthe V, egg level 4, Bajos de Santa Rosa, Río Negro (MML-PH 1131), Argentina; note that the upper arrow shows the node, the lower arrow shows the accretion lines. Bar length = 300 μm. (h) Radial thin section of *M. cylindricus*, PLM (MML-PH 1131), Berthe V, egg level 4, Bajos de Santa Rosa, Río Negro, Argentina; note basal cap, the upper arrow shows wedges lines and the lower arrow shows the base of the basal cap. Bar length = 300 μm.

Remarks. *Megaloolithus cylindricus* is an oospecies, which was erected by Khosla and Sahni (1995), and this oospecies shows a lot of microstructural variations as listed below:

(1) There is lot of variation in the thickness of *M. cylindricus* (1.7–3.5 mm).
(2) Long slender, elongated, cylindrical and compressed spheroliths.
(3) Pore canals sometimes run throughout the thickness of the eggshell and at places stop in the middle of spheroliths but otherwise pore canals are straight (Table 2).

Mohabey (1998) has discussed that the oospecies *M. rahioliensis* is similar to (?) Titanosaurid Type-I (Sahni 1993; Sahni et al. 1994). Up to now, two oospecies (i.e. *M. cylindricus* and *M. rahioliensis*) have been compared with

Table 2. Common microstructural features present in these three oospecies.

M. cylindricus (Khosla and Sahni, 1995)	*M. rahioliensis* (Mohabey, 1998)	Tipo 1d (Fernández, 2013)
		
1. **Shape of egg**		
Spherical	Spherical	Eggshell fragments
2. **Egg diameter**		
120–200 mm	125–160 mm	Unknown
3. *Eggshell thickness*		
Range: 1.70–3.50 mm (Jabalpur, Madhya Pradesh); Patbaba ridge: 2.10–2.52 mm (Jabalpur, Madhya Pradesh); Dholiya: 2.10–2.45 mm (Dhar District, Madhya Pradesh); Walpur: 2.24–2.52 mm (Jhabua District, Madhya Pradesh); Balasinor: 2.87–3.50 mm (Gujarat, Western India)	2.80–3.50 mm (Rahioli, Gujarat)	Range: 3.4–3.6 mm with average thickness of 3.5 (Berthe V, VI egg level 4, Allen Formation, Río Negro)
4. **Height/width ratio**		
4:1	4:1	3.5:1
5. **Shape of spherolith**		
Cylindrical	Cylindrical	Cylindrical
6. **Basal caps**		
Medium sized and subcircular in shape (0.2–0.5 mm in diameter)		Subcircular basal caps 0.1–0.5 mm in diameter
7. **Previous description**		
Previously described as Kheda Type-B (Srivastava et al. 1986) and (?) Titanosaurid Type-I (Sahni et al. 1994)	Previously described as Type-2 (Mohabey 1984); Titanosaurid Type-I (Sahni et al. 1994)	Referred to Titanosaurid Type-I (Sahni et al. 1994) in Fernández 2013)

(?) Titanosaurid Type-I. The eggshell types (?) Titanosaurid Type-I was originally described by Sahni (1993) and Sahni et al. (1994). Khosla and Sahni (1995) gave a parataxonomic name *M. cylindricus* to the (?) Titanosaurid Type-I. Therefore, we are suggesting here that *M. cylindricus* was published first (Khosla and Sahni 1995) and *M. rahioliensis* published later in 1998 by Mohabey and Type 1d by Fernández (2013). Even though eggshell fragments belonging to Tipo 1d was not assigned to any parataxonomic oospecies by Fernández (2013) but here we are suggesting that *M. rahioliensis* and eggshell fragments from Argentina belonging to Tipo 1d should be assigned to *M. cylindricus*. Megascopically, the size of oospecies *M. rahioliensis* (125–160 mm) comes within the range of *M. cylindricus* (120–200 mm) (Table 2, Figure 2).

The record of a single complete more or less spherical-shaped dinosaur egg (200 mm in diameter) with well-preserved shell from the marine Maastrichtian of Ariyalur area, South India (Kohring et al. 1996), is a remarkable one, as the dinosaur eggs have previously been known only from the Late Cretaceous Lameta Formation. The oospecies *M. cylindricus* shows remarkable similarity to the eggshell micro- and ultrastructures of Ariyalur eggshell specimens (Kohring et al. 1996; Vianey-Liaud et al. 2003). Both the eggshell specimens exhibit nodose ornamentation, cylinder-shaped spheroliths, with straight pore canals. The only difference is that the Ariyalur eggshell specimens are thinner (2.7–2.8 mm) and have a lesser height/width ratio (3.5:1) as compared to the oospecies *M. cylindricus* (4:1).

Elsewhere in the world, similar eggshells are known from the Upper Cretaceous of France (Thaler 1965; Erben 1970; Penner Type-I in Vianey-Liaud et al. 1987). The Indian eggshell oospecies shows remarkable similarity to the eggshell microstructure (Type No. 4) found from Maupague locality of Lower Rognac Limestone, France (Williams et al. 1984). *Megaloolithus cylindricus* is closely similar in micro- and ultrastructural characters to *M. microtuberculata* (García and Vianey-Liaud 2001a, 2001b) recovered from LaCairanne, France, while the Indian oospecies is larger in size (120–200 mm in diameter) and in eggshell thickness (1.7–3.5 mm) than the French oospecies (size of egg is 160 mm and eggshell thickness is 1.84–2.52 mm). Vianey-Liaud et al. (2003) remarked that *Megaloolithus siruguei* resembled *M. cylindricus*. *Megaloolithus siruguei* have a thickness range from 2.7 to 2.8 mm, it is within the range of thickness of *M. cylindricus* (1.7–3.5 mm). Sellés et al. (2013) remarked that *M. siruguei* have discrete spherulitic units formed by radiating calcite crystals and pore system with transversal channels, these types of channels have not been found in *M. cylindricus*. Khosla and Sahni (1995) have noted the similarities between both oospecies and commented that Indian oospecies is thicker than the French oospecies. *Megaloolithus cylindricus* is recorded from five localities (see Vianey-Liaud et al. 2003). *Megaloolithus cylindricus* shows similarities with *M. siruguei* as seen above, and also with *M. microtuberculata* (García 1998; García and Vianey-Liaud 2001a). On the other hand, the eggshell thickness of the Argentinean eggshells Tipo 1d ranges from 3.4 to 3.6 mm with average thickness of 3.5 mm, which fits very well with *M. cylindricus* from Balasinor (2.87–3.50 mm, Gujarat, Western India); Mohabey (1998) stated that *M. cylindricus* closely resembled *M. siruguei* from the Upper Cretaceous of France, but differed in having a subcircular nodes. In Tipo 1d, eggshells (Fernández 2013) have an average node diameter of 1.04 mm, ranging from 0.5 to 1.7 mm; shell units are long compressed, nearly cylindrical in shape and not fused to adjacent units. The shape of shell units of Argentinean eggshells is the same as that of the Indian eggshells. The average height/width ratio in Tipo 1c is greater than *M. cylindricus*, i.e. 3.5:1. Finally, the growth lines are arched upwards and follow the contour of the external profile; pore circular to elongate in shape; tubocanaliculate pore system (pore canals subvertical); subcircular basal cap 0.1–0.5 mm in diameter like we described here for *M. cylindricus*.

Megaloolithus megadermus Mohabey, 1998: 353–357

Hypselosaurus (Kerourio, 1987: 257) (see Mohabey 1998)

(*Type locality.* Dansle Basin, France)

Figure 3(a)–(d)

Type locality. Dholidhanti (Gujarat, India).

Type horizon and age. Sandy carbonate (= limestone) bed; Late Cretaceous, Lameta Formation.

Description. The eggs are spherical in shape with diameter variable from 130 to 180 mm. The eggshell thickness ranges from 4.0 to 4.80 mm (Figure 3(b)–(d)). The eggshell shows compactituberculate ornamentation, coarse and densely packed nodes. The spheroliths are discrete, tall and narrow, and the lateral margins of spheroliths are straight (Figure 3(a)–(c)). The average height/width ratio is 9.6:1. The pore canals are long, straight and broad and are of tubocanaliculate type. The basal caps are short (less than one-tenth of spherolith).

