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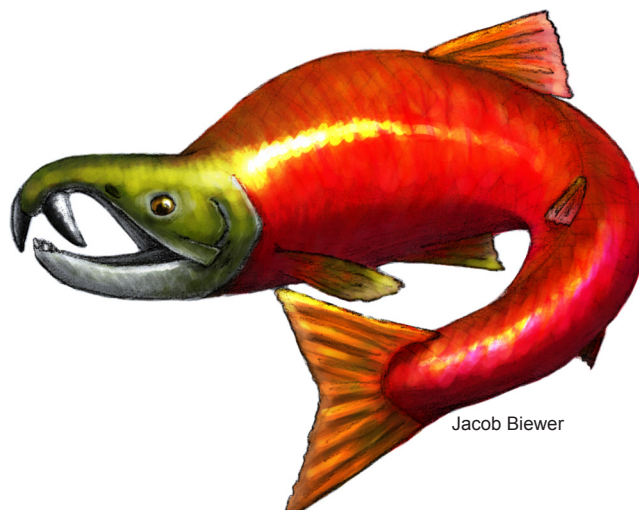
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WESTERN ASSOCIATION OF VERTEBRATE PALEONTOLOGY ANNUAL MEETING



PROGRAM WITH ABSTRACTS

CALIFORNIA STATE UNIVERSITY, STANISLAUS
NARAGHI HALL OF SCIENCES, TURLOCK, CA

FEBRUARY 14–15, 2015

Host Committee:

Julia Sankey and **Jacob Biewer**, Sankey Paleo Lab,
Geology Program, California State University, Stanislaus

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2015 WAVP SCHEDULE OF EVENTS

Registration, 7:30–8:30 AM		Naraghi Hall, hallway in front of N 101
Oral presentations		Naraghi Lecture Hall 101
8:30–8:45	Sankey and President Sheley	Welcome and opening remarks
8:45–9:00	Inman	The Table Mountain latite: Its relationship to the Mehrten Formation and California's geologic history
9:00–9:15	Sankey et al.	Giant salmon, tortoises, and other wildlife from the Mio-Pliocene Mehrten Formation, Stanislaus County, California
9:15–9:30	Biewer et al.	First description of the large tortoise from the Mio-Pliocene Mehrten Formation of Stanislaus County, California
9:30–9:45	Balisi et al.	Fossil canids from the Mehrten Formation, Late Cenozoic of Northern California
9:45–10:00	Wang	Cold comfort: Tibetan megafauna origins
10:00–10:15		Morning break
10:15–10:30	Hilton	Constraining paleofaunas near High Rock Lake, Northwest Nevada
10:30–10:45	Santos and Parham	Description of the late Uintan Talega Bonebed from Orange County, California
10:45–11:00	Famoso et al.	Updated biostratigraphy of the Turtle Cove Member (John Day Formation) in the John Day Basin, Oregon
11:00–11:15	Padian	Can we detect sexual selection in dinosaurs?
11:15–11:30	Kloess	Changes in seabird abundance during the late Neogene of California
11:30–11:45	Barnes et al.	A new pontoporiid dolphin from the Sharktooth Hill Bonebed, central California; the oldest known member of its family
11:45–12:00	Marsh	Preliminary U-Pb detrital zircon dates from the Kayenta Formation of Arizona
12:00–1:30 PM		Lunch break
1:30–1:45	Monson et al.	South African fossil baboons and evolutionary changes in <i>Papio</i> postcanine dental morphology
1:45–2:00	Brasil et al.	South African fossil monkey mandibles in the University of California Museum of Paleontology
2:00–2:15	Morales et al.	On the abundance of flightless auks from the middle Miocene to early Pliocene
Poster session, 2:15–3:30 Paleo Lab tour		Naraghi Hall, Atrium Authors/titles listed on next page
Oral presentations (continued)		Naraghi Lecture Hall 101
3:30–3:45	Molnar	The dual nature of taxa—as distinct lineages and as classifiable entities
3:45–4:00	Rowland	The new Tule Springs Fossil Beds National Monument in Las Vegas Valley
4:00–4:15	Thomson and Thomson	New vertebrate track localities and track types from the Lower Triassic Moenkopi Formation, central Utah.

2015 WAVP PROGRAM & ABSTRACTS

4:15–4:30	Stewart and Hakel	Remanié <i>Desmostylus</i> fossils in the Tulare Formation
4:30–4:45	Shaw and Howard	Facial asymmetry in the sabercat (<i>Smilodon fatalis</i>) and wolf (<i>Canis dirus</i>) from Rancho La Brea, Los Angeles, California
4:45–5:00	Sankey	Closing remarks

Poster presentations, 8:30–5:00 Authors will be present 2:15–3:30	Naraghi Hall, Atrium	
Bronson and Maisey	Chondrichthyan discoveries from the Fayetteville Formation of Arkansas	
Cortez and Parham	An articulated fossil White Shark from the “Monterey Formation,” Orange County, California	
Ellingson et al.	Late Pleistocene amphibians and reptiles from Woodburn, Oregon.	
Gee, Soler, Parker	A <i>Koskinodon perfectus</i> (Temnospondyli: Metoposauridae) from the Adamanian of Petrified Forest National Park	
Haight and Rowland	First report of dinosaur and therapsid trackways in the Jurassic Aztec Sandstone of the Gold Butte area, Southern Nevada	
Hamlin et al.	Was the theropod dinosaur <i>Richardoestesia isosceles</i> a fish-eater? A comparison to dolphins	
Hardy and Rowland	Stable isotope paleoecology of the Late Pleistocene long-horned bison <i>Bison latifrons</i> : A preliminary report	
Magallanes and Parham	A nearly complete fossil walrus from Orange County, California: Implications for the phylogeny of odobenids	
Pu and Xiaong	Fossil eggshell from the Kaiparowits Formation (Upper Cretaceous) of southern Utah	
Rode and Romero	Preliminary results from digitization and geometric morphometric analysis of fossil trackways: Two case studies	
Sankey et al.	Miocene-Pleistocene geology and paleobiology, Stanislaus County, California	
Scherzer, Benjamin	Miocene teleost fish from Chino Hills: Preliminary results from the Vila Borba Project, San Bernardino County, California	
Shore, D.	The creation of a virtual museum with a focus on the California Central Coast	
Withey	Applications of high resolution computed tomography and 3D printing for study of a multituberculate mammal skull	
Weaver and Nichols	Lateral and temporal distribution of early Eocene primates in relation to relative paleosol maturity, Willwood Formation, Bighorn Basin, Wyoming	

FOSSIL CANIDS FROM THE MEHRTEN FORMATION, LATE CENOZOIC OF NORTHERN CALIFORNIA

BALISI, Mairin, University of California, Los Angeles, Los Angeles, CA, USA; WANG, Xiaoming, Natural History Museum of Los Angeles County, Los Angeles, CA, USA; SANKEY, Julia, California State University, Stanislaus, Turlock, CA, USA

The Mehrten Formation has yielded several representatives of borophagine and canine canids, yet previous workers have conflicted on the species identification of these taxa. Initial study had identified all larger canid fossils recovered from the Modesto Reservoir and Turlock Lake localities as sexually dimorphic specimens of *Osteoborus cyonoides*, a borophagine, and had assigned all smaller canid fossils to *Canis* cf. *C. davisii*, a canine. Later analysis split *O. cyonoides* into two taxa, *Borophagus parvus* and *B. secundus*, and updated *Canis* cf. *C. davisii* to *Eucyon davisii*, yet omitted very fragmentary remains of possible vulpines. The present reexamination of specimens located at the Los Angeles County Natural History Museum and the University of California Museum of Paleontology suggests that the Mehrten contains at least four canid species: two borophagines and two canines. As the size difference between the two putative sexes of *O. cyonoides* exceeds size sexual dimorphism in modern canids, we uphold the division of *O. cyonoides* into a smaller form, *B. parvus*, and a larger and more hypercarnivorous form, *B. secundus*. Specimens of *B. parvus* co-occur with *B. secundus* only in the lower part of the Modesto Reservoir Member; higher in the sequence, in the upper part of the Modesto Reservoir Member, *B. parvus* co-occurs only with canines. The two canines are *E. davisii*, as previously diagnosed, and an unidentified species of vulpine. Despite the seeming turnover in its co-inhabitants, no size change is apparent in *B. parvus* over the sequence. Lastly, a single specimen from the Coyote Hill fauna, earliest in the sequence, had been assigned to *Osteoborus* near *O. cyonoides*; the relationship of this specimen to the other borophagines remains unclear. Resolving these species will enable further ecological and other analyses, such as investigating the possibility of character displacement among the Mehrten Formation canids.

