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First dinosaur eggshells from Texas: Aguja Formation (late Campanian), Big Bend National Park

Ed Welsh[1]

Julia T. Sankey[2]

1 Museum of Geology, South Dakota School of Mines and Technology, Rapid City, South Dakota 57701. edtwelsh@hotmail.com

2 Department of Physics and Geology, California State University, Stanislaus, Turlock, California 95382. Julia@geology.csustan.edu

Key Words

Dinosaur, eggshells, Late Cretaceous, Aguja Formation, Big Bend National Park, Texas.

1. Abstract

Numerous dinosaur eggshells (~300) were surface collected from microsites in a particularly rich horizon within the upper Aguja Formation (late Campanian) of Big Bend National Park, Texas. This is the first report of dinosaur eggshells from Texas, and is the southernmost dinosaur eggshell site in the United States. The eggshells provide important information about Late Cretaceous dinosaur paleoecology for this southern biogeographic province, an area that is considerably less well known compared to more northern areas. Six different types of eggshell morphologies are documented, demonstrating that a variety of

dinosaurs nested in this area, including both ornithischian and theropod dinosaurs. Some eggshells have a mammillary layer and a continuous layer, which are typical of theropods (including birds). Other eggshells have spherulitic shell units, typical of hadrosaur eggs. Two eggshell types are identifiable to the ?oogeneric level. Many of the eggshells have the angusticanaliculate type of pore canal system, which is common in eggs from arid environments. There is sedimentological evidence for aridity in Big Bend starting in the late Campanian. Although no nests have been found, the search for nests should focus on the more inland and better-drained floodplain deposits of the uppermost Aguja and Javelina Formations.

2. Introduction

2.1. Importance of microsites in Big Bend National Park, Texas

The recovery of dinosaur eggshells from Big Bend National Park, Texas (Fig. 1) demonstrates the importance of microsite collection. No eggshells would be known from Big Bend without the intensive surface collection of the microsites in this area. This is the first report of dinosaur eggshells from Texas, and is the southernmost fossil eggshell site in the United States. The eggshells provide important information about Late Cretaceous dinosaur paleoecology for this southern biogeographic province, an area that is considerably less well known compared to more northern areas.

STANDHARDT (1986) reported dinosaur eggshell fragments from a screened microsite (VL-113; late Campanian-early Maastrichtian) in the upper Aguja Formation (Fig. 2) at Dawson Creek, in Big Bend, but no illustrations or descriptions were made. The dinosaur teeth from the same site were identified, and include teeth from hatchling or juvenile hadrosaurs, ceratopsians, ankylosaurs, and theropods (STANDHARDT 1986; SANKEY et al. 2005). Microsites in the upper

Aguja Formation at Talley Mountain (late Campanian) have also produced teeth from hatchling or juvenile hadrosaurs, ceratopsians, ankylosaurs, and theropods (SANKEY 1998, 2001). Although SANKEY (1998, 2001) concluded that both the presence of dinosaur eggshells and juvenile dinosaur teeth were evidence that dinosaurs nested in Big Bend, no eggshells were described or illustrated. The first identifications of dinosaur eggshells from Big Bend were by WELSH (2004, 2005), collected from the sites reported here.

(((FIGURE 1 NEAR HERE)))

2.2 Aguja Formation

The Aguja Formation is a widespread sedimentary unit in Big Bend. It represents an eastward thinning deposit composed of 135 to 285 meters of sandstones interbedded with shale and lignite. Environments of deposition vary from marine, paralic, to inland floodplain (LEHMAN 1985). The upper shale member represents the last of the pre-Laramide tectonic sedimentation in the area (LEHMAN 1991), and records the final marine regression of the Western Interior Sea from west Texas (Regression 8 of KAUFFMAN 1977). The lower part of this member contains carbonaceous mudstones, thin lignite beds, and large siderite ironstone concretions from distributary channels, levees, crevasse splays, and poorly drained interdistributary marshes and bays. The variegated mudstones and sandstones of the upper Aguja Formation contain conglomeratic lags of paleo-caliche nodules, and represent fluvial environments within a deltaic coastal floodplain and inland floodplain (LEHMAN 1985). A variety of well-developed paleosols formed on the inland floodplain represented by the upper Aguja and overlying Javelina Formations, and their stage of development has been linked to sea level fluctuations in the nearby Western Interior Seaway (ATCHLEY et al. 2004).

Typical large vertebrate fossils from the lower part of the upper Aguja include the giant crocodilian *Deinosuchus riograndensis* and the horned dinosaur *Chasmosaurus mariscalensis*. The hadrosaur *Kritosaurus* sp. is more abundant higher in the upper Aguja (LEHMAN 1985). All are known from quarries with associated skeletons. The vertebrate paleontology from the upper Aguja Formation has been well documented, especially from microsites (ROWE et al. 1992; STANDHARDT, 1986; SANKEY 2001, 2005a, 2005b, 2006, this volume; SANKEY et al. 2005). The age of the upper Aguja is late Campanian to early Maastrichtian (LEHMAN 1985, 1987; SANKEY 1998; SANKEY & GOSE 2001).