Remarks. Spherical-shaped eggs of *M. megadermus* are known from the Lameta Formation of Dholidhanti and Paori in Dohad area (Panchmahal District) and Daulatporia (Kheda District), Gujarat (Mohabey 1998). Recently, 15 eggshells belonging to the oospecies *M. megadermus* (Mohabey 1998) have been discovered from the Lameta Formation of Jhabua District, Madhya Pradesh (Khosla, work in progress). The materials found in Argentina are scarce. Fernández (2013) documented eggshells with large thickness and an unknown egg diameter, and assigned as Tipo 1e. The

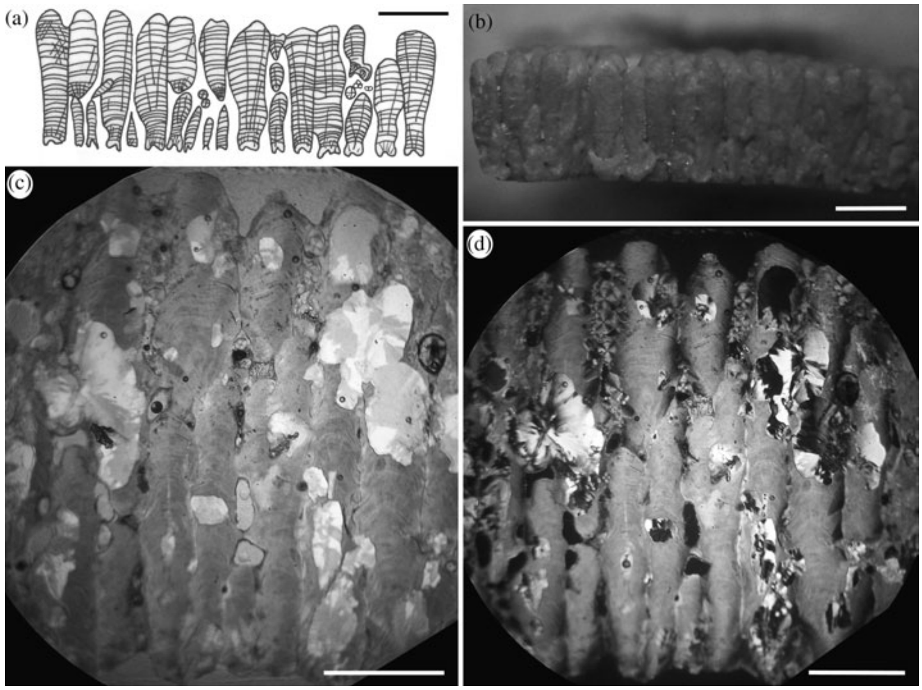


Figure 3. (a) Schematic drawing of the Indian eggshell oospecies *M. megadermus* (modified from Mohabey 1998). Bar length = 2 mm. (b) Radial view under BL of *M. megadermus* (MML-Pv 914) from Río Negro province. Bar length = 2 mm. (c) Thin section of *M. megadermus* under common light microscope (MML-PH 1143). Spheroliths discrete, tall and narrow; lateral margins of spheroliths are straight; shell units show accretion lines. Bar length = 1 mm. (d) Thin section of *M. megadermus* under PLM (MML-PH 1143). Fan-shaped shell units. Average height/width ratio is 9.6:1. Short basal caps (less than one-tenth of spherolith). Bar length = 1 mm.

eggshell thickness of Argentinean eggshells ranges from 4.1 to 4.9 mm with an average thickness of 4.43 mm. The eggshell shows compactituberculate ornamentation (subcircular nodes) with an average node diameter about 0.76 mm with overall diameter ranging from 0.4 to 1.1 mm. The spheroliths are compressed, shell units long (Figure 3, Table 3) and nearly cylindrical in shape. The average height/width ratio is 6.42:1. The growth lines are moderately arched upwards and follow the contour of the external profile (Figure 3(c),(d)). The pores are circular in shape and are of tubocanaliculate pore system (pore canals subvertical and inclined). The basal caps are subcircular in shape and are of 0.4–1 mm in diameter and an average diameter of 0.7 mm (Table 3).

Both types of eggshells have a high ratio between height and width of shell unit, but the Indian eggshells show a higher ratio 9 (Table 3). The microstructures of these eggshells are the same, both have long and straight shell units, ornamentation comprises of coarse and densely packed nodes. The eggshells described by Mohabey (1998) also resembled the eggshells described from the Dansle Basin, France; Kerourio (1987) further assigned these eggshells to the titanosaurid *Hypselosaurus.* In both eggshells, the shell microstructure is similar, because, as has been previously described by Mohabey (1998), *M. megadermus* has units formed by competing growing spherulites.

Fusioolithidae Oofam. nov

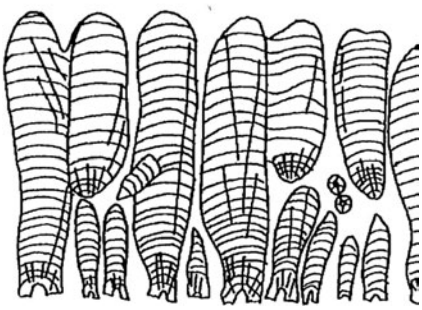
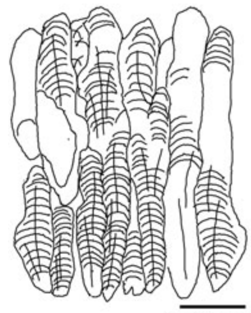
Dinosauroid-spherulitic basic type, tubospherulitic morphotype, tubocanaliculate pore system (Mikhailov 1997). The ornamentation is compactituberculate. The accretion lines cross the boundary between shell units starting on the one-third of the inner of the eggshell thickness and sometimes continue to the external surface. Eggshell is composed of circular cones without clearly demarcated boundary lines; the shell units are partially fused. The shell units are fan shaped similar to the eggs of oofamily Megaloolithidae but it differ in the nature of the eggshell units in which they are partially fused. We found significant differences with Spheroolithidae too, because this oofamily has a different ornamentation pattern.

Fusioolithus Oogen. nov

Derivation of name. Named in response as its characteristics shell units fused, words ‘oo’ relating to an egg or ovum and ‘litho’ meaning a stone.

Description. The eggs are large and round, with both transverse and longitudinal diameters ranging 90–

Table 3. *Megaloolithus megadermus,* comparison of Indian and Argentinean oospecies.

M. megadermus (Mohabey, 1998)	Tipo 1e (Fernández, 2013)
	
1. **Shape of egg**	
Spherical	Fragmentary eggshells
2. **Egg diameter**	
130–180 mm	Fragmentary eggshells
3. **Eggshell thickness**	
4.0–4.80 mm; Dholidhanti and Paori in Dohad area of Panchmahal District, and Daulatpoira (Kheda District), Gujarat	4.1–4.9 mm with average thickness of 4.43 (Berthe II, egg level 5; Bajos de Santa Rosa, Río Negro, Argentina).
4. **Height/width ratio**	
9.6:1	6.42: 1
5. **Shape of spherolith**	
Long and straight and some time fused to adjacent units	Shell units long compressed and some time-fused to adjacent units
6. **Basal caps**	
Small	Small

200 mm. External surface ornamentation is compactituberculate. The external nodes are partially fused, the node is the projection of accretion lines. This oogenus includes some oospecies previously described as *Megaloolithus*; we consider those oospecies should belong to this oofamily and oogenus because they do not have sharply separated shell units. In this oogenus, the eggshells have partially fused shell units and a thickness ranging from 0.8 to 4.5 mm.

Included ootaxa. *Megaloolithus baghensis* (Khosla and Sahni 1995) now *Fusioolithus baghensis* Fernández and Khosla, this paper; *Megaloolithus dhaliyalensis*, *M. mohabeyi*, *M. padiyalensis*, *M. petralta*, *M. mammillare*, *M. pseudomamillarae*, *M. microtuberculata*, *M. aureliensis, Cairanoolithus dughii*, *C. roussetensis* and *Fusioolithus berthei* oosp. nov. Fernández and Khosla, this paper. All these Megaloolithidae oospecies should be included in this new oofamily, because they have partially fused shell units.

Fusioolithus baghensis (Khosla and Sahni, 1995)
Figure 4(a)–(c)

Type locality. Bagh Caves (Jabalpur, Madhya Pradesh, India).

Type oogenus. *Fusioolithus* oogen. nov. (Fernández and Khosla, this paper).

Type oospecies. *Fusioolithus baghensis* (Khosla and Sahni 1995).

Type horizon and age. Sandy carbonate (= limestone) bed; Late Cretaceous, Lameta Formation.