A NEW PONTOPORIID DOLPHIN FROM THE SHARKTOOTH HILL BONEBED, CENTRAL CALIFORNIA; THE OLDEST KNOWN MEMBER OF ITS FAMILY

BARNES, Lawrence G., TOHILL, Lisa, and TOHILL, Sean, Department of Vertebrate Paleontology, Natural History Museum of Los Angeles County, Los Angeles, CA, USA

The family Pontoporiidae is a group of archaic dolphins with a poor fossil history. The only extant species in the family, *Pontoporia blainvillei* (the Franciscana), lives in shallow marine waters along the eastern coast of South America. A primitive pontoporiid dolphin, representing a new genus and new species, has been found in the middle Miocene (14.5 to 16.1 Ma) Sharktooth Hill Bonebed, which is in the upper part of the marine Round Mountain Silt in Kern County, central California, USA. This is the geochronologically oldest known pontoporiid. Members of this family are known from younger age deposits on the Atlantic and Pacific coasts of North and South America, and Europe. The morphology of the new species from California suggests that the primitive characters of the Pontoporiidae include small body size, slender and intermediate length rostrum, asymmetrical cranial vertex, small orbit, small diameter nares, and a long mandibular symphysis. The Sharktooth Hill Local Fauna, a global standard of comparison for marine vertebrate assemblages of its age, includes about 12 other odontocete species: two sperm whales, a long-snouted platanistoid, several kentriodontid dolphins, and some less precisely identified species.

FIRST DESCRIPTION OF THE LARGE TORTOISE FROM THE MIO-PLIOCENE MEHRTEN FORMATION OF STANISLAUS COUNTY, CALIFORNIA

BIEWER, Jacob, and SANKEY, Julia, Department of Physics and Geology, California State University, Stanislaus, Turlock, CA, USA; HUTCHISON, J. Howard, Escalante, UT, USA; WAGNER, H., Auburn, CA, USA; GARBER, D., Modesto, CA, USA

The Miocene/Pliocene Mehrten Formation is exposed in the low foothills of the Sierra Nevada Mountains and consists of andesitic volcanic sedimentary deposits. The uppermost Mehrten, the Modesto Reservoir Member, represents river flood plain environments, with occasional lake deposits. Based on biostratigraphic correlation to the Pinole Formation (from the Bay Area), the Modesto Reservoir Member is Hemphillian (North American Land Mammal Age) or approximately 5 Ma. It is of interest for its abundance of fossils including ground sloth, mastodon, giant tusk-toothed salmon, and many plants. Additionally, large tortoise specimens were collected from the upper Mehrten, but have never been described. We describe them here for the first time, an important contribution to our knowledge of the Mehrten and also to California as a whole, as the literature on tortoises in California is sparse. Yet the presence of tortoises provides important information on the paleoenvironmental and paleoclimatic

conditions for an area. Additionally, we aim to re-locate and document the tortoise localities in more detail in order to provide better geologic and age control. Most of the tortoise specimens described here were collected by Hutchison, Garber, and Wagner, and are curated in the University of California Museum of Paleontology, Berkeley, and Natural History Museum of Los Angeles County. All of the specimens are from seven localities from the Modesto Reservoir Member exposed in and around Turlock Lake and Modesto Reservoir. Deposits are a pink-tan fine sandstone, and are interpreted to be floodplain deposits based on lithology, fossils, and paleosols. There are 56 specimens total, ranging from small to large pieces of carapace and plastron. This includes at least 12 identifiable elements of plastron, and at least 17 identifiable elements of carapace. The shell is relatively thick, averaging 14 mm. Three intact costal plates range from 254 to 269 mm in length. Two pieces making up two halves of the posterior plastron measure 190 mm and 202 mm, from the hypoplastral bridge to midline. A right and left hyoplastron is 294 mm from one hyoplastral bridge to the other. We estimate the complete plastron was approximately 600 mm long. We tentatively refer these specimens to *Hesperotestudo* sp., based on the size and thickness of the shell. *Hesperotestudo* was a large, thick-shelled land tortoise that ranged from the Oligocene to Pleistocene of North America. The presence (and abundance) of a large tortoise in the northern San Joaquin Valley during the late Miocene-early Pliocene provides important information on the paleoenvironmental and paleoclimatic conditions of this area. Tortoises are generally not tolerant of frost, so their presence in the upper Mehrten indicate milder winter conditions during this time, in agreement with the paleobotanical records.

SOUTH AFRICAN FOSSIL MONKEY MANDIBLES IN THE UNIVERSITY OF CALIFORNIA MUSEUM OF PALEONTOLOGY

BRASIL, Marianne, and MONSON, Tesla, Department of Integrative Biology, University of California Berkeley, Berkeley, CA, USA; HLUSKO, Leslea, Department of Integrative Biology, Museum of Paleontology, and Human Evolution Research Center, University of California Berkeley, Berkeley, CA, USA

The University of California's Museum of Paleontology (UCMP) participated in a large-scale expedition between 1947 and 1948 to collect fossil material from South African localities. As a result, twenty-six Old World monkey mandibular specimens are currently housed in the UCMP, representing seven Plio-Pleistocene localities within the Buxton Limeworks, Bolt's Farm, and Witkrans areas of

South Africa. We identified these specimens on the basis of qualitative descriptions and linear dental metrics as *Papio hamadryas robinsoni* (n=6), Tribe Papionini (n=18) and Family Cercopithecidae (n=2). *Papio h. robinsoni* specimens demonstrated elongated third molars relative to first and second molars, consistent with the pattern observed in the maxillary dentition reported in the literature. All *P. h. robinsoni* specimens are from the later Bolt's Farm deposit, whereas the majority of the specimens identified only to tribe level are from earlier Buxton Limeworks deposits. This difference in level of taxonomic identification possible is consistent with the observation that earlier papionin taxa are more similar in dental proportions, whereas recent evolutionary changes have resulted in the derived proportions characterizing extant *Papio*. Results of morphological examination suggest that relative molar length (i.e., portion of the total molar row occupied by each molar) may be a useful criterion for taxonomic identification, in part because it is not affected by absolute differences in size such as those due to sexual dimorphism. Traits traditionally used to identify taxa were not found to be diagnostic when used in isolation (e.g., fourth premolar to first molar index, absolute dental dimensions). The identification of diagnostic dental traits is particularly important because the relatively small number of bony features available when examining the mandible alone limits taxonomic description. Comparisons with a large dataset of extant *Papio*, collected as part of an earlier NSF grant, were particularly valuable in identifying potentially diagnostic traits, as well as in establishing expected ranges of intrataxonomic variation. This study was funded by the National Science Foundation, grant number BCS-0616308.

CHONDRICHTHYAN DISCOVERIES FROM THE FAYETTEVILLE FORMATION OF ARKANSAS

BRONSON, Allison W., and MAISEY, John G., American Museum of Natural History, New York City, NY, USA

The Fayetteville Formation is a famous source of well-preserved fossil material, but to date, most studies have focused primarily on its flora and invertebrate fauna. At the American Museum of Natural History, we are studying the morphological diversity expressed by well-preserved fishes from the shallow, marine ARC-07 locality of the formation. Though we have only discovered a single bony fish fossil, numerous highly diverse shark skeletons contain an array of unusual features, including gill covers and serrated teeth. The material is in exceedingly good condition—skeletons are often intact and, in some cases, three-dimensionally preserved. This formation consists

of a different assemblage from that of Bear Gulch and the shallow basins of Illinois, and can therefore provide new insights into Mississippian environments. This locality has previously yielded valuable information about the morphology of early cartilaginous fishes (*Ozarcus*), and we expect this new material to be equally valuable for resolving the stem of the chondrichthyan tree.

AN ARTICULATED FOSSIL WHITE SHARK FROM THE "MONTEREY FORMATION," ORANGE COUNTY, CALIFORNIA

CORTEZ, Crystal, Department of Geological Sciences, California State University, Fullerton, CA, USA; PARHAM, James F., John D. Cooper Archaeological and Paleontological Center, Department of Geological Sciences, California State University, Fullerton, CA, USA

We present an articulated fossil shark skeleton (OCPC 4618, from the John D. Cooper Center) that includes vertebrae, dentition, and a brown film found outlining the specimen that is believed to be calcified cartilage prisms. Specimen OCPC 4618 is a juvenile *Carcharodon hastalis* (white shark) skeleton collected during paleontological monitoring in 1992 from "Monterey Formation" diatomite in Laguna Niguel, California. Articulated shark specimens are rare in the fossil record so most of our knowledge of extinct shark species comes from isolated teeth. Studies on isolated teeth can be problematic because of heterodonty (more than one kind of tooth morphology), a condition found in most sharks. The 'heterodonty problem' has led to the misidentification of some shark specimens, especially by the incorrect splitting of a single species based on intra-individual variation. One goal of this study is to help ameliorate these issues by providing a complete tooth set, therefore allowing morphological variation within the jaw to be fully studied. Since OCPC 4618 is a juvenile, the ontogenetic stage was characterized by conducting a comparative study on developmental stage of extant *Isurus oxyrinchus*, a close relative to the white shark.

