seawater. These overall biogeochemical patterns are evident across sub-Saharan Africa. I compare these results with the published literature on fossil hominins, including *Australopithecus* and *Paranthropus*, and I conclude that the durophage model has not been falsified.

Preparators' Session, Thursday 10:30

WHO WANTS THE WHITE MEAT? PREPARATION, RESTORATION, MOLDING, AND CASTING OF AN EXCEPTIONALLY PRESERVED *TYRANNOSAURUS REX* CRANIUM USING A NEWLY-DEVELOPED APPARATUS

SHAW, Allen, Carnegie Museum of Natural History, Pittsburgh, PA, USA

In 2004, an exceptionally well-preserved but largely unprepared *Tyrannosaurus rex* skull and mandible was loaned to Carnegie Museum of Natural History (CMNH) for its full preparation, restoration, molding, and casting. This skull is remarkable in being nearly complete and exhibiting only minor distortion; it is therefore arguably the best-preserved *T. rex* skull yet discovered. Upon delivery to CMNH, the bulk of the skull was contained within a single large block, with several smaller blocks containing additional disarticulated skull elements, many teeth, and the lower jaws. Although the dorsal surface of the skull had been partially prepared prior to arrival at CMNH, many months were still required to remove all matrix from the palate and the numerous cranial fenestrae and foramina. The final preparation of the skull entailed the use of an air abrasive over its entire surface, as well as on the numerous disarticulated skull elements and teeth. Restoration of the skull involved using an epoxy resin to fill in numerous cracks and reconstruct missing pieces. The preparation of the new *Tyrannosaurus* skull required that it be rotated and ultimately inverted. Also, due to spatial issues, we needed a device that could be rotated in place, allowed maximum accessibility, and added structural and load support. Even though similar problems have already been resolved during the preparation of other large theropod skulls, with satisfactory results, we developed a novel and very effective apparatus. Two large wooden wheels connected by six metal struts and resting on electric tube rollers became known as the "*Tyrannosaurus* rotisserie." This device allowed us not only to fully prepare and restore the skull, but to also mold and cast it as well. Here I provide an overview of this exceptionally preserved *T. rex* cranium, and reveal the surprises and problems we encountered in preparing and restoring this exceedingly large and fragile specimen.

Student Poster Session (Thursday)

PARTIAL SKULL OF LATE CRETACEOUS DUROPHAGOUS SHARK, *PTYCHODUS ANONYMUS* (PTYCHODONTIDAE), FROM NEBRASKA

SHIMADA, Kenshu, DePaul University, Chicago, IL, USA; KIM, Sun, DePaul University, Chicago, IL, USA; RIGSBY, Cynthia, Children's Memorial Hospital, Chicago, IL, USA

Ptychodus (Ptychodontidae) is an extinct durophagous shark genus known from Late Cretaceous marine deposits nearly worldwide based primarily on isolated crushing-type teeth. The University of Nebraska State Museum, Lincoln, houses a previously undescribed *Ptychodus* specimen (UNSM 123607) found from the Greenhorn Limestone in Nebraska. The specimen, tentatively identified as *P. anonymus* Williston, is significant because it preserves partial upper and lower dental plates along with calcified cartilage pieces including fragments of neurocranium and paired Meckel's cartilages, vertebrae, and placoid scales. The use of computed tomography imaging technique reveals that there are at least 267 teeth preserved in the specimen and that the two dental plates are anteroposteriorly elongate. The largest teeth in the mouth are the symmetrical lower medial teeth, measuring 7.0 mm in crown height. Although the palatoquadrates are not discernable in the specimen, the partial paired Meckel's cartilages show elongate fused jaw symphysis and elongate jaw rami posterior to the symphysis. The outline of the neurocranium is not clear in the specimen. However, calcified cartilage pieces of the neurocranium significantly extend anteriorly and laterally with respect to the position of the dental plates, suggesting that the head of the taxon was laterally broad and had a subterminal mouth. The vertebrae, which likely represent anteriormost ones in the vertebral column, are weakly calcified and taphonomically compressed, but their diameter was likely about 11.5 mm. Placoid scales generally measure up to 0.5 mm in height and are characterized by a massive crown and a bulbous root, that are nearly equal in size and are well separated by a constriction. The apex of the scale crown is generally flat or gently rounded, some of which exhibit multiple blunt longitudinal keels weakly extending from a rounded anterior crown edge. Although the exact body form of the species remains enigmatic, the cartilaginous remains in the specimen at least suggests that the shark had a broad head with a narrow mouth, and its weakly keeled scale indicates that the shark was a sluggish swimmer.