Derivation of name. The oogenus *Fusioolithus* has been derived due to partially fused units. The oospecies have a worldwide distribution.

Holotype. VPL/KH/551 Bagh cave section, Dhar District, Madhya Pradesh.

Diagnosis. Spherical eggs 140–200 mm in diameter; nodose ornamentation, eggshell 1.0–1.70 mm thick; average node diameter about 0.60 mm; fan-shaped spheroliths distinct or even partially fused; height/width ratio 2.32:1; pore subcircular to elliptical; swollen-ended,

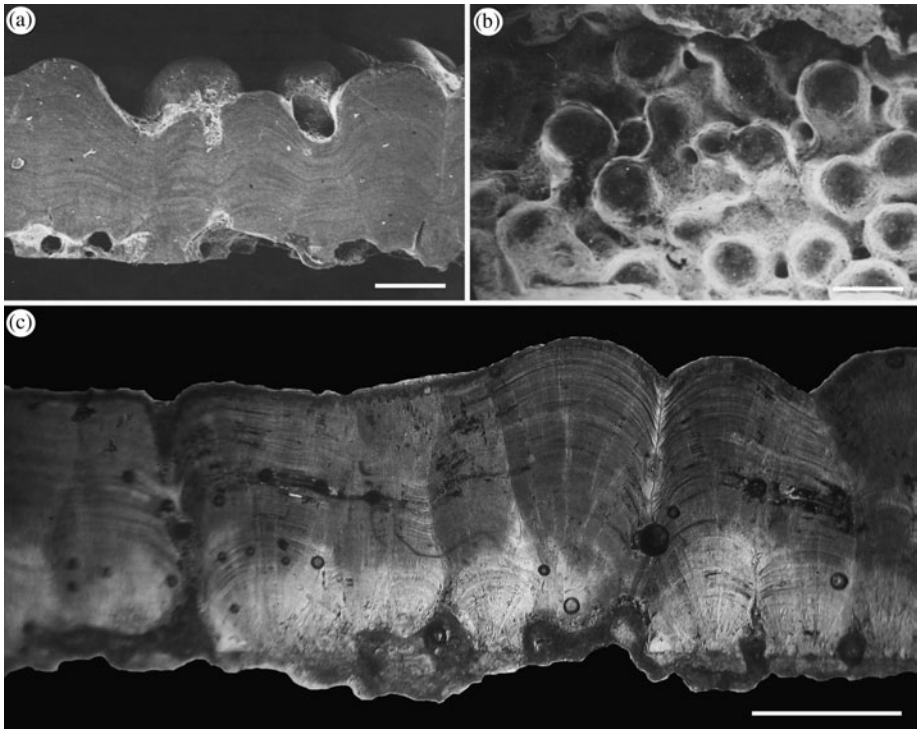


Figure 4. (a) Radial thin section of *F. baghensis*, Anjar (VPL/AS/SB/561, Kachchh District, Gujarat); note large and small fused spheroliths with moderately arched growth lines confluent to those of adjacent spheroliths. Bar length = 1 mm. (b) Outer surface of eggshell, SEM, Anjar (VPL/AS/SB/560, Kachchh District, Gujarat). Note discrete and fused nodes with subcircular to elliptical pores. Bar length = 500 μm. (c) Radial thin section of *F. baghensis*, Mansilla I, egg level 3 (MML-PH 1133), Bajos de Santa Rosa, Río Negro, Argentina. Note fusion between several shell units. Bar length = 500 μm.

variably spaced basal caps (0.2–0.3 mm in diameter) (Figure 4(a)–(c)).

Fusioolithus baghenisis (Khosla and Sahni, 1995)
Figure 4(a)–(c)

Megaloolithus baghensis Khosla and Sahni, 1995: 91–92 (*Type locality.* Bagh Caves, Madhya Pradesh, India)

Megaloolithus pseudomamillare (Vianey-Liaud, Hirsch, Sahni and Sigé, 1997: 78–81) (*Type locality.* Les Breguieres)

Megaloolithus balasinorensis (Mohabey, 1998: 357–358) (*Type locality.* Balasinor, India)

Patagoolithus salitralensis (Simón, 2006: 517, 521–523) (*Type locality.* Salitral Moreno, Argentina)

Megaloolithus cf. *baghensis* (Sellés, Bravo, Delclòs, Colombo, Martí, Ortega-Blanco, Parellada and Galobart, 2013) (*Type locality.* Coll de Nargó)

Type locality. Bagh Caves (District Dhar, Madhya Pradesh, India).

Description. The eggs are spherical in shape with diameter variable from 140 to 200 mm. The eggshell thickness ranges from 1.0 to 1.70 mm (Figure 4(a),(c)). The eggshell shows compactituberculate ornamentation, coalesced and discrete nodes (Figure 4(b)). The nodal diameter ranges from 0.40 to 0.80 mm and the average nodal diameter is about 0.60 mm. The spheroliths are short, broad and fan shaped and distinct or even partially fused. The lateral margins of spheroliths are straight to conical type. The height/width ratio is 2.32:1. The growth lines are moderately arched beneath the nodes and enter into adjacent spherolith with concavity while in multinodal spheroliths growth lines are horizontal to subhorizontal in shape. The pores are subcircular to elliptical in shape and are of tubocanaliculate pore system. The pore canals are short, curved and narrow; swollen-ended, variably spaced basal caps (0.2–0.3 mm in diameter).

Remarks. This oospecies was included previously in the oofamily Megaloolithidae (Khosla and Sahni 1995). We consider the diagnosis of the oofamily Megaloolithidae which was erected by Zhao (1979); this author clearly stated, 'Eggshell is composed of circular cones with clearly demarcated boundary lines.' In the present work, we are creating a new oofamily, which includes eggshells with fan-shaped eggshell unit pattern, tubocanaliculate pore system and spherical eggs. The oospecies of these eggs have been related with sauropod dinosaur (Chiappe et al. 1998, 2001). This oospecies was earlier described as (?) Titanosaurid Type-III by Sahni (1993) and Sahni et al. (1994) and has been widely recorded from the Late Cretaceous intertrappean localities of peninsular India (Vianey-Liaud et al. 1987; Bajpai et al. 1990; Sahni 1993; Sahni et al. 1994; Khosla and Sahni 1995; Loyal et al. 1996). Complete spherical eggs (140–200 mm in diameter) of this oospecies have been recorded from the Lameta Formation at Balasinor Quarry in Kheda (Srivastava et al. 1986). The eggshell microstructure of this oospecies is quite different from other *Megaloolithus* oospecies. The eggshells are characterised by short and broad fan-shaped spheroliths. The spheroliths are discrete, fused and mostly of multinodose type exhibiting shallow arched and near-horizontal growth lines that follow the contour of the outer shell surface (Figure 4(a),(c)). *Fusioolithus baghensis* (Khosla and Sahni, 1995) is the same as *M. balasinorensis* (Mohabey, 1998) as both the oospecies show similar microstructural characteristics listed in Table 4.

We are changing the oospecies *Megaloolithus baghenisis* to the new oofamily Fusioolithidae, and the oogenus *Megaloolithus* as *Fusioolithus*.

Elsewhere, this eggshell oospecies shows close resemblance in shape and size to the eggshell material known from the Upper Rognacian (Maastrichtian) of Aix-en-Provence of France, which has been assigned to Type No. 3.2 (Williams et al. 1984). Vianey-Liaud et al. (1997) and Vianey-Liaud and Martinez (1997) have made a parataxon *M. pseudomamillare* known from Les Breguieres, Aix Basin of Late Rognacian age (Maastrichtian), France, and from the Suterranya locality, Tremp Basin, Southern Pyrenees, Lleida of Late Rognacian age (Maastrichtian), Spain, Peru and Bolivia. *Megaloolithus baghensis* is closely similar in shape, size, micro- and ultrastructural characters to *M. pseudomamillare*. *Megaloolithus baghensis* is similar to *Patagoolithus salitralensis* (Simón 2006) (Figure 4) known from the Upper Cretaceous deposits of Salitral Moreno, Argentina. Microstructurally, the range of nodal diameter in *Patagoolithus salitralensis* is slightly high (0.08–1.10 mm) but the average node diameter in Indian, Argentinean and French eggshells is about 0.60 mm. The size of mammillae in *Patagoolithus salitralensis* is slightly larger (0.15–0.82 mm) than Indian counterparts (0.2–0.3 mm in diameter). *Megaloolithus baghensis* is closely similar in shape, size, micro- and ultrastructural characters to *Patagoolithus salitralensis*. The pore canals diameter of *Megaloolithus* is much larger than that found in *Patagoolithus salitralensis*. *Megaloolithus* has a diameter of 50 μm and *Patagoolithus salitralensis* has pore channel with a diameter of 5–10 μm. Therefore, *M. baghensis* (Khosla and Sahni 1995) has publication priority over *M. pseudomamillare* and *Patagoolithus salitralensis*, and the latter are considered as the junior synonyms of *M. baghensis*.

