

Technical Session IX (Friday, October 19, 10:45 am)

SPATIAL AND TEMPORAL SHIFTS IN PALEOGENE CROCODYLIFORM DIVERSITY AND A NEW GLOBIDONT ALLIGATOROID FROM THE MIDDLE EOCENE OF WEST TEXAS

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Most of our knowledge regarding the loss of diversity within Crocodyliformes in the Middle and Late Eocene comes from specimens from the central Western Interior. However, crocodylians from the Middle Eocene Devil's Graveyard Formation (DGF) of West Texas provide additional information from southern North America during that period of faunal reorganization. Here we describe a new taxon of alligatoroid from the middle member of the DGF based on the most complete alligatoroid material known from Tertiary deposits outside of the Western Interior. The precise age of the new taxon is unclear because of a lack of associated fauna or datable tuffs. However, the holotype was recovered from a stratigraphic horizon between the Late Uintan Purple Bench locality and the Duchesnean Skyline Channels localities. The new taxon is similar to alligatorine material from the Uinta Formation of Utah and shares the presence of nearly spherical tooth crowns with previously published mandibular fragments from lower in the DGF stratigraphic section. However, the new DGF taxon can be distinguished from the Uinta Formation material and all other alligatorines on the basis of several caiman-like features, including a prominent, notched, descending lamina of the pterygoid posterior to the choana and a long descending process of the exoccipital that makes contact with the basioccipital tubera. Additionally, autapomorphies of the new taxon include rounded anterior processes of the palatines and a prominent, anteriorly extending crest on the dorsal surface of the skull anterior to the orbit. Although the posterior maxillary teeth are bulbous (a feature shared with basal alligatorines), the posterior alveoli are smaller than the fourth and fifth maxillary alveoli, which is a feature shared with *Alligator* and another new species from the Uinta Formation. Our morphological phylogenetic analysis indicates that the new DGF taxon has potential affinities with Alligatorinae. This new taxon adds to the diversity of specialized globidontans in the Paleogene and represents the southernmost known occurrence of a blunt-toothed alligatoroid in the Paleogene of North America. Other crocodylians known from the DGF include a pristichampsine and *Borealosuchus*. Crocodyloids are not identified from this formation, suggesting slightly lower crocodyliform diversity in West Texas than in Uintan deposits further north.

Preparators' Session (Thursday, October 18, 9:00 am)

METHODOLOGY AND RESULTS OF A COMPREHENSIVE SPECIMEN CONSERVATION CONDITION SURVEY OF AN ACTIVE BONE BED AND STORAGE COLLECTION AT THE MAMMOTH SITE OF HOT SPRINGS, SD, INC.

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The Mammoth Site of Hot Springs, SD (MSHS) poses unique challenges for collections management, conservation, and preservation in that it is both an active, on-going paleontological excavation site and a research collection. Discovered in 1974, the development of the site and the museum has paralleled the growth and development in the field of museum conservation. Over the past two decades the MSHS has applied conservation methods and materials used in the stabilization and preservation of the specimens. The museum has also undergone various assessments of its operations, developed a long-range conservation plan, and acted on the recommendations of the assessors. The comprehensive specimen condition survey, an object by object survey, is the most detailed conservation assessment available. The assessment consists of visual and tactile observations of individual specimens and recording ordinal numerical rankings of specimen and matrix condition and treatment priority. The ranking system was developed by the conservator (Storch) in collaboration with the MSHS staff (Potapova and Wilkins). The amount of time in hours required for conservation treatments (e.g. stabilization, cleaning, reversing improper treatments, etc.) were also estimated. The bone bed and collections storage specimens were assessed in two on-site visits of ten days each. Eight hundred and thirty individual bones were assessed and results tallied for the three metrics mentioned above. Condition assessment reports were filled out for each specimen and will be added to the more detailed collections specimen records. Images of representative conditions for each ranking were taken and are included in the final project report. In the bone bed, 12% of the specimens are in the poor to fair condition categories, 68% in good, and 20% rated as excellent. The condition of the "poor/fair" specimens, and many of the elements in the "good" ranking, is due to the presence of darkened and aged cellulose nitrate and polyvinyl butyral polymer resins applied as preservatives and consolidants to the bone surfaces and matrix. Results are similar for the specimens in storage. The final project report summarizes the results within a conservation risk assessment framework of ten agents of deterioration including disassociation, or the separation of provenience information from the specimen. The project also applied the condition rankings to the specimen location information in ArcGIS for the site as an additional mapping layer so the in-situ exhibit specimens can be highlighted by condition ranking for identification and preservation work planning.