LATE PLEISTOCENE AMPHIBIANS AND REPTILES FROM WOODBURN, OREGON

ELLINGSON, David, Woodburn High School, Woodburn, OR, USA; STENGER, Alison, Institute of Archaeological Studies, Portland, OR, USA; SHAW, Christopher A., George C. Page Museum, Los Angeles, CA, USA

A small herpetofauna is reported from the central Willamette Valley at Woodburn, Oregon, consisting of leopard frog (*Rana pipiens*), western pond turtle (*Actinemys marmorata*), alligator lizard (*Elgaria* cf. *E. multicarinata*), and western rattlesnake (*Crotalus viridis*). Woodburn is a

rural city in the middle of the Willamette Valley that has a small, seasonal creek which bisects the city. Since 1996, paleontological excavations have been conducted along the Mill Creek drainage as it passes south of Woodburn High School by scientific personnel utilizing volunteer labor from members of the community and student body. This has afforded biology students as well as community members the opportunity to conduct scientific inquiry and collect samples from the late Pleistocene soils that are 3.5–4 m (10–12 ft) beneath the surface. These soils contain a well preserved biota, numbering nine species of plants and 25 vertebrate species. Calibrated radiometric dates of between about 13–13.5 kyBP have been acquired from remains of ancient bison (*Bison antiquus*). The presence of these amphibian and reptile species, along with recovery of other water-loving species of birds and mammals, indicate that the Mill Creek drainage may have been a more permanent water source than it is today.

UPDATED BIOSTRATIGRAPHY OF THE TURTLE COVE MEMBER (JOHN DAY FORMATION) IN THE JOHN DAY BASIN, OREGON

FAMOSO, Nicholas A., Department of Geological Sciences and Museum of Natural and Cultural History, University of Oregon, Eugene, OR, USA; SAMUELS, Joshua X., National Park Service, John Day Fossil Beds National Monument, Kimberly, OR, USA; HOPKINS, Samantha S.B., Clark Honors College and Department of Geological Sciences, University of Oregon, Eugene, OR, USA; EMERY, Meaghan M., and DAVIS, Edward Byrd, Department of Geological Sciences and Museum of Natural and Cultural History, University of Oregon, Eugene, OR, USA

The John Day Formation in eastern Oregon preserves a unique and remarkably complete record of volcanic and volcanoclastic sedimentary rocks spanning about 20 million years. The 400 m of the Oligocene aged Turtle Cove Member (30.8–25.9 Ma) preserve evidence of diverse mammalian communities perturbed by at least ten volcanic events, including five dated tuffs and the large Picture Gorge Ignimbrite (PGI). We examined and independently identified 2,072 fossil mammal specimens from classic sites within the vicinity of the Sheep Rock Unit of John Day Fossil Beds National Monument. This included material from all stratigraphic units within the Turtle Cove Member (A-K2) and many new specimens collected over the last six years, representing a total of 96 species. Updated biostratigraphy for the Turtle Cove Member is particularly important, as it will facilitate comparisons with similar aged faunas from other sites in North America. This study yielded more refined taxonomic ranges than previous studies, as it used actual

occurrences of species and did not lump geologic units together. Several taxa had biostratigraphic ranges that differ from those noted in previous work, including some taxa with expanded ranges (e.g., *Gentilicamelus*, *Nanotragulus planiceps*, *Eporeodon*, and *Archaeolagus*) and others with reduced ranges (e.g., *Archaeotherium*). Our reassessment of taxonomy and identifications led to the inclusion of several previously unrecognized taxa (e.g., *Stibarus*, *Leptochoerus*, *Sinclairiella dakotensis*, and “*Cynorca*” *sociale*). This also led to updated identifications of several clades, most notably the oreodonts, canids, and aplodontid rodents. Results indicate that within unit A of the Turtle Cove Member from the John Day Basin there are no taxa characteristic of Whitneyan faunas. We also found that the last occurrence data of several index taxa do not occur at the Ar1-Ar2 boundary (e.g., *Eusmilus*, *Perchoerus*, and *Agriochoerus*), but rather within Ar1. These discrepancies from the definitions of the Wh, Ar1, and Ar2 are likely the result of volcanic activity within the basin, other regional climatic changes, and the ecological and climatic differences between the Pacific Northwest and the Great Plains, the latter being the region where these land mammal ages were typified.

A KOSKINONODON PERFECTUS (TEMNOSPONDYLI: METOPOSAURIDAE) FROM THE ADAMANIAN OF PETRIFIED FOREST NATIONAL PARK

GEE, Bryan, Pomona College, CA, USA; SOLER, Jose, Natural History Museum of Los Angeles County, LA, CA, USA; PARKER, William, Petrified Forest National Park, AZ, USA

Metoposaurids are Late Triassic temnospondyl amphibians with broad flat heads, laterally placed orbits in the rostral half of the skull, and cylindrical intercentra. In October 2013, a team from the Natural History Museum of Los Angeles County (NHM) recovered a partial metoposaurid skull from the Lot’s Wife Beds (lower Sonsela Member) of the Chinle Formation of the Petrified Forest National Park, Arizona (PEFO). The specimen (PEFO37123 accession as LACM 154866) is the only metoposaurid skull known from the Lot’s Wife Beds. These strata have not been too forthcoming in producing vertebrate remains, and the majority of metoposaurid specimens in the park come from the older Blue Mesa Member. PEFO37123 is three-dimensionally preserved, with a maximum preserved length of 430 mm. The dermal bones that form the skull roof display the honeycomb-like ornamentation of subequal pits, typical for temnospondyls. Most of the original sutures of PEFO37123 are weakly or not readily identifiable because of numerous

post-mortem fractures and the slight displacement of some elements along their sutures. PEFO37123 is referred to *Koskinonodon perfectus* based on the presence of a well-developed tabular horn, a deep otic notch, and the lacrimal entering the rostral margin of the orbit. The species is an index fossil of the Adamanian/Revueltian boundary (approximately 220–213 Ma), which has been proposed as a marker of a localized faunal turnover in western North America. PEFO37123 is the stratigraphically highest occurrence of *K. perfectus* in the southern end of the PEFO and the only skull recovered from the lower part of the Sonsela Member, providing a previously unknown biostratigraphic reference point that completes and augments the faunal assemblage of the lower part of the Sonsela Member, which documents the onset of the faunal turnover and major decline of large temnospondyls at the Adamanian/Revueltian boundary.

FIRST REPORT OF DINOSAUR AND THERAPSID TRACKWAYS IN THE JURASSIC AZTEC SANDSTONE OF THE GOLD BUTTE AREA, SOUTHERN NEVADA

HAIGHT, Gordon, and ROWLAND, Stephen M., Department of Geoscience, University of Nevada, Las Vegas, NV, USA

Fossil trackways of dinosaurs and squirrel-size therapsids (protomammals) are well documented in the Jurassic Navajo Sandstone of Utah and Colorado. In the past three years such tracks have also been reported and described in the correlative Aztec Sandstone of Southern Nevada—in Valley of Fire State Park and Red Rock Canyon National Conservation Area. Another extensive exposure of Aztec Sandstone occurs in the remote Gold Butte area, between the Overton Arm of Lake Mead and the Arizona border, however no tracksites have previously been reported from Gold Butte. Avid Gold Butte hikers Tom Cluff and Michele Burkett have been systematically and successfully prospecting for fossil tracks in the Gold Butte region and have kindly shared their discoveries with us. Here we present the first account and photogrammetric documentation of Jurassic tracks in the Gold Butte region. Two dinosaur tracksites have been discovered so far. These are very similar to each other, but unusual for the Aztec Sandstone. Most dinosaur tracks in the Aztec Sandstone are assignable to the ichnogenus *Grallator*, the track of a small theropod. However, the Gold Butte dinosaur tracks are atypical. They are small tridactyl tracks, about 10 cm long, with a very short stride of about 38 cm; they are possibly the tracks of an ornithomimid dinosaur rather than a theropod. In addition to the dinosaur tracks, several therapsid tracksites have now been discovered in Gold

Butte. These are assignable to the well-known ichnogenus *Brasilichnium*. Our continuing research on tracksites in the Aztec Sandstone of Southern Nevada will involve a comparison of the recently discovered Gold Butte tracks with those in other regions, and a reconstruction of the ecosystem in which the trackmakers lived.

