CRETACEOUS & BEYOND

PALEONTOLOGY OF THE WESTERN INTERIOR

A Symposium Focusing on Cretaceous and Paleogene Vertebrate Paleontology of the Western Interior

September 14th and 15th, 2019
at
Dickinson State University

MISCELLANEOUS SERIES NO. 94
NORTH DAKOTA GEOLOGICAL SURVEY
Edward C. Murphy, State Geologist
Lynn D. Helms, Director Dept. of Mineral Resources
2019

Cretaceous and Beyond: Paleontology of the Western Interior

Host Committee

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Cover Image: *Outcrops of the Oligocene Brule Formation at the Fitterer Ranch paleontological locality. In the foreground is an outcrop of the middle portion of the Brule Formation that preserves a fossiliferous incised channel. In the background on the right are exposures of the upper portion of the Brule Formation, with possible caprocks of the Arikaree Formation. View is to the southeast.*

PURPOSE

The main emphasis of the meeting is the evolution, ontogeny, and paleoecology of vertebrates from the Late Cretaceous and Paleogene (Paleocene, Eocene, Oligocene) of North America. However, presentations on relevant non-vertebrate fields such as stratigraphy, geochronology, palynology, paleobotany, and invertebrate paleontology will also be welcome, keeping in mind the audience of mainly vertebrate paleontologists. Presentations on other time periods or geographic regions should clearly explain their relevance for vertebrate researchers in the Cretaceous and Paleogene of the Western Interior (e.g. intercontinental migration or variation, with Asian fauna, etc.).

VENUES

DICKINSON STATE UNIVERSITY

Presentations will be hosted at Murphy Hall on the Dickinson State University campus. Dickinson State Normal School was established in 1916. The historic campus was built on a hilltop in the city of Dickinson, North Dakota. This gave it the nickname “College on the Hill.” Over 100 years later, Dickinson State University continues to lead the region in high-quality, affordable education. A number of hotels and restaurants are located within walking distance of Dickinson State University, with many more available within a short drive.

BADLANDS DINOSAUR MUSEUM

Formerly operating as Dakota Dinosaur Museum (1992-2015), Badlands Dinosaur Museum is located within the city of Dickinson and is part of the 12 acre campus of the Dickinson Museum Center. The museum was acquired by the City of Dickinson in 2015 and is undergoing a complete overhaul of facilities and exhibits as part of its transition into a public institution. The museum will host the Saturday evening reception for the symposium, where attendees will have the opportunity to tour the facility and view the exhibits, including the award winning feathered dinosaur models.

NORTH DAKOTA GEOLOGICAL SURVEY

The Paleontology Resource Protection program at the North Dakota Geological Survey maintains the North Dakota State Fossil Collection, which is the official state repository for fossils and associated data, and operates an extensive field and classroom based educational outreach program. Their offices are in the North Dakota Heritage Center & State Museum in Bismarck (100 miles east of Dickinson), which includes exhibits on the paleontology and geology of North Dakota. The North Dakota State Fossil Collection consists of tens of thousands of plant, invertebrate, and vertebrate fossils from Cretaceous through Pleistocene rocks in North Dakota and from surrounding states.

Saturday, September 14th PROGRAM AT A GLANCE

All events are in Room 117 in Murphy Hall on the Dickinson State University campus unless otherwise noted.

8:30 am	**Opening Statement**	
8:40 am	Krumenacker et al.	Growing Taxonomic Diversity of the mid-Cretaceous (late Albian-Cenomanian) Wayan Formation Vertebrate Assemblage of Idaho
9:00 am	Noto et al.	At the Crossroads of the Cretaceous: The Woodbine Group and Understanding the Evolution of Appalachian Continental Ecosystems in the Late Cretaceous
9:20 am	Hanks et al.	Updates to the Dinosaur Fauna of the Late Cretaceous Coleraine Formation (Cenomanian) in Central and Northern Minnesota
9:40 am	Westgaard & Hanks	The Hill Annex Paleontology Project: A Citizen Science Research and Outreach Program
10:00 am	Smith et al.	A New Species of Nanhsiungchelyid Turtle from the Arlington Archosaur Site, Woodbine Formation, Texas: Macro- and Micro-anatomical Analyses
10:20 am	**BREAK**	
10:25 am	DeMar & Gardner	New Paleogene Fossils from the Western USA Document a New Paleocene Species and Temporal Range Extension into the Eocene for the Sirenid Salamander *Habrosaurus*
10:45 am	Woodruff & Evans	A New Species of *Sphaerotholus* (Dinosauria: Pachycephalosauria) from the Upper Cretaceous Hell Creek Formation of Montana
11:05 am	Fowler et al.	The Horned Dinosaur *Leptoceratops* (Ornithischia: Neoceratopsia) Raised its Young in Communal Nesting Burrows: Evidence from Three New Bonebeds in the Hell Creek Formation (Maastrichtian, Late Cretaceous), Montana
11:25 am	Bamforth & Street	Unusual Ceratopsian Frill Morphologies from the uppermost Maastrichtian Frenchman Formation (66 Ma) of Saskatchewan, Canada
11:45 am	**LUNCH**	OPTIONAL: Ukrainian Cultural Institute, 10 minute walk from Murphy Hall
1:20 pm	McDonald et al.	A New Crested Brachylophosaurin (Dinosauria: Hadrosauridae) from the Upper Cretaceous Menefee Formation of New Mexico and Judith River Formation of Montana
1:40 pm	Freedman Fowler & Fowler	"Warwick's Duck", an Exceptional Specimen of *Edmontosaurus* (Dinosauria: Hadrosauridae) with Extensive Caudal Neural Spine Pathologies: Evidence of Mating Injuries in Hadrosaurs?
2:00 pm	Bertozzo et al.	A Comparison of Paleopathological Lesions and Diseases between Lower and Upper Cretaceous Ornithopod Dinosaurs
2:20 pm	Canoy Illies & Fowler	*Triceratops* with a Kink: Co-ossification of Five Distal Caudal Vertebrae from the Hell Creek Formation of North Dakota
2:40 pm	Welsh et al.	A Nimravid (Mammalia: Carnivora) with Split Carinae, Supporting the Hypothesis of Genetic Polymorphism in Homologous Tooth Abnormality Found Within Theropod Dinosaurs
3:00 pm	Dececchi et al.	Running on Empty: Investigating the Energetics of Theropod Predators and Community Structure of the Latest Cretaceous Frenchman Formation Ecosystem
3:20 pm	**BREAK**	
4:00 pm	Public Panel Discussion	Open to the Public. Scheduled from 4:00 pm to 6:00 pm.
7:00 pm	Welcome Reception	Badlands Dinosaur Museum: Explore the exhibits while enjoying a buffet dinner catered by The Wurst Shop, specializing in local North Dakota German cuisine. Tours of the paleontology lab and collections will be available. Cash bar.

Sunday, September 15th PROGRAM AT A GLANCE

All events are in Room 117 in Murphy Hall on the Dickinson State University campus unless otherwise noted.

9:00 am	Street et al.	A Juvenile Elasmosaur Skull Preserved in a Concretion from the Upper Cretaceous Bearpaw Formation of Saskatchewan, Canada
9:20 am	Turcios & Hastings	Previously Unreported Historical Remains of an *Elasmosaurus* Recovered from Wyoming in 1927
9:40 am	Van Vranken & Boyd	An Update on Mosasaurine (Reptilia; Squamata) Remains from the Hell Creek Formation, North Dakota, USA
10:00 am	Hastings et al.	New Records of Marine Reptiles from the Late Cretaceous of Minnesota
10:20 am	**BREAK**	
10:25 am	Williams et al.	A Basal Alligatoroid from the Upper Cretaceous (Campanian) Two Medicine Formation of Montana
10:45 am	Boyd & Householder	A New Species of Alligatoroid with European Affinities from the earliest Paleocene (Puercan) Ludlow Formation (Fort Union Group) of North Dakota
11:05 am	Person	Newly Reported *Borealosuchus* (Crocodylia, Eusuchia) from the Camels Butte Member (Eocene) Golden Valley Formation of North Dakota
11:25 am	Various	Lightning Talk Session
11:45 am	**LUNCH**	
1:20 pm	Poster Session	Poster Session. Authors must be present.
2:20 pm	Atwater & Scannella	A Stagodontid Marsupial from the Upper Cretaceous Hell Creek Formation of Montana
2:40 pm	Cruz	Analysis of the Masticatory Apparatus of *Uintatherium anceps*
3:00 pm	Welsh & Moore	A Newly Discovered *Phlaocyon*-like Dog (Borophaginae) from the Orellan of Nebraska and its Implications for early Oligocene Dog Diversification
3:20 pm	Spearing & Custer	Paleobiology of *Mesocyon temnodon*; a Preliminary Study
3:40 pm	Liggett	Using ARCGIS Online (AGOL) to Greatly Improve the Documentation of Paleontological Resources
4:00 pm	**BREAK**	
4:05 pm	McKellar & Cockx	Filling Gaps in the Amber Record and Adding Facets to Bonebed Palaeoecology: Late Cretaceous and Paleocene Amber Deposits from Western Canada
4:25 pm	Freimuth & Varricchio	Dissecting Dinosaur Pellets? Taphonomy of Modern Raptor and Carnivore Gastric Pellets Guides the Identification of Fossil Feeding Traces at Egg Mountain, a Dinosaur Nesting Site
4:45 pm	Bamforth	Log Jams and Juveniles: Unusual Deposits at the Cretaceous-Paleogene (K-Pg) Boundary in the Maastrichtian (66 Ma) Frenchman Formation of Saskatchewan, Canada
5:05 pm	Tanke	Evidence of Head-hunting, Selective Bone Sampling and Incomplete Collection of Major Late Cretaceous Dinosaur Skeletons in Southern Alberta, Canada: A Cautionary Note on True Specimen Completeness to Fieldworkers and Researchers Everywhere

POSTER SESSION

Posters can be put up on Saturday morning and remain up for the entire weekend. However, presenters must be present in front of their poster for the poster session, Sunday September 15th from 1:30 pm to 2:20pm.

Hanks et al.	A New Occurrence of a Shark Bitten Pterosaur Wing Bone And A Dromaeosaur Tooth From The Carlile Shale (Turonian) of Milbank, South Dakota
Laframboise	Scavengers, Predators and Dinosaurs of the Bearpaw Formation (Belly River Group) of Alberta
Chavarría-Arellano et al.	Lissamphibians and Squamates from the Upper Cretaceous (upper Campanian) El Gallo formation of Baja California, Mexico
Noto et al.	Hydrodynamic Transport Potential of Modeled Turtle Shell in a Controlled Fluvial Setting: a Case Study in Experimental Taphonomy
Farke et al.	Newly Recognized Specimens from the White River Formation (Eocene/Oligocene) Represent Wyoming's Last Crocodyliforms
Ferguson & McGregor	Preliminary Results of the First Avian Eggs and Possible Clutches in the Bridger Formation, Wyoming
Ferguson	Preliminary Results of Possible in Situ Turtle Eggs in the Kaiparowits Formation, Grand Staircase-Escalante National Monument, Utah
Swisher	A New Ceratopsian Discovery in the Lance Formation (Late Cretaceous, Maastrichtian) of East Central Wyoming
Cochran-Bjerke et al.	Accuracy of Measurements Collected from 3D Digital Models of Fossils
Aguilar-Pedrayes	Beaks and Teeth: An evolutionary example of negative correlation between traits?

OPTIONAL FIELD TRIPS

Paleogene Faunas of North Dakota - September 13th, 2019

This field trip will start in the Paleocene swamps of the Fort Union Group with stops at sites preserving diverse vertebrate and invertebrate faunas deposited in large, shallow lakes in the area of Medora, North Dakota. From there we'll move on to the Little Badlands area, where local exposures of the Eocene through Oligocene Golden Valley, Chadron, and Brule Formations record the transition from a warm and humid to a cooler and dryer environment.

K-Pg Boundary in North Dakota - September 16th, 2019

This field trip will visit several important paleontological sites both immediately below and above the boundary, as well as areas with good exposures of the K/Pg tonstein, providing participants with a chance to learn about the current state of knowledge regarding this mass extinction event.

Judith River and Hell Creek Formation of Montana - September 17th and 18th, 2019

During the Late Cretaceous, northern Montana was a vast floodplain with deltas and coal swamps reaching out into the shallow seaway that covered the Dakotas and what became the central United States. The Judith River (~79-76 Ma) and Hell Creek (~67-66 Ma) formations of Montana represent terrestrial deposition during this time, and we will spend a day in each of these units investigating the paleontology and geology.

