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CSI: WYOMING, PREDATOR/PREY RELATIONSHIPS OF THE BRIDGER FAUNA AS EVIDENCED BY SKELETAL TRAUMA

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The Middle Eocene Bridger Formation preserves vertebrate fossils of most represented orders as articulated skeletons. This is a result of air fall ash deposits that frequently inundated a subtropical closed canopy forest environment. The rapid burial of remains often preserved evidence of para mortem damage or pathology on these skeletons. Tooth marks, claw punctures and crushing wounds have been frequently found on mammal and reptile remains. It is occasionally possible to match the shape and spacing of puncture wounds with the likely predators or scavengers that made them. Damage inflicted on bones by mammalian predators, crocodilians, raptorial birds and even fish can be distinguished. Predator/prey relationships between particular sets of animals can be inferred. The manner in which certain species were being selectively killed and consumed may indicate the nonrandom taphonomic mechanisms whereby they are being incorporated into the fossil record.

FIRST REPORT OF FOSSILS FROM THREE HEMPHILLIAN LOCALITIES AT PETRIFIED FOREST NATIONAL PARK, ARIZONA

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Since 1917, published reports of fossiliferous sediments at the Bidahochi Formation from White Cone peak in the Hopi Reservation and Navajo Nation have garnered research into a series of collections and publications of this material. The fossils from White Cone peak include both vertebrate (Actinopterygii, Reptilia, Aves and Mammalia) and invertebrate (Mollusca) materials. Biochronologic and radiometric dating place this material at the Hemphillian (Late Miocene – Early Pliocene) North American land mammal age. In the spring of 2018, we conducted a multiple day survey of presumptive Bidahochi Formation materials at Petrified Forest National Park. The nearest site surveyed lies approximately forty miles to the southeast of the White Cone peak sediments. Except for a small amount of unidentified Artiodactyla innominate fragments collected at the B3 locality, this represents the first survey of the three Bidahochi material sites at Petrified Forest National Park. These Hemphillian sediments overly the Upper Triassic Chinle Formation, producing a nearly 200-million-year unconformity. Of the three sites we surveyed, each turned up fossil materials, though distinct fossil taxa were located at each. This supports distinct paleo environments of dry lands, lacustrine and fluvial habitats for each. Here we make the first report of fossil materials from the only Neogene localities at Petrified Forest National Park. At the southern B3 locality we located additional large mammal fragments, though no taxa are yet identified. The central B2 locality had an abundance of freshwater bivalves, supporting permanent water, either as a lake or slow-moving river. The northern B1 locality had the most diverse assemblage, including microvertebrates and two taxa of gastropods. The microvertebrates recovered include Rodentia teeth and a Boidae (Erycinae, *cf. Lichanura*) vertebra. Future surveys will determine if these northern sites are indeed in the Bidahochi Formation or a younger undocumented unit within Petrified Forest National Park.

HISTORY OF RESEARCH AT THE MILK CREEK FORMATION, ARIZONA

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The first known reports of fossil bearing materials from the Walnut Grove or Milk Creek formation in central Arizona were from local ranchers reports in 1938. In 1948 scientific interest dawned when fossils were presented to Harold S. Colton of the Museum of Northern Arizona. After 1948 the Milk Creek formation at the Walnut Grove locality has had considerable ongoing interest from several institutions.

In 1949 the first significant survey and collection of the Milk Creek locality ensued with a joint venture effort from individuals at the Museum of Northern Arizona and the Arizona State Museum in Tucson. The most recent publications and reviews place the Milk Creek formation fauna in the Clarendonian NALMA. A survey in 1950, likely from members of the Arizona State Museum, added specimens to the University of Arizona Laboratory of Paleontology (UALP) collections.

Ted Galusha, a collector for Childs Frick began working here in 1956. Galusha's efforts have produced the largest single collection from this site, which are currently housed as a part of the Frick collection at the American Museum of Natural History in New York city.

After the 1949 and 1950 collections, John Lance, and then Ev Lindsay, at the University of Arizona collected materials beginning when Ted Galusha was active. Specimens from these efforts are housed at the UALP, UC Berkeley and at the Museum of Northern Arizona. Everett Lindsay persisted in bringing many students and researchers to the Walnut Grove localities and greatly enlarged upon the considerable specimens held at the UALP collection, representing their field site

number one. The collections at the UALP now spans efforts over portions of five decades.

Brian McClelland and Milo McDouglas of the Mesa Museum of Natural History and the Southwest Paleontological Society led some collecting at the Milk Creek formation in the mid 1990's. Norm Tessman of the Sharlot Hall Museum in Prescott, Arizona also established a small amount of materials from the mid 1990's.

Since the 1990's efforts at this site have continued with Beth Boyd and Jeb Bevers from Yavapai College. Ongoing collecting efforts have now amassed the third largest collection of specimens, currently housed at Yavapai College.

DID DIETARY DIVERSIFICATION COINCIDE WITH TAXONOMIC RADIATION IN NORTH AMERICAN CRETACEOUS METATHERIAN MAMMALS?

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Metatherians (the clade that includes marsupials and their closest therian relatives) exceeded eutherians (the clade that includes placentals and their closest therian relatives) in taxonomic richness prior to the Cretaceous-Paleogene mass extinction. In North America, metatherians underwent a Cretaceous taxonomic radiation, where five major lineages diverged by the Albian-Cenomanian–late Santonian (100–85 Ma). However, in contrast to their taxonomic diversity, North American Cretaceous metatherians have been conventionally viewed as having little dietary diversity and have been seen as mostly insectivorous mammals. To assess the amount of ecological expansion metatherians underwent during the Cretaceous, as well as how patterns of dietary diversification relate to patterns of taxonomic richness through time, we analyzed metatherian dental morphology and function within a phylogenetic framework.

We generated 3D digital elevation models (DEMs) from microCT data fossil metatherian molars to characterize dietary ecology. We sampled molar specimens of 20 fossil species from the Santonian to Maastrichtian. From the 3D DEMs of the sampled specimens, we quantified morphological disparity and inferred diet from dental topographical measures including relief index, Dirichlet normal energy, and orientation patch count—all of which have been have been shown to correlate with diet in extant mammalian taxa. Preliminary results show that, coincident with the Cretaceous taxonomic diversification, multiple clades of metatherians expanded from regions of the morphospace that correspond to insectivorous diets to regions that corresponds to plant-based diets. This apparent ecological expansion of North American Cretaceous metatherians may be related to the broadly concurrent adaptive radiation of angiosperms—increased diversification and ecological abundance of angiosperms may have provided new dietary niches became available to metatherians.