Student Poster Session (Thursday)

BITE FORCE ANALYSIS OF THE PTYCTODONT PLACODERMS, THE EARLIEST VERTEBRATE DUROPHAGE

SHIN, Ji-Yeon, University of California, Davis, Davis, CA, USA; MOTANI, Ryosuke, University of California, Davis, Davis, CA, USA

Durophagy, the ability to crush hard prey, has convergently evolved multiple times among both bony and cartilaginous fishes. Devonian ptyctodont placoderms are considered to be one of the earliest durophagous vertebrates based on their beak-like tooth plates. However, it is usually impossible to establish durophagy in fossil vertebrates based only on their tooth morphology. The goal of this study is to understand the mechanical basis of ptyctodont feeding to test whether durophagy was possible. The range of potential hard prey that durophagous species eat can be defined by identifying maximum bite force. A four-bar linkage model, which focuses on lower jaw depression associated with opening and closing of mouth, was used to estimate the bite force of ptyctodonts. Morphometric data for bite force analysis were collected from the skulls of two ptyctodont species, *Campbellodus decipiens* and *Austroptyctodus gardineri* from Gogo Formation, Western Australia. The preliminary theoretical bite force analysis of these ptyctodonts revealed a range of 8.04-24.02 N in estimated body size of 13-30 cm. Published data show that bite force ranges from 12-87 N in extant holocephalan, *Hydrolaguscolliei*, in body size of 21-44 cm while for horn shark, *Heterodontus francisci*, it ranges from 95-133 N in body size of 63-73 cm. Shell strength per area of invertebrate shell materials varies depending on the species (e.g. bivalve, *Scrobicularia plana* ranges from 2.7-3.6 Ncm^{-2}). Estimated bite force of ptyctodonts is not only comparable with the bite force of cartilaginous fishes considering scaling effects, but also with the shell strength of potential invertebrate prey. The result supports the hypothesis that ptyctodont placoderms were durophagous, and that durophagous vertebrates were already present as early as Mid Devonian.

Poster Session II (Thursday)

PYRITE OXIDATION: REVIEW AND PREVENTION PRACTICES

SHINYA, Akiko, The Field Museum, Chicago, IL, USA; BERGWALL, Lisa, The Field Museum, Chicago, IL, USA

Pyrite (FeS_2) is a common mineral found in sedimentary rock and fossils and its decay is a major problem in the conservation of fossil specimens. Pyrite oxidation, also referred to as pyrite disease or pyrite decay, is identified by a sulphuric acid odor, white crystalline powder, yellow sulphide powder, and/or gray to yellowish microcrystalline mass in and out of specimens. Its presence can be devastating to a geological collection. In the presence of oxygen, pyrite breaks down to ferros sulphate ($FeSO_4$) and sulphur dioxide (SO_2). If water is present, sulphuric acid (H_2SO_4) is also produced and can cause damage to labeling and storage containers. The most effective method to preventing rapid pyrite oxidation decay is to store specimens within a moisture and oxygen barrier containing an oxygen absorber/scavenger. Further oxidation can be reduced or eliminated by storing specimens in an environment with a humidity level below 30%. Additionally, ammonium gas and ethanolamine thioglycolate treatments neutralize sulphuric acid and remove ferros sulphate, and are reportedly effective in partly or completely removing oxidation reaction products. Specimens that contain large amounts of pyrite and are in danger of losing morphological information through pyrite oxidation should be molded and cast. Because latex rubber contains ammonium, its use as a molding material can have the added benefit of neutralizing sulphuric acid and ferros sulphate. Although not tested in a controlled scientific experiment, it has been reported that this method was successful in halting the oxidation process in some specimens.

Technical Session III, Wednesday 3:00

PLEISTOCENE CAVE FAUNAS FROM THE ANDES OF CENTRAL PERU: A GLIMPS OF ANDEAN LIFE OF THE GREAT AMERICAN BIOTIC INTERCHANGE

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Recent fieldwork in caves of the Central Andes of Peru reveals rich Pleistocene faunas. Taxa discovered include foxes (cf. *Pseudalopex* spp.), cats (*Puma, Smilodon*), extinct sloths (*Megatherium*, mylodontid indet., and the newly recognized megalonychid, *Diabolotherium*), Lama, caviomorph rodents, bats, and some specimens of horse (*Onohippidium*). The caves under study include Jatun Uchco (located within cliffs above the Huallaga River near Ambo in the Departamento de Huánuco), Trigo Jirka (in a cliff overlooking the Río Marañón, near Huacaybamba, Depto. de Huánuco) and Mantero Cave (located on land owned by a mining interest near Huancayo, Depto. de Junín). The quality and quantity of the fossils has inspired various studies. For example, the numerous canid fossils are providing data regarding the variation within the population. Trigo Jirka has preserved organic material (i.e., keratin claw and quantities of dung, apparently from sloths), which has initiated attempts to recover DNA to be