Presented Abstracts

Poster Session: Sunday, September 15, 1:30-2:20 pm
Beaks and teeth: An evolutionary example of negative correlation between traits?

AGUILAR-PEDRAYES, Isaura; Montana State University, Bozeman, MT.

Across the evolutionary history of tetrapods, diverse jaw structures have evolved for obtaining food. About two-thirds of current species use teeth and the rest (birds and turtles) use beaks. Most studies involving embryonic developmental and paleontological research of birds and some extinct relatives in the fossil record, seem to indicate that beak acquisition is accompanied by irreversible tooth loss. Currently there are many hypotheses that state an adaptive advantage for this trade-off, but haven't been tested in a macroevolutionary scale and most studies are biased towards this taxon. These include lightening the avian body as an adaptation of flight, tactile sensitivity for both food grasping and chick rearing, and (or) having a beak as a "less metabolic expensive" alternative to teeth. Non-adaptive alternatives have yet to be explored thoroughly—for example, trait evolution correlation and phylogenetic history. The objective of this study is to test if tooth count reduction coevolved with the appearance of the beak, that is a keratinized epidermis that covers the jaws. This research will focus on dinosaur taxa. I collected the following data from Aves, a group that includes taxa from *Archaeopteryx* to extant Neornithes: beak presence/absence and tooth-count. I will also add non-avian saurischians and ornithischians known to have developed beaks. I will also leverage Bayesian phylogenetic comparative methods to test for negative selection (reduction) on tooth count by beak presence, accounting for phylogeny. Lastly, I will assess if phylogenetic error affects our results by using two alternative phylogenies for Dinosauria. Literature research mentions birds and non-avian theropods independently evolved beaks three times, and tooth loss evolved at least four times in Mesozoic birds. Preliminary results using BayesTraits V3 favor a linear regression model where tooth count reduction in the premaxilla is correlated with beak presence, accounting for phylogenetic signal ($\lambda \approx 1$); in other words, the appearance of a keratinous surface in the premaxilla (beak) seems to contribute to tooth count reduction. Adding non-avian theropods and ornithischian might help clear this inquiry. Also, in a broader aspect this research will provide insights into the evolution and diversification of animals, and help determine if current hypotheses apply for all beaked animals that ever lived.

Sunday, September 15, 2:20 pm

A Stagodontid Marsupial from the Upper Cretaceous Hell Creek Formation of Montana

ATWATER, Amy L; Museum of the Rockies, Montana State University, Bozeman, MT. SCANNELLA, John B; Museum of the Rockies, Montana State University, Bozeman, MT.

The uppermost Cretaceous Hell Creek Formation (HCF) of Montana and surrounding regions preserves the remains of one of the last Mesozoic ecosystems in North America. Mammals from the HCF are primarily known from teeth and less commonly from other cranial and postcranial remains. Metatherians are a clade of mammals that includes marsupials and stem marsupials and those currently recognized from the HCF of Montana include pediomyids, alphadontids, glasbiids, deltatheridiids, herpetotheriids, and stagodontids. Stagodontids are an extinct family of carnivorous metatherian mammals that lived during the Late Cretaceous and reached relatively large body sizes. Here we describe a new stagodontid fossil from the upper half of the HCF in eastern Montana. MOR 10904 is a partial left dentary with a complete m4 and a partial m2. The m4 displays a reduced metaconid and strong development of the paraconid as well as an emphasis on prevallid shearing. The m4 paraconid is lingually positioned and appressed to the metaconid and this distalmost molar is medial to the coronoid process. The coronoid process is near vertical displaying an angle between 95 and 105 degrees. These characters indicate MOR 10904 is referable to the genus *Didelphodon*. However, MOR 10904 exhibits features which appear to distinguish it from previously described examples of this genus. MOR 10904 exhibits a less pronounced ventral boss for the insertion of the mandibular adductor and unique dental dimensions. This new specimen is further distinctive in having a shallower mandible height as measured from the base of the final molar compared to the known species of *Didelphodon*. MOR 10904 appears to most closely resemble *D. coyi* and may illustrate individual variation within the species; alternatively, it may represent a new species of *Didelphodon*. This specimen provides new insights into the morphology of Late Cretaceous metatherians and furthers our understanding of HCF ecosystems.

Sunday, September 15, 4:45 pm

Log Jams and Juveniles: Unusual Deposits at the Cretaceous-Paleogene (K-Pg) Boundary in the Maastrichtian (66 Ma) Frenchman Formation of Saskatchewan, Canada

BAMFORTH, Emily L.; Royal Saskatchewan Museum, Eastend, SK, Canada.

The latest Mesozoic and earliest Cenozoic rocks of southwest Saskatchewan contain exceptional exposures of the Cretaceous-Paleogene (K-Pg) Boundary. The Frenchman Formation represents a northern extension of the latest Maastrichtian (66 Ma) Hell Creek Formation into Canada. This formation, and the overlying Paleocene Ravenscrag Formation, preserve a continuous sequence of time immediately before, during and after the end-Cretaceous mass extinction. One of the most notable K-Pg sites in the province is a locality known as 'Hwy 37'. Here, the distinct K-Pg tonstein ('boundary clay') is 1-2 cm thick, and is bounded above and below by a coal seam measuring 1.5 m in total thickness. The coal above the boundary is characterized by blocky anthracite and is overlain by 35-45 cm of finely laminated carbonaceous shale. (This shale is a localized feature; it is much thinner or absent at other K-Pg sites in the province). The coal immediately below the K-Pg tonstein is also anthractic, but contains recognizable tree fossils. These fossils are represented by compressed segments of coalified logs, ranging in length from 15 – 40 cm, some with details of the bark and growth rings preserved. Interestingly, a similar deposit reoccurs 3.5 m lower in the Frenchman Formation. This 'log jam' deposit, which extends laterally for at least 400 m, is characterized by compressed segments of coalified trees, some with lengths exceeding five meters. Most specimens are so well preserved that bark structure, burls, and blisters of amber can be discerned. These logs often overlap one another, do not appear current-aligned, and are preserved in a fine-grained unconsolidated sandstone. The fine-grained sediment and lack of current ripples suggests this matrix was deposited in a lower energy environment after the original deposition event. Abundant sulfur-rich nodules may reflect low oxygen conditions that developed in pools of water around the jam. There are rare vertebrate fossils associated with this deposit, most of which seem to represent juvenile animals. These include a hatching troodontid metatarsal, a small dentary from a very young ceratopsian, and a juvenile hadrosaur scapula and parietal. These two deposits at and just below the K-Pg Boundary could be reflective of one or more event deposits, similar to that recently described from the Tanis Site in North Dakota. Ongoing research will help to better understand the nature of these deposits, providing more information about the events that occurred around the time of the Chicxulub impact.

Saturday, September 14, 11:25 am

Unusual Ceratopsian Frill Morphologies from the uppermost Maastrichtian Frenchman Formation (66 Ma) of Saskatchewan, Canada

BAMFORTH, Emily L.; Royal Saskatchewan Museum, Eastend, SK, Canada. STREET, Hallie P.; Royal Saskatchewan Museum, Eastend, SK, Canada

Large-bodied ceratopsians from the latest Maastrichtian (66 Ma) of North America are traditionally classified into two genera, *Triceratops* and *Torosaurus*. Debate exists as to whether these belong to a single ontogenetic series, represent one taxon with taphonomic/pathologic variances, or truly represent distinct taxonomic groups. The Frenchman Formation of southern Saskatchewan represents a northern extension of the upper Hell Creek Formation into Canada. In the Frenchman Formation, ceratopsian material accounts for approximately 70% of all dinosaur fossils recovered, the majority of which is referred to *Triceratops prorsus*. Although not necessarily reflective of taxonomic diversity, two unusual ceratopsian specimens under Royal Saskatchewan Museum curation suggest an underappreciated morphological diversity in ceratopsians from this time period. 1) Specimen EMP 16.1, collected in the 1920s and originally identified as 'cf. *Torosaurus*', is represented by a parietal–squamosal frill and associated post-crania. The frill is large, broad and quadrangular in shape, lacking epoccipitals. The parietal bar is missing taphonomically, but the parietal fenestrae are suggested to be symmetrical, and larger and more oblong than what is typical for *Torosaurus*. The specimen also displays smaller symmetrical, oblong squamosal fenestrae. EMP 16.1 may represent an atypical morph of *Torosaurus*, an undescribed ontogenic stage of the same, or possibly a new species. 2) Specimen RSM P3218.1, collected in 2017-2018, consists of a partial frill, nasal horncore, nasals and partial rostrum. Immediately adjacent to the parietal-squamosal suture, the parietal frill displays a distinct thinning of the bone, ending in defined, crenulated margins less than 1 cm thick. These margins form the edge of two partially preserved oblong fenestrae. The thinning out of the bone surrounding fenestrae has been suggested to represent ontogenic parietal thinning in older ceratopsian animals. Interestingly however, RSM P3218.1 also appears to display sub-adult characters. The recovery of more of this specimen may help to elucidate these unusual features. The anomalous characters displayed in EMP 16.1 and RSM P3218.1 may be reflective of ontogenic/morphological variations in *Triceratops* and/or *Torosaurus*, could represent northern regional variants, or may be new species. Future research will help to establish ceratopsian taxonomic diversity in the Frenchman Formation, as well as the range of phenotypic plasticity that may be expected in ceratopsian skulls from a single taxon.

Saturday, September 14, 2:00 pm

A Comparison of Paleopathological Lesions and Diseases between Early and Late Cretaceous Ornithopod Dinosaurs

BERTOZZO, Filippo; Archaeology and Palaeoecology, School of Natural and Built Environment, Queen's University Belfast, Northern Ireland. TANKE, Darren H; Royal Tyrrell Museum of Paleontology, Drumheller, Alberta, Canada. MURPHY, Eileen; Archaeology and Palaeoecology, School of Natural and Built Environment, Queen's University Belfast, Northern Ireland. RUFFELL, Alastair; Archaeology and Palaeoecology, School of Natural and Built Environment, Queen's University Belfast, Northern Ireland. GODEFROIT, Pascal; Royal Belgian Institute of Natural Sciences, Brussels, Belgium.

Ornithopoda is the clade that show the highest prevalence of pathologies among the Dinosauria, especially in Cretaceous taxa. During this period, they reached a worldwide distribution, with a high occurrence of remains, from isolated bones to complete skeletons. Diseases and trauma are events that affect only a part of a given population, thus the more specimens one finds, the more pathological information can be retrieved. This data can finally unveil aspects linked to the behavior of the affected species, as well as their interaction with their environment. However, paleopathological analyses were, and often still are, confined to case-studies. Hypotheses regarding ecological and phylogenetic influences can be assumed, however, using a substantial database of pathologies from a selected clade. During the Early Cretaceous, the lands were dominated by styracosternan dinosaurs such as *Iguanodon* and similar taxa. These animals show the highest number of paleopathological lesions in the dorsal vertebrae, middle region of the tail, pelvic girdle and pedal phalanges. However, some lesions are considered as possible pseudo-pathologies. The pathological distribution in the "*Iguanodon*-like" body is low when compared to those of hadrosaurid dinosaurs of the Late Cretaceous, especially in the northern American regions. These ornithopods show a very high amount of pathologies (about 1600 at least), with similar body distribution to earlier taxa, but with higher numbers in the trunk region, limbs and skull. The fact that the neck is consistently the area with the fewest pathologies recorded is noteworthy, which is a sign of extremely low resilience. Although the ornithopod paleopathological dataset is not yet complete, some conclusions can be drawn even when preservation and collection biases are considered: the tail was the area that suffered most from injuries, while osteochondrosis (aka, cartilage developmental failure) extensively affected hadrosaurid pedal phalanges, with no clear evidence in non-hadrosaurid iguanodontians. Analyses of further collections will extend the current dataset, thereby enhancing behavioral and ecological interpretations.

Sunday, September 15, 10:45 am

A New Species of Alligatoroid with European Affinities from the earliest Paleocene (Puercan) Ludlow Formation (Fort Union Group) of North Dakota

BOYD, Clint A; North Dakota Geological Survey, Bismarck, ND. HOUSEHOLDER, Mindy L; North Dakota Geological Survey, Bismarck, ND.