PALEOSOLS AND MAMMOTH TRACKWAY REVEAL PLEISTOCENE (45 KA) LANDSCAPE ECOLOGY OF FOSSIL LAKE, OREGON

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Behavior of Columbian mammoths (*Mammuthus columbi*) is revealed by a newly discovered trackway at the Pleistocene locality of Fossil Lake, Oregon. Our 8 by 20m excavation of the mammoth trackway found 117 tracks, including one 20-m-long adult trail, partial trackways of 3 additional adults, a yearling and a baby all heading generally west. The tracks are in the Marble Bluff biotite tuff (43.2calka), which forms a surface horizon to the Pogani silty clay loam paleosol (Natrargid), with a cracked surface and a columnar -structured, subsurface (Bn) horizon, like soils under desert soda pans with alkali shrubland. Directly below is the Yada silty clay paleosol (Xeroll) with crumb textured surface (A) horizon like grassland soils. The Pasiwa loam (Psamment) is a thin brown siltstone, with sparse roots and burrows of lake-margin early successional vegetation. The Pui sandy loam (Aquent) is well-bedded tuff and sand (A) with subhorizontal calcareous rhizomes and adventitious roots, like those of lake-margin tule reeds (*Schoenoplectus acutus*). Columbian mammoths may have moved like modern elephants with infants in matriarchal groups through landscapes of sagebrush and grassland, and this trackway includes a limping female attended by concerned juveniles. Grassland paleosols common in the Fossil Lake beds, are now rare in the same region, perhaps related to extinction of proboscidean and equine grazers.

MORPHOLOGICAL VARIATION OF THE VERTEBRAE OF ALLODAPOSUCHID, EUSUCHIANS FROM THE UPPER CRETACEOUS OF SPAIN. IMPLICATIONS ON THE ACQUISITION OF THE MODERN VERTEBRAL COLUMN IN EXTANT CROCODILES.

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Vertebrae of eusuchian crocodiles found at the Upper Cretaceous (late Campanian-early Maastrichtian) site of Lo Hueco (Cuenco, Spain) are described. Two taxa of allodaposuchid eusuchians are already described based on

cranial elements from Lo Hueco: *Agaresuchus fontisensis* and *Lohuecosuchus megadontos* (Narvaez et al., 2015, 2016).

Definite vertebral column morphologies have only been described minimally, or not at all, for both taxa. The vertebral elements found in the proximity of cranial material are believed to belong to one of the two previously described taxa. Considering that these are the only two crocodilyfoms identified so far in the site and that the morphology of the vertebrae described is compatible with a basal eusuchian, it is considered that these can be assigned to one of the two allodaposuchids from Lo Hueco. Allodaposuchidae is one of the most basal groups of Eusuchia and probably the sister group of Crocodylia. Vertebral column description is a critical morphological indicator to help determine phylogenetic relationship to Eusuchian within Neosuchia. The transformation of the morphology of the vertebrae shows some of the well-known synapomorphies of modern crocodiles.

The vertebral material described in Lo Hueco helps to understand the primitive morphology of the vertebrae of the basal groups of the crown group Crocodylia. The mapping of vertebral characters in the basal nodes of Eusuchia allows us to identify the order of acquisition of the transformations that make up the modern vertebral column in crocodiles and to discuss the differences in the main lineage of Crocodylia.

The implications of the analysis of this new data result in the revision of the eusuchian phylogeny in order to best reflect acquisition of evolutionary novelties in the vertebral column along the phylogenetic relationships of basal groups of Eusuchia.

AMATEUR-PROFESSIONAL-NGO COLLABORATIONS IN PALEONTOLOGY IN OREGON

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Collaboration between numerous groups in Oregon have resulted in a number of significant Paleontology discoveries and activities. Major fines include ancient marine reptiles, Saber tooth Salmon and a whale. Major activities include public and school outreach and education, field collecting, fossil preparation and avocational education. Major players are the University of Oregon, the North America Research Group, the Oregon Museum of Science and Industry, Oregon Health Science University, various rock clubs, the Rice NW Museum of Rocks and Minerals and Woodburn school district.

LATE CRETACEOUS DINOSAURS AND BIRDS FROM MICROVERTEBRATE SITES, HELL CREEK FORMATION, SOUTHWESTERN NORTH DAKOTA

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The Late Cretaceous Hell Creek Formation is exposed in North Dakota, South Dakota, Wyoming, and Montana. This formation contains one of the best records of vertebrates from prior to the Cretaceous/Paleogene (K/Pg) mass extinction. A previous study of the Hell Creek of southwestern North Dakota documented numerous vertebrate fossils, all tied to the K/P boundary. These fossils were recovered by surface collecting microvertebrate sites and by excavating larger fossils. Our study focused on recovering small fossils by screenwashing a selection of these microvertebrate fossil sites. We recovered thousands of small fossils of many vertebrate species including some that were previously missed or undersampled by surface collection. We have identified 184 dinosaur and bird teeth (and tooth fragments) based on comparisons to the literature and to collections in the University of California Museum of Paleontology, Berkeley (UCMP). This includes 123 hadrosaurian and 16 ceratopsian (cf. *Triceratops*) teeth. The hadrosaurian teeth are 1 cm or less in length; the ceratopsian teeth are 1-2 cm in length. These teeth are considerably smaller than teeth from mature individuals in the UCMP, and are from hatchlings or juveniles. This indicates that there were dinosaur nesting sites in the area, a new record for the Hell Creek of North Dakota. We also identified 45 theropod and bird teeth: 10 tyrannosaurids, one "*Paronychodon*", 16 *Richardoestesia* (including some *R. isosceles*), four *Saurornitholestes*, and 14 bird (*cf. Hesperornithiformes*). The tyrannosaurid teeth and fragments are small, and are also from hatchlings or juveniles. All of the theropod and bird taxa recovered in this study were previously documented from this area. However, our screenwashing did produce relatively more *R. isosceles* and bird teeth than other theropods; this is different from the previous work. *R. isosceles* has been interpreted as a fish-eater. Its relative abundance (and that of the birds and of small fish, sharks, and rays) fits our interpretation that this was a coastal area very close to the Western Interior Seaway.

A BONEBED OF ENANTIORNITHINE BIRDS FROM THE LATE CRETACEOUS OF BRAZIL

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Despite abundant discoveries of Mesozoic birds in the last few decades, knowledge of their evolution during the last 20 million years of the Cretaceous remains scant. However, this time interval is vital for understanding the rise of modern birds as well as the pattern of avifaunal turnover during the Cretaceous-Paleogene transition. We report on a remarkably rich site (William's Quarry) contained in the Upper Cretaceous Adamantina Formation (Bauru Group) of southeastern Brazil (Presidente Prudente, western São Paulo State). Excavations at this site have produced hundreds of partially articulated and isolated remains of small to medium-sized enantiornithine birds concentrated in a very small area (approximately 6 m2) of red-pink fluvial sandstones and claystones. The remains include numerous postcranial elements as well as many skull portions (isolated rostra, mandibles, and crania) preserved in three-dimensions. This site constitutes the most abundant avian Mesozoic locality in the Americas and the richest avian site of Late Cretaceous age in the world. As such, this site provides key information for contrasting hypotheses about avian diversification during the K-Pg transition and the earliest divergences of modern birds. Together with other Late Cretaceous localities from Gondwana, the information revealed at this site indicates a clear abundance of enantiornithine bird species during the ~80-70 mya interval. Such a record is difficult to reconcile with hypotheses arguing that modern (neornithine) birds originated in the southern hemisphere during the Late Cretaceous.