Fusioolithus berthei **nov. sp.** Fernández and Khosla

Figure 5(a)–(d)

Type locality. Santos II B, egg level 3 (see Salgado et al. 2007; Fernández 2013), Salitral de Santa Rosa, Río Negro, Argentina.

Other locality. García I, egg level 3.

Type oogenus. *Fusioolithus* oogen. nov. Fernández and Khosla, this paper.

Fusioolithus berthei oosp. nov

Type horizon and age. Thick succession of sandstones and mudstones, with intercalations of carbonate and evaporitic rocks in its upper part, Allen Formation Campanian–Maastrichtian (Upper Cretaceous).

Etymology. Oogenus previously described, and the rest of the name in honour to Ms Liliana Berthe, for hosting us during last 10 years of field trip in Salitral de Santa Rosa, Río Negro Province, Argentina.

Material and preservation. Eggshell fragments from four disintegrated eggs.

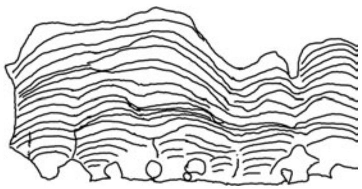
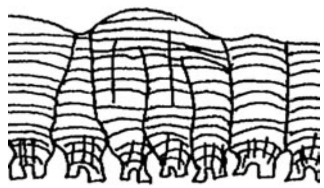
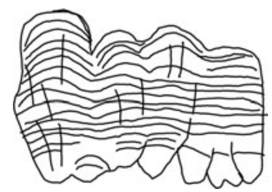
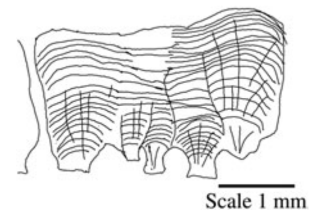
Referred specimen. Tipo 1c (Fernández 2013).

Holotype. MML-PH 1269.

Diagnosis. These eggshells have a thickness ranging from 2.45 to 2.9 mm (Figure 5(c),(d)); compactituberculate ornamentation (subcircular nodes) (Figure 5(a)); average node diameter about 0.66 mm with diameter ranging from 0.3 to 0.7 mm; fan-shaped units have variable width and shape; lateral margins of spheroliths are conical and non-parallel, and the eggshell units are partially fused (Figure 5(c),(d)). This is the most important difference between *M. jabalpurensis*, which have sharp eggshell units as its oofamily materials. The upper and external parts of the units have a big wide difference with the inner parts. The average height/width ratio is 3.27:1; growth lines moderately arched upwards and follow the contour of the external profile; pore circular to elongate in shape; tubocanaliculate pore system (pore canals subvertical and inclined); subcircular basal caps 0.1–0.5 mm in diameter.

Description. The Santos II B material is well preserved, with external deposition of calcitic sediments in both surfaces (see Fernández 2013). In this material, the nodes are very distinct, the external surface appears ornamentated. The new oospecies is close to those eggs described by Grigorescu et al. (1994) from Hateg (Romania). These investigators described nest (associated hadrosaur skeletal remains, more precisely *Telmatosaurus transsylvanicus* Nopcsa, 1899) with eggs diameters ranging from 156 to 175 mm, and shells have a tubocanaliculate pore system and with shells thickness

Table 4. Comparison of four synonymous oospecies.

M. baghensis (Khosla and Sahni, 1995)	*M. balasinorensis* (Mohabey, 1998)	*M. pseudomamillare* (Vianey-Liaud, Hirsch, Sahni and Sigé, 1997)	*Patagoolithus salitralensis* (Simón, 2006)
			
1. **Shape of egg**			
Spherical	Spherical	Spherical	Spherical to sub-spherical (Chiappe et al. 1998)
2. **Egg diameter**			
140–200 mm	140–180 mm	190–210 mm	130–150 mm (Chiappe et al. 1998)
3. **Eggshell thickness**			
1.0–1.70 mm	1.45–1.65 mm	1.0–2 mm	1.05–1.61 mm (Simón, 2006) 1.00–1.78 mm (Chiappe et al., 1998)
4. **Height/width ratio**			
2.32:1	2:1	–	2.28:1
5. **Previous description**			
Previously described as Kheda Type-A (Srivastava et al. 1986) and (?) Titanosaurid Type-III (Sahni 1993; Sahni et al. 1994)	Previously described as Kheda Type-A (Srivastava et al. 1986)	Previously known from Aix Basin, France, Peru and Bolivia (Vianey-Liaud et al. 1994, 1997; Vianey-Liaud and Martinez 1997)	Previously described by Auca Mahuevo Megaloolithid type associated with sauropod dinosaur (Chiappe et al. 1998); *Patagoolithus salitralensis* Simón, 2006, Santa Rosa Type-2A (Salgado et al. 2007, 2009) Tipo 1a (Fernández 2013)

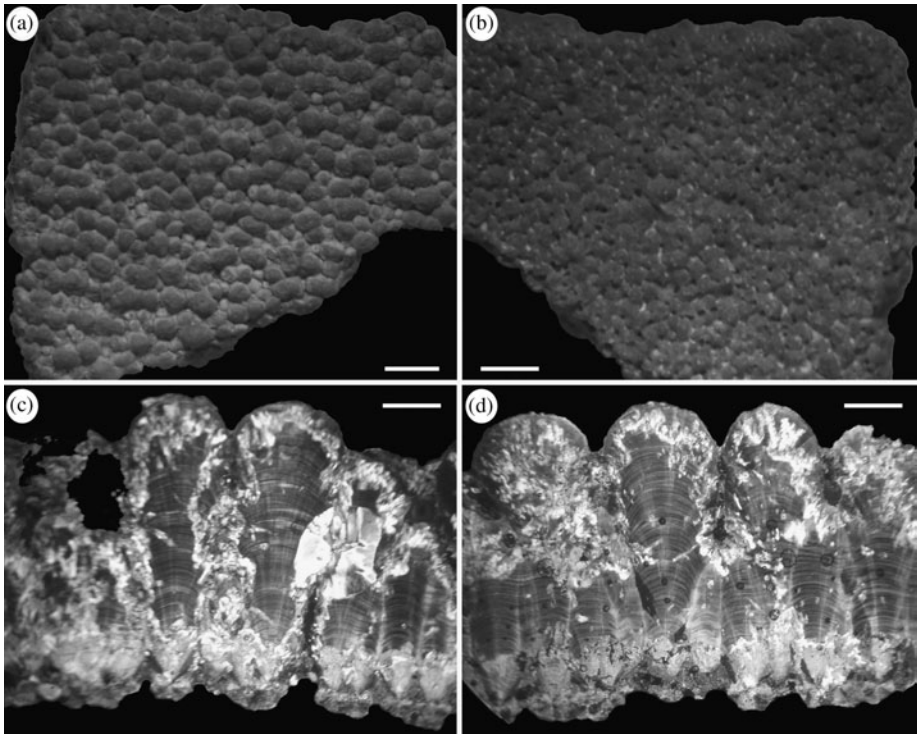


Figure 5. (a) Outer surface of the eggshell (*F. berthei*) (MML-Pv 947), Berthe V egg level 4, Salitral de Santa Rosa, Río Negro, Argentina under BL; note compactituberculate ornamentation, with circular to subcircular nodes. Bar length = 1 mm. (b) Inner surface of *F. berthei* (MML-Pv 947), Berthe V egg level 4, Salitral de Santa Rosa, Río Negro, Argentina. Under BL; note basal cap and the pore opening circular around the basal cap. Bar length = 1 mm. (c) Radial thin section (*F. berthei*) under PLM (MML-PH 1269), Berthe V egg level 4, Salitral de Santa Rosa, Río Negro, Argentina. Note accretion lines cross the boundaries of the shell units, and units are partially fused and wedges lines are seen perpendicularly crossing the entire thickness of the shell. Bar length = 500 μm. (d) Radial thin section of *F. berthei* under PLM (MML-PH 1269), Berthe V egg level 4, Salitral de Santa Rosa, Río Negro, Argentina. Note accretion lines crossing the boundaries of the shell units, and units are partially fused and wedges lines are perpendicularly crossing the entire thickness of the shell. Bar length = 500 μm.

ranging from 2.1 to 2.7 mm. Microstructurally, the eggshells have partially fused shell units, which is in agreement with the dinosauroid-spherulitic morphotype described by Hirsch and Quinn (1990) and Mikhailov (1987, 1991).

