

**THE DISTRIBUTION OF “MULTILAYERED DINOSAUR EGGSHELL” IN
THE CONTINENTAL MAASTRICHTIAN OF SOUTHERN FRANCE**

By

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Abstract

The study of the numerical importance and the distribution of multilayered dinosaur eggshell, at different levels of the continental Maastrichtian in the South of France, makes us to declare that this type of pathological development cannot be considered, because of its rarity, as a mechanism for explaining the extinction of the dinosaurs at the end of the Cretaceous.

Introduction

1-Structure of Multilayered Eggshell

Among the dinosaur eggs from the continental Maastrichtian of Southern France there is a type of development characterized by a considerable abnormal augmentation of the thickness of the eggshell (1, 2, 3, 4, 5 and 6). These eggshells are unusually thick, and the examination of radial sections shows that they are composed of two or more “beds”. D. Dughi and F. Sirugue (1,2 and 3) interpreted these multiple beds as the result of interruptions in growth of the calcite spheruliths constituting the shell. H. K. Erben *et al* (6) showed, by an examination of these eggshells under scanning electron microscope, that these “beds” were, in effect, complete shells, superposed in varying numbers. For these authors, pathological development was identical to the case called “*ovum in ovo*” in living birds, crocodiles and tortoises. This theory was contested by R. Dughi and F. Sirugue (3) for whom each of the united crystals of the second bed was a continuation, after interruption, of the united crystals of the first bed. “There are not two series of superposed mammillary layers, since what one could take for an external shell does not comprise complete terminal mammillary layer points and bears an internal network, but is not different than the crystallographic suite of incomplete mammillary layers corresponding to the internal series.” [(1) p. 203].

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These multilayered eggshells were described by A. V. Sochava (7) from the Senonian of Naran-Bulak in the Gobi Desert. Curiously, of all pathological eggshells are there none known, at this time, from the deposits of North American dinosaur eggs from Montana, Wyoming and Utah? (K. Hirsch, J. Jensen, *in litteris*).

2. Significance attributed to multilayered eggshells.

These pathological eggshells were considered by a number of authors as revelatory signs of physiological and metabolic troubles affecting dinosaurs close to the end of the Cretaceous, and continuing to the time of their extinction. For R. Dughi & F. Sirugue (2 and 3), who adopt the thesis of ectothermy for dinosaurs, of brief cold periods that would have involved a suspension or a perturbation of physiological and metabolic activity of dinosaurs, which would translate to an interruption, or successive interruptions, in the elaboration of the eggshell. For H. K. Erben *et al* (6), these eggshells would have been caused by a hormonal deficiency, which in turn was caused by climatic or ecological upsets. For all these authors, these eggshells would have had the primary consequence of asphyxiating the embryo by obstruction of air canals (2, 3, 4 and 6). As a secondary consequence, this embryo had it stayed alive, would have been incapable of breaking the shell when the moment of hatching arrived (3 and 6). Over the long term, this phenomenon of unhatched abnormal eggshells would have involved a demographic drop in reptile populations, a disaggregation of the ecological pyramid and a relatively rapid extinction of this large group of reptiles.

These authors unanimously realized that surrounding the idea of these multilayered eggshells was the signs of a radical upset of the climatic and ecological order, arriving unexpectedly at the end of the Cretaceous and driving over a short term the disappearance of the dinosaurs. Meanwhile, these adepts of the catastrophic theory, destined to explain the massive Cretaceous faunal extinction, underestimated the study of the real quantitative importance of these pathological eggshells and their distribution at different levels of the continental Maastrichtian of the south of France.

New Observations

The collection of a large number of eggshell fragments (8,420) and the study of numerous eggs, *in situ* or conserved in public or private collections (155), allowed for specification of certain aspects of the problem that preceding studies had neglected.

1- Numerical importance of pathological eggshells (Table 1)

Multilayered pathological eggshells are rare at all the levels of the continental Maastrichtian in Southern France. Their proportion is never greater than 4%, and the most often comprise between 0.5 and 2.5%. Whole eggs rarely present a pathological shell. Only three eggs of this type have been discovered by this author, after several years of research on a number of layers of the southern Mediterranean. Two among them, the one coming from the basal layer of the Upper Rognacian (formerly lower Vitrollian) of the region of Chateauneuf-le-Rouge (Bouches-du-Rhône), the other from the terminal layers of Begudian (lower Maastrichtian) of the region of Fos-sur-Mer (Bouches-du-Rhône) were isolated. The third, coming from the lower Rognacian of the region of Beaureceuil (Bouches-du-Rhône), was associated with two normal eggshells, in the same layer. The very weak percentages contrast with the relative abundance of these pathological eggshells, made noteworthy by R. Dughi & F. Sirugue [(1) p. 199; (3) p. 30]. In addition the layers of eggs situated in the levels of the basal Upper Rognacian of the region of Rousset (Bouches-du-Rhône) revealed varying percentages of pathological eggshells, according to the authors, from 4-10% [(6) p. 389; (8) p. 347]. These percentages are far higher compared to the systematic counts that could be established for the fossiliferous levels of the Rousset region (Table 1). The rarity of these shells is of such great significance that for their innate nature (strong thickness and better resistance to natural agents of destruction), they lend themselves better than normal eggshells to fossilization.