WAS THE THEROPOD DINOSAUR *RICHARDOESTESIA ISOSCELES* A FISH-EATER? A COMPARISON TO DOLPHINS

HAMLIN, Karolyn, Department of Biological Sciences, California State University, Stanislaus, Turlock, CA, USA; SANKEY, Julia, and GONZALES, Maria, Department of Physics and Geology, California State University, Stanislaus, Turlock, CA, USA

The Hell Creek and Lance Formations of Montana, North Dakota, South Dakota, and Wyoming are valuable sources of Maastrichtian age (Late Cretaceous) fossils. Studying the fossils of these formations is not only key to understanding the effects the K-Pg extinction had on biodiversity, but to understanding the biodiversity trends leading up to it. *Richardoestesia isosceles* and “*Paronychodon*” are species of small theropod dinosaurs known only from the high abundance of their teeth in Late Cretaceous microfossil sites. The slender, straight profile of *R. isosceles* teeth is similar to that of known fish eaters such as plesiosauroids and dolphins, suggesting a piscivorous diet. To test this, we compared wear patterns of *R. isosceles* teeth to wear patterns in extant dolphins. Fifty-six teeth (*R. isosceles*, *Richardoestesia* spp., and “*Paronychodon*”) were examined and photographed under a microscope for apical wear, relative flatness of labio-lingual sides, the presence and strength of longitudinal striations, and possible jaw placement where determinable. Apical wear shape was categorized as either blunt, round, or angular based on the extent and direction of wear. Teeth of three dolphin species (seven total specimens) were examined for wear and wear distribution along the length of the jaw. All dolphin species showed distinctive shearing/flaking wear from the tip of the tooth downwards, in various directions. Additionally, there were teeth cracked down the middle. While both dolphin teeth and theropod teeth had apical wear, the shape of the wear was dissimilar. Theropod teeth did not have shearing/flaking wear, and dolphin teeth did not show blunt, round, or angular wear. It is surprising that there is not more commonality given the similarity of their triangular silhouettes. This suggests that the difference in tooth wear patterns may originate from their differences in cross sectional shape. Dolphin teeth are conical with a circular cross section, while *R. isosceles*

teeth exhibit labio-lingual compression characteristic of ziphodonts. We conclude that wear patterns alone are not comparable between *R. isosceles* and dolphins due to a lack of common characteristics, and that further study should focus on the effects of piscivory on wear patterns in teeth with different cross sectional shapes.

STABLE ISOTOPE PALEOECOLOGY OF THE LATE PLEISTOCENE LONG-HORNED BISON *BISON LATIFRONS*: A PRELIMINARY REPORT

HARDY, Fabian, and ROWLAND, Stephen M., Department of Geoscience, University of Nevada, Las Vegas, NV, USA

Bison latifrons was a Late Pleistocene North American megaherbivore with a temporal range of 130–85 ka. It is commonly supposed that *B. latifrons* was primarily a woodland species, while its contemporaneous congener *B. antiquus* inhabited grasslands. However, no stable isotope studies have yet been conducted to test this view. We are using carbon isotopes recorded in tooth enamel to test the hypothesis that *B. latifrons* was a woodland species. So far, we have sampled late-erupting *B. latifrons* molars from the Diamond Valley Lake fauna in southern California, the Wilkins Quarry site near Panaca, Nevada, and the American Falls Formation in southern Idaho. We anticipate also sampling teeth from the high-elevation Snowmass site in Colorado, and from Florida sites. The $\delta^{13}\text{C}$ values of the Idaho and Nevada specimens are in the range of -6 to -7‰ VPDB, which is indicative of a mixed diet of C_3 and C_4 grasses. In contrast, the Diamond Valley Lake specimens have a more depleted value of around -10‰ VPDB, which indicates a more forested habitat. Of the three sites sampled, only one—Diamond Valley Lake—contains both *B. latifrons* and *B. antiquus*. The *B. antiquus* $\delta^{13}\text{C}$ values from Diamond Valley Lake are only slightly less depleted than those of *B. latifrons*, which suggests that these two species were competing for the same forage. Our preliminary conclusion is that *B. latifrons* was not consistently a woodland browser. These bison commonly consumed a mixed diet of C_3 and C_4 grasses, and occasionally they were in direct competition with *B. antiquus*.

CONSTRAINING PALEOFAUNAS NEAR HIGH ROCK LAKE, NORTHWEST NEVADA

HILTON, Richard, Geology, Sierra College, Rocklin, CA, USA; HAUSBACK, Brian P., Geology, California State University, Sacramento, CA, USA

The High Rock fauna from the High Rock Lake area of NW Nevada, was first described by John C. Merriam and R.A. Stirton in the early 1900s. The fossils here are

contained in bedded and reworked largely rhyolitic tuff found well above an unexposed white lapilli tuff argon-dated at 15.914 ± 0.012 Ma. and are only ~7.5m below the 14.5 Ma Fly Tuff. We concur with Stirton to restrict these fossils and outcrop to be west of the fault displacing the 16.14 ± 0.01 Ma Soldier Meadow Tuff (SMT) at N $41^{\circ} 18' 54.67''$, W $119^{\circ} 16' 21.96''$ and north of High Rock Lake. Because the High Rock fauna lies west and on the down-side of the fault, younger beds here are still exposed and are higher in the section. East of the fault in Fly Canyon proper and ~4 km downstream in a side canyon are older fossils found above the SMT and below a white lapilli tuff dated here at 15.914 ± 0.012 Ma. We informally refer to these fossils as the Fly Canyon fauna. Other vertebrate fossils have been collected ~ 7.5 km south of High Rock Lake in the Smoky Canyon area by Merriam, other workers and the authors. We dated a fine-grained glassy tuff within fossil-bearing lahars in this southern locale at 15.55 ± 0.017 Ma. The stratigraphy in Smoky Canyon does not match either of the other two faunas mentioned above. Other fossils were found by the authors in Smoky Canyon between High Rock Lake and the dated southern area and are undated. The authors tentatively lump all the fossils found south of High Rock Lake informally to the Smoky Creek fauna.

THE TABLE MOUNTAIN LATITE: ITS RELATIONSHIP TO THE MEHRTEN FORMATION AND CALIFORNIA'S GEOLOGIC HISTORY

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The Mehrten Formation, located in the foothills just east of Stanislaus County, is composed primarily of andesitic sediments with provenance related to Miocene volcanism. These volcanoclastic sediments are interbedded with extrusive volcanic units, representing both explosive and effusive eruption styles, and fluvial sediments from the many westward flowing stream channels in the region. As a result, many of the fossils found in the area are located in sedimentary units bound by volcanic rocks. The lower Mehrten is host to the Stanislaus Group which is composed of extrusive andesite and latite flows including the Table Mountain Latite. This unit is exposed in the large canyon carved by the modern Stanislaus River, just east of Knights Ferry. The canyon highlights the close relationship between sediments and volcanics in the Mehrten and records evidence of two orogenic events in California's geologic history. There are three primary rock units exposed at Table Mountain. The basement rock is exposed along the bottom of the canyon; they are steeply-foliated

metamorphic rocks oriented in the NW direction. They are interpreted as having formed in response to the rise of the Nevadan Mountains to the east during the Jurassic, 200 to 150 Ma ago. Petrographic analysis indicates a volcanoclastic protolith and a mineral assemblage consistent with the green schist facies. The middle unit is formed by andesitic sandstones and conglomerates deposited by the paleo-Stanislaus River. The uppermost unit is the Table Mountain Latite lava flow, erupted 10 Ma ago. The lava flowed for nearly 100 km, filling the canyon of the paleo-Stanislaus River, from a source that now is east of the Sierra Nevada crest. Uplift of the Sierra Nevada, 5 Ma ago, rejuvenated the Stanislaus River and gave it enough energy to cut through the lava and underlying basement rocks to form the Grand Canyon of the Stanislaus River we see today.