Remarks. Fusioolithus berthei corresponds to Tipo 1c of Fernández (2013). *Fusioolithus berthei* is somewhat similar to *M. jabalpurensis* in having fan-shaped spheroliths of variable width and shape and subcircular nodes having common average nodal diameter (0.67 mm) but differs in having eggshell thickness of both oospecies. The eggshell thickness of *M. jabalpurensis* ranges from 1.0 to 2.38 mm whereas that of *F. berthei* ranges from 2.45 to 2.9 mm. The lateral margins of *F. berthei* are fused and are diagenetically altered. The average height/width ratio of *F. berthei* (3.27:1) is more than *M. jabalpurensis* (2.45:1). The basal caps are more pronounced than *M. jabalpurensis.* We are erecting a new oospecies for these eggshells as they do not fit with any other kind of oospecies, which were described previously. The eggs from Romania have a similar microstructure; in radial section the eggshells show columnar bundles of calcite radiating from opaque centres (basal caps), and these eggshells preserve fine-arched growth lines passing between adjacent bundles, as occurring in *F. berthei*. The hatched eggs from Romania are more or less compressed and fractured by burial so it is difficult to know the real shape of the egg and, on the other hand, the other two unhatched eggs appear to be only slightly deformed. These eggs have sub-spherical and slightly ellipsoidal morphology. The three axes of the best preserved specimens are 7.5, 5.6 and 6.0 cm long, respectively. The eggs of *F. berthei* are fragmentary. Externally, Romania eggs like *F. berthei* have its surface covered with hemispheric tubercles raised 0.15–2.0 mm from their base (Grigorescu et al. 1994). Grigorescu and colleagues described that these eggshells belong to tubospherulitic morphotype and also described that the eggshell units are partially fused. So, here we describe *F. berthei* with a tubospherulitic morphotype, but the shell units are broader and loosely arranged; less sharply separated from each other (Mikhailov 1997). The vertical borders and the fan-like pattern are well displayed only up to two-third to three-fourth of the eggshell thickness (Mikhailov 1991).

Discussion

The Upper Cretaceous deposits of India and Argentina have yielded a variety of dinosaur eggshells belonging to the oofamily Megaloolithidae (Figures 6, 7). We compared different oospecies and materials from Lameta and Allen Formations and found several similar oospecies from Indian and Argentina subcontinent and have synonimised them. One of the Fusioolithidae oospecies has no equivalent in either country, because of that we erect *F. berthei* for materials referred as Tipo 1c in Fernández (2013). We synonymise *M. jabalpurensis* as senior synonymous, with *M. matleyi* and *M. patagonicus* as junior synonymous. The three oospecies present the same macro- and microstructures, and the description of thin sections shows the similarities. *Megaloolithus cylindricus* was described for India; in our study, we found that materials previously described as Tipo 1d by Fernández (2013) are similar to this oospecies, so we consider they belong to this oospecies as previously described in results section. After our study, we found that Tipo 1e materials previously described by Fernández (2013) certainly belong to *M. megadermus* (Mohabey 1998). We also studied the microstructure of several oospecies from the oofamily Megaloolithidae and found that *M. baghensis*, *M. dhaliyaensis*, *M. padiyalensis* and *M. mohabeyi* have partially fused shell units, so we have proposed a new oofamily Fusioolithidae with a dinosauroid-spherulitic type of tubospherulitic morphotype and a tubocanaliculate pore canal system, which include all the fused *Megaloolithus* oospecies, which are cited above. In this article, we are changing the oogenus name *Megaloolithus* to *Fusioolithus* for those oospecies where shell units are broader and loosely arranged and have their shell units less sharply separated from each other. Therefore, we are calling here the oospecies *F. baghensis* as the previously assigned oospecies was *M. baghensis* (Khosla and Sahni 1995) and now synonymising it with *M. pseudomamillare*, *M. balasinorensis* and *Patagoolithus salitralensis*. In *Patagoolithus salitralensis*, Simón (2006) argued that the pore canals of *M. baghensis* is smaller than *Patagoolithus salitralensis*, but Fernández (2013) and Khosla (2001) commented that the diameter of pore canals would not be a good character to study the eggshells because it is often affected by diagenesis-like dissolution and recrystallisation (Fernández and Matheos 2011). Simón (2006) erected oospecies *Patagoolithus salitralensis* based on the difference between the diameters of the pore canals. On the other hand, the diameter of the pore canals could indicate the type of nesting environment or even more important these differences may be due to the shells coming from different parts of the egg (top, middle or bottom; Varricchio et al. 2013).

Recently, Fernández (2013) described a Tipo 1c eggshell and assigned it to the oofamily Megaloolithidae. We have studied in detail the microstructure and consider that these eggshells are different of all oospecies described till date. We compared them with *M. jabalpurensis*; it is quite different because *M. jabalpurensis* has shell units sharply separated from each other as it was defined in the diagnosis of Megaloolithidae and the new oospecies *F. berthei* shows partially fused shell units. It is due to this reason, we have erected the new oospecies *F. berthei*. We compared these eggshells with those studied by Grigorescu et al. (1994) too and found similarity in microstructure characteristics. Scarce eggshell fragments have been recorded from Río Negro Province, so we could not compare the shape of complete eggs with those of Romania, but the micro- and macrostructures of the eggshells are quite similar. Oofamily Fusioolitidae shelter the unique oospecies related with embryonic bones, those eggs from Auca Mahuevo. Chiappe et al. (1998) related these eggshells with megaloolithid eggs; in their description, they said:

> Shell units consist of calcitic, radial–tabular ultrastructure, with an average midsection width of 0.5 mm. The typically parallel shell-unit margins interlock and extend to the surface in the upper three-quarters of the shell, but are separate and distinct in the lower quarter. Nearly horizontal growth lines cross adjacent shell units, but dip slightly where shell-unit margins separate in the lower, interior portion of the shell.

As these authors explain that the shell-unit margins interlock, these materials under PLM show the typically partially fused units described by Simón (2006) in Salitral Moreno materials, named as *Patagoolithus salitralensis*. This pattern is a very important character to distinguish Auca Mahuevo materials from *M. patagonicus* which have sharply separated shell units (Calvo et al. 1997). All other measures of nodose diameter and partially fused nodose, eggshell thickness and egg diameter are the same in Auca Mahuevo eggs and *Patagoolithus salitralensis*.

Auca Mahuevo eggs have been wrongly related to *M. patagonicus*, and Calvo et al. (1997) and Chiappe et al. (2003) indicate that Auca Mahuevo eggs are indistinguishable from those from Neuquén city:

> (...) *Megaloolithus patagonicus* (Calvo, Engelland, Heredia and Salgado, 1997), an oospecies described from the Anacleto Formation at Neuquén City that was recently regarded as a possible junior synonym of *Megaloolithus jabalpurensis* from the late Cretaceous (Maastrichtian) of India. (Vianey-Liaud et al. 2003)

We disagree with this statement. *Megaloolithus patagonicus* has sharply separated shell units, and Auca Mahuevo do not, as occurring in *Patagoolithus salitralensis* and *M. jabalpurensis*.