included in phylogenetic analyses. Collagen has been recovered from specimens of two caves was were submitted for accelerated mass spectrometry radiocarbon dating. A sample of the sloth, *Diabolotherium*, from Trigo Jirka, yielded a ^{14}C age estimate of 29,140 ± 260 year BP and that of *Onohippidium*, from Mantero Cave, an age estimate of 23,340 ± 120 years BP. Preliminary study suggests that these low latitude faunas have potential for resolving questions regarding some migrations from South America to North America and the West Indes. For example, though megalonychid sloths are common in the Plio-Pleistocoene of North American and the West Indes, they are uncommon in South America. The excellent material of *Diabolotherium*, a megalonychid having a relatively generalized dentition, may serve as a model sister taxon to North American and West Indian megalonychids. The cave faunas may also enlighten the evolutionary history of immigrants from North America. Life history studies combined with molecular, and palynology analyses have the potential to illuminate the paleoecological context into which these North American taxa immigrated.

Poster Session II (Thursday)

THERE'S A WHOLE LOTTA SHAKIN' GOIN' ON - PALEONTOLOGICAL RESOURCE MANAGEMENT IMPLICATIONS FOR 3-D GEOPHYSICAL EXPLORATION: CASE STUDY FROM THE WIND RIVER BASIN, FREMONT COUNTY, WYOMING

SHOUP, Ben, ARCADIS U.S., Inc., Buffalo, WY, USA

The Madden North 3-D geophysical exploration project, using primarily vibroseis technology, was conducted by Burlington Resources Oil & Gas Company in the northern Wind River Basin, Fremont County, Wyoming on public lands administered by the Bureau of Land Management. Vibroseis operations utilize a metal plate that is lowered from a large all-terrain vehicle to create energy source points by intensely vibrating the plate. The project area included approximately 29,500 acres and encompassed extensive bedrock exposures of several formations known to contain significant paleontological resources, including the Eocene Wind River Formation and the Jurassic Morrison and Sundance Formations. A two-phase assessment was conducted to evaluate impacts to paleontological resources. In the first phase, prior to exploration activities, an investigation was conducted for the project area, including background research and a pedestrian field survey to identify localities within the area of potential effects (APE). Background research uncovered numerous localities, including type localities for the informally named Lysitean and Lostcabinian subages of the Wasatchian North American Land Mammal Age. The field survey resulted in twenty-seven new paleontological localities discovered in the Wind River Formation and one new locality discovered in the Sundance Formation. As the effects of this type of vibroseis activity have not been previously analyzed, a post project impact assessment was conducted following completion of the geophysical exploratory operations to evaluate the direct and indirect impacts of vibroseis activities on paleontological resources. The results of this post-project assessment indicated very little direct impact to paleontological resources. It is suggested from this study that the best management practices for vibroseis-type geophysical exploration projects should be completion of a field survey prior to the activity, avoidance of identified localities, and that no concurrent or post-activity monitoring is warranted.

Technical Session XIV, Saturday 10:15

THE BIOMECHANICS OF SCALE: A PHYLOGENETIC AND ONTOGENETIC INVESTIGATION OF TYRANNOSAUROID DINOSAURS USING GEOMETRIC MORPHOMETRICS AND THE FINITE ELEMENT METHOD

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Scale has profound consequences on biological structure and function. As a structural tissue, bone has evolved the ability to remodel and adapt in response to changing biomechanical stress. This occurs throughout the history of many vertebrate lineages as well as throughout the lifetime of an individual animal. Like any material, bone has limiting properties that constrain its shape while it attempts to avoid mechanical failure with increasing scale. Therefore, the goal of this project was to record skeletal modifications that may have occurred due to significant changes in size. Tyrannosauroids were chosen to study since they exhibit a seven-fold increase in cranial dimensions during phylogeny and ontogeny. Twenty-six juvenile and adult tyrannosauroid crania were analyzed using geometric morphometrics to determine morphotypic distribution. A generalized procrustes method of superimposition allowed comparisons while removing the influence of scale. Load cases simulating regressed bite forces were determined for each specimen using the Subtemporal Fenestral (STF) method of bite force estimation and bite force was calculated for three points along the alveolar margin. Ten specimens representing theoretical phylogenetic and ontogenetic stages were analyzed using the finite element method. Each cranium was scaled to similar lengths of 500mm and subjected to 500 N (newton) bite forces to facilitate comparative observations. Peak stress was recorded at four highly deformed regions in the lateral crania within the rostrum-braincase junction; (1) the lacrimal-postorbital; (2) the maxilla-nasal-lacrimal; (3) the jugal-postorbital; and (4) the jugal-maxillary region. This allowed the investigation of cranial design and suture morphology. Results show that with increasing scale tyrannosauroid crania adapted to biomechanical stress by developing (1) robusticity and (2) suture complexity in specific areas of the cranium. It is hoped that future research will provide further insight into the biomechanics of scale, contributing to debates surrounding the ultimate size limits in functional vertebrate design.

