

1 **Preservation of aragonite in Late Cretaceous (Campanian) turtle eggshell**

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15

16 **Abstract**

17 Among amniotes, turtles are the only clade that lay aragonitic eggs. Because aragonite is a  
18 metastable mineral, unequivocal preservation of aragonite in fossil turtle eggs has only been  
19 reported from Pliocene deposits. Here, we report *in situ* preservation of aragonite in a turtle  
20 egg from the Judith River Formation (Campanian) of Montana, USA. We utilized electron  
21 backscatter diffraction (EBSD) and Raman spectroscopy to explore the carbonate mineral  
22 polymorphs in the eggshell. The EBSD maps show the presence of both aragonite and calcite

23 with the former preserved as needle-like crystal, a feature of all turtle eggshells. The presence  
24 of aragonite is independently validated by Raman maps. This dual approach provides direct,  
25 unambiguous evidence that the record of aragonitic turtle eggshell dates back at least to the  
26 Campanian (ca. 76 Ma) and supports the hypothesis that aragonitic eggshell is a  
27 synapomorphy of all turtles. The presence of pristine aragonite also indicates minimal  
28 taphonomic alteration at the fossil locality. Consequently, diverse invertebrate or vertebrate  
29 fossils from localities with aragonitic turtle egg may provide high quality, unaltered  
30 palaeoenvironmental information.

31 **Keywords:** aragonite; EBSD; eggshell; Judith River Formation; Raman spectroscopy; turtle

32

### 33 **1. Introduction**

34 Although the main biomineral of vertebrates is calcium phosphate, eggshells of amniotes  
35 are composed of calcium carbonate (i.e. calcite, aragonite, and vaterite). Most amniotic  
36 eggshells are composed of calcite (Mikhailov, 1997; Dauphin et al., 2021) with a few rare  
37 avian eggshells coated with vaterite (Hauber et al., 2018; Portugal et al., 2018). Unlike  
38 eggshell from all other amniotes, turtle eggshell mostly consists of aragonite (Hirsch, 1983;  
39 Kusuda et al., 2013; see also Baird and Solomon, 1979; Al-Bahry et al., 2009 for the presence  
40 of calcite and vaterite). Previous studies on fossil turtle eggs have shown that the  
41 characteristic acicular (needle-like) crystals of eggshells are morphologically similar to those  
42 of modern turtles (Hirsch, 1983; Kusuda et al., 2013; Lawver and Jackson, 2014). However,  
43 few studies have shown the unaltered preservation of aragonite. Hirsch (1983, 1996), Hirsch  
44 and Lopez-Jurado (1987), Zelenitsky et al. (2008), and Mueller-Töwe et al. (2011) used X-  
45 ray diffraction (XRD) and Kohring (1990) used staining to test for the presence of aragonite  
46 and argue for the preservation of aragonite in Late Jurassic to Pliocene turtle eggs. Among

47 these studies, only Mueller-Töwe et al. (2011) presented a supporting XRD diffractogram  
48 of aragonite from Pliocene eggs but other studies did not present XRD diffractograms, which  
49 are essential for unequivocal confirmation of aragonite. Therefore, Pliocene has been the  
50 oldest age for confirmed aragonite in turtle eggs. Considering that turtles may have originated  
51 as early as 265–242 Ma (Lyson and Bever, 2020), there is a very large temporal gap between  
52 the earliest turtles and the oldest confirmed aragonitic egg.

53 Detecting aragonite in the fossil record has been an important issue in invertebrate  
54 palaeontology and marine palaeoenvironmental studies because it provides a direct evidence  
55 of the aragonite- and calcite-sea secular variation in the Phanerozoic (Balthasar et al., 2011;  
56 Janiszewska et al., 2017). Accordingly, invertebrate palaeontologists/zoologists have actively  
57 applied imaging techniques to detect *in situ* presence of aragonite (e.g. Cusack et al., 2008;  
58 Taylor et al., 2008; Balthasar et al., 2011; Janiszewska et al., 2017, 2018; Stolarski et al.,  
59 2021) by using crystallographic approaches (e.g. EBSD or XRD) and/or a vibrational  
60 spectroscopic approach (e.g. Raman spectroscopy); the combination of both approaches  
61 provides manifest evidence for phase identification (Balthasar et al., 2011; Stolarski et al.,  
62 2021). Because turtle eggs are the only aragonitic eggs among amniotes, fossil turtle eggs  
63 provide the best opportunity to introduce these technical advancements to vertebrate  
64 palaeontology.