Poster Session III (Friday, October 19, 4:15 - 6:15 pm)

MYRMECOPHAGOUS MAMMAL MICROWEAR

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Faunivorous mammals eat an extensive array of food items that vary substantially in their physical properties and offer different foraging challenges. Therefore, it is not surprising there are equally diverse adaptations for feeding on these foods including two morphological extremes. Small-bodied primate, bat, insectivoran, and marsupial insectivores tend to hunt and feed primarily on individual coleopterans, lepidopterans, and orthopterans. Morphologically they have elongate shearing crests and high dental complexity values relative to frugivores. On the other extreme are the myrmecophagous mammals from many groups (anteaters, tamandua, armadillos, echidna, aardvark, pangolin, numbats, sloth bears, and aardwolves) that have evolved to prey upon on colonial insects (hymenopterans and isopteran). The true specialists of this group have convergently evolved reduced dentitions and dentaries. Additionally, many other modern mammals include large quantities of colonial insects in their diets but do not demonstrate the extreme masticatory system reduction of species such as anteaters and pangolins. The question explored in this study was whether there is a dental microwear signal correlated to ant and termite feeding that could be used to identify fossil taxa that regularly eat colonial insects regardless of whether or not they demonstrate masticatory reduction.

Scanning electron micrographs at 500x magnification of lower molars were analyzed for microwear feature size and density on the only myrmecophagous mammals that have retained enamel-covered teeth: *Proteles cristatus* (aardwolf), *Melursus ursinus* (sloth bear), and *Myrmecobius fasciatus* (numbat). These data were compared to earlier work on other faunivorous mammals and data from the literature for frugivores and folivores. Results indicate that feature density is probably the microwear signal most suggestive of some sort of faunivory, with faunivores have much higher feature densities than either frugivores or folivores. Additionally, although termite/ant feeders tend to have same high feature density range as previously reported for other types of faunivorous diets, they can be distinguished from these by lower pit frequencies. These data suggest that the microwear signal of myrmecophagous mammals is unique and can potentially be identified in the fossil record.

Poster Session IV (Saturday, October 20, 4:15 - 6:15 pm)

RE-EXAMINING THE AFFINITIES OF *MOSASAURUS GRACILIS* – IS IT TRULY A *MOSASAURUS*?

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In 1822, the genus *Mosasaurus*, based on remains from the Maastrichtian of the Netherlands, became the first named taxon of mosasaur, followed in 1829 by the addition of the specific epithet to the specimen of "*hoffmanni*". *Mosasaurus missouriensis* (originally described as *M. maximilliani*) from the Upper Campanian of North America was the second described species of *Mosasaurus*, followed in 1849 by the description of *M. gracilis* from very fragmentary remains from the Middle to Upper Turonian (Upper Chalk) of the southeast English Coast. The type material of *M. gracilis* includes an associated pair of right and left dentaries, an isolated vertebra, and three articulated vertebral fragments, all from the Middle to Upper Turonian sections of the Offham Pit, near Lewes; and a right dentary originally described as a maxillary fragment, from the Chalk at Dorking. Examination of the type specimens of *M. hoffmanni* and *M. missouriensis*, with comparisons to *M. gracilis*, reveals that the latter taxon does not share any generic-level anatomical features with either the generic type, or these two other species of *Mosasaurus*. In fact, *M. gracilis* exhibits more shared characters, such as a short rostrum on the dentary anterior to the first tooth, with rusesellosaurine mosasaurs. In addition, *M. gracilis* is known from Turonian-aged deposits, while other species belonging to *Mosasaurus* are Upper Campanian to Maastrichtian in age. Based on the evidence of shared characters and contemporaneity, we suggest that *M. gracilis* be removed from *Mosasaurus* because it shares more affinities with rusesellosaur-like mosasaurs.