(((FIGURE 2 NEAR HERE)))

2.3 Rattlesnake Mountain Microsites

The dinosaur eggshells were surface collected from the "Purple Hill" microsites in the upper Aguja Formation (late Campanian) at Rattlesnake Mountain. Approximately 300 specimens were collected. All eggshell fragments are 6 mm in diameter or less. Eggshells were scattered over the surface of the outcrop for approximately 75 by 75 meters. One particular region of this outcrop, about 100 square meters in area, produced most of the eggshells. Eggshells and teeth of hatchling or juvenile dinosaurs have been collected from the same areas. In one case, an eggshell fragment and an unworn tooth from a juvenile or hatchling *Saurornitholestes* were found embedded in the rock and within centimeters of one another. The sedimentary rocks are grey, organic-rich siltstones with abundant small fragments of carbonized plants, large pieces of burned wood, large isolated dinosaur bones, and small bones and/or teeth from a variety of vertebrates.

The microsites are approximately ten meters below the first well-developed purple-colored paleosol of the upper shale member of the Aguja, and represents the start of the inland floodplain facies. This purple bed is useful for correlating the deposits exposed in the southeastern flank of Rattlesnake Mountain because it is widespread and easy to recognize from a distance. Above the purple paleosols in this area are approximately 100 meters of predominately tan to brown sandstones within the upper shale member of the Aguja Formation; they extend to the first igneous rocks in the cliffs of Rattlesnake Mountain.

The following vertebrate fossils have been identified from small bones and/or teeth from these microsites. Rays are present, but rare; rays are known from brackish to freshwater deposits from the Western Interior. Large gar scales and vertebrae are present; gars are common in fresh and brackish water deposits. Frogs and salamanders are present. Eight types of turtles are present, with trionychids the most diverse and abundant (SANKEY 2006). Teeth and scutes from a variety of crocodilians are abundant. Teeth and bones of dinosaurs are present. Several isolated hadrosaur bones are present. Tiny teeth of hatchling and juvenile hadrosaurs are some of the most abundant vertebrate fossils at the site. Two caudal vertebrae from hatchling or juvenile hadrosaurs have been found. Two teeth of juvenile or hatchling ankylosaur were collected, in addition to ankylosaur scutes. Teeth of a tyrannosaurid, and of the small theropods, *Richardoestesia* and *Saurornitholestes,* are present. Unguals and metacarpals of ornithomimids have been found. One partial metacarpal from a possible bird and one multituberculate mammal incisor were recovered. More detailed identifications and descriptions of the vertebrates from the upper Aguja Formation are reported in SANKEY (2005b, this volume).

2.4 Objectives of Study

The purpose of this study was to document and describe the first dinosaur eggshells from Texas. In particular, the goals were to: 1) describe and illustrate the eggshell microstructure morphologies in detail; 2) compare the eggshells to published eggshell morphologies; 3) identify the eggshells to known taxa, where possible; 4) discuss how the eggshells were transported to the site; and 5) discuss the paleoecological and paleoclimatic implications of these new discoveries.

3. Methods and Materials

3.1 Curation

All fossils are curated in the Louisiana State University Museum of Natural Science (LSUMNS) Geology Collections in Baton Rouge.

3.2 Eggshell Images

Eggshells were photographed with a digital camera under a dissecting microscope after being coated with vaporized ammonium chloride. Some of the specimens were carbon coated, then examined and photographed with a Scanning Electron Microscope (SEM) at the University of Wyoming and the South Dakota School of Mines and Technology. Some of the specimens were left uncoated and were photographed using Backscatter Electron Imagery of the SEM. A few of the eggshells were thin sectioned, then examined and photographed using a petrographic microscope at Chadron State College, Nebraska.

3.3 Eggshell Identification

There is some controversy about the use of eggshell morphotypes in eggshell classification (ZELENITSKY et al 2002). However, for the purposes of this paper we classify eggshells according to the system established by MIKHAILOV (1997), until a new system of

classification for eggs is published.

4. Systematic Paleontology

4.1 Dinosauroid Spherulitic

Figure 3A

Specimen. V-17891.

Description

V-17891 contains a single layer of radiating and tightly packed shell units, typical dinosauroid spherulitic-type eggshell. Two horizontal color bands are present through the upper portion of the single layer.

Discussion

V-17891 closely resembles discretispherulitic or angustispherulitic morphologies (CARPENTER 1999). However, it is more similar to angustispherulitic because its shell units are partially fused and the individual units are difficult to distinguish. The angustispherulitic morphotype is found in elliptical eggs that may belong to ornithopods whereas the discretispherulitic morphology is found in sauropod eggs (CARPENTER 1999). The Dinosauroid Spherulitic eggshell microstructure is found in non-theropod dinosaurs (CARPENTER 1999).

(((FIGURE 3 NEAR HERE)))

4.2 Dinosauroid Prismatic

Figure 3B

Referred specimen. V-17892.

Description

Specimen V-17892 has two layers, prismatic and mammillary, with no clear boundary between the two, typical of dinosauroid prismatic microstructure. The SEM image of the specimen shows a contrast in mineral composition, with lighter colored deposits at the surface; this may be diagenetic. There is surface ornamentation in the form of small domes.