65 Detecting aragonite preservation in fossil eggs is important for both palaeontology and  
66 taphonomy of fossil bearing deposits. First, it provides the most direct evidence for the  
67 unique history of turtle reproduction. Considering the fact that (recently extinct) non-  
68 testudines turtle *Meiolania* laid aragonitic eggs (Lawver and Jackson, 2016), it is likely that  
69 aragonitic eggs have been synapomorphic to all turtle, but palaeontological evidence is very  
70 scarce. Indeed, although there are numerous reports of fossil turtle eggs, many of these

71 studies reported that fossil turtle eggs are composed of calcite rather than aragonite (e.g.  
72 Hirsch, 1983; Fukuda and Obata, 1991; Isaji et al., 2006; Cadena et al., 2019; Moreno-  
73 Azanza et al., 2021). Only through fossil turtle eggs with preserved aragonite, we can gather  
74 palaeontological evidence that aragonite has been a main carbonate phase for all turtle eggs  
75 since the cladogenesis of the Testudinata (shelled-turtles). Secondly, because aragonite is  
76 metastable and can be easily converted into calcite in many sedimentary settings (Hall and  
77 Kennedy, 1967; Balthasar et al., 2011), preserved aragonite carries significant taphonomic  
78 implications (e.g. Hall and Kennedy, 1967; Fricke et al., 2008) for the fossil locality. In this  
79 study, we report the preservation of aragonite in turtle eggshells from the nonmarine Judith  
80 River Formation (Campanian, Late Cretaceous) of Montana.

81

## 82 **2. Geological Setting**

83

84 The holotype of the ootaxon (egg-type) *Testudoolithus zelenitskyae* (catalogue number:  
85 Museum of the Rockies (MOR) 710) used in this study was recovered from the Egg White  
86 Site (Fig. 1; MOR locality JR-122L; north-central Montana) of the Judith River Formation  
87 (Lawver and Jackson, 2017). Vertebrate fossils (including dinosaur egg clutches) from the  
88 Judith River Formation near Havre were mostly found in the Coal Ridge Member above the  
89 mid-Judith discontinuity (Rogers et al., 2016). Thus, MOR 710 very likely came from the  
90 fossiliferous Coal Ridge Member (Lawver and Jackson, 2017). The age of the Coal Ridge  
91 Member is well constrained by absolute age dating as between 76.2 and 75.2 Ma, middle to  
92 late Campanian (Rogers et al., 2016).

93

94        **3. Material and method**

95

96        Lawver and Jackson (2017) provided a detailed morphological description of MOR 710.  
97        Briefly summarizing the description, the eggs are beige in colour, 34–39 mm in diameter,  
98        with eggshell 660–760  $\mu\text{m}$  thick. The eggshell consists of a single layer with acicular  
99        crystals, a diagnostic feature of turtle eggshells (Hirsch, 1983; Schleich and Kastle, 1988;  
100        Kusuda et al., 2013), but some parts of the eggshells are composed of two overlapping  
101        layers (Lawver and Jackson, 2017).

102        EBSD and Raman spectroscopy were used to identify the carbonate phases of MOR 710.  
103        We further investigated chemical composition and morphology by using scanning electron  
104        microscope (SEM) and energy dispersive X-ray spectroscopy (EDS). In addition, the  
105        presence of thermally altered organic matter in the eggshell was tested by using Raman  
106        spectroscopy. For EBSD and Raman spectroscopy analyses, we followed established  
107        protocols (Moreno-Azanza et al., 2013; Choi et al., 2019, 2021). Detailed methodologies are  
108        presented in the Text S1.

109

110        **4. Results**

111

112        EBSD phase analysis shows that aragonite is dominant in MOR 710 (Fig. 2A), which still  
113        preserves acicular crystals (Fig. 2B, C; Fig. S1). The aragonitic eggshell is mainly composed  
114        of a single layer but some parts have an additional layer (Figs. S1, S2). Calcite is usually  
115        present in the inner part (Fig. 2A) and it is likely that this calcite represents alteration of  
116        original aragonite (see below). In backscattered diffraction (BSE) images, the calcite is

117 typically brighter than associated aragonites (Fig. S1), indicating the presence of elements  
118 heavier than calcium. EDS analysis (Fig. S1) shows that, compared to aragonite, calcite is  
119 enriched with O, Mg (very weakly), Mn, and Fe, while depleted Ca. The depletion of Mg and  
120 enrichment of Ca in aragonite is similar to that of relic aragonite reported by Balthasar et al.  
121 (2011). Because Mn, Fe, and Mg can be enriched in diagenetic calcite (converted from  
122 biogenic aragonite; Brand, 1989), the three elements in the calcite of MOR 710 are most  
123 probably exogeneous.