Technical Session II, Wednesday 8:45

NEW TEMNOSPONDYLS FROM THE TRIASSIC OF ANTARCTICA

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Antarctic rocks are the premier source of paleontological data for high-latitude regions of Gondwana during the Triassic. Exposures of the Fremouw Formation in the central Transantarctic Mountains record Lower and Middle Triassic ecosystems inhabiting the Polar Circle, with locally abundant vertebrate, invertebrate, and plant fossils. The vertebrate fauna has long been recognized as very similar to that of South Africa's Karoo Basin, with an inferred *Lystrosaurus* and *Cynognathus* biozone equivalency. Although known since the 1960s, lower Fremouw temnospondyls are poorly understood taxonomically; recent systematic revisions fail to recognize valid temnospondyl genera from Antarctica, despite the common perception that at least four families are present (viz. Brachyopidae, Lyddekerinidae, Mastodonsauridae, Rhytidosteidae). Upper Fremouw temnospondyls were first noted in the 1980s, but only recently described. Notably, the recognition that *Parotosuchus* was present in the Antarctic portion of Gondwana suggests an extremely broad distribution for this genus (it also known from Germany, Kazakhstan, Russia, and South Africa). A new giant temnospondyl is represented by a large snout fragment characterized by greatly enlarged transvomerine and parachoanal tooth rows, as well as a distinct process on the palatal surface of the premaxilla. Although it does not preserve anatomy permitting its higher-level taxonomic position to be understood at this time, the recognition of an endemic genus is surprising, given that Triassic vertebrates from Antarctica are typically considered a subset of coeval taxa from the Karoo. The new genus also provides evidence that high latitude Triassic tetrapods might have had a more restricted geographic distribution than previously considered. Biostratigraphically, the fauna of the upper Fremouw Formation is best correlated with the *Cynognathus* Assemblage Zone of South Africa's Beaufort Group, although the lack of species-level identifications for many of the Antarctic fossils precludes a more refined correlation.

Evolutionary History of Bats Symposium, Thursday 10:15

THE PRIMITIVE CONDITION OF LOWER MOLARS AMONG BATS

SIGÉ, Bernard, Université Claude Bernard, Villeurbanne, France; MAITRE, Elodie, UMR CNRS 5125, Villeurbanne, France; HAND, Suzanne, School of Biological Science, Sydney, Australia

Among various tooth characters found in insectivorous bats, two distinctive patterns in lower molars (particularly m1 & m2) are recognized. The most common pattern is nyctalodonty, in which the posterior crest (postcristid) extends from the labial hypoconid cusp to the disto-lingual hypoconulid cusp and then to the entoconid. The other, less common pattern is myotodonty, in which the postcristid (which is taller and sharper than in nyctalodont forms) directly connects the hypoconid to the entoconid, isolating the reduced hypoconulid on the posterior face of the entoconid. Transitional conditions between these patterns are rare, but occur in a number of extinct and extant species. These two major dental morphotypes correspond to two different evolutionary steps. Myotodonty is more specialized, the taller, sharper postcristid enhancing its cutting function against the anterior face of the metacone of the upper molar. Some bats reported from Early Eocene strata on some continents (e.g. Europe, North America), mainly archeonycteridids *s.l.*, display typical nyctalodonty. However, other early Paleogene bats from various areas (e.g. *Ageina, Honrovits, Necromantis, Palaeophyllophora, Australonycteris* as well as unnamed or undescribed bat material) are characterized by large hypoconulids in a median or sub-median position. This feature, being found in diverse, ancient lineages, most likely represents the primitive condition among bats, characterizing also the (as yet unknown) earliest bats. Here we name this dental morphotype necromantodonty. Necromantodonty, and to a large extent the general tooth morphology in these latter bat taxa, is shared by various insect-feeding arboreal fossil eutherians (e.g. early leptictids, nyctitherians, adapisoriculids, euprimates), including those that are probably closely related to bats.

The Dissorophoidea - Early Amphibian Radiation Symposium, Friday 11:30

THE BRAINCASE AND OTIC REGION OF THE AMPHIBAMID *DOLESERPETON* (TEMNOSPONDYLI), AND ITS IMPLICATIONS FOR THE ORIGIN OF FROGS

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There is at present no consensus as to the evolutionary origins of lissamphibians. However, the Lower Permian amphibamid *Doleserpeton* has been suggested as a close relative of salientians (frogs and proanurans). As frogs alone among lissamphibians possess a tympanic auditory system, it is possible to argue for a strong link between this