Discussion

Dinosauroid Prismatic eggs contain a two-part ultrastructure without a clear boundary between two layers, and the mammillary layer is within the lower half; these eggshells are thought to be from theropods (CARPENTER 1999). The Aguja specimen has a similar microstructure to *Troodon* eggshell except that this specimen has a distinctive surface ornamentation of single rounded nodes; this is not present in *Prismatoolithus* eggshells such as those found associated with *Troodon* (HIRSCH & QUINN 1990). Additionally, troodontid specimens are unknown from Big Bend, although a few teeth have been recovered from the San Juan Basin of New Mexico (WILLIAMSON pers. comm., 2005).

4.3 cf. Ornithoid Prismatic

Figure 3C

Referred specimen. V-17894.

Description

Specimen V-17894 has a microstructure that may be Ornithoid Prismatic. Three distinct layers can be seen from the SEM image, the external, continuous, and mammillary layers.

Discussion

Ornithoid eggshells usually have abrupt boundaries between the three layers, and the innermost or mammillary layer has calcite crystals radiating from an organic core. The outermost

layer has no distinct shell units. This Ornithoid Prismatic microstructure is found in birds and some theropods (CARPENTER 1999). Although the Aguja specimen resembles this type of microstructure, most Cretaceous bird eggshells are usually thinner than this specimen (ZELENITSKY pers. comm.), so this remains a tentative identification.

4.4 Ornithoid Ratite

Figure 3D-F

Referred specimen. V-17893

Description.

V-17893 has an Ornithoid Ratite microstructure, with a sharp boundary between the continuous and mammillary layers. It has a domed surface ornamentation. The pore structure is angusticanaliculate, meaning it has a system of small (~0.01 to 0.1 mm) straight pores scattered sparsely throughout the eggshell.

Discussion

Eggshells of the Ornithoid Ratite morphology are commonly from theropods. V-17893 appears to share characteristics seen in the oofamily Elongatoolithidae. Elongatoolithid eggshells have been correlated to non-avian theropods based on eggs discovered with associated skeletal material from oviraptorids (NORELL et al. 1994, 1995; DONG and CURRIE, 1996). Eggshells with the angusticanaliculate pore system are often found in eggs from arid areas (CARPENTER 1999).

4.5 Oogenus cf. *Continuoolithus* ZELENITSKY, HILLS, & CURRIE 1996

Figure 4A-B

Referred specimens. V-17738 (16 fragments)

Description.

The specimens have closely spaced, single, and fused nodes forming short ridges. Pore openings are at the bases of these nodes. The pore system is angusticanaliculate. Eggshell thickness is approximately 1 mm.

Discussion.

Based on the surface ornamentation and eggshell thickness, the specimens are similar to the oogenus *Continuoolithus canadensis* (fig. 11A, ZELENITSKY et al. 1996), in which the eggshell thickness varies from 0.94 to 1.24 mm. *C. canadensis* is from late Campanian deposits of southern Alberta and Montana. However, the Aguja specimens have a surface ornamentation of ridges, which is more similar to *Macroelongatoolithus* (oofamily Elongatoolithidae) from Asia and Utah (ZELENITSKY et al. 2000).

4.6 Oogenus cf. *Porituberoolithus* ZELENITSKY, HILLS, & CURRIE 1996

Figure 4 C-D

Referred specimen. V-17739 (4 fragments)

Description.

Surface ornamentation of V-17739 consists of isolated, flattened nodes that are approximately one-third the height of shell thickness. The thickness ratio of the continuous layer to mammillary layer is approximately 2:1. The pore system is angusticanaliculate.

Discussion.

Surface ornamentation, pore system, and microstructure are similar to those of oogenus *Porituberoolithus* (ZELENITSKY et al. 1996). *Porituberoolithus* was described from the late

Campanian of southern Alberta (ZELENITSKY et al. 1996). *Porituberoolithus* has a continuous layer and a mammillary layer, which suggests a theropod origin (ZELENITSKY et al. 1996).

(((FIGURE 4 NEAR HERE)))

5. Discussion

5.1 Dinosaur nests in Big Bend?

The best sites for dinosaur eggs, eggshells, and hatchling bones are from the paleosols in of ancient floodplains (CARPENTER 1999). The location of nests in Alberta (ZELENITSKY et al. 1996; SANKEY pers. obs. 1999) and Montana (CARPENTER 1999) are from the more inland and well-drained part of the floodplain. How far the Big Bend eggshells were transported is difficult to determine. TOKARYK & STORER (1991) showed that eggshells are remarkably durable and can withstand long transport; up to 70 km without decreasing in size. Many of the small dinosaur bones and teeth from the Aguja microsite are from juveniles or hatchlings, in particular from hadrosaurs. Based on the sedimentology of these Aguja microsites and the small size of the eggshells, nesting sites may have been eroded and transported upstream, from the more inland and better-drained inland floodplain deposits. Where are the dinosaur nests in Big Bend? It would be worthwhile to search for nests in the more inland and better-drained floodplain deposits of both the uppermost Aguja and Javelina formations.

5.2 Eggshells and Paleoclimate

Southern North American Late Cretaceous vertebrate faunas are not as well known compared to northern assemblages. Based on the record of vertebrate bones and teeth, the Big Bend vertebrates were taxonomically distinct at the species level or higher from contemporaneous northern faunas such as from Alberta. The dinosaur eggshells described here also do not match eggshell types know from contemporaneous faunas to the north. These

taxonomic differences were probably partly due to differences in climate between the northern and southern areas, with periodic aridity occurring in Big Bend earlier than in northern areas. Understanding the effects of climate change on the Late Cretaceous terrestrial ecosystems is important in order to separate the terrestrial from extraterrestrial factors involved in the Cretaceous/Tertiary extinctions.