A PROPOSAL FOR INVESTIGATING OSTEOPHAGY IN *ALLOSAURUS* USIING DENTAL MICROWEAR TEXTURE ANALYSIS

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Inferring feeding habits in more detail than just carnivore versus herbivore is important for reconstructing the detailed paleoecology of extinct organisms. Questions regarding the food quality available to or exploited by certain taxa can be particularly difficult to approach. There is some circumstantial evidence to suggest that Allosaurus engaged in osteophagy, at least occasionally. The presence of processed bone in a coprolite from the Upper Jurassic of the Morrison Formation may indicate that Allosaurus engaged in mastication of bone. Statistical analysis shows that Allosaurus teeth are within the range of bone masticating theropods, namely *Gorgosaurus*, with respect to crown compression ratios. Conversely, tooth-marked bones from the Morrison Formation support the hypothesis that predatory dinosaurs did not regularly chew the bones of their prey. Also, biomechanical modeling suggests that *Allosaurus* processed carcasses differently than large tyrannosaurids which have been considered bone crushers. Dental microwear texture analysis (DMTA) has recently been shown to be a useful tool in predicting the feeding habits of extant carnivoran mammals. DMTA quantifies microscopic, three-dimensional tooth textures and provides a valid proxy for the degree of durophagy in which an individual engages. Dental microwear has been found in several dinosaurian taxa, both carnivorous and herbivorous, but has yet to be documented for *Allosaurus*. The extensive collection of Allosaurus material recovered from the Cleveland-Lloyd Dinosaur Quarry includes several dentaries, premaxillae, and maxillae complete with teeth. We plan to perform a DMTA of these teeth which could help settle whether or not, and to what degree, *Allosaurus* may have engaged in osteophagy.

OCCLUSAL ENAMEL COMPLEXITY IN RHINOS (RHINOCEROTIDAE; PERISSODACTYLA) OF OREGON

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Members of the Family Rhinocerotidae are present throughout the entire section of the John Day Fossil Beds National Monument of central and eastern Oregon, representing about 50 million years of evolution of this family in one region. Each genus of rhino has a distinct occlusal enamel pattern. The processes influencing the evolution of these occlusal patterns in this clade have not been thoroughly investigated. I investigated Occlusal Enamel Index, a quantitative method for the analysis of the complexity of occlusal patterns. I tested whether rhino teeth increase resistive cutting area for food processing during mastication, as expressed in occlusal enamel complexity, in response to increased abrasion in their diet. Preliminary results suggest that occlusal enamel complexity was influenced by climate and phylogeny through time. Occlusal enamel complexity in the rhinos of Cenozoic Oregon increased as the animals experienced increased tooth abrasion and a cooling climate.

EXTINCTION AND EPISTEMOLOGY

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Paleontologists use a variety of logical tools to infer conclusions about the deep past. Many of those inferences—for example, phylogenetic reconstructions, faunal analyses, and work in functional morphology—have logical structures that place those arguments in a class termed “inferences to the best explanation.” Not all paleontological inferences belong in that class, however; in particular, inferences about extinction belong in another class of arguments termed “enumerative inductions.” Two statistical methods of extinction analysis—the Gaussian Resampled Inverse Weighted Method and “Deconvolution”—are here examined to highlight their logical structures. The logical structure of extinction analysis is then compared with analysis of other processes to determine whether or not

methodological differences are driven by functional differences between extinction and other processes.

THE TRAGEDY OF THE COMMON FOSSILS: PUBLIC STEWARDSHIP, MOTIVATION, AND THE FOSSIL COMMONS

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Paleontological inquiry ultimately relies on the discovery of entombed remains of previous generations of organisms, mostly managed through "convenient fictions" such as boundaries and policies. There is a bewildering variety of relatively recent laws and regulations applied to fossils found on public lands ("the Commons") throughout the world, with no two countries having identical policies. In the Americas, the first permits for collecting vertebrate fossils were issued just over 100 years ago by the U. S. Department of the Interior to the Carnegie Museum for the collection of fossils on tribal lands in Utah, and later at what is now Dinosaur National Monument.

Many scientists disregard the importance of effective land management to their work, despite the obvious need of a verifiable "laboratory" providing an opportunity for others to replicate and/or falsify research conclusions. Despite a few odd investigators clamoring for unregulated access to the fossil commons, a conservation ethic is the historical norm; indeed, vertebrate paleontologists have a proud tradition of supporting the preservation and wise stewardship of most natural resources, including fossils.

Scientific and public usefulness of materials exhumed from the commons appears to have much more to do with the collector's motivation, rather than the academic credentials of the workers. Providing for the appreciation and preservation of specimens for others to benefit in a myriad of ways (evidenced by appropriate research and curation) seems a more appropriate use of the commons than supporting individuals on "the Me Plan" (viewing fossils as marketable commodities, or merely satisfying one's personal hobby/research interest, etc.). This applies across all taxonomic biases. There is no valid reason why an unusual assemblage of fossil plants, soft-bodied invertebrates, or trace fossils should be regarded as less significant than any vertebrate fossils. For example, widespread occurrences of millions of fossil fish - so common as to be essentially worthless as research material - can scarcely compare to many fragile and/or unique invertebrate and botanical sites.

We encourage paleontologists of ALL disciplines to re-think legislative efforts and management plans on a broad scale, making the fossil commons less tragic for curation and study.

EVIDENCE OF INCREASED NEOTHEROPOD DIVERSITY FROM THE UPPERMOST TRIASSIC OF NEW MEXICO, USA

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The understanding of the diversity of members of Neotheropoda has been in flux due to refining diagnosis in taxonomic studies. Presented here is a nearly complete tibiotarsus of an unnamed Neotheropod dinosaur, specimen number MCCDM 1744. This specimen exhibits a unique, gracile morphology similar to other known Neotheropods like *Camposaurus arizonensis* and *Coelophysis rhodesiensis*. The specimen shows significantly pronounced anteriorly projecting condyles of the astragalocalcaneum, a raised fibular crest, and a cnemial crest lacking a proximal notch. It also shares a globular process on its posteromedial surface with *C. arizonensis* and *C. rhodesiensis*. In anterior view, the specimen has a concave ventral margin of the astragalus. Unfortunately, most of the distal posterior view of the astragalocalcaneal portion is poorly preserved and makes the study of the area problematic. This character analysis of MCCDM 1744 indicates the presence of a potentially new species of coelophysid Neotheropod in the Quay Member of the Redonda Formation (latest Triassic, Rhaetian) of New Mexico. Adding insight into the origins of Neotheropods, the specimen also presents a unique opportunity in future diversity studies of Coelophysidae, although the clades exact phylogenetic structure remains uncertain.