CHANGES IN SEABIRD ABUNDANCE DURING THE LATE NEOGENE OF CALIFORNIA

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Previous studies of historic changes in seabird diversity in the Neogene of the North Pacific were based on literature reviews. We use a specimen-based approach to test and refine these proposed diversity patterns, and describe patterns of relative abundance and occurrence of seabirds through time. The foundation of this research, a previously unstudied collection of over 300 bird specimens, comes from the relatively complete sequence of middle Miocene to early Pliocene Orange County strata ("Topanga," Monterey, and Capistrano Formations). We compare the Orange County specimens with those from other museums across California, in order to provide a complete and detailed view of avian communities and their responses to physical drivers during this period. Previous literature-based studies found a marked increase of alcid species into the early Pliocene. In addition to this diversification, we find the relative abundance of specimens increase from 7% of the identified middle Miocene seabird community to over 70% by the early Pliocene. This coincides with a noted decrease in sulid abundance during this same observed time period (48% to 6%), as well as a decrease in sulid diversity. These changes are coincident with global temperature decrease following the Middle Miocene Climatic Optimum and changing circulation patterns in the North Pacific resulting from the development of the Isthmus of Panama and movement of Australia. Increased

nutrient upwelling, resulting from the development of these climate and circulation patterns, has been attributed to morphological changes and the response in diversity observed in other contemporaneous marine species of the North Pacific, e.g., fish and whales. The abundance and diversity changes that we find in late Miocene avian communities are also likely the result of changing circulation and upwelling in the region.

A NEARLY COMPLETE FOSSIL WALRUS FROM ORANGE COUNTY, CALIFORNIA: IMPLICATIONS FOR THE PHYLOGENY OF ODOBENIDS

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A nearly complete fossil pinniped was discovered in the Miocene to Pliocene-aged Oso Sand Member of the Capistrano Formation in Orange County, California. This specimen (OCPC 11141) consists of crania and postcrania and represents a new genus and species of fossil odobenid. The Odobenidae includes three clades within it: the Odobeninae (including the extant *Odobenus rosmarus*), Dusignathinae, and ‘Imagotariinae.’ The Dusignathinae and ‘Imagotariinae’ are two extinct groups of walrus known from Miocene to Pliocene sediments across the North Pacific, from the east coast of Asia to the west coast of North America. The dusignathine walruses are a monophyletic group that are diagnosed by the presence of enlarged upper and lower canines that form tusks. The ‘imagotariines’ are a paraphyletic group that includes at least eight genera and seven species that are diagnosed by the lack of synapomorphies found in dusignathines or odobenines. OCPC 11141 represents a new taxon that includes a combination of characters previously restricted to both ‘imagotariines’ and dusignathines. As such, OCPC 11141 provides new insights into the morphology of basal walruses, and prompts a reassessment of their phylogenetic relationships.

PRELIMINARY U-PB DETRITAL ZIRCON DATES FROM THE KAYENTA FORMATION OF ARIZONA

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The Glen Canyon Group of western North America includes rocks that span the end-Triassic mass extinction and Triassic-Jurassic boundary, and it preserves fossils of terrestrial animals that had not occurred previously in the Late Triassic of North America. Owing to the absence of

dateable ash beds or useful biostratigraphic invertebrate fossils, the Early Jurassic rocks within the Glen Canyon Group have been poorly constrained temporally in western North America and their chronology has been constructed upon difficult superpositional relationships and the presence of vertebrate taxa. Presumed Early Jurassic fossils in western North America such as frogs, caecilians, turtles, crocodyliformes, ornithischians, sauropodomorphs, and large-bodied theropod dinosaurs are found almost exclusively in the Silty Facies of the Kayenta Formation in northeastern Arizona. However, the Kayenta Formation has been assigned to either the Late Triassic or Early Jurassic at least nineteen different times since it was first mapped in 1882. A previous attempt to directly date fossil dinosaur bone from the Kayenta Formation using high-resolution laser ablation inductively-coupled plasma mass spectrometry (LA-ICP-MS) yielded anomalously young U-Pb apatite dates that are incongruent with stratigraphic data that suggest an Early Jurassic age for the deposition of the Kayenta Formation. Further investigations into the spatial distribution of isotopes in the fossil bone indicate open-system behavior mostly as a result of uranium enrichment, where U was found in concentrations as high as 1,100 ppm in the fossil bone. Detrital zircons were collected from matrix removed directly from the same fossil bones and four other fossil localities within the Kayenta Formation near Gold Spring, AZ. These zircons were analyzed for U-Pb dates using high-resolution LA-ICP-MS. The type locality of the sauropodomorph dinosaur *Saraksaurus aurifontanalis* was dated at 183.7 ± 2.7 Ma and shifts the age designation for the Kayenta Formation from the Sinemurian-Pliensbachian to the Pliensbachian-Toarcian. Current efforts are sampling the rest of the Glen Canyon Group in order to construct the first chronology of the Early Jurassic rocks in western North America.

THE DUAL NATURE OF TAXA—AS DISTINCT LINEAGES AND AS CLASSIFIABLE ENTITIES

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A valid taxon is—presumably—one that corresponds to a unique discrete lineage (at the species level) or a group of lineages more closely related to each other than to lineages outside the group (above the species level). Most publications in paleontology proposing new taxa define a new taxon—ideally—by (1) giving its unique features or unique combinations thereof in a diagnosis, and (2) stating how the proposed new taxon differs from its closest relatives

in a differential diagnosis (presumably in accord with ICZN rules). Often the authors then go on to classify the new taxon, positioning it in a phylogenetic dendrogram. It seems to be generally assumed that all valid taxa are classifiable, however instances can easily be imagined that do not meet this criterion. Historically, a distinct taxon was a valid taxon, regardless of whether or not it could be classified, hence the status of *incertae sedis*. An example is the non-avian theropod *Paronychodon* known only from isolated teeth of unique form. It seems clearly distinct, but no one seems to know definitively its relationships to other theropods. In mycology, the distinction between being distinct and being classifiable is exemplified in the concept of fungi imperfecti, taxa that although clearly distinct lack the characters necessary for them to be classified (because these characters are usually found in the reproductive structures, e.g., mushrooms, and the reproductive structures are not known for fungi imperfecta).

SOUTH AFRICAN FOSSIL BABOONS AND EVOLUTIONARY CHANGES IN *PAPIO* POSTCANINE DENTAL MORPHOLOGY

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From 1947 to 1948, the University of California's Museum of Paleontology (UCMP) directed an expedition to collect fossils from nearly 50 site localities in South Africa. More than 200 fossils identified as Family Cercopithecidae were excavated from over 15 Plio-Pleistocene sites, including the cave associated with the well-known *Australopithecus* "Taung Child" fossil. We examined the postcanine dental morphology of fossil *Papio* (n=7) from Bolt's Farm and Buxton Limeworks, South Africa, stored in the UCMP. We used frequency and descriptive statistics to compare maxillary dental metrics of the UCMP monkeys with dental measurements of a large sample of extant *Papio hamadryas* (n=209), collected as part of an earlier NSF grant, as well as measurements of fossil *Papio h. robinsoni* (n=28) from the literature. Absolute third molar length and relative third molar length, taken as a percentage of the total molar row length, are smallest in the UCMP fossils and largest in the extant sample. Increased relative third molar length is paired with reduced relative first molar length in extant *Papio*, while the percentage of the total molar row occupied by the second molar is consistent (35%–36%) across the sample. The modularity

of the mammalian dentition structures adaptation and the evolution of derived molar morphologies. Ecological changes and the expansion of C4 grasses in Quaternary Africa have been associated with increasing third molar length in some mammalian lineages, including primates and ungulates. These data suggest that a shift in dietary niche over the last two million years may have contributed to the absolute elongation of, and relative increase of the portion of the molar row occupied by, the third molar in genus *Papio*. This study was funded by the National Science Foundation, grant number BCS-0616308.

ON THE ABUNDANCE OF FLIGHTLESS AUKS FROM THE MIDDLE MIOCENE TO EARLY PLIOCENE

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Mancallines are a group of extinct, wing-propelled diving auks (Alcidae and their close fossil relatives), interpreted to be similar in ecology to modern penguins, known from the middle Miocene to late Pleistocene of California, Japan, and Mexico. Previous research has addressed the phylogeny, diversity, and systematics of Mancallinae, making them one of the better-known fossil seabirds from the Pacific Basin. In the context of studying seabird community changes (see Kloess and Parham abstract, this volume) it was noted that alcid abundance changed dramatically through time, and so this study was initiated to examine the relative abundance of mancallines to other aluids. The foundation of this study is a collection of unstudied alcid (including mancalline) fossils from Orange County strata ("Topanga," Monterey, and Capistrano Formations) housed at the John D. Cooper Archaeological and Paleontological Center. The Cooper Center specimens were compared with previously identified museum collections and morphological descriptions found in the literature and identified to the finest level possible. Once identified, the specimens were compared to other museum collections to determine the relative abundance of mancallines to other aluids. Beginning in the middle Miocene, the alcid population shifts from predominantly non-mancalline to being dominated by mancalline species (65% by the early Pliocene). In addition to increased abundance during the early Pliocene, we have identified the first appearance of *Mancalla cedrosensis* and *M. vegrandis* in Orange County, extending the geographic range of these two species north from San Diego County and Baja California. These

changes in mancalline and alcid abundance and community diversity are synchronous with tectonic movements of continents, as well as a global drop in temperature and increased nutrient-upwelling.