There is ample evidence from the sedimentology and paleontology of the upper Aguja Formation that west Texas was periodically arid beginning at least in the late Campanian (LEHMAN 1985; SANKEY 2001; SANKEY 2006; SANKEY this volume). Eggshells can also provide information on climate (HAYWARD et al. 2000). MIKHAILOV (1997) suggested that the angusticanaliculate pore canal system, with sparse pores, limited gas exchange and evaporation from the eggshell, and that this canal system is primarily found in eggs from dry environments. Not surprisingly, many of the Aguja eggshells have the angusticanaliculate type of pore canal system.

6. Conclusions

This is the first report of dinosaur eggshells from Texas. It is also the southern most record for dinosaur eggshells in the United States. Thus, these dinosaur eggshells provide the following important and new information: 1) dinosaurs nested in the Big Bend area; 2) at least six different types of dinosaurs and possibly birds nested in this area; 3) search for dinosaur nests should be focused on the inland floodplain deposits of the uppermost Aguja and Javelina Formations.

7. Acknowledgements

The dinosaur eggshells reported here were collected from microsites discovered by Sankey in March, 2001 on a field trip to Big Bend National Park, Texas with William Clark (O.J. Smith Museum of Natural History, Albertson College of Idaho), and she thanks the Clark family for their help in Big Bend beginning in 2000. Subsequent collections from the microsites were made by Sankey and students from the South Dakota School of Mines and Technology (Rapid City) in January, 2002; Chadron State College (Chadron, Nebraska) in May, 2002; and California State University, Stanislaus (Turlock) in January, 2005. We thank Mike Leite and Ron Weedon for organizing the Chadron State College field trip. Welsh found many of the dinosaur eggshells during the Chadron trip, studied them for his senior research thesis, and has returned to the sites with Sankey (January, 2005 and 2006) and significantly increased the collection.

Collections were made under National Park Service research permits to Sankey: BIBE-2001-SCI-0010, BIBE-2002-SCI-0001, and BIBE-2005-SCI-0001, and we thank Don Corrick and Vidal Davila (Science and Natural Resources Division) for their help. Louisiana State University Museum of Natural Science is the repository for these Big Bend collections, and we thank Drs. Schiebout (curator) and Ting (collections manager) for this important and ongoing support.

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8. Literature Cited

ATCHLEY, S.C.; NORDT, L.C.; DWORKIN, S.I. 2004. Eustatic control on alluvial sequence stratigraphy: a possible example from the Cretaceous-Tertiary transition of the Tornillo Basin, Big Bend National Park, West Texas, U.S.A. - Journal of Sedimentary Research **74**(3): 391-404.

CARPENTER, K. 1999. Eggs, Nests, and Baby Dinosaurs: A Look at Dinosaur Reproduction. Indiana University Press, Bloomington, 336 pp.

DONG, Z. & CURRIE, P.J. 1996. On the discovery of an oviraptorid skeleton on a nest of eggs at Bayan Mandahu, Inner Mongolia, Peoples Republic of China. - Canadian Journal of Earth Sciences **33**: 631-636

HAYWARD, J.L.; ZELENITSKY, D.K; SMITH, D.L.; ZAFT, D.M.; CLAYBURN, J.K. 2000. Eggshell taphonomy at modern gull colonies and dinosaur clutch sites. - Palaios **15**: 343-355

HIRSCH, K.F. & QUINN, B. 1990. Eggs and eggshell fragments from the Upper Cretaceous Two Medicine Formation of Montana. - Journal over Vertebrate Paleontology **10**: 491-511.

KAUFFMAN, E.G. 1977. Geological and biological overview: Western Interior Cretaceous Basin. - The Mountain Geologist **14**: 75-99.

LEHMAN, T.M. 1985. Stratigraphy, sedimentology, and paleontology of upper Cretaceous (Campanian-Maastrichtian) sedimentary rocks in Trans-Pecos, Texas. - Ph.D. Dissertation, University of Texas, Austin, 299 pp.

LEHMAN, T.M. 1987. Late Maastrichtian paleoenvironments and dinosaur biogeography in the Western Interior of North America. - Palaeogeography, Palaeoclimatology, Palaeoecology **60**: 189-217

LEHMAN, T.M. 1991. Sedimentation and tectonism in the Laramide Tornillo basin of west Texas.

- Sedimentary Geology **75**: 9-28.

MIKHAILOV, K.E. 1997. Fossil and recent eggshell in amniotic vertebrates: fine structure, comparative morphology, and classification. - Special Papers in Palaeontology **56**: 1-80.

NORELL, M.; CLARK, J.; CHIAPPE, L.; DASHZEVEG, D. 1995. A nesting dinosaur. - Nature, **378**: 774-776.

NORELL, M.; CLARK, J.; DASHZVEG, D.; BARSBOLD, R.; CHIAPPE, L.; DAVIDSON, A.; M. MCKENNA, M.; PERLE, A.; NOVACEK, M. 1994. A theropod dinosaur embryo and the affinities of the Flaming Cliffs dinosaur eggs. - Science, **266**: 779-782

ROWE, T.; CIFELLI, R.L.; LEHMAN, T.M.; WEIL, A. 1992. The Campanian Terlingua local fauna, with a summary of other vertebrates from the Aguja Formation, Trans-Pecos, Texas. – Journal of Vertebrate Paleontology **12**: 472-493.