LATE CRETACEOUS CROCODILIANS AND TURTLES FROM MICROVERTEBRATE SITES, HELL CREEK FORMATION, SOUTHWESTERN NORTH DAKOTA

GISSLER, Danah P., California State University Stanislaus, Turlock, CA, United States of America; MORA, Margaret E., California State University Stanislaus, Turlock, CA, United States of America; CHAVEZ, Amanda J., California State University Stanislaus, Turlock, CA, United States of America; DALTON, Abigail M., California State University Stanislaus, Turlock, CA, United States of America; SANKEY, Julia T., California State University Stanislaus, Turlock, CA, United States of America

The Hell Creek Formation is a Late Cretaceous terrestrial unit exposed in Montana, Wyoming, and North and South Dakota. It is famous for the well-documented Cretaceous/Paleogene (K/Pg) boundary and for its many dinosaurs and other vertebrates. The Hell Creek of southwestern North Dakota has been extensively studied, and numerous vertebrate fossils have been recovered from high-resolution sections tied to the K/Pg boundary. An important previous study on the vertebrate diversity prior to the K/P boundary in this area focused on fossils recovered by

excavation of large specimens and the surface collection of small fossils from microvertebrate sites. However, no screen-washing of microvertebrate sites was done. Were small fossils and some taxa missed? To address this question, we surface collected and screen-washed twelve previously collected microvertebrate sites. We recovered thousands of small fossils, including abundant sharks, rays, and other fish, which had previously been missed or undersampled. Here we report on the crocodilians, champsosaurs, and turtles. We identified the fossils using literature and comparison to collections at the University of California Berkeley Museum of Paleontology (UCMP). Based on at least 204 teeth and tooth fragments, we identified the following taxa of crocodilians and champsosaurs: *cf. Borealosuchus* (17), *Brachychampsa* (60), *Leidyosuchus* (70), and *Champsosaurus* (35). All are taxa that had previously been reported from the Hell Creek of North Dakota, with the except of *cf. Borealosuchus*, which may be new to the record of this area. Based on numerous turtle scutes, we identified: *Compsemys*, Trionychidae, Baenidae, Chelydridae, and *Adocus*. Trionychids are the most abundant turtles, with baenids also common. In contrast to prior collections from the Hell Creek of North Dakota, we found that *Compsemys* and *Adocus* were more abundant in our study than in previous studies from this area.

A NEW DREPANOSAUROMORPH SPECIES FROM THE CHINLE FORMATION OF PETRIFIED FOREST NATIONAL PARK, ARIZONA

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Drepanosauromorpha is an extinct group of reptiles known from the Middle to Late Triassic (237–212 MA). The clade currently includes seven genera (*Avicranium, Dolabrosaurus, Drepanosaurus, Hypuronector, Kyrgzsaurus, Megalancosaurus*, and *Vallesaurus*) that are known from fossils collected in Europe (Italy, UK), North America (Arizona, New Mexico, New Jersey), and Asia (Kyrgyzstan). The first described drepanosauromorph, *Drepanosaurus unguicaudatus,* was based on a flattened holotype preserving most of a complete skeleton. Subsequently described drepanosauromorphs contain some of the following features: the length of the chevrons is substantially longer than caudal (tail) neural spines, the cervical (neck) vertebrae are heterocoelous (saddle-shaped articular surface), the cervical ribs are absent as distinct ossifications and the chevrons are fused to the centra. In recent years, both three-dimensionally preserved partial skeletons and isolated material of drepanosauromorphs have been found across both Europe and North America. These discoveries have helped shape our understanding of the biology and diversity of drepanosauromorphs. However, comparing isolated, three dimensionally preserved specimens to the more complete, yet two dimensionally preserved articulated specimens is difficult due to differences in preservation. Here, we describe a new drepanosauromorph species from the Chinle Formation in Petrified Forest National Park, Arizona based on the ungual phalanx of the second digit of the hand. Some of the characteristics that distinguish this claw from most drepanosauromorphs is the size of the claw. It differs significantly from all known *Drepanosaurus* specimens (like the Italian holotype and the Hayden Quarry Drepanosaurus) because of the ventral placement of the cotyle, the height of the claw, the lack of compression along the pre-axial/post-axial plane and a furrow along the midline. This new taxon not only shows how much morphological variation there is within Drepanosauromorpha, but this taxon also helps create a clearer understanding of the evolutionary history of smaller-bodied reptiles within the Triassic.

A SHARK BOARDS A VIKING FUNERAL SHIP AND TAKES A CRUISE TO SOUTHERN ALASKA

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Paleocene and Eocene marine vertebrates are rare in the eastern North Pacific. Those previously-reported are primarily known from central to southern California and along the coast in northern Oregon, through Washington, and into southernmost British Columbia. Here I report two new localities from the Kulthieth Formation in the Yakutat district of southern Alaska. Both localities were collected for fossil invertebrates by Don J. Miller of the US Geological Survey during geologic mapping of the area south of Robinson Glacier along the Gulf of Alaska and are the only vertebrate sites known for the formation. Shark teeth with characteristic enamel striations and shape can be attributed to the sand tiger shark *Striatolamia macrota* were found preserved as well-mineralized, three dimensionally preserved fossils in marine sandstones, along with natural molds or casts of marine invertebrates, principally the gastropod *Boreoscala*. Biostratigraphic correlation of the molluscs suggests a late middle Eocene or late Eocene age.

Today these sites occur at approximately 60 degrees north latitude and represent the most northerly known Eocene marine sites in the eastern Pacific. However, the Kulthieth Formation occurs on the Yakutat Block, an accreted terrane that has moved northward along the strike-slip Queen Charlotte-Fairweather Fault System. As such, the Yakutat Block represents a classic example of a biogeographic Viking Funeral Ship, a piece of continental crust rifted away from one landmass and travelling to an adjacent landmass, carrying fossils from one area, where the populations had lived, to a second area

where the fossil biota had never lived. Recently published geophysical models suggest that the Yakutat Block was birthed from the Yellowstone hotspot and accreted to North America (along with Siletzia) as it moved westward over the hotspot. Deposition of the Kulthieth Formation and *Striatolamia* teeth likely occurred at approximately 45 degrees N at a latitude similar to known sites in Oregon, Washington, and southernmost British Columbia but slightly further to the west and should be studied in the context of those faunas, rather than as a representative of a more northerly biota.

COMPARATIVE CRANIAL HISTOLOGY OF THE PACHYOSTOTIC AND NON-PACHYOSTOTIC SKULL ROOF IN PERMIAN BURNETIAMORPHS (THERAPSIDA: BIARMOSUCHIA) AND GORGONOPSIANS (THERAPSIDA: GORGONOPSIA)

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Elaborately thickened skulls have convergently evolved in several groups of nonmammalian synapsids, including dinocephalians and burnetiamorphs. To assess differences in the construction and growth of pachyostotic tissues in synapsids, we histologically analyzed two burnetiamorph individuals of small and inferred sub-adult sizes. We compared these pachyostosed skulls to the more normal (i.e., non-pachyostosed) skull of a gorgonopsian to highlight differences in sutural morphology as well as bone tissue density and organization.