2-Stratigraphic distribution of pathological eggshell (Table 1)

According to several authors who have studied the question, these abnormal eggs characterize essentially the last levels of the continental Maastrichtian and more precisely, the terminal levels of the Upper Rognacian, immediately underneath the Cretaceous-Tertiary boundary (3, 4, and 6). This proposition is not rigorously exact.

Location	Stratigraphic Position	C.I.	C.I.P.	%	O.E.	O.E.P.
<u>1. Arc Syncline</u>						
A. North	L. Rognacian (u.c.h)	1300	30	2.3	65	1
B. Center	L. Rognacian (u.c.h)	1200	0	0	30	0
	L. Rognacian (i.c.h)	600	2	0.3	1	0
	U. Rognacian	900	24	2.7	35	1
C. East	U. Begudian	700	1	0.1	2	0
	L. Rognacian (u.c.hr)	100	2	2	4	0
	L. Rognacian (i.c.h)	150	1	0.6	4	0
	U. Rognacian	500	0	0	10	0
<u>2. Rians Syncline</u>						
East	L. Rognacian A	550	0	0	0	0
	L. Rognacian B	600	24	3.8	0	0
	L. Rognacian C	150	0	0	0	0
<u>3. Salernes Syncline</u>						
Center	U. Rognacian	150	0	0	0	0
<u>4. Montmeyan Syncline</u>						
Center	U. Rognacian	900	6	0.6	0	0
<u>5. Etang de Beare Syncl.</u>						
Fos-sur-Mer Region	Begudian	150	0	0	3	1
Rognac Region	L. Rognacian (u.c.h)	350	1	0.2	1	0
<u>6. Eyguieres Syncline</u>						
West	L. Rognacian (u.c.h.)	120	1	0.8	0	0
TOTAL		8420	92	1	155	3

Table 1—Distribution of multistratified eggshell in the continental Maastrichtian of Provence (C.I.: Normal Isolated Eggshell; C.I.P.: Isolated pathological eggshell; O.E.: whole normal eggs; O.E.P.: whole pathological eggshells; u.c.h.: under the Rognac calcite horizon; i.c.h.: intercalated into the Rognac calcareous horizon.

These pathological eggshells exist in the Begudian (eastern part of the Arc syncline, and syncline of the Etang de Berre in the Bouches-du-Rhône), although they are believed to be rare. These abnormal eggshells are also encountered on top of all the highest lower Rognacian (levels underneath chalk horizon of Rognac and levels inserted in this horizon) while meanwhile there are very distinct local differences. In addition, pathological eggshells look derived from the lower Rognacian (levels underneath the Rognac chalk) of the central part of the Arc synclinal (Rousset region, Bouches-du-Rhône), whereas previous authors have attested to different levels of lower Rognacian of the northern section of this region (closer south to Mt. Sainte-Victoire) where their global proportion is on the order of 2%. These eggshells are absent from the basal levels of the lower Rognacian of the eastern Rians syncline (Pallieres region, Var) whereas previous authors recount it as being in certain levels of the terminal part. In the Arc syncline, the number of pathological eggshells in the sandstone and marl of the Upper Rognacian does not provide a case of a satisfying indication that may relate to the sudden disappearance of the dinosaurs. The overall proportion of these levels in the central part of the Arc syncline (Chateaneuf-le-Rouge and Rousset region) is 2.5%. The majority of these eggshells come from the lower level of this series. The terminal beds, immediately under the calcareous lacustrine horizon that marks the Maastrichtian-Paleocene boundary in the Aix-en-Provence basin (3) does not contain the scarce abnormal eggshell. These same terminal levels that come up to the eastern part of the of the Arc syncline (Puylobier region) do not appear to have any pathological eggshell. This is the same situation as the levels immediately underlying the calcareous horizon of Rognac in the central part of the Salernes (Var) syncline.

Conclusion

The general rarity of pathological eggshell fragments, the extreme rarity of entire pathological eggs, and the great disparities establishing the geographic and stratigraphic distribution of these eggshells, permitting the affirmation of this pathological eggshell type cannot, in any case, be considered a worthwhile explanation or means of comprehension of the disappearance of the dinosaurs at the end of the Cretaceous, but instead as a statistically minor pathological manifestation. Furthermore, if these anterior suppositions were to be true, this is to say if a relation existed between multistratified pathological eggshell and the extinction of the dinosaurs, one would also have to find these eggshells in the levels of Upper Cretaceous North American eggshells (North Horn Formation in Utah, and the Lance Formation in Wyoming).

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