124 Raman spectroscopy maps show that aragonite and calcite phases detected by EBSD yield  
125 dominant aragonite and calcite Raman peaks, respectively (Fig. 2D–F, H). The consistency  
126 between the EBSD and RS maps is explicitly represented by calcite/aragonite ratio mapping  
127 (Fig. 2F). Notably, whereas EBSD maps yield binary mineral identification, Raman  
128 spectroscopy maps show the presence of aragonite and calcite more continuously so that  
129 subtle transformations from aragonite to calcite (e.g. point iii in Fig. 2F, H) are more  
130 effectively demonstrated. It shows that calcite-dominant points under EBSD still preserve  
131 small amounts of aragonite (e.g. point i in Fig. 2F, H), consistent with this calcite having  
132 originated as aragonite. We additionally obtained Raman spectra with an extended spectral  
133 range (1000–1800  $\text{cm}^{-1}$ ) to test the presence of thermally altered organic matter (Choi et al.,  
134 2020, 2021). As anticipated by the light colour of eggshell, there was no sign of thermally  
135 altered organic matter, which would normally be represented by broad graphite (G) and  
136 disordered carbon (D) bands at 1200–1700  $\text{cm}^{-1}$  (Fig. S3; Buseck and Beyssac, 2014; Henry  
137 et al., 2019).

138

## 139 **5. Discussion**

140

141 *5.1 Importance for preservation of aragonite*

142

143 In this study, advanced analytical techniques typically applied to fossil and modern  
144 invertebrates to test for remnant biogenic aragonite (e.g. Balthasar et al., 2011; Janiszewska et  
145 al., 2017; Stolarski et al., 2021) were successfully introduced to vertebrate palaeontology via  
146 turtle eggshells from the Judith River Formation. A recent study by Moreno-Azanza et al.  
147 (2021) suggested the possible presence of aragonite in Eocene (55.8–33.9 Ma) turtle eggshell  
148 based on EBSD analysis. However, their results remain ambiguous, as it was unclear whether  
149 the signal was biogenic aragonite or indexing artifact due to the low abundance of aragonitic  
150 signal (Moreno-Azanza et al., 2021). On the other hand, previous studies used  
151 cathodoluminescence (CL) to study the preservation of turtle eggshells (Lawver et al., 2015;  
152 Lawver and Jackson, 2016, 2017; Cadena et al., 2019). CL is useful for detecting diagenesis  
153 by finding a luminescence signal such as  $Mn^{2+}$ , which is a proxy for recrystallization (Pérez-  
154 Huerta et al., 2018). However, although intense CL reaction may mean that the aragonite is  
155 transformed into calcite, the absence of luminescence reaction does not necessarily mean the  
156 lack of diagenesis (Pérez-Huerta et al., 2018). In addition, pristine (modern) biogenic  $CaCO_3$   
157 can show luminescence reaction under CL (Barbin, 2013). Thus, compared to indirect CL  
158 approach, EBSD and Raman spectroscopy provide direct evidence of preserved aragonite in  
159 fossil turtle eggshells. Finally, XRD is a useful tool, which has previously been used to  
160 investigate preservation of aragonite in fossil turtle eggs (see Introduction). However, XRD  
161 has relatively low sensitivity so that low abundance of aragonite (~ 1–2%) may not be always  
162 detected and abiogenic secondary aragonite in a material cannot be differentiated by XRD  
163 diffractograms alone (Cusack et al., 2008). In addition, XRD analysis is not suitable to  
164 measure preservation variations on a spatial scale of micrometres (e.g. Fig. 2) so a XRD

165 diffractogram is less informative than *in situ* EBSD or Raman maps (Cusack et al., 2008;  
166 Milano et al., 2016).