We recognize four histological zones visible in coronal thin-section in both burnetiamorphs. Zones A and B make up the endocranial region of the skull cap and consist of disorganized fibrolamellar bone (Zone A) and an avascular border surrounding a region of primary and secondary osteons (Zone B). Zone C is the thickest in both individuals and is extremely vascularized with radial fibrolamellar bone. Zone D makes up the ectocranial surface and similarly consists of radial fibrolamellar bone but preserves shorter canal lengths. This results in a less porous but still highly vascularized outer tissue layer termed Zone D.

Remnant suture patterns extend throughout Zone C and appear open and interdigitated towards the endocranial region but are completely obliterated towards the ectocranial bone surface. We suggest that the rapid ectocranial expansion in burnetiamorphs drove sutures to grow together resulting in the clade's characteristic spongey bone surface devoid of obvious external sutures. In contrast, the gorgonopsian skull preserves visible sutures on the skull surface as well as in thin-section. Due to the limited availability of gorgonopsian skulls for destructive sampling, we do not have thin-sections of the skull roof but report open and interdigitated sutures from the snout.

The differences in bone histology present in burnetiamorphs and gorgonopsians suggest that rapid ectocranial expansion caused sutures to obliterate in small and inferred sub-adult burnetiamorphs. In contrast, gorgonopsian tissue reflects more typical skull growth typified by replacement and bone remodeling. Future work could investigate whether sutures are obliterated or maintained in the thickened and ornamented skulls of other synapsids (e.g., dicynodonts or dinocephalians).

BIOSTRATIGRAPHY AND FAUNAL ANALYSIS OF A LATE PLEISTOCENE MEGAFAUNA QUARRY AT VANDENBERG AIR FORCE BASE, SANTA BARBARA COUNTY, CALIFORNIA

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'Eiko's Elephant Graveyard' (EEG) quarry at Brown's Beach is a diverse and well-preserved Rancholabrean megafauna locality on a late Pleistocene marine terrace at Vandenberg Air Force Base (VAFB) in Santa Barbara County. EEG is located in the northern portion of VAFB, south of Point Sal State Beach. Fossils in this locality have previously been found within three distinct beds approximately 2 meters above the wave-cut platform of marine terrace 5a (80ka), and below a thick sequence of alluvial sediments that comprise the upper half of the terrace deposit. The base of the EEG Quarry is marked by a red, erosionally resistant, iron-rich caliche layer. The overlying beds contain disarticulated, but associated, *Paramylodon harlani* elements, with over 50% of the skeleton and over 100 osteoderms recovered to date. Other fossils recovered from EEG include *Camelops hesternus*, *Smilodon fatalis, Bison sp., Equus sp., Emydidae indet.,* and more.

Additional fossils have recently been discovered in the hillside just north of the quarry, with beds that appear to be stratigraphically higher than the three previous layers found in EEG. A *Mammut americanum* pelvis and *Emydidae indet.* carapace fragments were recovered from the lower sand bed and a complete *Megalonyx jeffersonii* skull was recovered in a dense clay bed approximately 2 meters above the pelvis.

Although *M. jeffersonii* has the largest geographic range of all the Rancholabrean sloths, they are rare in California. This is the first record of the species in Santa Barbara County, and the first multi-taxa sloth locality known from the Central Coast. The presence of *M. jeffersonii* and *P. harlani*, and the preservation of the fossils within the quarry, emphasizes the significance of the fauna at EEG.

LATE PLEISTOCENE *MAMMUTHUS* AND *CUVIERONIUS* (PROBOSCIDEA) FROM TÉRAPA, SONORA, MEXICO

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The gomphothere, *Cuvieronius*, and the mammoth, *Mammuthus*, are recovered from the San Clemente de Térapa (=Térapa) local fauna, east-central Sonora, Mexico. Basaltic Tonibabi lava flow forced the Río Moctezuma west within its valley and created a small catchment basin which preceded to in-fill with side-streams from the east. The impoundment created two episodes of a short-lived marsh and open-water environments, both filled with vertebrate and invertebrate remains. Bison remains place the local fauna within the Rancholabrean LMA. Analyses using infrared stimulated luminescence (IRSL), amino acid racemization (AAR), and radiocarbon (14C) show the impounding basalt and fossiliferous sediments occurred 43,000 to 40,000 years ago (Oxygen Isotope Stage 3; pre-last full glacial). *Cuvieronius* and *Mammuthus* are found throughout the stratigraphic profile at Térapa. Both proboscideans visited the basin as soon as it was formed by the lava flow and began filling with sediments. The record from Térapa and elsewhere in northern Sonora illustrates that *Cuvieronius* had reached its apparent northern limit of Late Pleistocene habitat tolerance in northern Sonora and did not (could not?) make it the approximate 135 km (85 mi) to habitats farther north in southern-most Arizona. *Mammuthus* appears more common in the Sonoran fossil record and occurred throughout non-glaciated North America. All data together, the implication is that the Late Pleistocene of Sonora had a cooler summer climate, one with more winter rains and less summer rains and less summer evaporation. Woodlands and shrub communities were in the upper bajadas and rocky hills. Valleys contained more grasslands than they do today. Such environments certainly permitted *Mammuthus* and *Cuvieronius* to exist over most of Sonora where the proboscideans and habitats are extinct today.

ALLOMETRY OF BONY SOUND RECEPTION STRUCTURES: CHAMELEONS AS A POTENTIAL FUNCTIONAL ANALOG FOR HEARING ABILITY IN NON-MAMMALIAN THERAPSIDS

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The evolution of the mammalian middle ear bones is one of the best-documented examples of a morphological transition. However, the functional role of the postdentary bones in non-mammalian therapsid hearing is still uncertain, precluding a full understanding of the selective pressures that drove this evolutionary change. The current leading hypothesis for the hearing ability of non-mammalian therapsids is that they used their reflected lamina, the homolog of the ectotympanic bone of mammals, to capture airborne sound vibrations and transmit them to the inner ear. Little evidence has been generated to support or refute this hypothesis, so we aim to test the function of the reflected lamina through comparison with a modern analog: the pterygoid plate of chameleons. Some chameleons have co-opted this muscle attachment site to receive airborne sound, so their pterygoid plate may have adaptations that make it superior in sound reception to that of 'non-hearing' chameleons (i.e. those that cannot hear airborne sound). One aspect of pterygoid plate morphology that could correlate with hearing function is its allometry with skull size. Sensory structures tend to exhibit negative allometry because the optimal size for performing a sensory function generally does not increase with body size. If this is true for bony sound reception structures, then chameleons that use their pterygoid plate for hearing should have more negative allometry in this bone than do the 'non-hearing' species. We measured basal skull length and pterygoid plate area in an ontogenetic series of skulls from hearing and non-hearing chameleon species. These data were fit to an allometric growth equation. Preliminary results from seven species indicate that hearing chameleons have a more positive coefficient of allometry than non-hearing ones do. This surprising result could be attributed to the small body size of the chameleons studied. In small reptiles, the tympanum generally shows positive allometry because the animal never grows large enough for its tympanum to reach its optimal size for hearing. If this is true for the pterygoid plate of chameleons, then differential allometry may be informative in assessing the function of the reflected lamina in small therapsids.