Paleogene rocks in North Dakota are rich sources of crocodylian fossils, previously providing the first records of *Borealosuchus formidabilis*, *Wannaganosuchus brachymanus*, and *Chrysochampsa mlynarskii*. While crocodylian fossils from the Bullion Creek and Sentinel Butte Formations of the Fort Union Group have received much attention, little effort has been focused on the collection and study of crocodylian fossils from the earliest Paleocene Ludlow Formation immediately following the Cretaceous-Paleogene extinction. Two crocodylian specimens collected from two different localities within the lower-most portion of the Ludlow Formation in southwestern North Dakota are the focus of this study. While these specimens are generally similar to some species of *Borealosuchus*, most of their shared traits are plesiomorphic for Crocodylia and all derived traits of the *Borealosuchus* clade (e.g., lateral curvature of the posterior portion of the maxillary toothrow) are absent in these specimens. These specimens do display several apomorphic traits typically only seen in alligatoroids, including subequal anterior processes of the surangular and an articular foramen aerum that is inset from the medial margin of the retroarticular process. Alternatively, they lack traits typically seen in globidontan alligatoroids such as a plate-shaped intercentrum and modest entry of frontoparietal suture into the supratemporal fenestrae, indicating a basal placement of the Ludlow taxon within Alligatoroidea. Preliminary phylogenetic analysis of these two specimens produced the following results: 1) these specimens are conspecific; 2) this taxon represents a previously undescribed non-globidontan alligatoroid lineage; and, 3) this taxon forms a clade with *Diplocynodon remensis* from the Paleocene of Europe. *Diplocynodon remensis* was the only Paleocene species referred to the diverse European taxon *Diplocynodon* and was previously cited as evidence for the dispersal of the *Diplocynodon* lineage into Europe prior to the Paleocene-Eocene Thermal Maximum. If correct, the removal of *D. remensis* from the Diplocynodontinae suggests that *D. remensis* represents the dispersal of a separate alligatoroid lineage into Europe during the Paleocene, making it uncertain if the *Diplocynodon* lineage dispersed to Europe before or after the Paleocene-Eocene Thermal Maximum. Further study of the Ludlow taxon will provide important insights into the early history of alligatoroid evolution and biogeographic dispersal.

Saturday, September 14, 2:20 pm

Triceratops with a Kink: Co-ossification of Five Distal Caudal Vertebrae from the Hell Creek Formation of North Dakota

CANOY ILLIES, Matthew. FOWLER, Denver W; Badlands Dinosaur Museum, Dickinson, ND

Paleopathologies present an unusual but direct source of information on dinosaur ecology, as they are often the immediate result of feeding or locomotory behaviors, social interaction, or predation. Here we present a series of five pathologically co-ossified caudal vertebrae from the Hell Creek Formation of North Dakota, which are part of an associated skeleton, NDGS 1715, of *Triceratops* (Dinosauria: Ceratopsidae). Comparisons to published ceratopsid tails demonstrate that the co-ossified mass probably represents caudal vertebrae 26-30, positioned approximately three-quarters of the way along the tail. The pathology takes the form of complete co-ossification of centrum faces, with the centra swollen by additional bone growth on the lateral and ventral margins. The co-ossified mass shows a gentle right lateral curvature through caudal centra 26-29. The posteriormost centrum, 30, continues the right lateral curvature, but at a higher angle, exhibiting a ~30° deflection at the contact with the face of the fourth centrum. The posterior face of centrum 30 is either damaged or very strongly distorted by the pathology as it is oriented at approximately 80° relative to the anterior face of the centrum 26. No caudal vertebrae more posterior than number 30 were found associated with the specimen. Thus, either the tail was bent, exhibiting a prominent 100° kink at approximately three quarters of its length, or it was truncated, immediately at the posterior end of the co-ossified mass. Similar pathologically co-ossified caudal vertebrae have been figured for other ceratopsids (TMP 1989.097.001 and TMP 98.93.77), possibly indicating a similar causal mechanism. Etiology of the pathology is however, difficult to determine, with possible causes including lateral crushing by conspecifics (trampling), collision with conspecifics or trees, truncation via predation, or disease.

Poster Session: Sunday, September 15, 1:30-2:20 pm

Lissamphibians and Squamates from the Upper Cretaceous (upper Campanian) El Gallo formation of Baja California, Mexico

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The El Gallo formation in Baja California, México, contains a moderately diverse, but still not well understood, non-marine assemblage of plants, invertebrates, and vertebrates dating from the Late Cretaceous (late Campanian and possibly "Edmontonian" equivalent). Historic collections made by the Los Angeles County Museum in the mid-1960s to mid-1970s and newer collections made by staff of the Universidad Nacional Autónoma de México and University of Washington from 2004 onwards, from multiple localities in the El Gallo formation, have yielded isolated, associated, and rare articulated lissamphibian and squamate bones. The lissamphibian component consists of the typical Late Cretaceous North American trio of anurans, caudates, and albanerpetontids. Bones currently available for the last two groups are uncommon and cannot be identified to lower taxonomic levels. Anurans are represented by larger numbers of skull and postcranial bones, with maxillae indicating the presence of two and, possibly, three taxa. So far the best documented squamate is the borioteiioid *Dicothodon bajaensis*, which is known by over a dozen jaws of different-sized individuals and at different ontogenetic stages, plus isolated teeth, skull fragments, vertebrae, and post-cranial material. Other squamates are represented by rare vertebrae of the primitive snake *Coniophis* and by larger numbers of vertebrae, jaws, and other skull elements pertaining to at least six additional taxa of lizards: Anguidae, *Contogenys*, *Exostinus*, *Odaxosaurus*, Varanoidea, and probable Chamopsiidae. The lissamphibian and squamate assemblage from the El Gallo formation helps fill a poorly sampled temporal interval for those groups in the North American record and its location in the southwestern portion of the continent makes it biographically interesting. Patterns of diversities and occurrences evident within the assemblage promise to refine our understanding of the evolutionary histories of lissamphibians, snakes, and lizards in western North America during the latter part of the Cretaceous.

Poster Session: Sunday, September 15, 1:30-2:20 pm

Accuracy of Measurements Collected from 3D Digital Models of Fossils

COCHRAN-BJERKE, Madigan M; South Dakota School of Mines and Technology, SD. PRICE, Maribeth; South Dakota School of Mines and Technology, SD. KEENAN, Sarah; South Dakota School of Mines and Technology, SD. JOHNSON, Roger; South Dakota School of Mines and Technology, SD.

High-resolution 3D digital models of fossil specimens can now be easily made and can be used to visually inspect and describe fossils. However, it is not known whether morphometric measurements made from such models are comparable to measurements made from the physical specimens. Fossil and model measurements are to be compared to test the accuracy of measurements collected from 3D digital models and to investigate the effects of user experience. The digital models were previously created using close-range photogrammetry techniques. Three measurements were identified for each model, ranging from easy to difficult based on the clarity of identifying landmarks. Volunteers of varying experience levels in collecting morphometric measurements will be recruited to collect measurements from both the models and the specimens in order to investigate the influence of experience level. The volunteers will be divided into two groups with comparable numbers of experienced and inexperienced individuals. The first group will collect the measurements from the specimens first and the second group will collect measurements from the models first in order to investigate whether or not handling the physical specimen prior to using its corresponding digital model has an effect on the measurements collected from the digital model. Results from one preliminary measurement session indicated that the average difference between physical and model measurements increases based on measurement difficulty. A t-test showed that 17 of the 21 measurements were statistically indistinguishable and four are not, with all volunteers identifying as having no experience in collecting morphometric measurements. Future analyses will utilize a 2-way ANOVA test to compare the means of measurements collected from the physical fossils and their corresponding 3D digital model.

Sunday, September 15, 2:40 pm
Analysis of the Masticatory Apparatus of Uintatherium anceps

CRUZ, Bob; Yale University, New Haven, CT

The Dinocerata is an extinct order of specialized herbivorous mammals who range from the Paleocene to the mid-Eocene of the Cenozoic. Migrating from Asia, they populated the North America Rocky Mountain region after the KPg extinction to become the largest land mammals of their time. They were also the first mammals to evolve distinctive head ornamentation, with 3 pairs of bony skull protuberances occurring in the earliest lines and large prominent bony skull knobs in the last members of the order. Both males and females had large saber-like incisors, with premolars and molars that tightly occluded (unlike any later herbivorous mammals). This research examines the jaw musculature and the dentition of the most commonly-occurring specimen, *Uintatherium anceps* of the early Eocene in order to evaluate feeding habits as well as consider possible reasons for extinction.

Saturday, September 14, 3:00 pm

Running on Empty: Investigating the Energetics of Theropod Predators and Community Structure of the Latest Cretaceous Frenchman Formation Ecosystem

DECECCHI, T Alexander, University of Pittsburgh Johnstown, Johnstown, PA. BAMFORTH, Emily, Royal Saskatchewan Museum T.rex Discovery Centre, Eastend, Sask. Canada. LARSSON, Hans CE, McGill University, Montreal, QC, Canada.

Top predators greatly influence community food webs. Their reach into the food web dictates many properties of ecosystem stability and dynamics. We bring these principles to begin estimating a well-studied terrestrial vertebrate community that lived immediately before the end-Cretaceous mass extinction. The community is in the Frenchman Formation of southern Saskatchewan, Canada. The large theropod, *Tyrannosaurus rex*, was clearly the top predator in this system. Starting with this taxon, we explore possible food web structures for the Frenchman Formation ecosystem. Reconstructions of large theropod hunting strategies have often been focused on maximizing extreme aspects of prey pursuit such as top speed or agility. Yet much of the daily energy budget for modern predators, especially those that target large vertebrate prey, is focused on search, stalking and low to medium speed pursuit. Here we incorporate these aspects, including shifting speed potential and foraging efficiency in terms of cost of transport across ontogeny, to determine realistic limiting factors impacting the foraging choices of large theropods dinosaurs in the Frenchman Formation ecosystem. We then compared this with speeds estimated for prey species such as the large ornithischians *Triceratops* and *Edmontosaurus* and smaller taxa such as *Thescelosaurus*, using both Froude and mass based reconstructions. We find that at all but the largest size class *Tyrannosaurus* would likely be faster and more agile than their prey, especially during the "teenage" years with masses between 2000-3000kg. Given the suggested pack hunting in tyrannosaurids and how modern pack hunters can capture prey items even if they do have a higher top speed through strategic such as communication between members of the pack, we suggest that maximizing speed would be of little advantage to *Tyrannosaurus*. As a result of the pronounced growth spurt in *Tyrannosaurus* in their "teen" years, this taxon soon reaches sizes where maximum speed is controlled by mass not leg length. This is unlike albertosaurines which do not show a strongly significant relationship between femoral circumference and hindlimb length as well as a much lesser increase in relative femoral circumference versus length. The growth spurt would have pushed *Tyrannosaurus* out of the zone where leg length helps with prey pursuit and into the range where it helps with energy savings quite quickly. We propose it's not the short periods of high speed chase that define the predation patterns seen in the latest Cretaceous ecosystems, but energetic efficiency over the longer periods of search and stalking matter when reconstructing the paleobiology of the top predators. The hypothesized food web reconstruction thus places deep reaches of *Tyrannosaurus* into the Frenchman Formation ecosystem. Such generalist predatory strategies are recognized as stabilizing factors in ecosystem stability suggesting the waning days of this dinosaur community were not particularly susceptible to ecosystem failure, placing more emphasis on a catastrophic cause for the end Cretaceous mass extinction.