Fernández (2013) studied materials from Río Negro and compared with Auca Mahuevo. This author found that all Auca Mahuevo eggs belong to the oospecies *Patagoolithus salitralensis*. In this work, we are synonymising *Patagoolithus salitralensis* with *M. baghenisis* from India, and changing this oospecies to a new

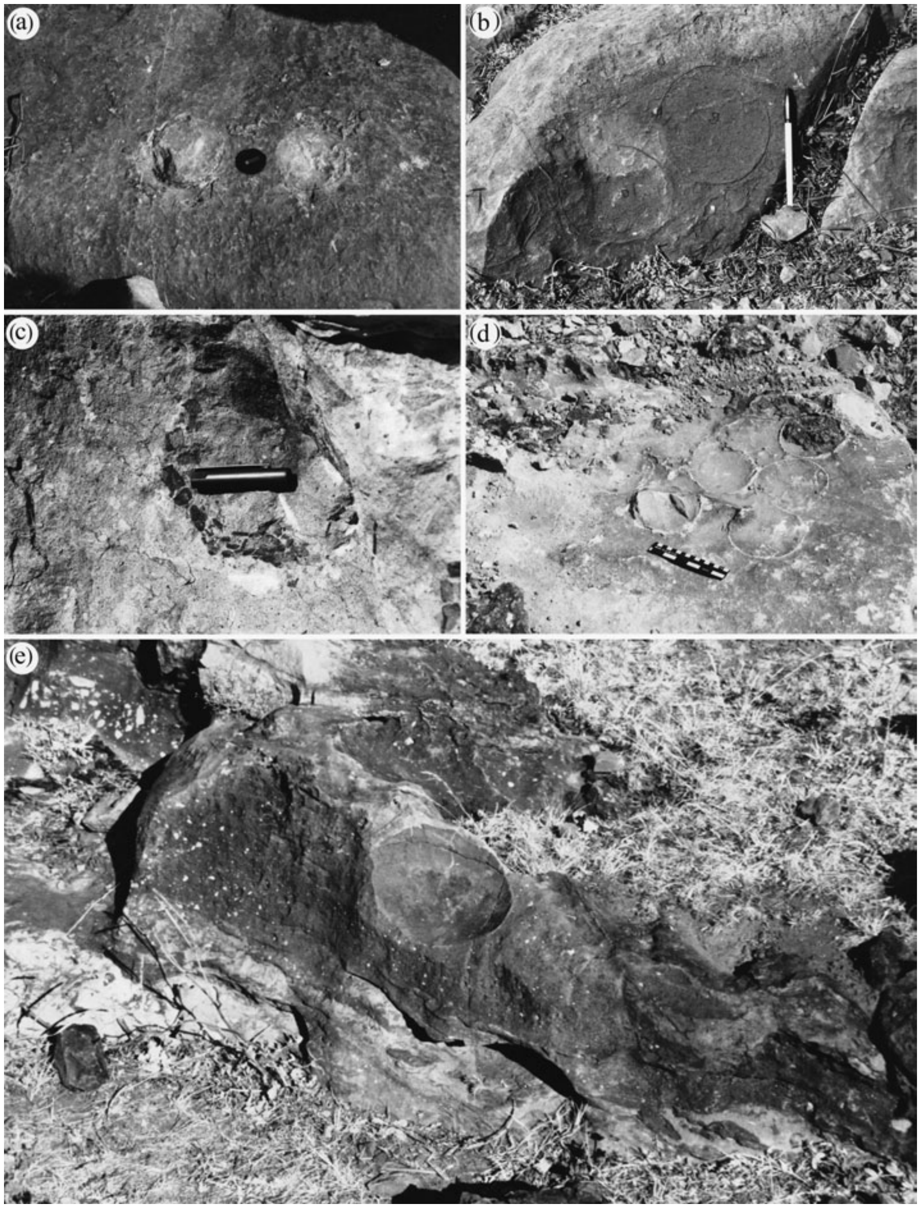


Figure 6. (a) Two nearly complete sauropod eggs belonging to oospecies *M. cylindricus* (Khosla and Sahni 1995) preserved in red Lameta Limestone at Rahioli village, Kheda District, Gujarat, India. Scale camera cap = 7 cm. (b) A clutch showing two complete sauropod eggs (diameter 150 and 160 mm) belonging to the oospecies *M. jabalpurensis* (Khosla and Sahni 1995) at Borkui village (Dhar District, Madhya Pradesh, India). Scale for Figures (pen = 15 cm). (c) A collapsed egg showing fragmentary eggshells belonging to the oospecies *M. cylindricus* (Khosla and Sahni 1995) preserved in white brownish Lameta Limestone at Chui Hill, Jabalpur, Madhya Pradesh, India. (d) A nest showing five spherical-shaped sauropod eggs (diameter 180 mm) belonging to the oospecies *M. cylindricus* (Khosla and Sahni 1995) preserved in Lameta Limestone at Rahioli village (Kheda District, Gujarat). Scale = 5 cm. (e) Inner part of the spherical sauropod egg (diameter 160 mm) belonging to the oospecies *F. baghensis* preserved in grey reddish Lameta Limestone at Kadwal village (Jhabua District, Madhya Pradesh). Scale = 160 mm, egg diameter.

oofamily in response to its own microstructure fused which does not fit with the oofamily Megaloolithidae definition. Finally, we extend the register of *M. baghenisis* (Khosla and Sahni 1995) to Argentina (Auca Mahuevo, Neuquén Province and Salitral de Santa Rosa, and Salitral Moreno, Río Negro Province) within the new oofamily Fusioolithidae.

The presence of the two oofamilies Megaloolithidae and Fusioolithidae in India, South America and southern Europe, highlights the Gondwanan component of the Late Cretaceous European dinosaur fauna (Vianey-Liaud et al. 2003). Moreover, the close relationships of some of the Indian, Spanish and French oospecies demonstrate a probable terrestrial association between the southern European islands

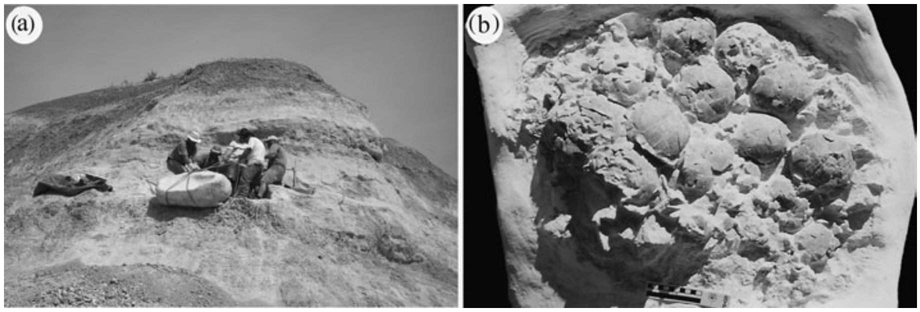


Figure 7. (a) Excavation of sauropod nest belonging to the oospecies *M. jabalpurensis* (MML-Pv 41) Berthe IV, egg level 3 at Argentina. The team is preserving them in plaster of paris jacket. (b) A nest (MML-Pv 41) showing 16 spherical-shaped sauropod eggs belonging to the oospecies *M. jabalpurensis* (Khosla and Sahni 1995) preserved at Berthe IV, egg level 3, Argentina. Scale = 10 cm.

with Gondwanan lands, such as India in the Late Cretaceous (Vianey-Liaud et al. 2003).

Indian and Argentinean morphostructural diversity

The revised synonymy presented here for the Indian dinosaur eggshells demands the interrelation of eggshell oospecies to animal taxa based on cranial and skeletal remains. In the Jabalpur area (Bara Simla Hill, Chui Hill and Lameta Ghat sections), three eggshell oospecies have been recognised namely *M. cylindricus*, *M. jabalpurensis* and *F. baghensis* (Figure 8, Khosla and Sahni 1995). The Late Cretaceous dinosaur skeletal material based on cranial and postcranial remains at Jabalpur included 15 species of Saurischia (Matley 1921; Huene and Matley 1933). This has tended to inflate the number of species and does not reflect a realistic taxonomic diversity based on megavertebrate remains. Therefore, the Indian Late