A RIDDLE WRAPPED IN A MYSTERY: THE ENIGMATIC FELID *NIMRAVIDES* IN THE MIOCENE OF OREGON AND IDAHO

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The Late Miocene is an important interval in feliform evolution in North America, with the appearance of the last and largest of the nimravids, *Barbourofelis,* as well as the first large felids on the continent. Notable among these big cats are the machairodontine *Machairodus* and the "North American sabertooth" *Nimravides*. Reconstructing the evolutionary history, ranges, and paleoecology of these taxa has proven difficult due not only to a fossil record dominated by non-diagnostic postcrania, but to widespread taxonomic disagreement and confusion. This confusion is best exemplified by the recent recognition that the species *N. catacopis* is in fact most likely referable to *Machairodus.* Correctly diagnosing Miocene feliforms and documenting their occurrence patterns would be beneficial to paleobiological studies throughout North America. This is especially true in the Inland Northwest, a region that was a biogeographic crossroads in the Miocene and is the focus of extensive paleoecological research. The

Hemphillian Dalles Group of northeast Oregon has yielded a spectacular skull of *Barbourofelis oregonensis* and potentially diagnostic dental fragments of *Machairodus,* as well as a wealth of impressive but uninformative postcrania. A previously unreported specimen from the Clarendonian Chalk Hills Formation of Idaho represents the first known occurrence of *Nimravides* in the region. The specimen (IMNH 38696) consists of an associated maxillary fragment, left dentary, and distal humerus. The dentary allows the specimen to be diagnosed as *Nimravides* due to the conical shape of the canine and the lack of a mandibular flange. Not only does this indicate a greater diversity of "big cats" in the region than had previously been recognized, but the rare association of dental material and a humerus may make it possible to more accurately identify feliforms from localities dominated by postcranial material.

A NEW *ENALIARCTOS* (MAMMALIA, CARNIVORA, PINNIPEDIMORPHA) RECORD FROM THE ASTORIA FORMATION OF OREGON

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Enaliarctos is a genus of stem pinniped that is often recovered as the most basal member of the pinnipedimorphs. This genus has previously been diagnosed as a metataxon, as there are no synapomorphies which unite all 5 species within it. This has historically been a point of interest among workers. Here, we consider a new specimen: a nearly complete and edentulous skull infilled significantly with a well-indurated and muddy sandstone from the Astoria Formation of Moolack Beach, Oregon. Given several characteristics of the visible morphology, including the termination of the jugal anterior to the M1, a “splint”-like squamosal-jugal contact, and a homodont postcanine dentition, we tentatively assign this specimen to *Enaliarctos emlongi*, a derived member of the *Enaliarctos*.

RANCHO CORDOVA: A LATE PLEISTOCENE-HOLOCENE SITE FROM THE STATE OF SAN LUIS POTOSI, MEXICO

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It is not common to have an archaeological site superimposed on a Late Pleistocene one, especially where several C-14 ages have been determined for both. However, this condition occurs near the city of Cedral in the state of San Luis Potosí, México. Discovery of the Rancho Córdova site came about in December of 2016. At that time Juan Rojas, an amateur collector from the city of Matehuala, discovered a mammoth rib and vertebra. Later this find came to the attention of archaeologists at the Universidad Autónoma de San Luis Potosí. Subsequent field work at Rancho Córdova revealed archeological as well as additional fossil materials. To date more than 120 days of fieldwork have been spent collecting both Holocene artifacts and Late Pleistocene fossils by professional archaeologists and paleontologists. The above site lies primarily in a roughly circular depression about 25m across and 5m deep. It exists on a regional plateau known as the “Zona del Altiplano Potosino.” This plateau measures approximately 1,700m in elevation. The site location is about 2km east, southeast of the city of Cedral. A preliminary geological study of this site and its surrounding area showed a series of ancient spring deposits. Wells were dug in modern times at or near old spring sites for water to cultivate the land. With a lowering of the water table the earlier springs no longer exist. The ancient spring deposits are those that contain the discovered fossils and artifacts. While some mudstone units make up part of the exposed beds, the major ones are forms of tufa. All the exposed strata to a depth of 5m exhibit a very high calcareous content. The strata in evidence here apparently extend unbroken for at least 2km beyond Rancho Córdova in all directions, implying a probable shallow lake in the area at times. At other times the water receded and a vegetated land surface developed. The lowest exposed stratum at Rancho Córdova is a calcareous mudstone. Its surface, directly underlying a thick tufa deposit, shows signs of a paleosol. Mudstone stringers, some with very thin carbon seams, exist within this tufa. These possibly represent burned zones and would have developed with vegetation covering the land surface. Small pieces of carbon and carbonized wood fragments occur throughout all the strata from Holocene through exposed Pleistocene deposits. Several samples of these have been dated using a C-14 AMS method. While results have not yet been obtained for all samples submitted, dates have come back for five. From oldest to youngest the determined ages run from 41,000+/- 1,300 ybp to 1,647+/- 57 ybp. Archaeological items so far viewed or recovered to date include projectile points made of various rock materials with abundant flakes present, tools also of various materials, carved and polished lithics as well as ceramics and matates. Some few pieces of ivory appear to have been worked by man which presumably came from mammoth tusks. Portions of some animal bone show indications of working by man, too. Also occurring with the artifacts are pieces of burned and unburned wood. Additionally, seeds of various types seem to be associated with the group of primitive hunter-gatherers responsible for the artifacts listed. Various animals are represented by their bones and teeth in the Holocene deposits along with the artifacts. Preliminary studies show the following

types: an anuran, mud turtle, lizard, two kinds of ducks, quail, hawk, three kinds of rabbit, eight types of rodents, wolf and coyote, mountain lion, peccary, deer, and sheep. Other animals, those associated with modern man and found in surficial deposits, include domestic pig, cattle, sheep and goat. A piece of bone from a domestic goat jaw was dated at 210+/- 30 ybp. Pleistocene fossils found at the Rancho Córdova site to date consist of dog, bear, very large felid, mammoth, rabbit, rodents, probably more than one species of horse, tayassuid, two kinds of camelids, possibly more than one type of bison and a goat. Dry screening produced many of the Holocene materials and some of the Pleistocene fossils. This work will be continued as deposits at Rancho Córdova likely will produce many more artifacts as well as more fossils. Although the sample size is still relatively small regarding Pleistocene fossils, present counts show that mammoth and horse provide the majority of large mammals present. According to the literature this apparently holds true for the majority of Pleistocene sites throughout Mexico. Sediments at Rancho Córdova indicate a wetter environment for this area than exits at present. The fauna, too, implies more moisture. Probably the surrounding terrain was composed of grasslands with scattered woods.