167 The presence of well-preserved aragonite in MOR 710 cross-validated by EBSD and  
168 Raman spectroscopy (Fig. 2) confidently dates aragonitic turtle eggshell as far back as the  
169 Campanian, extending the previous age from Pliocene (Fig. 3). Currently, turtle eggs are  
170 known from Jurassic to Quaternary deposits (Lawver and Jackson, 2014) but reports of  
171 preserved aragonite (both confirmed and alleged ones) are very limited (Fig. 3). We suggest  
172 that our approach of combining EBSD and Raman spectroscopy techniques should be  
173 extended to spatiotemporally diverse turtle eggs in the world (Fig. 4; Table S1) to ultimately  
174 trace the history of aragonitic eggshells.

175 The presence of aragonite in MOR 710 supports the hypothesis that eggs of the most recent  
176 common ancestor (MRCA; Fig. 5) of all turtles were composed of aragonite, thus,  
177 synapomorphic to all turtles (Lawver and Jackson, 2016). Although recently extinct,  
178 *Meiolania* is a non-testudines turtles and had aragonitic eggshells (Fig. 3; Lawver and  
179 Jackson, 2016). Because all extant Testudinata eggs are, to our knowledge, mainly composed  
180 of aragonite, it is most parsimonious to hypothesize that all descendants of the turtle MRCA  
181 laid aragonitic eggshells (Fig. 5; Witmer, 1995). The unequivocal presence of aragonite in the  
182 MOR 710 specimen (Fig. 2) and a Pliocene egg (Mueller-Töwe et al., 2011) and other turtle  
183 eggshells alleged to preserve aragonite support this view (Fig. 5). Only fossil turtle eggs with  
184 clear presence of aragonite can support the hypothesis above with palaeontological data.  
185 Thus, we emphasize that materials with alleged aragonite must be revisited to provide more  
186 supporting evidence for the history and monophyly of aragonitic eggshell. Potentially  
187 contradicting this hypothesis, Cadena et al. (2019) reported calcite from eggs of  
188 *Desmatochelys* (Early Cretaceous sea turtle; Chelonioidea) and interpreted this taxon as



189 having laid calcitic eggs (Fig. 3). However, aragonite is metastable, and therefore, easily  
190 transformed into calcite (Hall and Kennedy, 1967; Hirsch, 1983; Balthasar et al., 2011).  
191 Considering that *Desmatochelys* eggs show rather poor preservation, the presence of  
192 originally calcitic eggs is debatable and further work is needed (ideally, microanalysis by  
193 EBSD or Raman spectroscopy).

194 Lastly, the crystallographic nature of turtle eggs may have an important implications in the  
195 controversial taxonomic affinity of turtles (i.e., either closer to Archosauria or Lepidosauria).  
196 Recent studies, especially those using molecular data, support an archosaurian affinity (see  
197 Field et al., 2014; Lyson and Bever, 2020). Although turtle eggs are composed of aragonite,  
198 the crystallographic arrangement is nearly the same as those of archosaur eggshells.  
199 Specifically, eggshell deposition starts from membrana testacea (Figs. 2, 3) and grows  
200 outward (Packard and DeMarco, 1991). In contrast, eggshells of lepidosaurs such as in  
201 Gekkota, show the opposite crystallographic arrangement where biomineralization starts from  
202 the outer surface and proceeds toward the inner surface (confirmed by EBSD; Choi et al.,  
203 2018). Both tuatara (Packard et al., 1988; Packard and DeMarco, 1991) and Cretaceous  
204 anguimorph eggshells (Fernandez et al., 2015) show similar crystal arrangement with that of  
205 gecko eggshells. Thus, between this dichotomic crystallography, turtle eggs clearly align with  
206 the archosaur-type, independently supporting their archosaur-affinity (Text S2).

207

## 208 *5.2 Taphonomic implications*

209

210 It is likely that the Coal Ridge Member of the Judith River Formation provides ideal  
211 conditions for the preservation of aragonite (Rogers et al., 2016) and several factors may