Technical Session XII (Friday, October 19, 2:15 pm)

AGE AND PALEOECOLOGY OF MOSASAURS AND PLESIOSAURS FROM THE LATE CRETACEOUS SOUTH ATLANTIC MARGIN AT BENTIABA, ANGOLA

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The geology of coastal Angola reflects the rifting of Africa and South America and the development of the South Atlantic Ocean. This study utilizes stable carbon isotopes derived from mollusk shells to constrain the age of mosasaur and plesiosaur teeth recovered from a single horizon, and uses carbon isotopic values derived from tooth enamel to refine the marine vertebrate niche partitioning. The vertebrate-bearing horizon is near the top of a marine section unconformably overlying continental syn-rift deposits. A basalt flow intercalated within the marine sequence is dated at 84.5 Ma (Santonian), and reflects a widespread magmatic interval along the South Atlantic margin. The age of the basalt ties $\delta^{13}\text{C}$ chemostratigraphy to the secular $\delta^{13}\text{C}$ curve of the English Chalk and Tunisia. Low in the section is a 4‰ positive excursion interpreted as Oceanic Anoxic Event 2 at the Cenomanian-Turonian boundary (93.5 Ma), indicating the sediments were deposited from

the Late Cenomanian to Early Maastrichtian. The $\delta^{13}\text{C}$ values derived from mosasaur and plesiosaur tooth enamel range from -5 to -16‰, showing a negative trend with increasing body size. This pattern is similar to that observed in modern marine mammals, in which more negative $\delta^{13}\text{C}$ values correlate with deep diving behavior and foraging habitats distant from the shoreline. Specimens of the mosasaur *Globidens* yielded values more negative than expected for their body size and are interpreted as reflecting long diving durations required by their durophagous feeding behavior. Plesiosaur specimens yielded $\delta^{13}\text{C}$ values between -5 to -14‰. The large range in values reflects taxonomic variation or habitat partitioning among individuals. The diversity of niches utilized by large bodied marine amniotes implied by these results suggests a high level of productivity during the Late Cretaceous across a range of habitats along the coast of Angola.

Poster Session III (Friday, October 19, 4:15 - 6:15 pm)

LATE CRETACEOUS FISH OTOLITHS FROM NORTHEAST MISSISSIPPI: IMPLICATIONS FOR NORTH AMERICAN TELEOSTEAN EVOLUTION AND DISTRIBUTION

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Well-preserved and relatively abundant fish otoliths from the Late Cretaceous Ripley Formation at the Blue Spring Site (MS 73.033) in southeast Union County in northeastern Mississippi (USA) have contributed to a better understanding of teleostean evolution and distribution in North America. Extensive leaching of Cretaceous strata often destroys the aragonitic fish otoliths and limits otolith occurrence to primarily clays and marls. Fortunately, highway construction exposed a large area of the Ripley Formation, which included the Coon Creek beds that contain aragonitic remains. Ten collections were acquired from the aragonitic clay beds through bulk sampling and surface collecting. These collections resulted in approximately 800 fish otoliths for study. The number of specimens from the Blue Springs Site is quite significant in that many previous North American Cretaceous otoliths studies have been based on 100 to 300 otoliths. Bulk samples were taken at four measured sections at the site with seven samples ranging from 11.5 to 25 kilograms (total of 102 kilograms). Bulk samples produced 446 otolith specimens, while three surface collections supplied an additional 355 otoliths. Statistical analysis for abundance was limited to the bulk sample otoliths.