OREGON HAS TWO DINOSAURS

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Before October 2018, there were no confirmed dinosaurs from the state of Oregon, but by the end of that month there were two. One of these is a toe bone of a large (5.1 m long and 678 kg live weight) ornithopod from near Mitchell, Oregon, found by Greg Retallack. Associated ammonites give a very precise age of 103 Ma (early Albian, Early Cretaceous), and also indicate that it was from a disintegrating carcass that drifted out into the ocean. The Mitchell ornithopod is a pedal phalanx lacking collateral pits and girdling sulcus of most dinosaur toe bones, but has lateral lappet basins like large ornithopod dinosaurs. The age of the Oregon toe bone is between that of well-known *Tenontosaurus* and *Eolambia* from Utah and Wyoming. Associated fossil plants in the same marine shales are evidence of a coastal redwood forest like that of modern Redwoods National Park. A further similarity with Northern California today, are the gravelly sediments of shingle beaches and alluvial fans from nearby sea cliffs. A second report in October was a sacrum of an equally large ornithopod from marine sandstone of Cape Sebastian, found along with ammonites and inoceramids dated to about 74 Ma (late Campanian, Late Cretaceous). This specimen was first discovered in 1969 by Don Savage of Berkeley, and collected in 1994 by David Taylor, but preparation from its very hard matrix was completed recently. It has eight co-ossified vertebrae, an undulose iliac bar, and tall strut-like sacral ribs fused centrally to the centra. The most similar known sacra are those of hadrosaurine duckbills of the genus *Kritosaurus*. Associated fossil leaves are evidence of broadleaf forest flanking shallow marine or shore-face sandstones of a low gradient coastal plain.

UPDATING THE LATEST CRETACEOUS VERTEBRATE DIVERSITY RECORDS AND PALEOENVIRONMENTAL INTERPRETATIONS PRIOR TO THE K/PG BOUNDARY, HELL CREEK FORMATION, NORTH DAKOTA

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Much of our understanding about latest Cretaceous paleocommunities from just prior to the K/Pg mass extinction come from the Hell Creek and Lance formations of Montana, Wyoming, and North and South Dakota. One important study documented the numbers of vertebrate species leading up to the K/Pg boundary based on numerous sites from the Hell Creek Formation of southwestern North Dakota. Although insightful, this work was based solely on specimens that were surface collected or excavated, and not from screen-washing microvertebrate sites. Were small specimens missed, such as shark teeth? Do these smaller specimens change the pre-K/Pg diversity patterns and the paleoenvironmental interpretations? To address these questions a selection of 12 microvertebrate sites were screen-washed from the same stratigraphic section. We used fine-mesh screens, and sorted the resulting matrix with a microscope. This work produced thousands of small specimens (teeth and bones) from numerous and diverse vertebrates, many of which had been missed by surface collecting. For example, screen-washing two sites (PTRM 86002 and 89003) produced sharks and rays (79%), amphibians (5%), lizards (2%), snakes (0.2%), crocodilians/champsosaurs (7%), hadrosaurs/ceratopsians (2%), theropods/birds (2%), and mammals (3%). Sharks and rays were the most common specimens recovered from screen-washing these two sites, yet they were missed during surface collection. Our screen-washing effort has changed the vertebrate diversity record leading up to the K/Pg and also has changed the paleoenvironmental interpretations for the upper Hell Creek Formation, indicating the proximity a seaway in this area.

IMPLIED VOCALIZATION BASED ON THE MORPHOLOGY OF THE HYOID APPARATUS IN THE SABERTOOTHED CAT, *SMILODON FATALIS* (MAMMALIA; FELIDAE; MACHERODONTINAE) FROM RANCHO LA BREA, LOS ANGELES, CALIFORNIA

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Rancho La Brea has recorded the most complete terrestrial biota from the late Pleistocene of North America. One of the many unique qualities of these fossiliferous asphalt deposits is the preservation of bones that are rarely found elsewhere in the fossil record. The complete structure of the hyoid apparatus has been recovered from several extinct species found at Rancho La Brea. Over 150 ossified hyoid elements have been studied representing the basihyal, thyrohyal, and stylohyal of *Smilodon fatalis*. These bones are morphologically distinct in size and shape when compared to large feline cats, including the extinct American lion (*Panthera atrox*) and extant African lion and leopard (*Panthera leo* and *Panthera pardus*). The structure of the hyoid apparatus in *Smilodon fatalis* is most similar to these extant large feline cats than to any other carnivoran clade. This form of hyoid structure entails a reduction of the total number of bones through loss and fusion, with an elastic ligament that stretches from the ventral ends of each (ie., left and right) stylohyal to each dorsolateral end of the basihyal. This configuration is associated with the ability to enlarge the cavity of the throat enabling living large feline cats to roar, which is an important communication ability.

Extant felines form two natural groups based on the structure of the hyoid apparatus. Most members of the feline clade have 9-11 ossified hyoid bones, which anchor the tongue and support the larynx, and these species can purr but not roar. The rest have reduced the number to 5-7 bones, which allows them to roar but not purr. The one exception to this general scheme is the clouded leopard (*Panthera uncia*), which has 5-7 ossified hyoid elements, but neither purrs nor roars. So, the similar condition of the hyoid apparatus to the roaring cats implies (at least) that *Smilodon fatalis* had the physical capability to enable roaring behavior. Laryngeal soft tissue also plays a role in roaring, which is difficult to assess in *Smilodon fatalis* fossils. Even so, vocalizations of various kinds are important communication abilities, and roaring may have been as important in a social group of *Smilodon fatalis* as it is today in *Panthera leo*.

VERTEBRATE PALEONTOLOGY OF THE LOWER TRIASSIC FREMOUW FORMATION IN THE SHACKLETON GLACIER AREA (ANTARCTICA)

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Rocks of the Transantarctic Mountains exposed in the area of the Shackleton Glacier were first investigated by vertebrate paleontologists during the 1970–1971 austral summer. Tetrapod fossils (e.g., *Lystrosaurus, Procolophon*, and *Thrinaxodon*) collected from the lower member of the Fremouw Formation were a critical link to coeval assemblages from the Karoo Basin of South Africa and elsewhere and provided compelling evidence that Antarctica once formed part of Pangea. Historic localities such as Halfmoon Bluff, Kitching Ridge, Shenk Peak, and Thrinaxodon Col provided the bulk of the geological and paleontological information about the Lower Triassic of Antarctica, but have received little attention since their initial discovery almost 50 years ago. In 2017, we conducted four weeks of helicopter-assisted fieldwork in the Shackleton Glacier area, leading to the rediscovery of old quarries and many new fossil localities.

Newly measured stratigraphic sections suggest that vertebrate fossils the lower Fremouw Formation primarily occur in crevasse splay deposits with abundant siliceous root traces in relict ripple cross laminated units, suggesting a meandering fluvial environmental setting. However, isolated bones often occur in intraformational conglomerates, especially near the base of the formation, in large channel forming trough cross-bedded sandstones. Footprints and trackways were rarely encountered in floodplain deposits, but large diameter sand-filled burrow casts (14 cm across) were occasionally locally abundant. Vertebrate fossils include isolated elements and partially articulated individuals preserving remarkable detail. Importantly, we collected the first diagnostic tetrapod material from the middle member of the Fremouw Formation. Although preparation is ongoing, our initial identifications suggest that both the lower and middle members are likely Lower Triassic, indicating broad-scale correlation to the Katberg Formation of South Africa. Interestingly, small temnospondyls are an important component of the middle Fremouw assemblage and likely represent a species allied with *Lapillospis* from the Triassic of Australia.