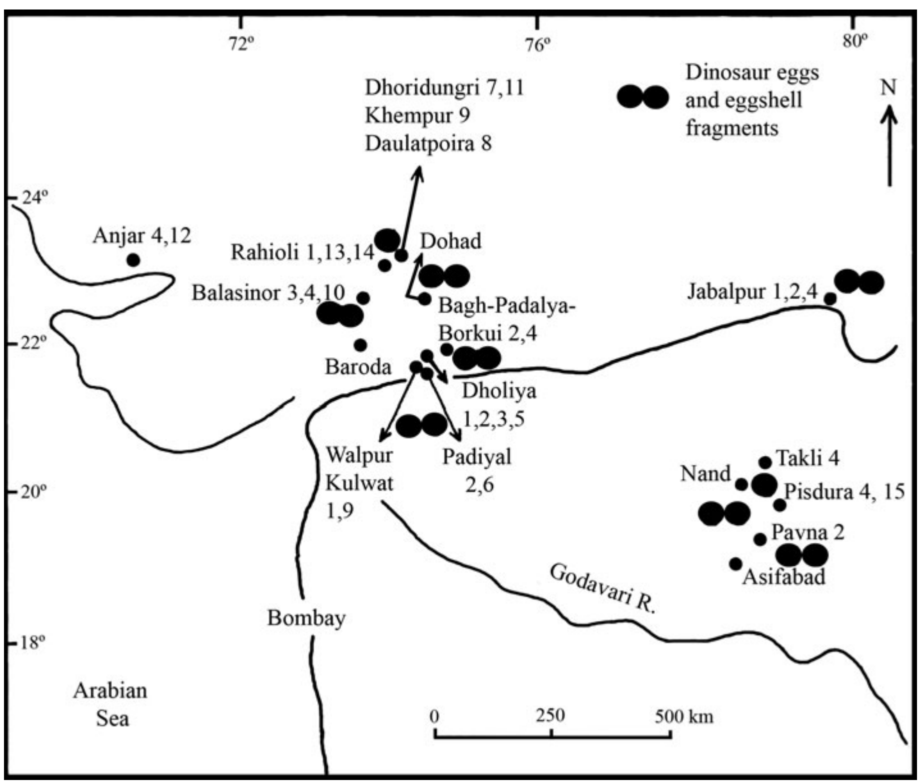


Figure 8. Map showing the distribution of the Indian Late Cretaceous dinosaur nesting sites: 1, *M. cylindricus*; 2, *M. jabalpurensis*; 3, *M. mohabeyi*; 4, *M. baghensis*; 5, *M. dholiyaensis*; 6, *M. padiyalensis*; 7, *M. dhoridungriensis*; 8, *M. megadermus*; 9, *M. khempurensis*; 10, *Problematica* (? Megaloolithidae); 11, *Incertae sedis*; 12, *Subtiliolithus kachchhensis*; 13, *E. khedaensis*; 14, cf. *Trachoolithus*; 15? *Spheroolithus*.

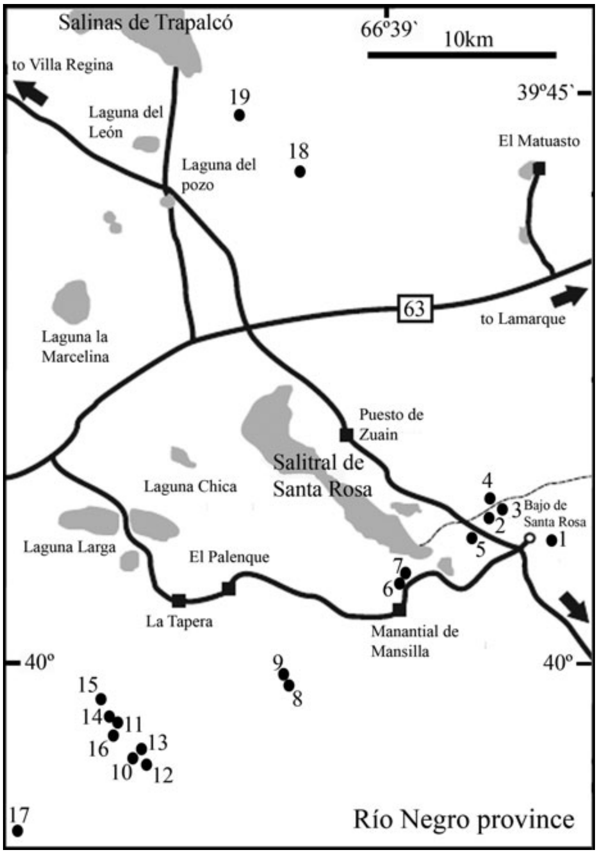


Figure 9. Map showing the distribution of the Argentinean Late Cretaceous dinosaur nesting sites: 1, Santa Rosa; 2, Santos I; 3, Santos II; 4, Santos III; 5, Santos IV; 6, Mansilla I; 7, Mansilla II; 8, García I; 9, García II; 10, Cerro Bonaparte; 11, Berthe I; 12, Berthe II; 13, Berthe III; 14, Berthe IV; 15, Berthe V; 16, Berthe VI; 17, Barranca de la Laguna; 18, Cerro Tortugas; 19, Cerro Laguna Trapalcó (modified from Salgado et al. 2007).

Cretaceous sauropod diversity for years remained in a confusing condition. Various workers such as Hunt et al. (1994), Jain and Bandyopadhyay (1997) and Wilson and Upchurch (2003) have revised the taxonomy of Indian Late Cretaceous Lameta sauropods, which are restricted to four species namely *Titanosaurus indicus*, *Titanosaurus blanfordi*, *Titanosaurus colberti*, *Titanosaurus rahioliensis* and *Antarctosaurus septentrionalis*. It is necessary to mention here that Hunt et al. (1994) have suggested a new species *Jainosaurus septentrionalis* in place of previously assigned genus *Antarctosaurus* but Wilson and Upchurch (2003) retained the species as *A. septentrionalis*.

In the Lameta Formation near Bagh town localities (Dhar and Jhabua Districts), seven eggshell oospecies have been recognised in six different localities (Figure 8, Table 5): two from Bagh Cave section (*F. baghensis* and *M. jabalpurensis*); two from Padalya (*M. jabalpurensis* and *F. baghensis*); two from Borkui (*F. baghensis* and *M. jabalpurensis*); four from Dholiya (*M. cylindricus*, *M. jabalpurensis*, *M. mohabeyi* and *M. dholiyaensis*); two from Padiyal (*M. padiyalensis* and *M. jabalpurensis*) and two from Walpur-Kulwat (*M. cylindricus* and *M. khempurensis*). This indicates that seven different types of sauropod dinosaurs had laid their eggs and presently no skeletal material has yet been recorded from any of the Lameta Formation near Bagh town localities. In the Lameta Formation at Kheda and Panchmahal Districts (Gujarat), eight eggshell oospecies and two indeterminable forms have been recognised in 15 different localities (Figure 8, Table 5): two from Dhoridungri section (*M. dhoridungriensis* and Incertae sedis); one from Paori, Dholidhanti and Daulatpoira sections (*M. megadermus*); one from Rahioli section (*M. cylindricus* = *M. rahioliensis*); one from Khempur and Werasa sections (*M. khempurensis*); two from Balasinor town, Sonipur, Phensani and Waniawao sections (*M. mohabeyi* = *M. phensaniensis* and Problematica? Megaloolithidae); one from Balasinor Quarry, Jetholi and Dhuvadiya sections (*F. baghensis* = *M. balasinorensis*) and two from Lavariya Muwada section (*E. khedaensis* and *Trachoolithus* sp.). In the Lameta Formation at Nagpur and Chandrapur District (Maharashtra), three eggshell oospecies have been recognised in five different localities: one from Pisdura section (*F. baghensis*); one from Dongargaon, Pisdura, Polgaon and Tidkepar sections (? *Spheroolithus*); and one from Pavna section (*M. jabalpurensis* = *M. matleyi*).

In this article, the oofamily Fusioolithidae contains the unique oospecies which has been linked with its producer, the Auca Mahuevo embryo. These sauropod eggs are widespread in Gondwana, and *F. baghensis* represent the titanosaur eggs. These eggs have tubospherulitic morphotype.

At present, presumed sauropod eggshell oospecies diversity is not in general covenant with species diversity based on skeletal material. For example, there are presently nine eggshell oospecies recorded including one problematica and the other *incertae sedis* (Khosla and Sahni 1995; Mohabey 1996, 1998) but only five species of sauropods based on skeletal remain (Hunt et al. 1994; Jain and Bandyopadhyay 1997; Wilson and Upchurch 2003).

In the Auca Mahuevo area, the egg-bearing level appears in Anacleto Formation and one eggshell oospecies was recorded, it was wrongly related with *M. patagonicus* (Chiappe et al. 2003; Grellet-Tinner et al. 2004). Microstructure of these eggshells shows that Auca Mahuevo eggshells belong to *F. baghensis* (Khosla and Sahni 1995, Table 6). Several nests were found in Auca Mahuevo locality with eggs containing embryonic skeletal remains (Figure 9, Chiappe et al. 1998). This has been considered one of the most important discoveries worldwide, and now we know that eggs belonging to the oospecies *F. baghensis* certainly belong to titanosaurs (Chiappe et al. 1998). The titanosaurs from South America laid eggs belonging to the oospecies *F. baghensis*, and similar kind of dinosaurs might lay by Indian and

Table 5. List of the four Indian Late Cretaceous dinosaurian eggshell oospecies recovered from different localities.