SANKEY, J.T. 1998. Vertebrate paleontology and magnetostratigraphy of the upper Aguja Formation (late Campanian), Talley Mountain area, Big Bend National Park, Texas. – Ph.D. dissertation. Louisiana State University, Baton Rouge. 263 pp.

SANKEY, J.T. 2001. Late Campanian southern dinosaurs, Aguja Formation, Big Bend, Texas. – Journal of Paleontology **75**(1): 208-215.

SANKEY, J.T. 2005a. Drought, fires, dinosaurs, eggs, and babies in the Late Cretaceous of Big Bend National Park, Texas. North American Paleontology Convention, Halifax, Nova Scotia, Canada. June 20-25, 2005. – PaleoBios. Museum of Paleontology University of California, Berkeley, **25**(2): 101.

SANKEY, J.T. 2005b. Late Cretaceous vertebrate paleoecology Big Bend National Park, Texas. In: BRAMAN, D.R.; THERRIEN, F.; KOPPELHUS, E.B.; TAYLOR, W., eds., Dinosaur Park Symposium, Short Papers, Abstracts, and Program: pp. 98-106. - Special Publication of

the Royal Tyrrell Museum, September 24-25, 2005. Drumheller, Alberta, Canada.

SANKEY, J.T. 2005c. Late Cretaceous Dinosaurs, Eggs, Babies, Fires, and Drought in Big Bend National Park, Texas. Journal of Vertebrate Paleontology Abstracts of Papers **25**(3): 109A.

SANKEY, J.T. 2006. Turtles of the upper Aguja Formation (late Campanian), Big Bend National Park, Texas. - In: LUCAS, S. & SULLIVAN, R., eds., Late Cretaceous Vertebrates from the Western Interior: 235-243. Bulletin **35** New Mexico Museum of Natural History and Science.

SANKEY, J.T. This volume. Late Cretaceous vertebrate paleoecology from microsites, Aguja Formation, Big Bend National Park, Texas, In: SANKEY, J.T. & BASZIO, S., eds., The Unique Role of Vertebrate Microfossil Assemblages in Paleoecology and Paleobiology, XXX-XXX. Indiana University Press, Bloomington.

SANKEY, J.T. & W.A. GOSE. 2001. Late Cretaceous mammals and magnetostratigraphy, Big Bend, Texas. Occasional Papers of the Museum of Natural Science, Louisiana State University No. **77**: 1-16.

SANKEY, J.T.; STANDHARDT, B.R.; SCHIEBOUT, J.A. 2005. Theropod teeth from the upper Cretaceous (Campanian-Maastrichtian), Big Bend National Park, Texas. In: - K. CARPENTER, ed., Carnivorous Dinosaurs: 127-152. Indiana University Press, Bloomington.

STANDHARDT, B.R. 1986. Vertebrate paleontology of the Cretaceous/Tertiary transition of Big Bend National Park, Texas. - Ph.D. Dissertation, Louisiana State University, Baton Rouge, 298 pp.

TOKARYK, T. & STORER, J.E. 1991. Dinosaur eggshell fragments from Saskatchewan, and

evaluation of potential distance of eggshell transport. - Journal of Vertebrate Paleontology Abstracts of Papers, **11**(3): 58A

WELSH, E. 2004. Oodiversity in the Aguja Formation at Big Bend National Park, Texas. - Program and Proceedings, The Nebraska Academy of Sciences: 49.

WELSH, E. 2005. Eggshells and baby dinosaurs in the upper Aguja Formation of Big Bend National Park, Texas. - Journal of Vertebrate Paleontology Abstracts of Papers **25**(3): 128A.

ZELENITSKY, D.K.; HILLS, L.V.; CURRIE, P.J. 1996. Parataxonomic classification of ornithoid eggshell fragments from the Oldman Formation (Judith River Group; upper Cretaceous), southern Alberta. - Canadian Journal of Earth Science **33**: 1665-1667.

ZELENITSKY, D.K.; CARPENTER, K.; CURRIE, P.J. 2000. First record of Elongatoolithid theropod eggshell from North America: the Asian Oogenus *Macroelongatoolithus* from the lower Cretaceous of Utah. - Journal of Vertebrate Paleontology **20**(1): 130-138.