Saturday, September 14, 10:25 am

New Paleogene Fossils from the Western USA Document a New Paleocene Species and Temporal Range Extension into the Eocene for the Sirenid Salamander Habrosaurus

DEMAR, David G, Jr, National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA; GARDNER, James D, Royal Tyrrell Museum of Palaeontology, Drumheller, Alberta, Canada

Habrosaurus is the oldest unequivocal, named genus of the paedomorphic eel-like salamander family Sirenidae and has a documented temporal record spanning the latter half of the Late Cretaceous and into the early Paleogene. Two named and one indeterminate species are known only from the Western Interior of North America, with largely non-overlapping temporal ranges. These include the nominal species *H. dilatus* (late Maastrichtian–middle Paleocene), *H. prodilatus* (middle Campanian–late Maastrichtian), and an indeterminate species of *Habrosaurus* (Santonian) identified on the basis of non-species-diagnostic atlantal centra. Differences in overall dental morphology, crown form, and degree and position of wear facets of the marginal teeth separate the two named species: *H. prodilatus* has chisel-like teeth exhibiting minimal wear, whereas *H. dilatus* has stout teeth with bulbous crowns that often show extensive occlusal wear. Here we report a new species of *Habrosaurus* from the lower Paleocene Tullock Formation, northeastern Montana, USA, represented by an incomplete left dentary with a unique dentition. The three preserved teeth are pristine and resemble those of *H. dilatus* and *H. prodilatus* in being non-pedicellate and having a constricted neck between the crown and shaft. However, the crowns principally differ from those of the named species as follows: i) incipiently mesiodistally tricuspid and labiolingually compressed, with a shallow, diamond-shaped lingual "basin" and a broadly rounded labial face; ii) covered in a thin distinct layer of semi-translucent enamel, with a sharp crest that extends mesiodistally across the occlusal surface; iii) mesially and distally, the crest extends basally a short distance onto the lingual face of the crown; and iv) wear facets poorly developed and restricted to the occlusal crest. Differences in the marginal dentition of these three diagnosable species of *Habrosaurus* imply successive shifts in feeding strategies from the Campanian to Maastrichtian and across the Cretaceous-Paleogene boundary, with the latter possibly being an ecomorphological response to the end-Cretaceous mass extinction.

Additionally, discovery of an atlantal centrum diagnostic of *Habrosaurus* from the Bridger Formation, southwestern Wyoming, USA, extends the known temporal range of the genus from the middle Paleocene forward into the middle Eocene. Thus, *Habrosaurus* overlapped in time and space with *Siren dunni*, the geologically oldest species of a modern sirenid genus.

Poster Session: Sunday, September 15, 1:30-2:20 pm

Newly Recognized Specimens from the White River Formation (Eocene/Oligocene) Represent Wyoming's Last Crocodyliforms

FARKE, Andrew A.; Raymond M. Alf Museum of Paleontology at The Webb Schools, Claremont, CA. CHAI, Benjamin; The Webb Schools, Claremont, CA. GERARD, Isabel; The Webb Schools, Claremont, CA. GRAF, Peter; The Webb Schools, Claremont, CA. HUEN, Alex Chun Ting; The Webb Schools, Claremont, CA. ZHANG, Shuwen; The Webb Schools, Claremont, CA.

Despite their current absence, crocodyliforms have a deep geological history in the Great Plains region of North America. The ebb and flow of their distribution is an important indicator of long-term environmental change and biogeographic corridors, and even fragmentary material provides crucial data points. The White River sequence of Nebraska, Wyoming, North Dakota, South Dakota, and Colorado preserves an exquisite faunal assemblage spanning the Eocene/Oligocene boundary. Among these fossils, the oldest definitive *Alligator* (*A. prenasalis*) is represented by numerous individuals from the Chadron and Brule formations in South Dakota and probably also Nebraska. In contrast, crocodyliform material from the White River Formation of Wyoming is extremely poorly known. Isolated elements have been mentioned in the literature, but not described, from the Yoder Member of the White River Formation in Goshen County (housed at SDSM, Museum of Geology, South Dakota School of Mines & Technology, and MCZ, Museum of Comparative Zoology, Harvard University). Spurred by the recognition of additional material in the collections of the Raymond M. Alf Museum of Paleontology (RAM), we surveyed all known crocodyliform fossils from the White River Formation of Wyoming.

Most material originates in the Yoder Member, representing isolated dorsal osteoderms (SDSM 6346, a single osteoderm; SDSM 53298, three unassociated osteoderms). Vertebrae reported by Schlaikjer cannot be located at the MCZ. Based on biostratigraphy, the Yoder fossils are probably early or mid-Chadronian in age (~35 Ma). A scrappy but associated specimen (RAM 24130) was collected within the Brule Member of the White River Formation in Niobrara County, Wyoming. It includes teeth with roots, cranial bone fragments, a vertebral fragment, and osteoderms. Teeth range in shape from conical to globidont, and the size of all of the elements is consistent with a small individual (<1.5 m body length). Unfortunately, none of the material includes synapomorphies that constrain the fossils beyond Crocodyliformes, although they are morphologically consistent with *Alligator prenasalis* material from South Dakota. The locality hosting RAM 24130 is likely early Orellan (~33.9 Ma), and thus represents the youngest known crocodyliform from the state of Wyoming. Compared with time-equivalent beds in South Dakota and Nebraska, crocodyliform material is vanishingly rare in Wyoming, which may reflect regional environmental differences.

Poster Session: Sunday, September 15, 1:30-2:20 pm

Preliminary Results of Possible in Situ Turtle Eggs in the Kaiparowits Formation, Grand Staircase-Escalante National Monument, Utah

FERGUSON, Ashley L.; Idaho State University, Pocatello, ID

The Upper Cretaceous continental deposits recorded by the Kaiparowits Formation are richly fossiliferous in amniotes, including turtles, crocodilians, lizards, and many dinosaur species. However, to date, very little has been published or presented on fossil eggs in these deposits. Currently, the only eggs that have been described and published from the Kaiparowits belong to a gravid *Adocus*. Here, I present evidence of in situ partial eggs tentatively identified as turtle. The eggshell was found in 2017 in the informal middle unit of the Kaiparowits Formation within a green mudstone. The gastropods *Lioplacodes* and *Viviparus* are common in the mudstone and a theropod tooth was also found in association with the eggshell. The eggshell fragments were spread over an area of three-square meters. At least seven eggs have been identified, with more yet to be prepped. Exposed partial eggs indicate that the eggs likely have a spherical morphology of approximately 3-4 cm in diameter. The eggshell is extremely porous, suggesting incubation by burial, and lacks surface ornamentation. The curvature, porosity, and lack of surface ornamentation of the egg is typical of turtle eggs. Counts of the eggshell fragments produce a ratio of 61:39 concave up to concave down eggshell, consistent with in situ preservation. Future work will include scanning electron microscopy, computed tomography, thin sections, and further preparation of the specimens to identify the ootaxa, verify the taxonomic identification, and describe the taphonomy of the site in more detail.

Funding for this work is provided by the Bureau of Land Management No. L17AC00095 to Leif Tapanila.

Poster Session: Sunday, September 15, 1:30-2:20 pm

Preliminary Results of the First Avian Eggs and Possible Clutches in the Bridger Formation, Wyoming

FERGUSON, Ashley L.; Idaho State University, Pocatello, ID. MCGREGOR, Douglas; Idaho State University, Pocatello, ID.

Avian eggs and nests in the fossil record are rare, particularly when compared to their non-avian ancestors. Currently, the record of avian nesting in the Paleogene is limited, with only three documented eggs and a possible nesting locality worldwide. Locating and describing eggs and nests from the Paleogene is crucial to understanding when the diversity of nesting behaviors in birds arose. Here, we describe preliminary results of the first partial avian eggs discovered in the Eocene Bridger Formation. The eggs were discovered in 2017 in the upper Blacks Fork Member in a gray siltstone. Steinkerns of unionid bivalves occur just below the locality in a gray lithic arenite. Two concentrations of eggs and eggshell were located approximately 25 cm apart. The first concentration contained four partial eggs with additional eggs and the second concentration contains several eggs as well. Both need to be prepared. A radial thin section of the eggshell confirms an ornithoid basic type. Counts of eggshell fragments produce a ratio of 55:45 concave up to concave down eggshell consistent with in situ preservation of the eggs. Future work will include scanning electron microscopy, computed tomography, further thin section analysis and preparation of the specimens.

Saturday, September 14, 11:05 am

The Horned Dinosaur Leptoceratops (Ornithischia: Neoceratopsia) Raised its Young in Communal Nesting Burrows: Evidence from Three New Bonebeds in the Hell Creek Formation (Maastrichtian, Late Cretaceous), Montana

FOWLER, Denver W; Badlands Dinosaur Museum, Dickinson, ND. WILSON, John P; Bozeman, MT. FREEDMAN FOWLER, Elizabeth A; Dickinson State University, Dickinson, ND. HORNER, John R; Chapman University, CA.

In over 100 years of collecting in the Maastrichtian of North America, only 11 specimens of the rare neoceratopsian dinosaur *Leptoceratops* have been reported, of which only one skull, one postcranium, and two teeth have been reported from outside of Alberta.

Here we report the discovery of three new *Leptoceratops* bonebeds in the Hell Creek Formation of Montana. The first site records two partial skeletons of adult *Leptoceratops* preserved articulated in 3D, standing upright in a bentonitic mudstone. Further excavation led to recovery of 252 additional elements, 95% of which are referable to *Leptoceratops*. This includes 117 teeth, mostly juvenile sized with many bearing roots (indicating origination from dead individuals rather than being shed teeth), and a probable associated fragmentary skeleton ~1/3 adult length. Although these in situ remains were initially considered as a miring event, the site is now hypothesized to represent a communal nesting burrow, with the adult specimens buried during burrow collapses. The relatively uniform distribution of juvenile teeth and other remains suggests that the same location was used over many generations, with the remains of multiple broods being evenly reworked into the sediment. A second, more areally limited site ~ 100m SE of Site1 and in the same bentonite horizon, also preserves juvenile and adult remains, suggesting the paleosurface was locally inhabited extensively by *Leptoceratops*, perhaps forming large communal burrow systems like extant prairie dogs. A third monodominant *Leptoceratops* bonebed ~ 100km NW, similarly exhibits many juvenile remains, including hatchling sized teeth and cranial bones, and three associated multituberculate teeth, suggesting that mammals might have contemporaneously burrowed into the same land surface, perhaps even sharing *Leptoceratops* burrows. Theropod shed teeth at Site1 and 3 suggest that the burrow horizons were frequented by predators.

The bentonite preserves root traces and insect burrows supporting interpretation as a paleosol. In parts of the bone-bearing layer, fine grained sandstone directly contacts the bentonite with rip-up fragments at its base, consistent with burrow infill reported at other dinosaur burrows. All sites were located in the lower third of the Hell Creek Formation, where the environment is hypothesized to represent a low-accommodation, better drained setting, more accommodating for burrowing organisms than the more swampy conditions of the upper Hell Creek, from which *Leptoceratops* remains are not recorded.

Funding kindly provided by the American Prairie Foundation, Nathan Mhyrvold, and the Evolving Earth Foundation. Fieldwork permits granted by the Bureau of Land Management and the state of Montana.

Saturday, September 14, 1:40 pm

"Warwick's Duck", an Exceptional Specimen of Edmontosaurus (Dinosauria: Hadrosauridae) with Extensive Caudal Neural Spine Pathologies: Evidence of Mating Injuries in Hadrosaurs?

FREEDMAN FOWLER, Elizabeth A; Dickinson State University, Dickinson, ND. FOWLER, Denver W; Badlands Dinosaur Museum, Dickinson, ND.

Pathologic neural spines have been noted in many specimens of hadrosaurid dinosaurs, which are abundant in Late Cretaceous units, offering a large sample for ecological analysis. Here we describe MOR 3003, a specimen of the Maastrichtian hadrosaurid *Edmontosaurus* (Hell Creek Formation, Montana) which is exceptional in the extent of the injuries to its caudal neural spines. The otherwise fragmentary skeleton includes 18 articulated and 26 disarticulated caudal vertebrae, which together form a near complete proximal caudal series. Of 42 preserved neural spines, only 3 are not pathological; 23 exhibit healed but displaced fractures and fracture calluses; and the remaining 16 preserve exostoses, remodeled surfaces and/or significant lateral warping. In 19 neural spines, the dorsalmost 5-10 cm have been broken and pushed down 1-6 cm to the left lateral side. Some of these neural spines exhibit a crushing fracture in which the dorsal tip is split vertically, sliding downward over both lateral surfaces of the remaining ventral part of the spine (similarly observed in a second new hadrosaurid specimen, BDM 003 from the Campanian Judith River Formation, Montana). Two adjacent neural spines are truncated approximately halfway, with the dorsal ends completely missing (hypothesized to have been resorbed in life), and the broken dorsal surface heavily remodeled. This truncation is comparable to a previously published *Edmontosaurus* specimen (DMNH 1493) which exhibits three truncated caudal neural spines in a similar serial position.