DOGS, DEATH, AND DIETARY VARIABILITY: TESTING PATTERNS OF CANIDAE MACROEVOLUTION USING DENTAL MICROWEAR TEXTURES

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The canid family (Mammalia: Carnivora), has an exceptional fossil history reflecting dynamic macroevolutionary patterns. One prevalent pattern is the macroevolutionary ratchet, where convergent evolution of successful morphotypes leads to increasingly specialized species over time, which are eventually driven to extinction. While this iterative process is well recognized in the fossil record, dietary specialization and its link to extinction risk has previously been indirectly inferred from morphological traits (e.g. body mass, molar surface area), not dietary reconstructions. While morphology reflects overall dietary behavior and metabolic constraints, individuals (and species)

frequently forage opportunistically in ways morphology cannot always predict. We investigated if direct reconstructions of canid dietary niche space align with macroevolutionary trends inferred from species-level morphologies. Specifically, we tested if a link exists between increased dietary specialization through time and the ultimate extinction of canid lineages. We quantified dietary niche space of 10 extinct species spanning the past 33.3 million years of Canidae evolution, representing the Hespercyoninae, Borophaginae, and Caninae subfamilies, via Dental Microwear Texture Analysis (DMTA). DMTA quantifies microscopic wear patterns created on tooth enamel as food is masticated, reflecting the types of foods consumed, and capturing a comprehensive picture of resource use including behavioral specialization and plasticity. DMTA parameters were used in a Bayesian framework to reconstruct three-dimensional ellipsoids reflecting dietary niche space for each species. Standard ellipsoid volumes were calculated for each species as a measure of dietary breadth and tested for correlation with species durations. We found that dietary behaviors inferred from DMTA parameters better explain species durations than morphological traits, including the widely-used metric of body mass. Counter to expectation, a positive correlation emerged between increased specialization (smaller niche breadth) and lineage duration. Dietary generalization was greatest for canids of intermediate body mass and not correlated with foraging strategies (i.e. hypo- or hypercarnivory). Our results disrupt the prevailing macroevolutionary ratchet hypothesis, suggesting that overspecialization in diet alone was not enough to drive iterative extinctions of fossil canid clades. Additionally, dietary specialization was not restricted to more derived species. Prevailing wisdom suggests specialization is linked to increased extinction risk, causing an inability to adapt to sudden fluctuations in prey availability. However, dietary specialization potentially offers additional benefits, such as reduced handling times and lower rates of competition with congeners.

A LITHOGRAPHIC ANALYSIS OF THE CROOKED RIVER MASCALL FORMATION

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This project presents a comprehensive lithological and biostratigraphic record of the Miocene Mascall Formation deposits of the Crooked River Basin in Central Oregon. The Columbia River Basalt Group (CRBG) covered the Crooked River Basin and much of the Pacific Northwest in the middle Miocene, altering the landscape and ecosystem. An analysis of the depositional history of this region is worthwhile because it explores the impact of large-scale basalt flows on subsequent basin evolution in a region that lacks extensive lithostratigraphic data. University of Oregon geology students have measured stratigraphic sections in several different locations across the Crooked River basin in order to quantify the differences in depositional history across the basin. The regions we have defined for a holistic representation of the region are Twin Buttes in the north, Hawk Rim in the west, Cave Basin in the east, and the South Fork of the Crooked River in the south. They are situated between the lower boundary CRBG and upper capping Rattlesnake Ash Flow Tuff (RAFT). For each region, we have chosen a representative stratigraphic column, and we correlate the depositional units between these disparate areas. The Mascall Formation in the Crooked River Basin is consistent with published descriptions of the Lower Mascall Formation: mostly fine siltstone and sandstone with diatomite, ash, and chert deposits and some tuff strata (Bestland, 1998). Each of the four sites share characteristics of the Lower Mascall which suggests similar depositional environments across the sites; however, the sections vary in the thickness and representation of individual identifiable strata, suggesting variation in where deposition was greatest through the half-million years of the section. This is the first comprehensive assessment of the stratigraphy of the Crooked River Basin, which will have significant implications for understanding landscape reorganization following large-scale basaltic volcanism.

PATTERNS OF P4 SHAPE IN LATE CRETACEOUS AND PALEOGENE MULTITUBERCULATES: FUNCTIONAL CONSTRAINTS AND THE EVOLUTION OF HERBIVORY

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Cimolodontan multituberculates were a diverse and long-lived group of mammals characterized by their large, blade-like lower fourth premolar (p4). Blade-like (plagiaulacoid) dentitions have evolved numerous times in distantly related mammal lineages. Here we investigate how this specialized dentition varied through time in the Cimolodonta and what role it played in their dental morphological evolution. We quantified important aspects of p4 shape, including ratios reflecting height (H:L), symmetry (L1:L), and height of the mesial face (H1:H), in a large sample of cimolodontans spanning the mid-Cretaceous to early Paleogene of North America. Using these data, we investigated how p4 shape disparity changed through time. We find that cimolodontans evolved a wide range of p4 forms by the mid-Cretaceous and that p4 shape disparity remained stable through the Late Cretaceous. We suggest that the chewing cycle of cimolodontans imposed functional constraints on their p4 morphology. After the Cretaceous-Paleogene boundary, p4 shape disparity increased sharply. This pattern is driven by the appearance of cimolodontans that reduced their use of p4, relaxing the functional constraints on p4 morphology. The fact that cimolodontans adapted to herbivory by increasing the size and complexity of their molars at the expense of p4, suggests

that this specialized tooth may have limited their dental morphological evolution.

COMPARATIVE HISTOLOGY AND DEVELOPMENT OF DICYNODONT TUSKS

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Dicynodonts were a diverse and distinct group of non-mammalian synapsids that originated in the middle Permian and persisted until at least Late Triassic times. One of the most distinct features of the group are the paired maxillary tusks found in most genera. Descriptions of these tusks are surprisingly variable; some have been described as ever-growing and others not, some have been described as enamel-covered and others not enamel-covered, and some have been considered attached to the jaw by a periodontal ligament and others were found to be fused to the jaw. Despite extensive interest and research into dicynodont tusks, a systematic survey and histological analysis of tusk development and its associated tissues have not been conducted. Here we present findings from work that aims to determine the tissues and development of tusks in a range of dicynodont genera (e.g. *Lystrosaurus, Diictodon, Oudenodon, Aulacephalodon*).

Our findings reveal several combinations of tusk composition, attachment tissues, and developmental strategy. We found a consistent correlation between development (i.e. ever-growing vs. deciduous) and tooth attachment, however the tissues of the tusk were varied and less consistent. Of particular note are potentially ever-growing tusks that also employ an enamel capping tissue. Unlike ever-growing teeth in extant mammals like rodents, enamel surrounds the entirety of the tusk in some dicynodonts. Together these data provide additional characters for dicynodont systematics, insight into the correlative evolution of dental characters, and reveal possible novel developmental patterns in the ever-growth teeth of extant taxa.