= Cairanoolithus =

Cairanoolithus is an oogenus of dinosaur egg which is found in Southwestern Europe . The eggs are large (15 ? 19 centimetres or 5 @.@ 9 ? 7 @.@ 5 inches in diameter) and spherical . Their outer surface is either smooth , or covered with a subdued pattern of ridges interspersed with pits and grooves . Multiple fossil egg clutches are known but the nest structure is unclear .

The parent of Cairanoolithus is probably some kind of non @-@ ornithopod ornithischian , possibly the nodosaurid Struthiosaurus .

The eggs were first named in 1994 , when the two oospecies were classified in distinct oogenera as Cairanoolithus dughii and Dughioolithus roussetensis . They are now considered to belong in a single oogenus , possibly even a single oospecies . Though it has been classified as a megaloolithid , Cairanoolithus is usually placed in its own oofamily , Cairanoolithidae .

= = Description = =

Cairanoolithus eggs are spherical and fairly large , measuring 15 ? 19 cm (5 @.@ 9 ? 7 @.@ 5 in) in diameter . The outer surface is smooth or covered with a subdued netlike pattern of ridges , interspersed with pits and grooves (sagenotuberculate ornamentation) . The eggshells are made up of partially interlocking column @-@ shaped shell units and range from 1 @.@ 10 to 2 @.@ 65 mm (0 @.@ 043 to 0 @.@ 104 in) thick .

Several egg clutches of C. dughii are known , containing as many as 25 fossilized eggs . Unfortunately , taphonomical alterations (changes during the fossilization process) make it difficult to determine the original structure of the nest . Cousin (2002) hypothesized that Cairanoolithus eggs were laid on the surface of the ground , possibly buried beneath a mound of plant matter . Tanaka et al . (2015) noted that the shell had a high rate of water vapor conductance . Therefore , they concluded that Cairanoolithus nests were covered by organic or inorganic material , similar to modern eggs with high vapor conductance .

= = = Oospecies = = =

Two oospecies of Cairanoolithus have been described :

Cairanoolithus dughii is the type oospecies . At 1 @.@ 57 ? 2 @.@ 41 mm (0 @.@ 062 ? 0 @.@ 095 in) , its eggshell is slightly thicker than that of C. roussetensis . It has slender , partially fused columnar eggshell units . Their outer surface is almost without ornamentation , and the inner surface is covered with hollows once filled by organic cores . C. dughii 's eggshell exhibits an angusticanaliculate pore system , i.e. its pores are long , narrow , and straight .

Cairanoolithus roussetensis , which was formerly classified in its own oogenus , Dughioolithus , can be distinguished from C. dughii by its thinner eggshell (measuring 1 @.@ 11 ? 1 @.@ 77 mm or 0 @.@ 044 ? 0 @.@ 070 in thick) , its broader eggshell units , and the relative prominence of its ornamentation . Like C. dughii , C. roussetensis typically has an angusticanaliculate pore system , though some specimens have prolatocanaliculate pores , meaning they have variable diameter across their length .

Some authors consider the two oospecies to be synonymous . Cousin (2002) argued that the differences between them were due to intraspecific variation or due to taphonomy . He also described several eggshell fragments that possibly belong to an additional distinct oospecies of Cairanoolithus , however these specimens were referred to C. roussetensis by Selles and Galobart (2015) .

= = Classification = =

While it was formerly considered a megaloolithid , Cairanoolithus is now considered to belong its own monotypic oofamily , Cairanoolithidae . It belongs to the dinosauroid @-@ spherulitic basic type , a group including sauropod eggs and ornithischian eggs , but paraphyletically excluding theropod

eggs .

The cladistic analysis done by Selles and Galobart in 2015 recovered Cairanoolithus as a sister taxon to the clade of ornithopod eggs Guegoolithus , Spheroolithus , and Ovaloolithus . Therefore , they considered it likely that Cairanoolithus belongs to a non @-@ ornithopod ornithischian dinosaur .

= = = Parentage = = =

Since embryos are unknown in cairanoolithid eggs , the identity of their parent is uncertain . They have long been considered to be eggs of titanosaurs or ornithopods (like Rhabdodon) . However , numerous characteristics distinguish Cairanoolithus from sauropod eggs (oofamilies Megaloolithidae and Faveoloolithidae) , even though they bear superficial similarities in size and shape . Cairanoolithus 's columnar eggshell units are quite unlike the fan @-@ shaped ones seen in Megaloolithus , Faveoloolithus , or Fusioolithus . Also , its subdued ornamentation contrasts strongly with the heavily sculpted eggshells of sauropod eggs , and it has a different pore system . Eggs of ornithopods (Spheroolithidae and Ovaloolithidae) , on the other hand , show much closer similarity to cairanoolithids in ornamentation and pore system . However , ornithopod eggs are typically much smaller , and the crystal structure of their eggshell units is distinct .