Pathologies of caudal and dorsal neural spines are commonly observed in large bodied ornithopod dinosaurs, suggesting that their ecology or bauplan may predispose them to this kind of injury. In the case of DMNH 1493, it was suggested that the neural spines might have been bitten off by a tyrannosaur. However, MOR 3003 and BDM 003 show consistent injuries over such a long section of the tail (as many as 23-39 neural spines) that a biting attack seems implausible. A lateral impact is also considered an unlikely cause as there is no damage to centra or chevrons. The pathology is most consistent with a strong impact onto the dorsal margin of the tail, perhaps being caused by a falling object. However, we consider it more plausible that these injuries were caused during mating, with the position of the injuries consistent with a male pressing down on to the female's dorsal and caudal neural spines while mounting. This hypothesis makes the potentially testable prediction that all individuals bearing these pathologies would be female.

Funding kindly provided by the Smithsonian Institution through Jack Horner. Fieldwork permits granted by U.S. Fish and Wildlife.

Sunday, September 15, 4:25 pm

Dissecting Dinosaur Pellets? Taphonomy of Modern Raptor and Carnivore Gastric Pellets Guides the Identification of Fossil Feeding Traces at Egg Mountain, a Dinosaur Nesting Site

FREIMUTH, William J.; Montana State University, Bozeman, MT. VARRICCHIO, David J.; Montana State University, Bozeman, MT.

Modern birds of prey (raptors), crocodilians, monitor lizards, snakes, and mammals are all terrestrial organisms that routinely regurgitate gastric pellets comprised of indigestible remains of prey items (typically bone and teeth). Despite the ubiquity of pellets in extant organisms, the fossil record of gastric pellets is sparse, particularly in Mesozoic terrestrial deposits. Those pellets that have been identified in the fossil record conform to the taphonomic characteristics of modern raptor pellets.

We describe two novel instances of potential gastric pellets and/or prey processing locales from Egg Mountain, a dinosaur nesting locality of the Upper Cretaceous Two Medicine Formation of Montana. The first amalgamation consists of a minimum of three individual metatherians (*Alphadon*) based on three pairs of disarticulated maxillae. In total, 70% of identifiable elements are cranial. A second amalgamation comprises a minimum of eight *Alphadon* and one lizard skull. Of the represented elements, 85% are cranial, including 29 dentary fragments (minimum of 13 dentaries), 12 maxillary fragments (minimum 11 maxillae), two braincases, and nine long bone shafts. Element breakage is sharp and terminated by matrix, indicative of pre-fossilization modification. The skewed distribution of cranial and tooth-bearing elements along with fragmentary long bone shafts resembles the distribution observed in modern raptor and carnivore pellets and contrasts element representation typical of hydraulic sorting. The size and composition of the amalgamations and their co-occurrence with two theropod egg types (*Troodon* and *Continuoolithus*) and shed teeth suggests producers were small theropods (e.g., *Troodon* or dromaeosaurids), though other potential producers (e.g., the large varanoid lizard, *Palaeosaniwa*) cannot be confidently excluded. Regardless, these feeding traces provide evidence for predation on marsupials and ecological activity at a dinosaur nesting site.

Poster Session: Sunday, September 15, 1:30-2:20 pm

A New Occurrence of a Shark Bitten Pterosaur Wing Bone and A Dromaeosaur Tooth From the Carlile Shale (Turonian) of Milbank, South Dakota

HANKS, H. Douglas; Science Museum of Minnesota, Saint Paul, MN. WESTGAARD, John; Minnesota Discovery Center, Chisholm, MN. HASTINGS, Alexander K; Science Museum of Minnesota, Saint Paul, MN

Research by the Science Museum of Minnesota from 1975-2014 produced numerous shark, plesiosaur, turtle, bony fish fossils and fragments of dinosaur teeth. Noteworthy among these specimens are a pterosaur wing bone with evidence of scavenging by the Cretaceous shark *Squalicorax*. Also present was a single dromaeosaur tooth which represents an isolated occurrence of this dinosaur along the Eastern margin of the Cretaceous Inland Sea in this area. Both specimens help to reconstruct the paleoenvironment of the Late Cretaceous of this area.

Saturday, September 14, 9:20 am

Updates to the Dinosaur Fauna of the Late Cretaceous Coleraine Formation (Cenomanian) in Central and Northern Minnesota

HANKS, H. Douglas; Science Museum of Minnesota, Saint Paul, MN. WESTGAARD, John; Minnesota Discovery Center, Chisholm, MN. HASTINGS, Alexander K; Science Museum of Minnesota, Saint Paul, MN

Dinosaur fossils remain rare and unreported in Minnesota with the exception of a single weathered centrum of a Hadrosaur found in Crow Wing County in 1972. Until recently this was the only known dinosaur specimen documented in the state. Current research in the last 15 years has added to the dinosaurian fauna of Minnesota. These specimens include a dromaeosaur ungual, a dromaeosaur tooth, a vertebral process of a non-crocodilian archosaur and numerous bone fragments. These specimens were found at the Hill-Annex Mine in Cretaceous stockpiles removed by open pit mining operations from 1913 to 1945. Further research should produce additional specimens in adjoining stockpiles and newer areas.

Sunday, September 15, 10:00 am

New Records of Marine Reptiles from the Late Cretaceous of Minnesota

HASTINGS, Alexander K.; Science Museum of Minnesota, Saint Paul, MN. WESTGAARD, John; Minnesota Discovery Center, Chisholm, MN. HANKS, H. Douglas; Science Museum of Minnesota, Saint Paul, MN.

Broad exposures of fossiliferous deposits from the Cretaceous Western Interior Seaway span across much of the Great Plains. However, the upper Midwest has very limited exposure. As a result of decades of iron mining in the Mesabi Range of northern Minnesota, Cretaceous-aged sediment was deposited at the surface as mining spoil. Numerous fossils have been recovered from these sizable deposits, pertaining to the Coleraine Formation (Cenomanian). Most fossils are shelled invertebrates, but a handful of bones begin to paint a larger picture of the ancient ecosystem. These are cataloged at the Science Museum of Minnesota (SMM) and the Minnesota Discovery Center.

Vertebrae, teeth, and potential limb bones recovered from the Hill Annex State Park in Calumet, Minnesota, reveal the presence of elasmosaurid marine reptiles. Isolated vertebrae from the cervical and dorsal regions measure 6.0–7.0 cm (centrum length), and exhibit fully fused neurocentral sutures, which suggest they were fairly mature individuals. Comparison to a nearly complete sub-adult *Elasmosaurus* exhibits much larger centra for these regions (9.9–10.7 cm). These suggest a much smaller relative was present in the northeastern shores of the ancient seaway, where water was much shallower than the Great Plains. Isolated teeth and potential limb bones likewise reflect relatively small body size.

Remains of sea turtles have also been recovered from the same area. Multiple fragments of costal bones from the carapace exhibit the shallow pitting characteristic of soft-shelled toxochelyid turtles. Toxochelyids have been previously reported in the seaway, but from more open-water deposits. A partial limb bone, however, seems most consistent with the left humerus of *Protostega*, suggesting the presence of at least two forms of sea turtle in Minnesota.

Numerous teeth of crocodylomorphs have been recovered as well. These often exhibit well-developed carinae as well as subtle fluting on both lingual and buccal surfaces. The teeth are notably recurved and form an acute apex. These teeth likely belong to the same taxon as an anterior snout recovered in 1967, *Terminonaris robusta*. This specimen (SMM P68.56.1) was initially designated as the holotype of the species *Teleorhinus mesabiensis*, but was synonymized in 2001.

Fieldwork continues each summer at the Hill Annex State Park and surrounding areas of northern Minnesota. In time, more complete material will likely be recovered to help identify which reptilian species were present in the warm coastal environment of Minnesota during the Late Cretaceous.

Saturday, September 14, 8:40 am

Growing Taxonomic Diversity of the mid-Cretaceous (late Albian-Cenomanian) Wayan Formation Vertebrate Assemblage of Idaho

KRUMENACKER, L. J., Idaho Museum of Natural History and Department of Geosciences, Idaho State University, Pocatello, ID. AVRAHAMI, Haviv, North Carolina Museum of Natural Sciences and Department of Biological Sciences, North Carolina State University, Raleigh, NC. IRMIS, Randall, Natural History Museum of Utah, University of Utah, Salt Lake City, UT. KIRKLAND, James I., Utah Geological Survey, Salt Lake City, UT. WEAVER, Lucas, Biology Department, University of Washington, Seattle, WA. WILSON, Gregory P., Burke Museum, University of Washington, Seattle, WA. ZANNO, Lindsay, North Carolina Museum of Natural Sciences and Department of Biological Sciences, North Carolina State University, Raleigh, NC

Previous sampling of the vertebrate assemblage of the mid-Cretaceous (late Albian-Cenomanian) Wayan Formation of eastern Idaho suggests a low taxonomic diversity, with the majority of fossil remains belonging to either eggshell assignable to *Macroelongatoolithus carleylei* (representing a giant oviraptorosaurian theropod) or skeletal elements of the burrowing orodromine neornithischian *Oryctodromeus cubicularis*. Collaborative work has demonstrated the presence of numerous new taxonomic records that are now undergoing preparation and description. A partial skeleton, consisting of dorsal and caudal vertebrae, limb elements, and armor elements represents a small nodosaurid ankylosaurian of as-yet uncertain affinities. A hadrosauroid of indeterminate affinities is known from very fragmentary associated vertebrae and a dentary fragment. A small tyrannosauroid, similar to *Moros intrepidus* from the Mussentuchit Member of the Cedar Mountain Formation in Utah, is known from a partial femur. Crocodyliforms include the partial skull of a large neosuchian similar to *Deltasuchus* from the Woodbine Formation in Texas, and a braincase of an as-yet unidentified diminutive taxon. At least four multituberculate mammal taxa are known from isolated teeth, including a new species of *Cimolodon*, representing the oldest known occurrence of the genus. Dental remains of metatherian and eutriconodont mammals have also been recovered from the Wayan and are currently undergoing description.

Paleobiota of the Wayan is most similar to that of the Cenomanian (98-96 Myr) Mussentuchit Member of the Cedar Mountain Formation. Both assemblages preserve an atypical abundance of eggshell referable to partially buried clutches and fossorial vertebrate remains, which may reflect an ecological signal and/or taphonomic biases operative in the upland monsoonal paleoenvironment. The presence of orodromine, caenagnathid, nodosaurid, tyrannosauroid, and hadrosauroid dinosaurs, neosuchian crocodyliforms, and multituberculate and metatherian mammals reflect the typical faunal components of later Late Cretaceous Laramidian assemblages, making the Wayan specimens integral in documenting the rise of typical Late Cretaceous faunas.

Poster Session: Sunday, September 15, 1:30-2:20 pm

Scavengers, Predators and Dinosaurs of the Bearpaw Formation of Alberta

LAFRAMBOISE, Marilyn C.; Royal Tyrrell Museum of Palaeontology, Drumheller, AB

The Bearpaw Formation (74-71 ma) is an extensive marine unit deposited during the last transgressive cycle of the epicontinental Western Interior Seaway. The Bearpaw Formation extends from immediately northeast of Edmonton, Alberta southward in ever thickening intervals to northern Montana, and outcrops as far east as southwest Saskatchewan. In southern Alberta the Bearpaw Formation is wedged between the overlying mostly non-marine St. Mary and Horseshoe Canyon Formations and the underlying non-marine Belly River Group. The Bearpaw along the St. Mary River near Lethbridge, Alberta is primarily laminated shale and siltstone with sandstone beds and kaolinitic claystone. Ammonite mining along the St. Mary River has exposed the Bearpaw Formation with particularly fossiliferous layers known as the Muddy Unit 1 or Baculites compressus Zone (4). The top of this unit has a distinct volcanic ash layer called the 10" (25 cm) Bentonite layer, and the underlying Lethbridge Coal Zone (Belly River Group) have been used to measure the vertical position of vertebrate remains.

The selection of scavengers, predators and dinosaurs of the Muddy Unit 1 presented here indicates a complex near shore habitat. Both exceptionally preserved mosasaurs and plesiosaurs are found to be biostratigraphically separate and equivalent plus both apex predators show scavenging by sharks. Stomach contents include turtles and fish including the much under studies *Enchodus*. Two partial skeletons of *Prosaurolophus* and theropod skull elements can be correlated to the same biostratigraphic level as two mosasaurs with signs of scavenging although the dinosaurs show none.

This important site can be useful in future research to correlate this particular bentonite signature in Bearpaw exposures in southeast Alberta and southwest Saskatchewan by the presence or absence of scavengers, predators and dinosaurs.