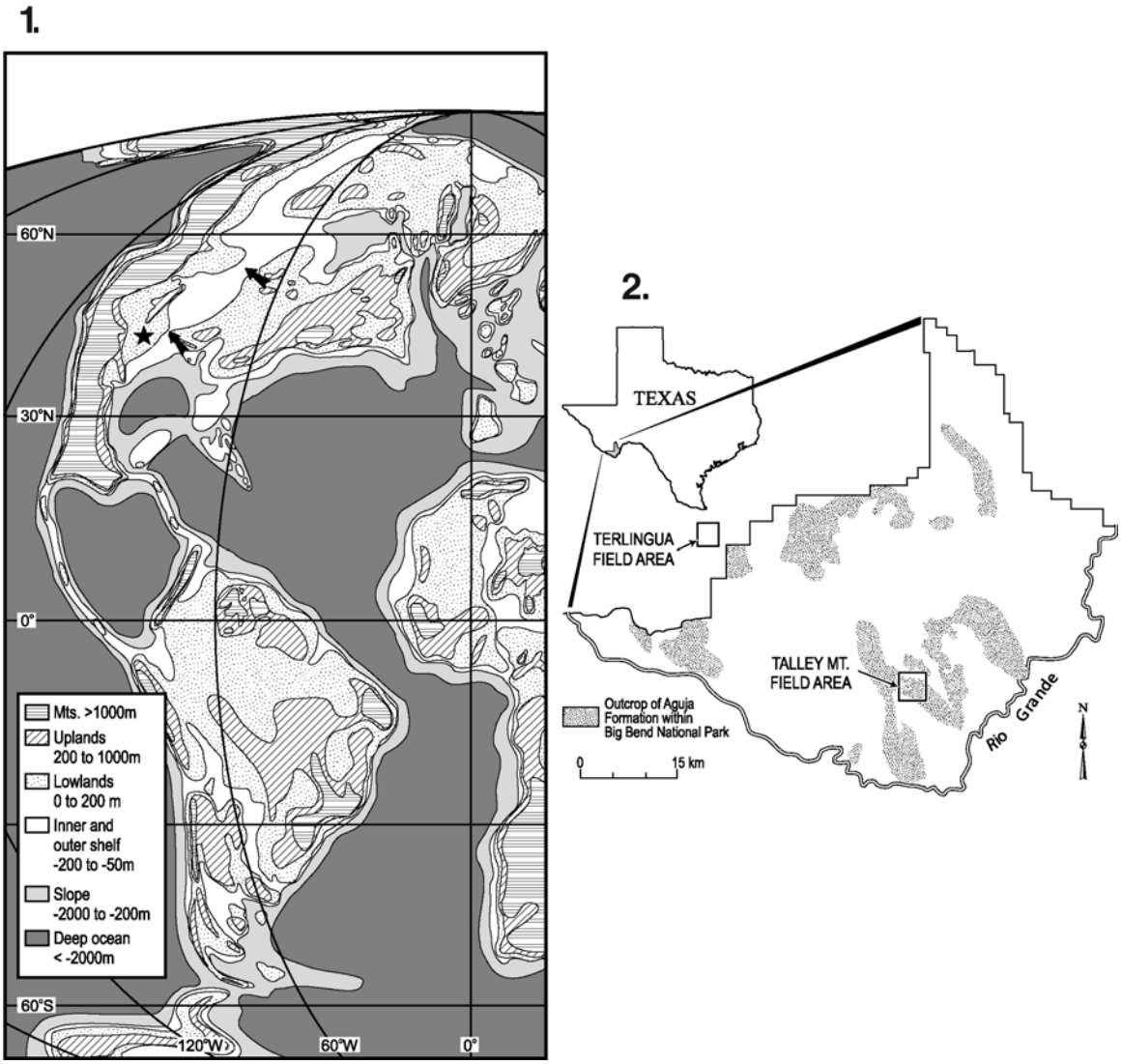

FIGURE 1-- Late Cretaceous (Maastrichtian) paleogeographic reconstruction (**A**) of North and South America (redrawn from ZIEGLER & ROWLEY 1998); Big Bend National Park (**B**), west Texas with Aguja Formation outcrops stippled. Fossil sites from Rattlesnake Mountain, Talley Mountain, Terlingua, and Dawson Creek are shown by arrows.