CAN WE DETECT SEXUAL SELECTION IN DINOSAURS?

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Much debate has raged about how to explain “bizarre structures” in dinosaurs and pterosaurs (Ornithodira). Sexual selection is one hypothesis. However, Darwin explicitly defined sexual selection as involving sexual dimorphism in features that attract mates or repel rivals. So, sexual dimorphism must first be established in taxa for which sexual selection is hypothesized. Lines of evidence that test these questions follow.

(1) To date, no reliable morphometric analysis has established dimorphism in any non-avian ornithodiran lineage. Reasons include poor sample sizes, poor stratigraphic and/or geographic control.

(2) No independent assessment of skeletochronology, which is critical because without knowledge of the actual age of the individual, it is not possible to compare ontogenetic stages, relative sizes, and degree of trait development with age. Hypothesized sexual “differences” (not dimorphisms) among individuals often merely reflect age differences, because linear skeletal growth stops before mass increase (see “robust” vs. “gracile” forms).

(3) Advocates of sexual selection often deny that sexual dimorphism is required for sexual selection, but they provide no other criteria for recognizing sexual selection. This makes it impossible to identify sexual selection in extinct organisms.

(4) Arguments against species recognition (a phenomenon that may explain many “bizarre structures” in extinct animals) assert that it is not viable for extinct forms because there is little evidence for it in living groups. However, many extinct groups have no living homologues, and “analogues” provide only weak arguments.

(5) The lack of study of species recognition by neontologists is explained by the confounding effects of mating behavior, the context in which most taxa are studied.

(6) Arguments about the “cost” of “bizarre structures” have never been quantified and are spurious given the long success of the lineages.

(7) Sexual selection is a small subcategory of a hierarchy of interactions that comprises species recognition, social selection, mate recognition, mate choice, mate

competition, and sexual selection. Animals must first recognize conspecifics before mating and other social behaviors can occur. Conspicuous structures that vary non-directionally in clades and are not dimorphic may often reflect selection for species recognition.

FOSSIL EGGSHELL FROM THE KAIPAROWITS FORMATION (UPPER CRETACEOUS) OF SOUTHERN UTAH

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Fossil eggshell is relatively abundant in the Kaiparowits Formation of southern Utah (late Campanian; 76.5 to 74.5 million years old). Here, we identified specimens collected from Grand Staircase-Escalante National Monument and housed at the Raymond M. Alf Museum of Paleontology, primarily using characteristics of microstructure and surface ornamentation. So far, we have identified eggshell pertaining to three oofamilies: Elongatoolithidae, Testudoolithidae, and Spheroolithidae. The majority of the specimens have been identified as Elongatoolithidae based on the presence of two distinct structural layers (a prismatic and mammillary layer) and distinctive, sagenotuberculate ornamentation. These specimens probably pertain to small non-avian theropod dinosaurs. Other specimens have been identified as Testudoolithidae based on the presence of a single aragonitic layer comprising needle-like structures originating from the shell membrane, along with a smooth outer surface. This morphotype matches specimens found *in situ* with turtle specimens. The last morphotype is identified as Spheroolithidae based on the presence of only a prismatic layer with distinct shell units and sagenotuberculate ornamentation. These specimens, which are relatively uncommon, match eggshell found in association with hadrosaurids elsewhere. Thus, our study finds evidence for small non-avian theropods, hadrosaurids, and turtles nesting within the depositional environments of the Kaiparowits Formation.

PRELIMINARY RESULTS FROM DIGITIZATION AND GEOMETRIC MORPHOMETRIC ANALYSIS OF FOSSIL TRACKWAYS: TWO CASE STUDIES

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In order to better understand fossil footprint formation, variation, and ichnotaxonomy, we are documenting trackways using geometric morphometrics applied to digitized specimens. We began with *Laoporus*, a tetrapod ichnotaxon common in the Coconino Sandstone (Permian) of

Arizona. Here, we generated three-dimensional digital models of footprints using both a laser scanner and photogrammetry, followed by analysis in software for placement of 3D landmarks. Variable preservation made it difficult to find and place homologous landmarks across specimens, so additional work is needed to develop methods for analysis of such specimens. In a second case study, we digitized camelid footprints from the Barstow Formation (Miocene) of southern California. The specimens studied included forty tracks from three trackways, made by individuals of similar size. The average length of each track is ~83 mm and the average width of each track is ~79 mm. Here, we used photogrammetry of individual tracks; approximately 10 photos of each were necessary to develop a model of appropriate resolution. We have found that the preservation and shape of these tracks is much more amenable to placement of homologous landmarks, allowing comparison of overall shape (e.g., width of feet and depth of footprints, etc.). Ongoing work is documenting detailed variation between tracks of a single trackway as well as between different trackways.

THE NEW TULE SPRINGS FOSSIL BEDS NATIONAL MONUMENT IN LAS VEGAS VALLEY

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Shortly before Congress adjourned in late December of 2014, it passed a bill that created Tule Springs Fossil Beds National Monument, a new National Park Service unit to be devoted to the study and interpretation of Late Pleistocene (Rancholabrean) fossils. The new national monument is a crescent shaped parcel totaling 22,650 acres on the northern fringe of Las Vegas Valley. The deposits are primarily ground-water-discharge deposits and associated fluvial sediments of the Las Vegas Formation. Five members are recognized in the Las Vegas Formation, each of which records a cool-wet interval when springs were flowing during the Wisconsin and latest Illinoian glacial intervals. These members are separated by paleosols that represent warm-dry intervals. The Tule Springs fauna is not yet well studied, and research by paleontologists from the San Bernardino County Museum and UNLV are ongoing. It is a Rancholabrean fauna dominated by megaherbivores such as *Mammuthus columbi*, *Camelops hesternus*, *Equus* sp., *Bison* sp., and *Megalonyx jeffersonii*. Carnivores are very scarce, although elements of *Panthera atrox*, *Canis dirus*, and *Smilodon* have been reported. The site has additional historical significance as the location where radiocarbon dating was first used (in the 1960s) on a large scale to explore the question of when humans first

arrived in North America and whether they interacted with the now-extinct Pleistocene megafauna. No evidence of hunting or butchering by humans of Pleistocene animals has yet been discovered in the Tule Springs Fossil Beds, but there is great potential for studying the impact of climate change on arid-land vertebrate communities, and for correlating intervals of terrestrial ground-water discharge with marine isotope stages. Specific plans for developing a visitor center and facilities for research and collections in the new national monument are just beginning.

GIANT SALMON, TORTOISES, AND OTHER WILDLIFE FROM THE MIO-PLIOCENE MEHRTEN FORMATION, STANISLAUS COUNTY, CALIFORNIA

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The Mio-Pliocene Mehrten Formation is exposed in the foothills east of Modesto, in the northern San Joaquin Valley, California. It consists of volcanic-sedimentary deposits representing lahar flows, stream, lake, and floodplain deposits. The Modesto Reservoir Member is the uppermost unit, and is exposed in and around Modesto Reservoir and Turlock Lake. This unit has yielded thousands of fossils, including plants and vertebrates, from over fifty fossil localities. Numerous mammals constrain this unit to the late Hemphillian (North American Land Mammal Age), ~ 5 Ma. Most of these fossils were discovered and collected by Dennis Garber, who donated the fossils to the University of California, Berkeley Museum of Paleontology (UCMP) and to the Natural History Museum of Los Angeles County (LACM). These important collections produced several key publications, including on the plants (Axelrod); the giant, tusk-toothed salmon, *Oncorhynchus rastros* (Cavender and Miller); and the mammals (Wagner). The mammal collections are particularly impressive: they are numerous and diverse, including many specimens of horse, camel, antelope, rhinoceros, giant ground sloth, mastodons, and carnivores. All are isolated bone and teeth. Garber also screen-washed selected sites, which produced thousands of specimens of rabbits, rodents, fish, amphibians, and reptiles; the majority of this material is in the LACM collections. Despite these immense collections, little has been published on the non-mammalian part of the fauna. Yet, these vertebrates provide important information about the paleoenvironments and paleoclimates

for this area. Our current research is on the large tortoise specimens from the Mehrten, which have not been previously described. Additionally, our focus is to relocate and re-examine the major fossil localities from Mehrten, to better document their geologic context, and to provide better age control. In particular, we are re-finding and documenting the localities with GPS and digital images; describing the sedimentary deposits; collecting and dating ash for geochronology; and placing the sites within measured stratigraphic sections. This work is providing more accurate information on the local paleoenvironmental and paleoclimatic conditions. For example, the early Pliocene (~5 MA) is an important and interesting time in earth history: it is the start of global greenhouse conditions, with higher levels of atmospheric CO₂ and temperatures. Based on paleobotanical records and research, the local climate was more moderate than today, with less severe summers and winters. The presence of the large tortoise supports this interpretation.