Sunday, September 15, 3:40 pm

Using ARCGIS Online (AGOL) to Greatly Improve the Documentation of Paleontological Resources

LIGGETT, Gregory A; Bureau of Land Management, Montana State Office, Billings, MT

The Bureau of Land Management (BLM), the agency managing the most public land, is tasked with managing paleontological resources, both in the field and after their collection.

An important aspect of this is maintaining data systems related to paleontological localities, however there presently is no national data standard or system to use. Most often, fossil localities are reported to BLM by permitted researchers or consultants. As part of the reporting requirements for their permits, they are to provide a completed locality form and a map at 24k scale or higher for each locality. The information on the paper forms is then translated into a BLM state-specific system, with many potentials for error in the data, such as: transcription errors occur when filling out the forms from field notes; carelessness of plotting maps, or not including maps with enough resolution; and errors of BLM staff in trying to translate locality forms into our own systems. Clearly, this situation is ripe for improvement.

In anticipation of a coming national solution to this issue through a program called RAPTOR, the MT/DKs BLM developed a prototype application built on AGOL, Collector, and Survey123. This prototype will be tested during the 2019 field season by recruited researchers and a contractor, utilizing the Geoplatform environment. A web map was developed that includes a feature service to collect data from four Survey123 forms. The four forms are the following: 1) Locality Information (basic information about the locality); 2) Locality Visit (information about the specific visit to the locality, since they can be visited multiple times over multiple years); 3) Locality Documents (to capture pictures or other documentation); and 4) Areas Surveyed (to record where the crews surveyed for localities, including where they didn't find localities). Utilizing mobile technology, the permittees will be able to record their new localities in the field, recording the required data through form interaction, and push that data directly to the BLM feature service on the fly.

This new process frees up users' time by having the most labor-intensive part of their required reporting finished when they leave the field. And BLM gets reliable data without the need to enter it manually. The prototype will greatly inform our needs for developing the fully national system in RAPTOR. The paleontology portion of RAPTOR is anticipated to begin in the fall of 2019, with locality modules being developed sometime after that, so the summer 2019 data collection provides an excellent test case.

Saturday, September 14, 1:20 pm

A New Crested Brachylophosaurin (Dinosauria: Hadrosauridae) from the Upper Cretaceous Menefee Formation of New Mexico and Judith River Formation of Montana

MCDONALD, Andrew T; Western Science Center, Hemet, CA, USA. WOLFE, Douglas G; Zuni Dinosaur Institute for Geosciences, Springerville, AZ, USA. FREEDMAN FOWLER, Elizabeth A; Dickinson State University, Dickinson, ND, USA.

The lower – middle Campanian Menefee Formation forms extensive badlands in the San Juan Basin of New Mexico, but apart from the partial skeleton of a centrosaurine reported in 1997, the unit's dinosaurs are fragmentary. New discoveries by an ongoing project conducted by Western Science Center (WSC) and Zuni Dinosaur Institute for Geosciences, with volunteers from Southwest Paleontological Society, are fleshing out the dinosaur assemblage, including the new nodosaurid *Invictarx* and tyrannosaurid *Dynamoterror* described in 2018.

WSC 10058, the partial skull and right forelimb of a large hadrosaurid, was collected in the upper Allison Member on BLM land in 2018. Based upon quadrate height, the skull is 98% the size of Museum of the Rockies (MOR) 794, an adult-sized *Brachylophosaurus* skull. Phylogenetic analysis places WSC 10058 in Brachylophosaurini, forming a trichotomy with *Probrachylophosaurus* and *Brachylophosaurus*, with *Maiasaura* and *Acristavus* as successive outgroups.

WSC 10058 shares with *P. bergei* and *B. canadensis* a corrugated nasofrontal suture that extends caudally onto the dorsal surface of the frontals. The nasofrontal suture of WSC 10058 extends farther caudally than in the ontogenetically mature holotype of *P. bergei*, but not as far as in adult-sized *B. canadensis*, in which the suture covers the entire dorsal surface of the frontals. The suture of WSC 10058 is also distinctive in forming an elevated concave ramp along the midline and ending caudally in two parasagittal bumps.

MOR 6636, an isolated brachylophosaurin right nasal from the lower Judith River Formation (= lower Oldman Formation, 24 m above the Marker A coal of the Taber Coal Zone) in Kennedy Coulee, Montana, mirrors the nasofrontal suture of WSC 10058, with a convex ventral surface ending in a deep parasagittal pit. MOR 6636 was 3D-printed at WSC and fits closely onto the frontals of WSC 10058, suggesting the two specimens might pertain to the same taxon. MOR 6636 was collected at least 6 m higher than the holotype of *P. bergei* and lower than specimens of *B. canadensis*. Its nasal crest is longer than the short wedge-shaped crest of *P. bergei*, but shorter than the elongated paddle-shaped crest of *B. canadensis*.

If WSC 10058 and MOR 6636 represent the same new genus and species of brachylophosaurin, morphologically and stratigraphically intermediate between *P. bergei* and *B. canadensis*, then it might help constrain the age of the upper Allison Member to between 79.2 Ma (based on *P. bergei* and MOR 6636) and 78.5 Ma (based on *Baculites perplexus* in the Cliff House Sandstone, overlying the Menefee).

Sunday, September 15, 4:05 pm

Filling Gaps in the Amber Record and Adding Facets to Bonebed Palaeoecology: Upper Cretaceous and Paleocene Amber Deposits from Western Canada

MCKELLAR, Ryan C; Royal Saskatchewan Museum, Regina, SK. COCKX, Pierre; University of Regina, Regina, SK, Canada.

The Upper Cretaceous rocks of North America have provided diverse amber assemblages from famous sites such as Grassy Lake, Alberta (Campanian, 'Canadian amber'), and New Jersey (Turonian, Raritan amber). However, these deposits represent disparate ecological settings separated by millions of years, which limits our ability to make faunal comparisons or assess diversity through time. Furthermore, few diverse amber deposits are known globally between the Campanian and the Eocene, limiting our understanding of how terrestrial arthropods responded to the end Cretaceous extinction event. Recent fieldwork efforts in the western Canadian provinces and adjacent states of the USA have resulted in the discovery of numerous fragile amber deposits that fill in this key time interval. These deposits are beginning to produce significant numbers of insect inclusions, yielding new species and providing palaeoecological information. The amber itself can also be analyzed to assess which groups of trees produced the fossil resin (using FTIR spectroscopy or GC-MS techniques) and what conditions the trees were living under (using stable isotope analyses of carbon to assess plant stress, and hydrogen for local precipitation patterns). When insect inclusions are combined with amber chemistry and composition analyses, these new deposits provide detailed snapshots of ancient forests, including a rare opportunity to observe soft tissue preservation and soft-bodied organisms. In terms of Canadian discoveries, new deposits have been found in the Upper Cretaceous and Paleocene rocks of Saskatchewan: the Campanian Foremost, Oldman, Dinosaur Park, and Bearpaw formations; the Maastrichtian Eastend and Frenchman formations; and the Paleocene Ravenscrag Formation. The Upper Cretaceous of Alberta has also been productive, with material coming from: the Campanian to Maastrichtian Foremost, Dinosaur Park, Horseshoe Canyon, and Scollard formations, and the Wapiti Group. Together, these deposits provide a sporadic amber record throughout the latter part of the Cretaceous and into the Paleocene. This provides detailed information from a warm temperate ecosystem that was variably influenced by the Western Interior Seaway, with some deposits extending coverage into high latitudes. Many of these deposits have been found within or adjacent to dinosaur bonebeds, providing a new source of information on the surrounding habitats.

Acknowledgements: Funding provided by NSERC Discovery Grant (R.M. and P.C.), and RSM Scholarship (P.C.).

Saturday, September 14, 9:00 am

At the Crossroads of the Cretaceous: The Woodbine Group and Understanding the Evolution of Appalachian Continental Ecosystems in the Late Cretaceous

NOTO, Christopher R; University of Wisconsin-Parkside, Kenosha, WI. ADAMS, Thomas L; Witte Museum, San Antonio, TX. DRUMHELLER, Stephanie K; University of Tennessee-Knoxville. ADRIAN, Brent; Midwestern University, Glendale, AZ. SMITH, Heather F; Midwestern University, Glendale, AZ. GROSSMAN, Ari; Midwestern University, Glendale, AZ.

The most extensive records of Cretaceous terrestrial and near-coastal vertebrate fossils in North America occur in Lower Cretaceous (Aptian-Albian) and Upper Cretaceous (Campanian-Maastrichtian) strata. The intervening 20 million years (Cenomanian-Santonian) separating these records spans a period of major faunal turnover that remains poorly known. To date, almost all fossils documenting this transition derive from Laramidia while Appalachian fossils remain scarce. One Appalachian fossil assemblage, from the Woodbine Group of north-central Texas, provides important information about the middle-late Cenomanian continental ecosystems of Appalachia early in this transition. The Woodbine assemblage contains over 40 vertebrate taxa including sharks, bony fishes, lungfish, turtles, snakes, amphibians, mammals, crocodyliforms, birds, and dinosaurs, as well as plants and invertebrates, from multiple localities deposited within an extensive deltaic system. Predatory species include four crocodyliforms, several aquatic turtles representing multiple ecomorphs, and a large size range of theropods including an allosauroid, tyrannosauroid, dromaeosaurid, troodontid, and caenagnathid. Herbivores are less diverse, represented only by the large-bodied hadrosauroid *Protohadros* and an early nanhsiungchelyid turtle. The Woodbine fauna provides the first record of multiple taxa on Appalachia. This assemblage is similar both in terms of ecological diversity and taxonomic composition to contemporaneous deposits in Laramidia, sharing multiple, phylogenetically close relatives. These links support the presence of a more cosmopolitan North American fauna shared between the two landmasses prior to completion of the Western Interior Seaway (WIS). The Woodbine faunal assemblage mixes Late Jurassic and Early Cretaceous groups with basal representatives of Late Cretaceous communities. The assemblage combines Laurasian and Gondwanan forms, Asian and European migrants, and endemic taxa. Preliminary work shows a faunal transition similar to Laramidia was underway in Appalachia by the middle Cenomanian, likely starting before the WIS was complete. However, adaptations by taxa of the Woodbine suggest a unique response to changes in local conditions created by the separation of Larimidia and Appalachia, leading to the evolution of divergent faunas on either side of the recently completed WIS.

Poster Session: Sunday, September 15, 1:30-2:20 pm

Hydrodynamic Transport Potential of Modeled Turtle Shell in a Controlled Fluvial Setting: a Case Study in Experimental Taphonomy

NOTO, Christopher R; Department of Biological Sciences, University of Wisconsin Parkside, Kenosha, WI. PETERSON, Joseph E; Department of Geology, University of Wisconsin Oshkosh, Oshkosh, WI. ACOSTA, Melissa; Department of Biological Sciences, University of Wisconsin Parkside, Kenosha, WI.

The Arlington Archosaur Site (AAS) is a fossil locality located in an urban area between Fort Worth and Dallas, Texas. The AAS contains a diverse array of Woodbine Group (~96 mya) fossils of many different vertebrate, invertebrate, and plant species. Evidence suggests most AAS fossils were deposited in a low-energy freshwater or brackish environment, such as a tidal coastal wetland. However, questions remain as to the nature of the depositional environment that originally created the site. Among the most abundant remains scattered throughout the site are whole and fragmented pieces of turtle shell (both carapace and plastron) of a variety of sizes. Shell pieces exhibit a diversity of preservation states from complete pieces to small, eroded fragments. To test the hypothesized processes of turtle shell deposition at the AAS, a series of taphonomic experiments were conducted to explore 1) potential entrainment velocities and settling orientations of shell pieces, and 2) abrasion of shell pieces during transport and entrainment. To test potential entrainment velocities and settling orientations of shell pieces, representative models of common shell elements were designed using CAD software and 3D printed. Molds made from the 3D prints were used to create Alumalite resin casts. Models were placed into a flume with manual velocity control. Flow velocity was increased to induce transport, and transport distance and settling orientations were recorded. To test the potential taphonomic modification to shell pieces during fluvial transport, modern turtle elements were placed in a rock tumbler with uniform sized sediment (silt, fine sand, coarse sand) for one week to observe patterns of wear. Preliminary results suggest element length and degree of curvature affect transport potential. Curved elements require lower entrainment velocities while smaller, flatter elements require greater entrainment velocities but, once mobile, are transported further. Surface wear was observed on all shell pieces, though the nature and location differed. In silt and fine sand wear was concentrated around the edges, while in coarse sand the majority of the surface was abraded. Studying turtle shell preservation patterns may be useful for understanding processes driving vertebrate accumulation at fossil sites such as the AAS, where experimental systems such as those outlined above may further elucidate the roles of water transport and/or surface exposure in bone preservation.