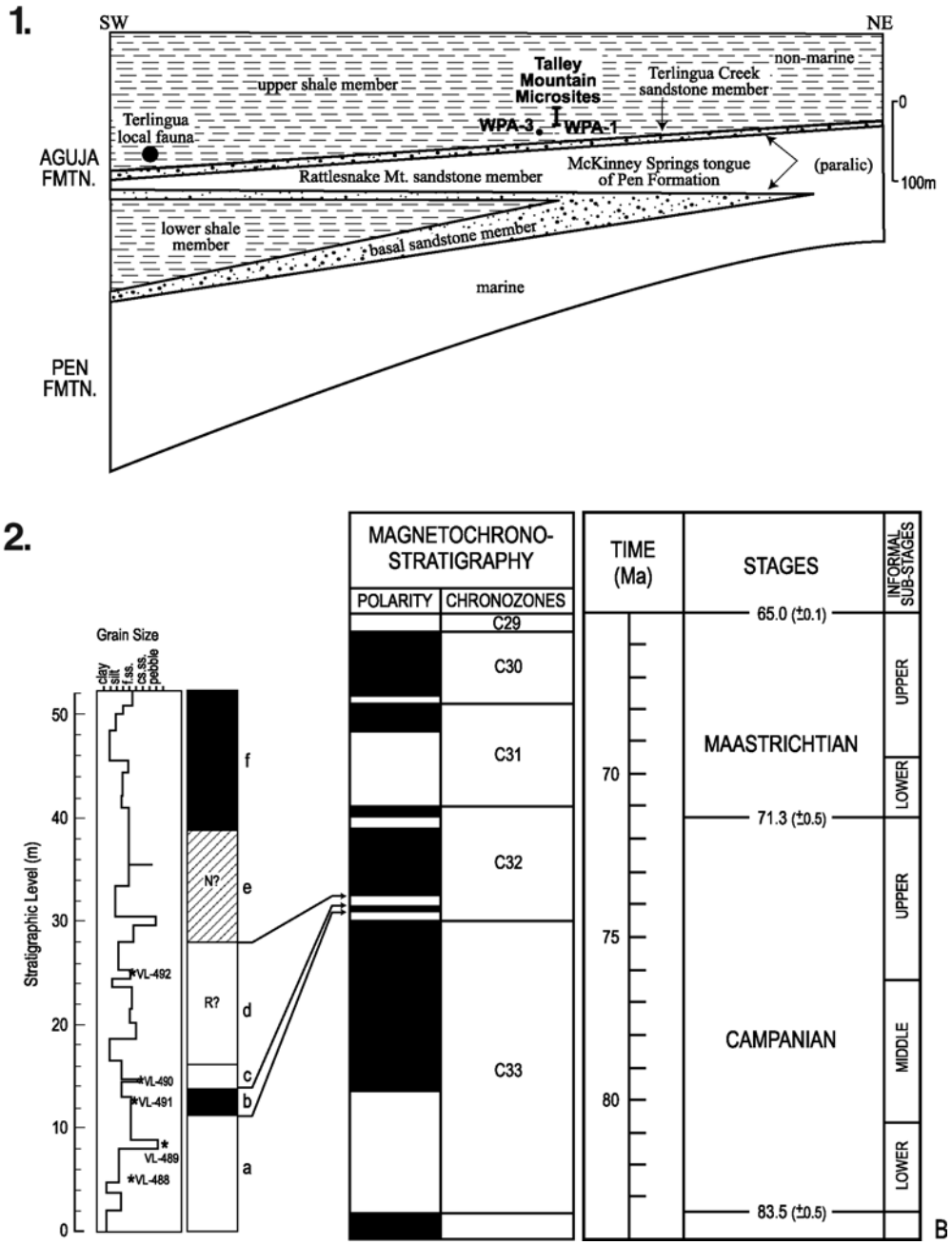

FIGURE 2--Stratigraphy of the Aguja Formation (**A**), Big Bend National Park, Texas. Lithostratigraphy of the Aguja Formation modified from ROWE et al. (1992), showing positions of the Rattlesnake Mountain sites (this paper), Talley Mountain sites (SANKEY 1998, 2001, SANKEY & GOSE 2001), and Terlingua site (ROWE et al. 1992). Stratigraphic position of the Talley Mt. microsites and WPA dinosaur quarries 1 and 2 (Work Progress Administration) from LEHMAN (1985; Plate III and written comm., 1998). Formal members of the Aguja Formation are capitalized; informal members are not. Magnetostratigraphic correlations (**B**) of upper Aguja Formation from Talley Mountain area to the geomagnetic polarity of GRADSTEIN et al. (1995) (from SANKEY & GOSE 2001).