The majority of the otoliths were sagitta, but there were lapilli from several anrid taxa (marine catfish). Some of the otoliths exhibited crenulated and lobated margins, which was an indication of their excellent state of preservation. The abundance and preservation of the fish otoliths contributed to the first North American Cretaceous occurrence of several taxa. Furthermore, the larger sized otoliths from the surface collections made it possible to identify several taxa with greater specificity than previously possible based on smaller, immature specimens. Otolith specimens that compare favorably with the synodontids (lizardfishes) *Saurida* and *Synodus* are reported for the first time from the Cretaceous in North America. Also, a small serranid otolith was identified as most likely belonging to *Centropristis* and represents the first *Centropristis* otolith from the North American Cretaceous. The specimen is especially significant in that it provides additional evidence for the presence of perciforms in the Cretaceous. Perciforms were long believed to be restricted to the Cenozoic, but otoliths studies from North America and Europe have clearly shown their presence in the Mesozoic. Well-preserved, larger otoliths from the surface collections made it possible to more precisely identify several forms. The otoliths previously identified as Polymixidae indeterminate appear to be closely related to *Polymixia*, and "genus Trachichthydarum" *oscitans* may be in the genus *Hoplostethus*.

Poster Session III (Friday, October 19, 4:15 - 6:15 pm)

COMPUTER TOMOGRAPHY INVESTIGATIONS INTO CRANIAL PNEUMATICITY IN A SMALL OLIGOCENE SULID (STEGANOPODES: SULIDAE)

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Sulidae is a family of coastal seabirds known for their ability to plunge-dive from great heights to catch prey. Extant sulids possess a series of sub-dermal air sacs and exhibit high levels of skeletal pneumatization, which together are hypothesized to cushion the bird during high-velocity impacts with the water surface. A skull from a new fossil sulid taxon reveals details of skull morphology, cranial pneumaticity and neuroanatomy of a basal member of this waterbird lineage. This taxon is smaller than any living species of Sulidae and lacks several derived features of extant *Sula* and *Morus*, suggesting it may represent a stem lineage sulid. The fossil was recovered from deposits of the Ashley Formation of South Carolina at the Charleston Airforce Base. These deposits are Early Oligocene to Late Oligocene in age.

Computed tomography scans were taken of the skulls of the fossil sulid, the extant *Sula leucogaster*, and the cormorant *Phalacrocorax auritus* to explore the endocranial morphology of Sulidae and a closely related non-plunge-diving waterbird. Virtual endocasts were generated using the volumetric rendering program Avizo. The endocranial anatomy of the fossil sulid and *S. leucogaster* are highly similar, as evidenced in both the brain endocasts as well as cross sections of the skulls. Within the brain, a number of parallels can be seen: a small flocculus, a well-developed optic tectum, and an expansive cerebellum. The cerebrum of *S. leucogaster* is more expansive than the cerebrum of the fossil sulid. Skull cross-sections reveal a high level of pneumaticity in the skulls of both the fossil sulid and *S. leucogaster*, while there is a low level of pneumaticity within the skull of *P. auritus*.

Together with evidence from sulid postcranial elements recovered from the same horizon of the Ashley Formation, the high level of pneumaticity found within the braincase of the fossil sulid implies that this basal member of the sulid lineage also employed plunge-diving despite its small size.