212 contribute to this. Situated above the mid-Judith discontinuity, the Coal Ridge Member is  
213 highly fossiliferous in both invertebrates and vertebrates, and characterized by a shallow  
214 water table, widespread tidal influence, and low-energy overbank (coastal environment)  
215 deposition (Rogers et al., 2016). Importantly, Rogers et al. (2016) found that the Coal Ridge  
216 Member experienced a two-fold increase in floodplain aggradation compared to the  
217 underlying McClelland Ferry Member and this higher rate of aggradation could have  
218 impeded flushing of cations, important for geochemical alteration, and encouraged burial and  
219 fossilization (see Cherns et al., 2008 for the importance of rapid burial for preservation of  
220 aragonite). Consistent with this view, aragonite was detected from Judith River Formation  
221 bivalves and the igloo-shaped traces left on their shells by their parasites (Fricke et al., 2008;  
222 Rogers et al., 2010, 2018). Among fossil turtle eggs (Fig. 4; Table S1), those from the  
223 Dinosaur Park Formation of Alberta, Canada (equivalent to the Coal Ridge Member; Rogers  
224 et al., 2016) and the upper Fruitland Formation, New Mexico, USA (equivalent to the Judith  
225 River Formation; Rogers et al., 2016), may also represent good candidates for preservation of  
226 unaltered aragonite (Zelenitsky et al., 2008; Tanaka et al., 2011; note that Zelenitsky et al.  
227 (2008) already mentioned the presence of aragonite in the Canadian material although data  
228 were not shown). The presence of aragonite in the bivalves from the Fruitland Formation  
229 indirectly supports this prediction (Fricke et al., 2009). Notably, the upper Fruitland  
230 Formation represents well-drained palaeoenvironments (Tanaka et al., 2011) dissimilar to the  
231 more mesic Judith River Formation (Rogers et al., 2010). Testing for the presence of  
232 aragonite in the Fruitland Formation turtle eggshell would, thereby, provide a chance to  
233 investigate the presence of aragonite in different terrestrial palaeoenvironments of similar  
234 age.

235 The preservation of aragonite in MOR 710 might have been possible due to minimal  
236 geothermal influence, which is known to impact fossil preservation (Casella et al., 2017,

237 2018; Wiemann et al., 2018; Pederson et al., 2019; Choi et al., 2020, 2021). MOR 710 lacks  
238 thermally altered organic matter (Fig. S3). Because turtle eggshell contains intracrystalline  
239 proteins (Kusuda et al., 2013), the absence of thermally altered organic matter implies very  
240 little to no geothermal alteration. In addition, acicular crystals of aragonite begin to lose their  
241 original structure at about 300°C and convert to calcite (Milano et al., 2016; Milano and  
242 Nehrke, 2018). This may occur at temperatures as low as 175°C when exposed to artificial  
243 burial fluids (see Casella et al., 2017, 2018). However, MOR 710 preserves the original  
244 acicular structure very well (Fig.2; Fig. S1, S2). The well-preserved acicular structure and  
245 lack of thermal alteration in the MOR 710 imply that the Coal Ridge Member was ideal for  
246 preservation of aragonite. This is further supported by the other aragonitic fossils in the  
247 Judith River Formation (Rogers et al., 2010, 2018).

248 That being said, aragonite preservation within a formation can be vary due to diverse  
249 factors, such as local corrosive pore water chemistry, microbial degradation of organic matter,  
250 sedimentation rate, lithology, and geothermal gradient (Gerhardt et al., 2000; Casella et al.,  
251 2017, 2018; Nohl et al., 2020). Although the Coal Ridge Member of the Judith River  
252 Formation and its equivalent formations may be ideal for aragonite preservation, the local  
253 factors should not be neglected for more advanced understanding for aragonite preservation,  
254 especially when turtle eggshells are entirely composed of calcite (e.g. Cadena et al., 2019).  
255 Given that local variation within a formation is fully considered, the investigation of  
256 aragonite in turtle eggshell would not only be helpful in understanding the paleobiology of  
257 turtles, but also informative for clarifying the taphonomic history of spatiotemporally diverse  
258 fossil localities (Hall and Kennedy, 1967; Fricke et al., (2008) used the presence of fossil  
259 aragonite as a strong indicator for the absence of intensive diagenetic alteration) where turtle  
260 eggshell occurs (Fig. 4; Table S1).

261

## 262 **6. Conclusion**

263

264 The presence of aragonite in fossil turtle eggs can be best demonstrated by a combination  
265 of EBSD and Raman spectroscopy, a technique frequently employed by invertebrate  
266 palaeontologists. Our results show the preservation of aragonite in the Late Cretaceous turtle  
267 egg with firm evidence. This study drastically reduces the large temporal gap that existed  
268 between the first osteological record of true turtles and the oldest confirmed aragonitic  
269 eggshells. We suggest that the presence of aragonite should be tested whenever fossil eggs of  
270 turtles are recovered. The spatiotemporally wide distribution of turtle eggs provides good  
271 opportunities to apply our approach. Furthermore, the preservation of aragonite is a  
272 taphonomic phenomenon that testifies that the fossil locality has been free from intense  
273 diagenetic alteration. Recognition of preserved aragonite in turtle eggs may indicate a locality  
274 where superb, pristine palaeoenvironmental information may be collected.