MIOCENE-PLEISTOCENE GEOLOGY AND PALEOBIOLOGY OF STANISLAUS COUNTY, CALIFORNIA

SANKEY, Julia, T., BIEWER, Jacob, GEORGE, Michael, MALDONADO, Nereida, CAMPOS, Maira, MARTINEZ, Victoria, GARNER, John, OCON, Jose, SNYDER, Mikayla, WILSON, Whitney, and MONSCHEIN, Amanda, Department of Physics and Geology, California State University, Stanislaus, Turlock, CA

The Miocene-Pleistocene sedimentary units in Stanislaus County, northern San Joaquin Valley, are primarily floodplain deposits, with occasional river and lake deposits. These terrestrial deposits are represented by several geologic formations. From oldest to youngest, they are the Valley Springs (late Miocene), Mehrten (late Miocene-early Pliocene), Turlock Lake (Pliocene), and Riverbank and Modesto Formations (Pleistocene). Plant and vertebrate fossils have been collected from all of these units, and are curated in the University of California Museum of Paleontology (UCMP) collections. Publications have focused on the material from the Mehrten, in particular the plants (Axelrod); giant, tusk-toothed salmon (Cavender and Miller), and the mammals (Wagner). Material from the other units have had less research and publication efforts. Here we review all of the relevant geology and paleobiology literature for the Miocene through Pleistocene units of Stanislaus County, and list the known fossil plant and vertebrate records and localities as documented in the UCMP online database.

DESCRIPTION OF THE LATE UINTAN TALEGA BONEBED FROM ORANGE COUNTY, CALIFORNIA

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Eocene terrestrial vertebrates from Southern California are known from Ventura, San Diego, and Orange Counties. Relative to the other two counties, the sites and specimens from Orange County are poorly known. Paleontology mitigation monitoring of the Talega Housing Development in San Clemente, Orange County, California in 1998 excavated a vertebrate bonebed from the Eocene-aged Santiago Formation. The bonebed, named the Talega Bonebed, represents just the second description of an Orange County locality to produce Eocene terrestrial vertebrates. The bonebed was excavated as 46 cubic meter blocks, five of which have been prepared using standard techniques and heavy liquid separation. The bonebed is approximately 10 cm thick and comprises densely deposited, disarticulated skeletal elements with no obvious associations. Sparsely distributed fossils can be found in the overlying layer. Sedimentologically, the Talega Bonebed matrix comprises a compositionally immature, orange-tan, muddy, very fine to coarse-grained sandstone. Fossils prepared from the bonebed exhibit varying degrees of weathering with denser skeletal elements, such as vertebrae, astragali, mandibles, and isolated teeth exhibiting better preservation. The Talega Bonebed is a highly productive fossil locality with 22 taxa identified to date. The more common macrofossil taxa identified from the bonebed are typical of the late Uintan fauna from Southern California, including brontotheres, amynodonts, crocodylians, and small artiodactyls, such as *Leptoreodon* and *Protylopus*. Other less common macrofossil specimens include tapiroids, turtles, miacids, and mesonychids. Microfossil taxa obtained through heavy liquid separation include taxa such as *Simimys*, *Microparamys*, *Sespedectes*, and *Dyseolemur pacificus*. The Talega Bonebed can be classified as a high diversity, multitaxic, and multidominant fossil accumulation. Based on the mostly poor state of fossil preservation, spacial density, and high diversity of taxa, it is likely the formation of the Talega Bonebed can be attributed to hydraulic concentration in which skeletal elements from multiple sources accumulated overtime in a fluvial environment. The high density of fossils within the bonebed may suggest that sediment input was low during deposition of the Talega Bonebed and categorizes it as a time-averaged, attritional accumulation.

MIOCENE TELEOST FISH FROM CHINO HILLS: PRELIMINARY RESULTS FROM THE VILA BORBA PROJECT, SAN BERNARDINO COUNTY, CA
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The Vila Borba Project is a 336-acre residential and commercial development in the city of Chino Hills, San Bernardino County, California. Phase I began in early 2014, with archeological and paleontological monitoring provided by Duke Cultural Resources Management (DUKE CRM). Phase I involved the northwest portion of the project, an area roughly bisected by the northwest-southeast trending Chino Fault. This area has been previously mapped as comprising the late Miocene (Late Luisian to ?Delmontian) Puente and Sycamore Canyon Formations.

In five months of monitoring, over 160 fossil specimens were found, including teleost fish, chondrichthians, bivalves, marine and land plants, coprolites, and burrows. Preliminary investigation of the teleost fish specimens identified *Chauliodus* sp. (viperfish), *Etringus* sp. (round herring), *Laytonia* sp. (halosaur), *Rhythmias* sp. (sheepshead), Clupeiformes (herring and anchovy), and Myctophiformes (lanternfish).

The sedimentology of the bedrock and the presence of fossils were distinctly different on either side of the Chino Fault. East of the fault (footwall), sediments were dominated by pebble to boulder conglomerates and sandstones, and relatively few fossils were observed. West of the fault (hanging wall), sediments were exclusively mudstones to very fine-grained sandstones, and the majority of fossils were encountered. The difference in fossil exposure in sedimentology on either side of the Chino Fault may reflect taphonomic differences within the same formation, or may signify a more complex geology in the project area than is currently mapped. Further phases in the Vila Borba Project may clarify the local geology and their respective fossil deposits.

FACIAL ASYMMETRY IN THE SABERCAT (*SMILODON FATALIS*) AND WOLF (*CANIS DIRUS*) FROM RANCHO LA BREA, LOS ANGELES, CALIFORNIA

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Rancho La Brea is a well-known late Pleistocene carnivoran trap site. For the two most common species from this site, the George C. Page Museum collections contain over 3,500 pathological items of *Canis dirus* and over 5,000 pathological items of *Smilodon*. Cranial maladies are

relatively rare in the collection, but when found many tend to result in facial asymmetry, in some instances that are quite remarkable. In both species, they tend to be related to dental problems, but in wolves frontal asymmetries are without doubt due to hunting injuries. It is proposed that some of this asymmetry is due to dental impactions, creating change through massive infections, while others are the result of subsequent infection and healing from traumatic injury inflicted by blows from potential prey species. Cranial injuries give provocative clues to different hunting strategies in these two carnivorans.

THE CREATION OF A VIRTUAL MUSEUM WITH A FOCUS ON THE CALIFORNIA CENTRAL COAST

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The Central Coast of California boasts an impressive diversity of geological, paleontological, and archaeological history. Unfortunately the great majority of this history remains unknown to the public at large, most specimens comprising this rich history are scattered through multiple museums outside the region.

Here I propose a solution: the creation of a virtual museum focused on the Central Coast. While some museums have been taking advantage of the information age many have been slow to tap into its full potential. This is usually due to a lack of funding and staffing. So instead of pressuring museums to take time away from their other activities, we suggest letting an amateur organization pick up the slack.

The virtual museum proposed here would host an online collection consisting of photos of specimens from the Central Coast. This virtual collection will not only bring the rich ancient history of the Central Coast to light, but can also be used to create virtual exhibits. Research related to this history can be housed in a virtual library. This museum serves the dual purpose of not only bringing all relevant information together for professionals and public alike, but also creating a novel and useful database that is not yet available.

By bringing together all information on the Central Coast (specimens, research, locations), this virtual museum could open whole new avenues of research and interest for everyone. The prototype can be viewed at: <http://ccppvirtualmuseum.org/>.