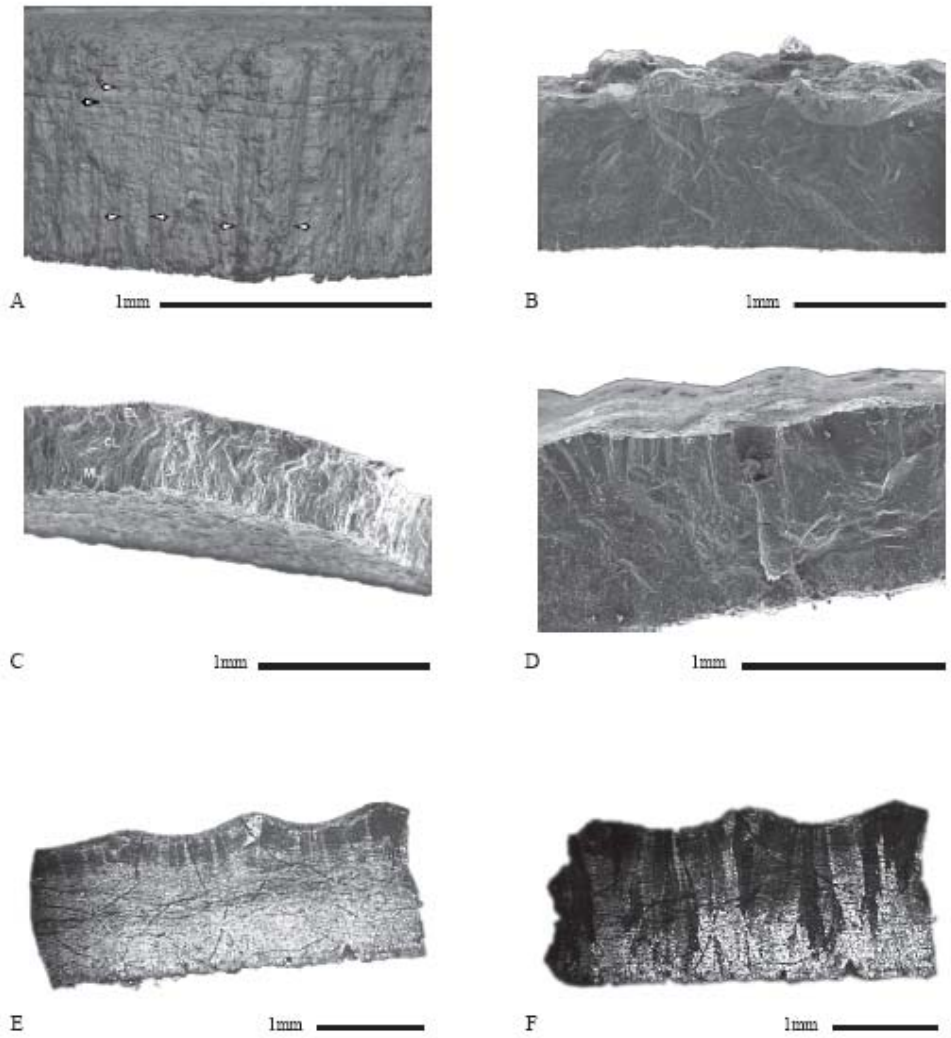

FIGURE 3- **A.** Dinosauroid Spherulitic morphotype. Radial view, SEM, backscatter image; V-17891. Two upper arrows indicate unusual banding through continuous layer. Note the single continuous later. No mammillary layer is present. **B.** Dinosauroid Prismatic morphotype. Radial view, SEM, backscatter image; V-17892. Thin mammillary layer (ML) with unclear boundary with the continuous layer (CL). Domed surface ornamentation. Notice the arrow indicating the lighter color above marking probable diagenetic alteration. **C.** Ornithoid Prismatic morphotype. Radial view, SEM, carbon coated image; V-17894. Note the three distinct layers: EL, external layer; CL, continuous layer; ML, mammillary layer. Also note the prismatic mammillary layer. **D-F.** Ornithoid Ratite morphotype. V-8251-E3. **D.** Radial view, SEM, carbon coated image. Note the distinct boundary between the continuous layer (CL) and mammillary layer (ML). Arrow indicates angusticanaliculate pore with fill. **E.** Radial view of thin section under normal light. **F.** Radial view of thin section under polarized light.

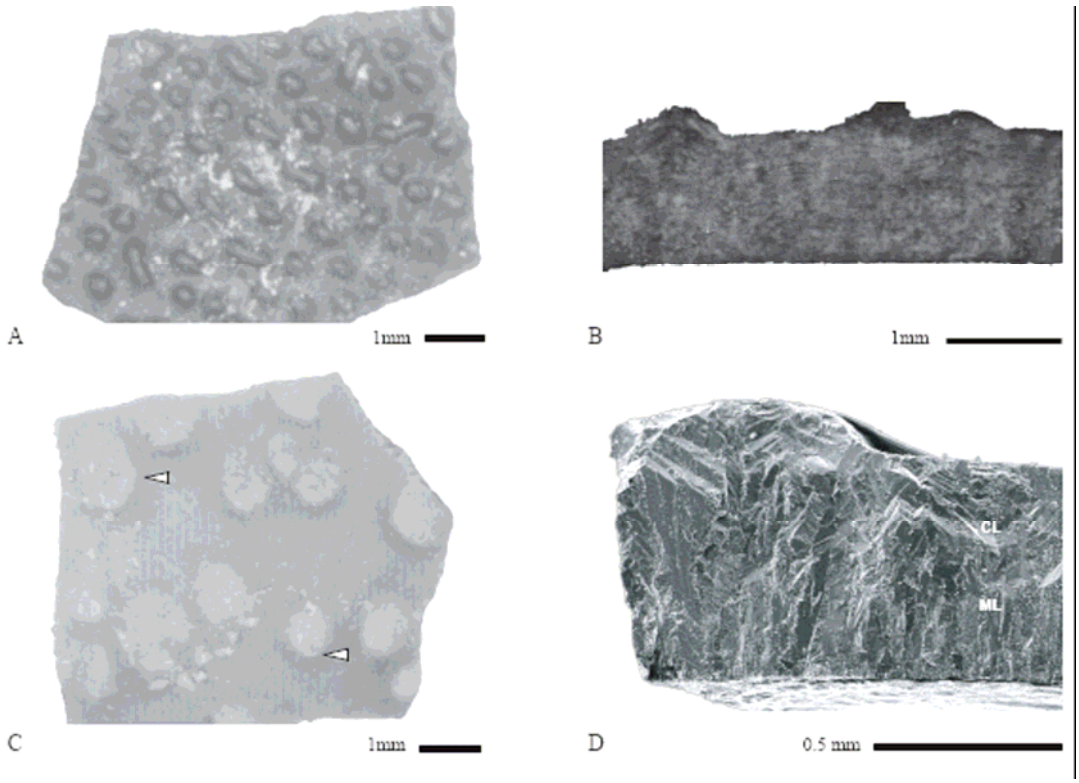

FIGURE 4 – **A-B.** Oogenus cf. *Continuoolithus* ZELENITSKY et al. 1996. V-17738. **A.** Surface view; digital photograph under dissecting microscope. **B.** Radial view of raw material. **C-D.** Oogenus cf. *Porituberoolithus* ZELENITSKY et al. 1996. V-17739 **C.** View of surface ornamentation; digital photograph under dissecting microscope. Arrows indicate pores located on flattened nodes. **D.** Radial view under SEM, carbon coated image. Note two distinct structural layers, continuous (CL) and mammillary (ML).