275

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284

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484 Figure captions

485 **Fig. 1.** Nonmarine Upper Cretaceous formations in Montana and the fossil locality for MOR  
486 710 (a blue star). Adapted from Vuke et al. (2007). A scale bar equals 100 km.

487 **Fig. 2.** EBSD and Raman spectroscopy maps for MOR 710 and a modern turtle (*Pelodiscus*  
488 *sinensis*) eggshell. (A) A phase map of MOR 710. Blue represents aragonite and red  
489 calcite. (B) Inverse pole figure (IPF) X map for aragonite of MOR 710. Note the  
490 preservation of acicular crystals. (C) IPF X map of modern turtle eggshell. (D–F) Raman  
491 spectroscopy maps of the area marked in the EBSD maps. D and E show the intensity map  
492 for peak of calcite at  $280\text{ cm}^{-1}$  and that of aragonite at  $200\text{ cm}^{-1}$ , respectively (Taylor et al.,  
493 2008; Stolarski et al., 2021). Red region in D represents the dominance of calcite and blue  
494 region in E aragonite (caution: blue region in D and red region in E do not mean the  
495 presence of aragonite in D and calcite in E, respectively). F, The normalized intensity map  
496 based on  $(280\text{ cm}^{-1})/(200\text{ cm}^{-1})$  ratio, equivalent to the intensity of calcite/aragonite.  
497 Raman spectra acquired from the lowercase Roman numbers are presented in H. Raman  
498 spectra at point iii indicates the co-occurrence of calcite and aragonite. (G) Interpretation  
499 keys for IPF X mappings of aragonite (B, C). Scale bar equal  $250\text{ }\mu\text{m}$  (A, B);  $100\text{ }\mu\text{m}$  (C);  
500  $50\text{ }\mu\text{m}$  (D–F).

501 **Fig. 3.** The confirmed (red symbols; this study; Mueller-Töwe et al., 2011) and alleged (blue  
502 symbols; Hirsch, 1983, 1996; Kohring, 1990; Hirsch and Lopez-Jurado, 1987; Zelenitsky  
503 et al., 2008) preservation of aragonite in turtle eggshells and simplified phylogeny of  
504 turtles (modified from Evers and Benson, 2019; Joyce et al., 2021). Clades marked with  
505 arrowheads are extant ones. *Meiolania* was recently extinct (Lawver and Jackson, 2016).  
506 R, Semi R, and S in the brackets represent rigid, semi-rigid, and soft eggshells as  
507 presented in the lower left of the figure (after Packard and DeMarco, 1991; MT represents

508 membrana testacea). The two clades marked by orange characters are fossil taxa and their  
509 eggs known by gravid females (Zelenitsky et al., 2008; Cadena et al., 2019; Ke et al.,  
510 2021).

511 **Fig. 4.** Spatiotemporal distribution of fossil eggs of turtles in the world. Based on the Table  
512 S1.

513 **Fig. 5.** Importance of aragonite preservation in fossil egg of turtles. (A) Because eggshell of  
514 *Meiolania* is composed of aragonite (confirmed aragonite is marked by red symbol;  
515 Lawver and Jackson, 2016), Extant Phylogenetic Bracket (EPB) predicts that MRCA of  
516 *Meiolania* and modern turtle (i.e. Testudinata) laid aragonitic eggshell (predicted aragonite  
517 is marked by blue symbol). (B) EPB predicts (or hypothesizes) that descendants of MRCA  
518 of all turtles laid aragonitic eggshells (Witmer, 1995). (C) Investigating the preservation of  
519 aragonite in fossil eggs of turtle provides the chances to test the hypothesis of EPB. MOR  
520 710 proves that the inference holds true in Cryptodira. Alleged aragonite in other fossil  
521 eggs of turtles (Fig. 3) provide more chances to solidify the hypothesis (B) if the  
522 preservation of aragonite is confirmed by supporting data (e.g. EBSD, Raman  
523 spectroscopy, XRD).