Basic Organisational Group **DINOSAUROID-SPHERULITIC** Mikhailov, 1991	
Structural Morphotype **DISCRETISPHERULITIC TYPE** Mikhailov, 1991	
Oofamily **MEGALOOLITHIDAE** Zhao, 1979a	
Oogenus ***MEGALOOLITHUS*** Vianey-Liaud, Mallan, Buscail and Montgelard, 1994	
Oospecies	**Indian localities**
1. *M. cylindricus* Khosla and Sahni, 1995	Patbaba ridge, Chui Hill (Jabalpur, Madhya Pradesh); Dholiya (Dhar District, Madhya Pradesh); Indwan, Kadwal, Walpur-Kulwat (Jhabua District, Madhya Pradesh); Rahioli (Kheda District, Gujarat); Ariyalur (South India).
2. *M. jabalpurensis* Khosla and Sahni, 1995	Bara Simla Hill, Patbaba ridge, (Jabalpur, Madhya Pradesh); Bagh Caves, Padalya, Borkui, Dholiya and Padiyal (Dhar District, Madhya Pradesh); Kadwal (Jhabua District, Madhya Pradesh); Waniawao (Panchmahal District, Gujarat); Pavna (Chandrapur District, Maharashtra)
3. *M. megadermus* Mohabey, 1998	Paori and Dholidhanti (Panchmahal District, Gujarat); Daulatpoira (Kheda District, Gujarat); Dholiya (Dhar District, Madhya Pradesh); and Indwan (Jhabua District, Madhya Pradesh)
Basic Organisational Group **DINOSAUROID-SPHERULITIC** Mikhailov, 1991	
Structural Morphotype **DISCRETISPHERULITIC TYPE** Mikhailov, 1991	
Oofamily **FUSIOOLITHIDAE** Fernández and Khosla	
Oogenus ***FUSIOOLITHUS*** Fernández and Khosla	
4.*F. baghensis* (Khosla and Sahni, 1995)	Bagh Caves, Padalya, Borkui (Dhar District, Madhya Pradesh); Kadwal (Jhabua District, Madhya Pradesh); Pisdura (Chandrapur District, Maharashtra); Anjar (Kachchh District, Gujarat); Takli (Nagpur, Maharashtra) and Balasinor Quarry, Jetholi and Dhuvadiya (Kheda District, Gujarat)

European *F. baghensis* eggs (Khosla and Sahni 1995; Mohabey 1998; Vianey-Liaud et al. 1997, Simón 2006) (Table 6). Calvo et al. (1997) described *M. patagonicus*, and this oospecies was compared with Indian and European materials but these authors erect a new oospecies, previously we argued that *M. patagonicus* is a synonymous of *M. jabalpurensis* Khosla and Sahni (1995). Both oofamilies Megaloolithidae and Fusioolithidae have been found in India and South America, probably these findings should involve an ancient connection between these subcontinents. The oospecies *F. berthei* is similar to Romania eggs, we consider that microstructurally both eggs and eggshells (Romanian and Argentinean eggs) are similar and probably the producer would be related too. In Romania, these kinds of eggs are related to hadrosaurid bones, but no embryonic material have been found inside the eggs, because of that their producer is unknown to date (Grigorescu et al. 1994, 2010). In Allen Formation, there are hadrosaurids bones, so it would be possible that this kind of egg would be produced by hadrosaur, but till date no embryo was found inside the eggs. Moreover, hadrosaurids embryos have been linked with

Table 6. List of the five Argentinean Late Cretaceous dinosaurian eggshell oospecies recovered from different localities.

Basic Organisational Group **DINOSAUROID-SPHERULITIC** Mikhailov, 1991	
Structural Morphotype **DISCRETISPHERULITIC TYPE** Mikhailov, 1991	
Oofamily **MEGALOOLITHIDAE** Zhao, 1979a	
Oogenus ***MEGALOOLITHUS*** Vianey-Liaud, Mallan, Buscail and Montgelard, 1994	
Oospecies	**Argentinean localities**
1. *M. cylindricus* Khosla and Sahni, 1995	Berthe V (egg level 4), Berthe VI (egg level 4), Salitral de Santa Rosa
2. *M. jabalpurensis* Khosla and Sahni, 1995	Mansilla I (egg level 3), Mansilla II (egg level 3), Arriagada III (egg level 2); Salitral de Santa, Rosa, Neuquén city
3. *M. megadermus* Mohabey, 1998	Berthe III (egg level 2) Salitral de Santa, Rosa
Basic Organisational Group **DINOSAUROID-SPHERULITIC** Mikhailov, 1991	
Structural Morphotype **DISCRETISPHERULITIC TYPE** Mikhailov, 1991	
Oofamily **FUSIOOLITHIDAE** Fernández and Khosla	
Oogenus ***FUSIOOLITHUS*** Fernández and Khosla	
4. *F. baghensis* (Khosla and Sahni, 1995)	Mansilla I and Mansilla II (egg level 3), Berthe III (egg level 2), Berthe IV (egg level 3), García I (egg level 5) and Arriaga-da I (egg level 4)
5. *F. berthei* oosp. nov.	Santos II B (egg level 3) Salitral de Santa, Rosa

Prismatoolithidae egg, so we are able to think that Romanian eggs are more likely to be titanosurids eggs than hadrosaurids (Varricchio and Jackson 2004; Zelenitsky et al. 1996).

Paleobiographic implications

During the Upper Cretaceous, the Indian subcontinent drifted northward as an isolated landmass. This subcontinent contains endemic forms (Whatley and Bajpai 2005, 2006; Sharma and Khosla 2009; Whatley 2012; Bajpai et al. 2013), cosmopolitan biota from Laurasia (Khosla and Sahni 2003; Prasad et al. 2010) and Gondwanan (Krause et al. 1997; Prasad et al. 2010). The Gondwanan fossil records show forms represented by a great variety of micro- and megavertebrate assemblages such as sauropod eggshells, abelisaurid dinosaurs, haramyid mammals, leptodactylid, hylid and ranoid frogs, madtosiid and nigerophiid snakes, baurusuchid and notosuchian crocodiles, pelomedusid and bothremydid turtles, which show sister-group relationships with Madagascan and South American forms (Krause et al. 1997; Sampson et al. 1998; Wilson et al. 2003, 2007; Prasad et al. 2007a, 2007b; Verma et al. 2012). Recently, a new oospecies (*Pseudomegaloolithus atlasi* Vianey-Liaud and García, 2003) from Morocco was found, these Megaloolithid eggshells have been related to South American eggshells and Indian eggshells in this work (Chassagne-Manoukian et al. 2013). These recent finds show an ancient Gondwanan ancestor and even display the relationship between these three areas. Five of the oospecies described in the present article (*M. jabalpurensis*, *M. cylindricus*, *M. megadermus*, *F. baghensis* and *F. berthei*) are common to India, South America, Africa and France, and it shows that there are considerable similarities in egg taxa between these four continents. The present study proposes close phyletic relationships, as well as the probable existence of a terrestrial connection of dinosaur fauna between India and Europe during the Upper Cretaceous, and between the three Gondwanan areas Patagonia, Africa and India (Vianey-Liaud et al. 2003; Chassagne-Manoukian et al. 2013). Based on this diverse biota, various land bridges have been anticipated such as Upper Cretaceous terrestrial connection between South America, Africa and India-Madagascar via Antarctica and Kerguelen Plateau (Krause et al. 1997; Prasad et al. 2010) and Late Cretaceous India and South America dispersal route via Ninetyeast Ridge-Kerguelen-Antarctica (Chatterjee and Scotese 2010) or via Gunnerus ridge that existed until 88 Ma (Krause et al. 1997; Hay et al. 1999; Case 2002). For the last one and half decade, a lot of debate has been witnessed over the issue of Upper Cretaceous land bridges between Indo-Madagascar and South America via Antarctica through the Kerguelen plateau/Gunnerus ridge, and several studies have unanimously argued that India and Madagascar remained connected to Antarctica through either the Gunnerus ridge or Kerguelen plateau in the Late Cretaceous (ca 80 Ma) (Krause et al. 1997; Hay et al. 1999; Case 2002; Samonds et al. 2013). Therefore, it had been widely established that the above-listed causeways existed between the three continents and persisted well into the Late Cretaceous, thus facilitating the biotic dispersals from South America to Indo-Madagascar. Further support to this causeway has gained importance by the discovery of a huge fossil frog, which has been recorded recently from the Upper Cretaceous deposits of Madagascar and has close affinities to hyloids of South America (Evans et al. 2009).

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