The cladistic analysis by Sellés and Galobart in 2015 supported an ornithischian parentage . Late Cretaceous ornithischians from Southwestern Europe are restricted to rhabdodontids and the nodosaurid Struthiosaurus . When Sellés and Galobart analyzed the pelvises of Rhabdodon (the largest known rhabdodontid) and Struthiosaurus , they found that Rhabdodon could not have laid eggs as big as Cairanoolithus . On the other hand , even though Struthiosaurus was relatively small , the unique orientation of its ischia would have easily allowed it to lay eggs as large as a 19 cm (7 @.@ 5 in) cairanoolithid egg . However , interpreting Cairanoolithus as the eggs of a nodosaur does raise the question of why Cairanoolithus or similar eggs have not been found in areas with a greater nodosaur abundance .

= = Distribution = =

Cairanoolithus is native to Southwestern Europe , including southern France and northern Iberia . Its fossils date to the late Campanian to early Maastrichtian . They are usually found in the Aix @-@ en @-@ Provence Basin below the Rognac Limestone . C. dughii is from the La Cairanne site in Bouches du Rhône , France , from Roquehautes @-@ Grand Creux and from the Villeveyrac Basin . C. roussetensis is found in the northern part of Iberia and from southern France (in Rousset Village , Roquehautes @-@ Crete du Marbre , the Villeveyrac Basin , and Argelliers @-@ Montamaud) .

= = Paleoecology = =

The Late Cretaceous ecosystems of Europe (which was then an island archipelago) show complex mixing of taxa originating from Africa , Asia , and North America . In Southwestern Europe , Cairanoolithus co @-@ occurs with numerous other types of fossil eggs ; Megaloolithus is particularly common , but theropod eggs such as Prismatoolithus and the ornithopod egg Guegoolithus are also present . Dinosaur body fossils are also common , including nodosaurids , rhabdodontids , titanosaurs , dromaeosaurids , basal iguanodontians , hadrosaurids , neoceratosaurians , and coelurosaurs . Other vertebrates include bony fish , squamates , cryptodiran turtles , alligatorids , and mammals .

= = History = =

The Aix Basin was first excavated for fossils in 1869 by French paleontologist Philippe Matheron . In the 1950s , Raymond Dughi and Francois Sirugue , a pair of French paleontologists working for

the Museum d 'Histoire Naturelle Aix @-@ en @-@ Provence , extensively studied the basin 's fossil eggshells . They divided the eggs they had found into ten different types , but they did not describe them in detail . In the 1970s and 1980s , further work was done by the French paleontologist P. Kerourio and the German paleontologist H. K. Erben .

In M. M. Penner devised one of the early classification schemes for egg fossils in his 1983 doctoral thesis . He was the first to recognize the eggs now named Cairanoolithus as a distinct type ; under his classification scheme , they were called " Group 2 " . In 1994 , French paleontologists M. Vianey @-@ Liaud , P. Mallan , O. Buscail and C. Montgelard described them under the modern parataxonomic system as Cairanoolithus dughii and " Dughioolithus " roussetensis . They did not assign either of them to any oofamily , but both oogenera were classified in the oofamily Megaloolithidae by the Russian paleontologist Konstantin Mikhailov in 1996 . Following further discoveries in 2001 , Géraldine Garcia and Monique Vianey @-@ Liaud synomized the two oogenera . In 2002 , French paleontologist R. Cousin took a step further and synonymized the two oospecies .

In 2012 , the first Cairanoolithus fossils discovered outside of France were first reported by Albert G. Selles in his PhD thesis at Universitat de Barcelona , in which he also proposed that Cairanoolithus be moved into its own oofamily . Three years later , Selles and Angel Galobart published a comprehensive reanalysis of Cairanoolithus , in which they formally named the new oofamily , Cairanoolithidae , to contain Cairanaoolithus . Contrary to Cousin 's conclusions , Selles and Galobart separated the oospecies C. dughii and C. roussetensis . Also , they demonstrated that Cairanoolithus was not the eggs of an ornithopod or sauropod and conjectured that it could be the eggs of a nodosaur .