Technical Session XVIII (Saturday, October 20, 4:00 pm)

BIOSTRATIGRAPHY AND CORRELATION OF VERTEBRATE AND PLANT FOSSILS FROM THE WIND RIVER FORMATION (YPRESIAN, EARLY TO MIDDLE EOCENE) OF CENTRAL WYOMING IN NORTH AMERICA

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Over the past five years, a concentrated effort has been made to investigate previously unexplored areas in the Wind River Basin, Wyoming, that further clarify the biostratigraphy and correlation of the early to middle Eocene Wind River Formation. A comprehensive stratigraphic framework incorporates chronostratigraphic, magnetostratigraphic, biostratigraphic and seismic data for local correlation of many formerly isolated exposures of the formation in the northwestern part of the basin and global correlation to the time scale. In addition, new discoveries of plant localities in this area can now be tied directly into the vertebrate biostratigraphic sequence. The Wind River Formation is the stratotype for the Wasatchian Biochronological Zone WA7 and the Bridgerian Biochronological Zone BRIA and is critical to the assessment of the Early-Middle Eocene boundary in North America. Data from plants and vertebrates indicate that peak Paleogene temperatures during the Early Eocene Climatic Optimum encompass this time interval. New samples of volcanic ash for isotope dating provide ages for the lower part of WA7 and the upper part of BRIA. New magnetostratigraphic data should further help clarify the age of the Wind River Formation as well. Well-log data shows a subsurface horizon that has been used to determine positions of different surface exposures of the Wind River Formation across the northeastern part of the basin from Hells Half Acre west to the Boysen Reservoir area. Records of Siluriformes fish and pristinichampsine crocodiles are known in the Wind River Formation only from BRIA and along with records of other early Bridgerian mammals (*Eotitanops*, *Hyrachyus*, *Trogosus*) establish the base of the Bridgerian (BRIA). Current work is focused on refinement of the magnetostratigraphy, isotopic dating, sampling of plant and vertebrate localities across the WA7-BRIA boundary, and exploration in new areas.

Technical Session I (Wednesday, October 17, 9:45 am)

TYRANNOSAURID DINOSAURS FROM THE UPPER CRETACEOUS WANGSHI GROUP OF ZHUCHENG, SHANDONG PROVINCE, CHINA: COEXISTING GIANT CARNIVORES AND A TYRANT WITH A TOOTHACHE

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Since the 1960s, vast and highly productive dinosaur quarries have been known to exist near the city of Zhucheng, Shandong Province, China. Excavations at the three Upper Cretaceous (probably Campanian) sites of Kugou, Zangjiazhuang and Longgujian have yielded thousands of bones from giant hadrosaurids and a smaller number from ceratopsians, ankylosaurs, small coelurosaurids, sauropods and tyrannosaurids. Much of this material remains undescribed. Tyrannosaurid teeth were among the initial specimens recovered from the quarries, and were first referred to the North American *Tyrannosaurus rex* and later assigned with an isolated metatarsal to the new putative species "*Tyrannosaurus zhuchengensis*".

Although these finds are taxonomically indeterminate, more diagnostic tyrannosaurid material has recently been collected and is being studied by our research group. An associated maxilla and dentary comparable in size and gross morphology to the corresponding elements in the Mongolian species *Tarbosaurus bataar* were recently described by some of us as a new large tyrannosaurine, *Zhuchengtyrannus magnus*. *Z. magnus* is distinct from *T. bataar* in important details of the maxilla, including the lack of a subcutaneous flange, the presence of a horizontal shelf on the lateral face of the ascending process, and the shape and position of the maxillary fenestra. A second tyrannosaurid maxilla and second dentary are known from the same quarry, and disarticulated postcranial bones and teeth have also been collected from the Zhucheng sites. The second maxilla is distinct from that of *Z. magnus* in many respects, including all three features mentioned above, but could be referable to *T. bataar* despite minor differences from previously described maxillae of that taxon. It is clear that two very large tyrannosaurine species coexisted in what is now the Zhucheng area during the Late Cretaceous, an unusual situation that presumably required some form of niche partitioning.

The second tyrannosaurid dentary shows clear pathological features, including a swollen, mediolaterally thickened overall shape and a mound-like prominence on the medial surface below the foramen intramandibularis oralis. CT scans suggest that the prominence represents the surface expression of a dental abscess, from which an osteomyelitic infection probably spread diffusely and altered the shape of the entire dentary. Although a dental abscess has previously been documented in a hadrosaurid dinosaur, the presence of this type of