REMANIÉ *DESMOSTYLUS* FOSSILS IN THE TULARE FORMATION

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Interstate 5 parallels the axis of the San Joaquin Valley. In several places in the vicinity of Arroyo Ciervo, it cuts through exposures of the Tulare Formation. The Tulare Formation exposures in this region are in the foothills of the Diablo Range. The Tulare Formation is generally regarded as being of late Pliocene and Pleistocene age. Some authors, however, consider that Tulare Formation deposition continued into the Holocene Epoch. Some facies are lacustrine, and others represent alluvial fans. All authors accept that the Corcoran Clay, a widespread lacustrine horizon, is contained within the formation. It is bracketed by radiometric dates of 730 ka and 612–618 ka. The *Desmostylia* is an order of herbivorous quadrupedal marine therytheres that inhabited the North Pacific Ocean. They ranged from the earliest Oligocene Epoch to the middle or late Miocene Epoch. The genus *Desmostylus* had the highest crowned cheek teeth of the order. The marine Temblor Formation in the Diablo Range has produced hundreds of *Desmostylus* teeth. More than 40 fragments of *Desmostylus* teeth have been found in Tulare Formation exposures near Arroyo Ciervo. However, the Tulare Formation was deposited after the extinction of the *Desmostylia*, and it has no marine facies. The Tulare Formation facies that produce the *Desmostylus* teeth appear to be alluvial fan facies. The *Desmostylus* teeth occur with gastropods, peleypods, echinoids, and barnacles that appear to be reworked from the Temblor Formation. Together, they constitute a *remanié* fauna. Temblor Formation exposures occur within three miles (west) of the Tulare Formation exposures in question. It is unclear whether these Tulare Formation exposures are above or below the Corcoran Clay.

NEW VERTEBRATE TRACK LOCALITIES AND TRACK TYPES FROM THE LOWER TRIASSIC MOENKOPI FORMATION, CENTRAL UTAH

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Vertebrate tracks attributed to swimming reptiles are abundant in the Lower Triassic Moenkopi Formation throughout the Colorado Plateau. However, tracks produced by a walking locomotion in shallow water or fully terrestrial settings are far less common. New track localities from the Circle Cliffs region of central-southern Utah shed light on the diversity of reptilian fauna that inhabited this region during the late Early Triassic. Specific localities information is held by the Utah Geological Survey

(UGS). The localities occur in the Torrey Member of the Moenkopi Formation which was deposited in a large delta complex. At UGS locality 42Ga1475 there are at least two and possibly three track types represented. The first type is lacertoid in morphology and can be assigned to the ichnogenus *Rhynchosauroides*. *Rhynchosauroides* has also recently been discovered at a new track locality in the San Rafael Swell (UGS 42Em0745). The second track type is similar to those recently reported from the Moenkopi Formation in Dinosaur National Monument and resembles the ichnogenus *Protochirotherium*. A third track type may be represented which consists of amorphous, tridactyl tracks, possibly with webbing between the digits, and linear central traces probably produced by dragging the body or tail through the substrate. However, these tracks are similar in size to *Protochirotherium* and it is unclear whether they were produced by a third trackmaker or are the result of different substrate conditions. Differences in preservation fidelity among the tracks indicate that the surface dewatered over time and is at least slightly time-averaged resulting in the diachronous passage of numerous individual trackmakers. Another locality in the Circle Cliffs (UGS 42Ga1406) preserves a new track type that cannot be attributed to differences in substrate conditions and therefore represents a new ichnogenus. This track type is 1.5–2 centimeters in width and comprises four, triangular-shaped digits arranged in a crescentic pattern. The morphology of these tracks is reminiscent of those produced by turtles in the Jurassic. New track localities and track types from the Moenkopi Formation provide valuable insight into the diversity and habitat preferences of reptiles during the Early Triassic.

COLD COMFORT: TIBETAN ORIGINS FOR ICE AGE MEGAFUNA

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At an average elevation of greater than 4.5 km above sea level, the Tibetan Plateau, also known as the “third pole” of the world, features some of the harshest environments in the world with bitter coldness, low oxygen, high UV radiation, and in places, severe aridity. Depending on the choice of uplift model, much of the plateau may have reached its present elevation during mid Cenozoic, possibly earlier. The harsh environments thus may have been in place for tens of million years and as such, must have served as the main driver of vertebrate evolution during the Cenozoic. Such evolution has resulted in an extant vertebrate community of low productivity, low diversity,

and high endemism. Many living mammals have acquired adaptations for better thermal insulation, more efficient oxygen transport, and enhanced DNA damage repair.

Our recent field works in Zanda Basin within the Himalaya Range of southwestern Tibetan Plateau attempt to add a deep time dimension to the modern Tibetan fauna. We have unearthed fossil forms in the Pliocene of Tibet that apparently are ancestral to some of the megafaunal elements elsewhere in the Pleistocene of modern Eurasia. These discoveries form the basis of an “out of Tibet” hypothesis, which suggests that Pliocene Tibetan fauna was adapted to cold climate (hypothermia), low oxygen (hypoxia), and high UV radiation, conditions that “trained” its megafauna for the coming Ice Age. The best documented example of our “out of Tibet” hypothesis is the Tibetan woolly rhinoceros (*Coelodonta thibetana*). Less compelling but equally intriguing variations of the theme may include Tibetan bharal (*Pseudois*), Tibetan antelope (*Pantholops*), Asian hunting dog (*Sinicuon*), and ancestral snow leopard (*Panthera blytheae*), all of them showing an earlier record in Tibet. Most recently, our “third-pole-to-north-pole” linkage of an extinct fox, *Vulpes qiuzhudingi*, with the late Pleistocene and extant arctic fox, *V. lagopus*, suggests another variation of this theme. The evidence is far from complete but Tibet is quite possibly a cradle for Ice Age megafauna.

LATERAL AND TEMPORAL DISTRIBUTION OF EARLY EOCENE PRIMATES IN RELATION TO RELATIVE PALEOSOL MATURITY, WILLWOOD FORMATION, BIGHORN BASIN, WYOMING

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The Willwood Formation of the Bighorn Basin in Wyoming is characterized by vast exposures of fossiliferous paleosols (ancient soils). The relative maturities of these paleosols have been attributed to the relative proximities of the sediments to fluvial channels, and therefore may correspond to different microhabitats as well. This author has investigated a relationship between paleosol maturity and primate species distribution from the Bighorn Basin in order to find evidence of microhabitat preference in these early Eocene primates. Data from the Colorado State University Department of Anthropology fossil mammal collection was used to test this relationship. Preliminary investigations suggest that paleosol maturity may not be a reliable proxy for determining microhabitat preferences in early Eocene primates. The relative distribution of fossil primates with respect to paleosol maturities instead probably reflects increased deposition and drying that

occurs through the time of deposition of the Willwood Formation. Therefore, paleosol maturity may be better utilized as a proxy for taphonomic processes and time when examined with respect to other meter levels. However, the lack of lateral variation in the distribution of these primate species may simply reflect their similar arboreal adaptations. If this is the case, niche partitioning on a small scale would not be significant enough to provide geologic resolution of these minute differences. Further research on more abundant and differentially adapted species, such as the small condylarth *Hyopsodus*, may be useful in resolving these possibilities.

APPLICATIONS OF HIGH RESOLUTION COMPUTED TOMOGRAPHY AND 3D PRINTING FOR STUDY OF A MULTITUBERCULATE MAMMAL SKULL

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Multituberculates, small rodent-like mammals, are a common component of early Paleogene faunal assemblages throughout western North America. The specimen under study, RAM (Raymond M. Alf Museum of Paleontology) 9048, was discovered in the Paleocene (Tiffanian)-aged Goler Formation of Kern County, California. Tentatively assigned to *Neoplagiaulax* sp, the fossil includes an articulated but slightly crushed cranium and lower jaws, preserved in an indurated concretion. Detailed micro-preparation exposed many of the teeth and some aspects of the bones, but concerns for specimen stability as well as poor visual contrast between matrix and bone halted further preparation. Thus, the specimen was scanned at the University of Texas High-Resolution X-ray CT Facility. Voxels in the resulting scan were 26.61 microns in all dimensions, with a total of 1,818 slices. As a result, many previously unexposed features can now be rendered digitally. Using the software 3D Slicer, individual teeth are segmented from the surrounding bone and matrix. From these segmented images, digital models are built. By enlarging the tooth on the screen, it is possible to count cusps (a critical feature for species identification), determine the type of tooth, and take measurements more easily and accurately than through direct examination of the physical specimen. Parts of the tooth previously covered by matrix (e.g., parts of the wear surfaces as well as the roots) can now be rendered. Additionally, I can use the 3D printer to create an enlarged model of the skull for physical study of each individual aspect of the fossil. With this new technology, I am able to dissect each of the teeth preserved inside and outside the skull and determine, later on, which species it most closely resembles and what it may have eaten.