Sunday, September 15, 11:05 am

Newly Reported Borealosuchus (Crocodylia, Eusuchia) from the Camels Butte Member (Eocene) Golden Valley Formation of North Dakota

PERSON, Jeff J.; North Dakota Geological Survey, Bismarck, ND

Five genera of brevirostrian crocodylians have been reported from the Golden Valley Formation of North Dakota. Large osteoderms recovered from a locality within the Camels Butte Member (Wasatchian North American Land Mammal Age, Eocene) of the Golden Valley Formation in southwest North Dakota indicate the presence of a large crocodyliform. No large crocodylian teeth or skull material that could pertain to this animal have been identified from this locality. One well preserved and nearly complete dorsal osteoderm has characters which indicate the presence of *Borealosuchus*. These characters include: 1) presence of anterolateral process, 2) no keel present, 3) rectangular in shape, 4) a smooth anterior surface, and 5) sutures on lateral surfaces. *Borealosuchus wilsoni* has been previously reported from Wyoming, Utah, and Colorado. The combination of the morphology, geologic age, and size of the osteoderms permits a referral to *Borealosuchus* cf. *wilsoni*. This report from North Dakota greatly increases the paleogeographic range of this species.

Saturday, September 14, 10:00 am

A new species of nanhsiungchelyid turtle from the Arlington Archosaur Site, Woodbine Formation, Texas: Macro- and micro-anatomical analyses

SMITH, Heather F.; Midwestern University, Glendale, AZ. ADRIAN, Brent; Midwestern University, Glendale, AZ. WILLIAMS, Avery A.; Midwestern University, Glendale, AZ. LEE, Andrew H.; Midwestern University, Glendale, AZ. NOTO, Christopher R.; University of Wisconsin–Parkside, Kenosha, WI. GROSSMAN, Aryeh; Midwestern University, Glendale, AZ.

The Nanhsiungchelyidae is a family of mostly large-bodied, terrestrial adocusian turtles from the Early to Late Cretaceous. While they are primarily an Asian radiation, one genus from this family (*Basilemys*) is known from North America and is considered endemic. Here we present the initial description of a second nanhsiungchelyid genus from the Cenomanian (early Late Cretaceous, 95-96 Mya) of the Arlington Archosaur Site (AAS) of Texas. Our analysis is based on a partial cranium, lower jaw, and numerous plastral and carapacial elements. The posterior half of the cranium is complete, but the face and dermal neurocranium are very incomplete. We assign the specimen to Nanhsiungchelyidae on the basis of a closed incisura columella auris, rounded tympanic openings, and outwardly radiating striations on the cranial roof. This specimen is unique and differs from *Basilemys* in having large, rounded processus trochlearis oticum with minimal parietal contribution, and large tubercula basioccipitale that project caudally and are bounded by deep fossae superiorly. The lower jaw has a complex triturating surface that divides into distinct posterior and anterior dentary pockets, a pronounced symphyseal hook, and the labial ridge of the dentary is serrated with a distinctive row of tooth-like denticles. The shell sculpture is typical of nanhsiungchelyids, consisting of large, sometimes-coalesced pits separated by rounded ridges. The cervical scute is substantially wider than in *Basilemys*, approximately twice as wide as it is long, and its lateral and posterior aspects are concave. We also compare the shell histology of the new nanhsiungchelyid to other adocusian taxa from the Arlington Archosaur Site. AAS adocid specimens display characteristics consistent with *Adocus*, including abundant Sharpey's fibers organized into plies (layers) and reticulated vascular channels. The AAS nanhsiungchelyids differs by lacking plywood-like organization and having minimal Sharpey's fibers. However, the AAS nanhsiungchelyids lack the characteristic wavy growth marks of *Basilemys*, more closely resembling basal Asian nanhsiungchelyids such as *Hanbogdemys orientalis*. This finding when combined with gross morphological traits suggest that the AAS nanhsiungchelyid is a new genus, distinct from *Basilemys*. These findings add to the terrestrial herpetofauna of AAS, further supporting environmental reconstructions of the site as a complex coastal ecosystem with a broad range of available terrestrial and aquatic niches.

Sunday, September 15, 3:20 pm
Paleobiology of Mesocyon temnodon; a Preliminary Study.

SPEARING, Kurt D; Morningside College, Sioux City, IA. CUSTER, Riley H; Morningside College, Sioux City, IA

The Oligocene canid, *Mesocyon temnodon*, is known from specimens collected from localities in South Dakota, North Dakota, Wyoming, Colorado and Nebraska. It is a member of the subfamily Hesperocyoninae, however as it is in a likely paraphyletic genus its exact phylogenetic position is somewhat unclear.

In the collections at the North Dakota Geological Survey there is a relatively complete specimen (NDGS 64) that conforms favorably to *Mesocyon temnodon* even though some of the diagnostic characters are not visible. It is unusual in that much of the post crania is present, this allows for examination of details not usually possible in this species. This preliminary study is examining several aspects of the paleobiology of this canid.

The first aspect that was studied in detail dealt with the retractability of the claws. This was studied because dogs in the Hesperocyoninae are sometimes described as “cat like” and some of them are hypothesized to have retractable claws. By examining the phalanges of the NDGS 64 specimen, three lines of evidence were tested to determine the retractability of the distal phalanges. The size of the extensor and flexor processes, the depth of arc in the claw, and the morphology of the middle phalanx. All three of these tests showed the claws to be not retractable.

Studies of its body mass, running speed, bite force, and ecological niche are in progress.

Sunday, September 15, 9:00 am

A Juvenile Elasmosaur Skull Preserved in a Concretion from the Upper Cretaceous Bearpaw Formation of Saskatchewan, Canada

STREET, Hallie P; Royal Saskatchewan Museum, T. rex Discovery Centre, Eastend, Saskatchewan, Canada. MEKARSKI, Michelle M C; Canada Science and Technology Museum, Ottawa, Ontario, Canada. BAMFORTH, Emily L; Royal Saskatchewan Museum, T. rex Discovery Centre, Eastend, Saskatchewan, Canada. SMITH, Anthony J; Redpath Museum, McGill University, Montreal, Quebec, Canada. TAHARA, Rui; Redpath Museum, McGill University, Montreal, Quebec, Canada. LARSSON, Hans CE; Redpath Museum, McGill University, Montreal, Quebec, Canada.

During the Cretaceous the North American continent was inundated by multiple incursions of the Western Interior Seaway. The Bearpaw Sea represents one of the final transgressions of this sequence and extended across parts of Alberta, Montana, and Saskatchewan during the late Campanian. Typically, the Bearpaw Formation consists of dark gray shales, but across Saskatchewan various near-shore localities with greater terrestrial influences exhibit differing lithologies. An unusual outcropping of the Bearpaw Formation from southwestern Saskatchewan preserves fossil material in concretions. Breaking the concretions open has revealed bivalve, ammonite, crustacean, echinoderm, and vertebrate material. Additionally, the layer that produces the concretions is underlain by a stratum that is highly bioturbated and preserves abundant infilled burrows.

One concretion from this site contains the skull and a vertebra of a very small elasmosaur. This specimen is interpreted as representing a young juvenile based on both its small size (skull ~13 cm long) and the poorly ossified state of the cranial bones. Due to the mode of preservation within the concretion, much of the preserved bone is quite brittle. Mechanical preparation was therefore not recommended, and the entire concretion was scanned using micro-computed tomography. Models rendered from the micro-CT scans reveal that the skull underwent little to no deformation during preservation. The scans also show that there is greater contrast between the matrix of the concretion and cranial elements with endochondral developmental origins than elements with dermatocranial origins. The poor contrast between the dermatocranial bones and the matrix could indicate that these elements were less well ossified than the endochondral elements. Considering that the dermatocranium typically ossifies first, this finding was unexpected. It is more difficult to study developmental patterns for fossil groups with no living descendants, but this specimen provides a rare example of early ossification in the plesiosaur skull.

Poster Session: Sunday, September 15, 1:30-2:20 pm

A New Ceratopsian Discovery in the Lance Formation (Late Cretaceous, Maastrichtian) of East Central Wyoming.

Swisher, Jayme; Missouri Institute of Natural Science, Springfield, MO.

In late spring 2013, on a private ranch in Eastern Wyoming, the all-volunteer staff from the Missouri Institute of Natural Science began excavations after a visual survey observed notable fossil bone trickling from a hillside. This initial excavation revealed post-cranial remains of an exceptionally large chasmosaurine ceratopsian (MINS V1036) primarily in the pelvic region including both femurs, the cervical to dorsal section of the vertebral column, and the scapulocoracoid. While the absence of a skull prevents species assignment with real certainty; and postcranial characteristics do not distinguish it from *Eotriceratops* or *Torosaurus*, the morphology of the remains are compatible with *Triceratops*. One feature that does distinguish MINS V1036 is its large size. Though the distal end is missing, one femur measures approximately 1070 mm of the bone that is present. Also of note, vertebrae show what appears to be the presence of osteoarthrosis or some unknown osteopathology. In subsequent years, volunteers discovered additional fragmental elements along with evidence of the broader paleoenvironment . Ultimately, MINS recovered 40-45% of the skeleton and is in the restoration and mounting process to serve as the museum centerpiece. When complete, it will be the first and only permanent exhibit of a fossil bone dinosaur mount in the state of Missouri.

The Allstate Foundation provides funding for this work with additional exhibit funds provided in part by the C.W. Titus Foundation.

Sunday, September 15, 5:05 pm

Evidence of Head-hunting, Selective Bone Sampling and Incomplete Collection of Major Late Cretaceous Dinosaur Skeletons in Southern Alberta, Canada: A Cautionary Note on True Specimen Completeness to Fieldworkers and Researchers Everywhere

TANKE, Darren H; Royal Tyrrell Museum of Palaeontology, Drumheller, AB.

Researching dinosaur sites of mostly pre-WWII vintage in southern Alberta has uncovered a troubling and growing realization. During fieldwork long ago, some skeletons had parts removed and the rest abandoned. Skulls, limbs, and perhaps single bones were selectively taken. In some cases, bones were accidently left behind, especially in widely disarticulated skeletons. 100+ years of erosion reveals new bones the first collectors missed. An example of the latter is noted here.

In 2007, the author found an accumulation of short lengths of old wire and a nail in the badlands of Dinosaur Provincial Park. A site visit in 2018 revealed a distal ankylosaur tibia emerging from the rock. Excavation revealed a loosely articulated ankylosaur femur and scattered ossicles. A tiny piece of plaster was also found. These new items and the wire/nail suggested this might represent an old quarry, yet none was visible. A short distance away, a sandstone outcrop with a long, narrow wedge of clay was exposed and the author recalled seeing a similar feature in a historical field photo. The relocated photo matched our site and was identified as an American Museum of Natural History (AMNH) ankylosaur quarry from 1913. Additional historical information found later showed the site was also worked in 1914. Using the 1913-1914 AMNH specimen lists, by process of elimination it was determined that this site was likely AMNH 5337, one of the most complete *Euoplocephalus* specimens known. 2018-2019 work by the Royal Tyrrell Museum (TMP) revealed more disarticulated in situ bones: a metatarsal, ossicles, two osteoderms, ischium, two spaced parallel rows of tail club tendons and a perfect 1.7 metre long tail club. An edge of the original and now filled in quarry was also found and 1913 newspaper scraps recovered.

This research provides a cautionary note. Unless the skeleton is just starting to emerge from the rock, it is possible that it has been seen by previous fieldworkers who may even have sampled bones from it. Long-term erosion masks or hides any clues as to their earlier digging. Knowing who, when and where the missing bones are today may prove problematic in the absence of good field notes, maps, and especially site photographs showing the skyline. Presently the skeletal remains of this *Euoplocephalus* are curated in at least two institutions and bear two known catalog numbers (AMNH 5337 and TMP 2018.012.0151). The author is aware of about two dozen skeletons in Alberta similarly affected by this sloppy collecting or sampling. Can we reassociate such specimens via repatriation, sharing of data, casts or 3D scans?

Sunday, September 15, 9:20 am

Previously Unreported Historical Remains of an Elasmosaurus Recovered from Wyoming in 1927

TURCIOS, Leo A; University of Wisconsin-River Falls, River Falls, WI. HASTINGS, Alexander K; Science Museum of Minnesota, Saint Paul, MN.

At its peak, the Cretaceous Western Interior Seaway reached 3,200 km long, with shores almost a kilometer apart, dividing North America in half from the Arctic Ocean to what is now the Gulf of Mexico. About 75 million years ago, this shallow inland sea was home to massive apex predators, larger than any other on Earth at the time, including mosasaurs and plesiosaurs, each capable of reaching lengths of 15 meters or more. However, these aquatic reptiles went extinct at the K/Pg boundary along with non-avian dinosaurs, leaving behind partial remains as the seaway retreated.

In 1927, a Macalester expedition to Mosasaur Hills led by Alexander Coll unearthed what appeared to be the remnants of an elasmosaurid in eastern Wyoming. *Elasmosaurus* is a genus of plesiosaur that lived in the Late Cretaceous Period with remains that have been found throughout marine and coastal deposits of North America from this time. In 1970, this specimen was accessioned at the Science Museum of Minnesota (SMM) as SMM P78.15.1, where it resides today. Not much is known about the SMM elasmosaurid, as it was transferred with very limited data. Accession notes did mention the bones were recovered from the Pierre Shale. Most of the skull is missing, making identification difficult; however, two fragments were recovered. The first fragment is a mid-line section of the frontal, due to the presence of the crista cranii frontalis. The second bone is a combination of the parietal bone, fused with prefrontal and postorbital bones on each side. The prefrontal and postorbital bones frame the posterolateral corner of the orbit, suggesting widely set eyes.

Postcranially, SMM P78.15.1 includes most of the pectoral and pelvic girdles, three limbs, 83 vertebrae, and partial ribs. Joints of the two humeri and one femur show poorly developed articular surfaces, suggesting the individual was a juvenile when it died. The potential cause of death may have been related to infections, found in several bones of SMM P78.15.1, characterized by heavily regrown bone surface. These features are very apparent on two of the proximal forelimbs, and may also be present in the preserved hind limb (the other hind limb was not preserved). Fragments of unidentified bones also appear to have scar tissue present. This elasmosaurid may have been attacked by another apex predator, and though it survived the initial barrage, its injuries likely became infected. The weakened state of the animal may then have led to its ultimate demise, sometime after the encounter.

Sunday, September 15, 9:40 am

An Update on Mosasaurine (Reptilia; Squamata) Remains from the Hell Creek Formation, North Dakota, USA.

VAN VRANKEN, Nathan E; Independent Researcher, The Colony, TX. BOYD, Clint A; North Dakota Geological Survey, Bismarck, ND.

Mosasaurs are a group of well-known carnivorous marine reptiles that once swam the epeiric sea that flowed over the Great Plains region in North America during the Late Cretaceous. Both North and South Dakota have sparse records of mosasaurid occurrences after the deposition of the Campanian Pierre Shale Formation. The discovery of new fossil remains collected from within the Maastrichtian Breien Member of the Hell Creek Formation in North Dakota suggests that large-bodied (8m or longer) mosasaurids were still present in the region before the complete recession of the seaway. Based on fossil elements collected from a new locality, along with an assessment of other geologically young mosasaurid remains found in North America we can confirm the presence of a mosasaurine mosasaur. The focus of this research is to help further develop the body of understanding of the latest Cretaceous intercontinental mosasaurs and bolster the biodiversity found within the marine units of the Hell Creek Formation.

Sunday, September 15, 3:00 pm

A Newly Discovered Phlaocyon-like Dog (Borophaginae) from the Orellan of Nebraska and its Implications for early Oligocene Dog Diversification

WELSH, Ed; Badlands National Park, Interior, SD. MOORE, Jason; University of New Mexico, Albuquerque, NM.

The conventional understanding of canid diversity proximal to the Eocene-Oligocene Transition (~33.7 Ma) is that *Hesperocyon* is the dominant canid through the White River sequence. There is interpreted to be a gradual diversification of other rare canid taxa through the early Oligocene followed by a major taxonomic and ecological diversification during the Whitneyan-Arikareean Transition (~30 Ma). Here we report the discovery of a new specimen of borophagine canid recovered from the uppermost Orella Member of the Brule Formation (~32.85 Ma) at Toadstool Geologic Park, Sioux County, Nebraska. The specimen consists of a highly diagnostic second lower molar, possessing a metaconid and protoconid of equal height, a basined talonid, and a small protostylid. The presence of a protostylid in Oligocene canids is unique to derived members of the borophagine tribe Phlaocyonini (*Phlaocyon* and *Cynarctoides*). No specimen within this clade has been previously confirmed from the Brule Formation or units of equivalent age anywhere in North America, with the possible exception of one questionable occurrence of *Cynarctoides* from the Whitneyan of South Dakota. Basal Borophaginae are known from Whitneyan assemblages throughout the Midwest, but only one taxon, *Otarocyon macdonaldi* (known from only two specimens), has ever been recovered from older, Orellan assemblages. All previously documented phlaocyonine taxa make their first appearances in the Arikareean. Based on the placement of Phlaocyonini in previous phylogenetic studies the newly discovered Toadstool Geologic Park specimen suggests that the previously suggested Arikareean diversification of canids actually occurred at least two million years earlier, in the late Orellan.

Saturday, September 14, 2:40 pm

A Nimravid (Mammalia: Carnivora) with Split Carinae, Supporting the Hypothesis of Genetic Polymorphism in Homologous Tooth Abnormality Found Within Theropod Dinosaurs

WELSH, Ed; Badlands National Park, Interior, SD. BOYD, Clint A.; North Dakota Geological Survey, Bismarck, ND. SPEARING, Kurt; Morningside College, Sioux City, IA.

The morphological anomaly of split carinae is a tooth abnormality which is well documented in disparate theropod taxa within Tyrannosauridae, Dromaeosauridae, and Carcharodontosauridae. This abnormality is noted in other vertebrate groups (e.g., Chondrichthyes and Phytosauria). Among these groups, only the theropods have been thoroughly examined to determine the cause of the split carinae abnormality. The three most parsimonious hypotheses that have been proposed for this particular abnormality are: it results from trauma; it results from aberrant tooth replacement; or, it is a form of genetic polymorphism. The frequent replacement of teeth in these taxonomic groups have made it difficult to provide a definitive causality for split carinae. We report on an anomalous specimen of the nimravid *Dinictis felina*, which displays the split carinae abnormality. The anterior carinae in the left and right upper canines of this specimen display normal orientation and serration morphology from the apex until the carinae bifurcate, with the accessory carinae diverging laterally before curving dorsally towards the tooth base. The anterior position of split carinae in *Dinictis felina* is similar to what has been observed in theropods, suggesting a homologous origin for the abnormality. We propose that genetic polymorphism is the most parsimonious interpretation for the origins of split carinae in both mammals and theropods, due to the nimravid's constrained tooth replacement, the bilateral symmetry of the split carinae, and lack of evident trauma.

Saturday, September 14, 9:40 am

The Hill Annex Paleontology Project: A Citizen Science Research and Outreach Program

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The Hill Annex Paleontology Project is a research endeavor directed on the Cretaceous deposits of the Minnesota area, begun in 2014. Focus has stayed mainly with the Coleraine Formation conglomerates of the Mesabi Iron Range, but includes the entire region surrounding Minnesota. Primary work has been based out of Hill Annex State Park in Calumet, Minnesota. Stratigraphic placement of the formation is within the Cenomanian, in coastal depositional environments of the Cretaceous Interior Seaway. This is a citizen science initiated project started by volunteers from the Science Museum of Minnesota. The Project is now based out of the Minnesota Discovery Center in Chisholm, Minnesota, with new fossil material being curated there. The project goals for research include the expansion of the existing base of scientific knowledge, documentation of existing known Coleraine Formation specimens in both public and private hands, and the digitization of the project collection. In conjunction with research energies, the Project aims to grow and expand community engagement and public outreach efforts in the area and regionally. Public interactions have included schools of all ranges, community groups and clubs, public gatherings and professional societies. We'll share some of our history, challenges and successes along the trail of our research.

Sunday, September 15, 10:25 am

A Basal Alligatoroid from the Upper Cretaceous (Campanian) Two Medicine Formation of Montana

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The Campanian Two Medicine Formation (TMF) is a series of fluviolacustrine deposits formed in seasonal semi-arid uplands between approximately 82 and 75 Ma. Like the correlative Judith River Formation and members of the Belly River Group, the TMF yields an extensive fossil fauna including dinosaurs, pterosaurs, champsosaurs, turtles, lizards, mammals, invertebrates, and insect traces. However, until recently there had been no reports of crocodyliforms from the TMF.

Here we report on a partial crocodyliform skeleton collected from the upper TMF by the Museum of the Rockies (MOR). This specimen (MOR 552) is comprised of partial limbs, a partial ilium, vertebral elements, osteoderms and a partial skull. MOR 552 was previously referred to *Borealosuchus*, but closer examination of the maxilla and quadrates reveals alligatoroid synapomorphies including a dorsally-shifted foramen aëreum and maxillary shelf separating the tooth row from the ectopterygoid. It closely resembles the basal-most known alligatoroid, *Leidyosuchus canadensis*, in several ways, including a rugose ventral maxillary surface between the tooth row and suborbital fenestra and dentary alveolar size distribution in which the 12th and 13th alveoli are enlarged. The surangular appears to extend to the posterior tip of the retroarticular process, a feature shared with *Borealosuchus*, but some specimens of *L. canadensis* approach the condition seen in the TMF form. Maximum parsimony analysis supports a close relationship with *L. canadensis*, but trees supporting a close relationship between the TMF form and *Diplocynodon*, a European basal alligatoroid lineage first appearing in the Paleocene, are not substantially longer.

Based on environmental differences between the TMF and correlative units in western North America, we hypothesize that TMF alligatoroids were better adapted for living in semi-arid conditions than taxa that lived closer to the Western Interior Seaway. This study of MOR 552 along with increased sample sizes from the TMF may help resolve the origin of *Diplocynodon* and document the transition from generalized snout shapes to the specialized short snouts with crushing dentition found in more derived alligatoroid clades.

Saturday, September 14, 10:50 am

A New Species of Sphaerotholus (Dinosauria: Pachycephalosauria) from the Upper Cretaceous Hell Creek Formation of Montana

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The Hell Creek Formation of western North America is home to some of our most iconic of non-avian dinosaurs, such as *Tyrannosaurus* and *Triceratops*. The Hell Creek Formation represents the last geologic interval in North America before the Chicxulub bolide impact; thus, it signifies a vital interval regarding pre-impact dinosaur paleobiology. The debate over increasing or decreasing dinosaurian pre-K/Pg diversity has ebbed and flowed, adding additional importance to the Hell Creek Formation ecosystem. While formerly reconstructed as extremely speciose, recent studies on the ceratopsians, tyrannosaurids, and pachycephalosaurids has caused the formation to potentially 'lose' four genera and seventeen species. While the larger bodied taxa appear to be less speciose than previously perceived, several new smaller bodied taxa have been described which still contribute to an increase in Hell Creek Formation dinosaur diversity.

The pachycephalosaurids of the Hell Creek Formation are popularly perceived to be *Pachycephalosaurus* and its ontogimorphs. Yet this an inaccurate reflection as the smaller statured *Sphaerotholus buchholtzae* co-occurred alongside *Pachycephalosaurus*. Here we report a new, and second species of *Sphaerotholus*. This new species of *Sphaerotholus* is distinguished by six characters, the most notable being three posterior and lateral node rows, and the lack of parietosquamosal nodes – compared to *S. buchholtzae* which possesses singular rows and parietosquamosal nodes. Recovered from the middle of the Hell Creek Formation, this new taxon appears to have co-occurred with both *S. buchholtzae* and *Pachycephalosaurus*. This new taxon signifies that not only was the genus *Sphaerotholus* more diverse during the Hell Creek Formation, but so too were Late Cretaceous North American pachycephalosaurids. Furthermore, while the larger bodied taxa of the Hell Creek Formation may not have been as speciose as previously thought, newer, smaller bodied taxa are highlighting that the formation may have still retained higher dinosaurian gamma diversity.