

information system (GIS) database with a spatial resolution of 14.5 meters. We used a feed-forward, back-propagated multilayer perceptron ANN model to locate other areas within the basin which shared the spectral signature of our known localities. Our algorithm identifies patterns of features that are common to fossil bearing deposits, and looks for these features in a "fuzzy" fashion throughout the entire study area. The model's output provides a classification of all pixels within the study area into one of the five land cover classes, along with associated probabilities. Post-hoc accuracy testing based on roughly 25% of the nearly 100 known localities in the GDB resulted in a correct classification of 79% of localities, while for all five land cover classes, a correct classification of 85% was achieved. The neural network approach that we have developed in the Paleogene of Wyoming is generalizable to paleontological field research in other geographic areas or time periods wherever productive localities share distinctive sets of geospatial and spectral features.

Poster Session II (Thursday, November 3)

RAPID MICROBIALY-MEDIATED CALCIUM CARBONATE PRECIPITATION: A MODEL FOR PERMINERALIZATION OF EMBRYONIC SOFT TISSUE IN SAUROPOD EGGS

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Extraordinary preservation of the embryonic contents of sauropod eggs in the Upper Cretaceous Anacleto Formation at Auca Mahuevo, Argentina provides evidence of rapid, microbially-mediated precipitation of calcium carbonate. We develop a preservational model for the Auca Mahuevo embryonic material (embryonic skin and eggshell membrane) by characterizing mineralogical composition and microfabrics of the fossilized egg contents using optical and cathode-luminescence (CL) petrography, X-ray diffractometry (XRD), and field-emission scanning electron microscopy (FEM).

Microfabric features within the fossilized embryos include spherulites comprising radiating acicular calcite, ooids, peloids, pellets, *Microcodium*, calcified filaments, and microcrystalline calcite (micrite). Collectively, these features represent the interplay of metabolic activity and chemical factors (e.g. pH, [Ca²⁺], anoxia) proximal to and within the decaying embryonic tissue facilitated by cyanobacterial and EPS (extracellular polymeric substances) biofilms and mucilaginous bacteria (spherulites/ooids), actinobacteria and saprotrophic fungi (*Microcodium*), fungi (calcified filaments), other indeterminate soil microbes (micrite), and invertebrates (pellets/peloids/micrite).

Metabolic activity within the microbial community (biofilm) colonizing the embryonic tissue facilitated calcium carbonate precipitation leading to exceptional preservation through calcite permineralization (microbial autolithification) of the embryonic soft tissue. The pathway of events driving this included: 1) microbial colonization of embryonic tissue following drowning and sediment burial under anaerobic conditions limiting autolysis, 2) embryonic tissue consumption leading to formation of biofilms that pseudomorphed the embryo form and structurally supported the soft tissue, and 3) microbially-mediated calcite biomineralization of the embryonic soft tissue pseudomorph by growth of and infusion with calcite crystals (permineralization). This process does not require preservation of endogenous soft tissue components, but rather only replication of original embryonic tissue as a biofilm pseudomorph entombed within calcite.

Technical Session XV (Saturday, November 5, 8:45 am)

DICYNODONT (THERAPSIDA, ANOMODONTIA) ASSEMBLAGES FROM THE LUANGWA BASIN, ZAMBIA: TAXONOMIC UPDATE AND IMPLICATIONS FOR BIOSTRATIGRAPHY AND BIOGEOGRAPHY

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Dicynodonts were among the first tetrapod fossils discovered in the Luangwa Basin in the late 1920s. As part of our ongoing research in Zambia, we conducted a comprehensive taxonomic revision of Permian and Triassic dicynodonts reported from the basin, incorporating new data from our 2009 field season. We recognize 14 dicynodont species in the Permian upper Madumabisa Mudstone, including two new, endemic species; reports of *Lystrosaurus* from this formation are in error. In addition, we found no significant partitioning of dicynodont taxa in the northern and southern parts of the basin, despite substantial differences in preservation, indicating the presence of a single faunal assemblage in the Upper Permian. The Madumabisa dicynodont assemblage is best correlated with the *Cistecephalus* Assemblage Zone of South Africa. The shared presence of *Dicynodon huenei* and *Katumbia* in the Luangwa Basin and the Ruhuhu Basin of Tanzania suggests that the Tanzanian Usili Formation also can be correlated with the *Cistecephalus* zone. Interestingly, the Madumabisa assemblage from Zambia is more similar to the coeval assemblage from South Africa, despite its closer geographic proximity to Tanzania. The Karoo and Ruhuhu basins also include more endemic species in the Permian than the Luangwa Basin. The Triassic Ntawere Formation preserves four dicynodont species, which occur at two stratigraphic levels. The lower Ntawere assemblage resembles the Omingonde Formation of Namibia in the presence of *Kannemeyeria lophorhinus* and potentially *Dolichuramus*. The upper Ntawere assemblage shares the genus *Sangusaurus* with the Manda beds of Tanzania, and includes the endemic *Zambiasaurus*. Comparisons of these assemblages to the Omingonde and Manda suggest

both are best correlated with the *Cynognathus* C subzone. When combined with data on other tetrapod taxa, our revised dicynodont assemblages contribute to an emerging picture of broad faunal similarity in southern and eastern Africa during the Late Permian, and increasing differentiation between the South African and other Karoo basins following the end-Permian extinction.

Poster Session IV (Saturday, November 5)

DEPOSITIONAL ENVIRONMENT OF ISOLATED SKELETAL ELEMENTS FROM THE FAIRMEAD LANDFILL LOCALITY (PLEISTOCENE, IRVINGTONIAN), MADERA COUNTY, CALIFORNIA

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Extensive horizontal exposures of fossiliferous strata at the Fairmead Landfill locality have provided an opportunity to evaluate interpretations of the fossils' depositional environment (fluvial deposition in or near alluvial fans) and provide insight into taphonomic pathways for the fossils' preservation. In the summer of 2007, 39 out of 57 *in situ* isolated skeletal elements were recovered from a reddish-brown argillaceous siltstone facies that contains mudcracks and burrows. The siltstone facies is cross-cut by 3 red to light tan, silty sandstone to coarse sandstone channel-fill facies, each 5-10 meters wide. The channel-fill facies extended from the northeast to the southwest across the landfill cell. The northeast-southwest orientation of the sand-filled channel facies supports previous interpretations of a southwest paleocurrent direction.

The siltstone facies represents deposition in an overbank environment with an attritional assemblage of isolated vertebrate skeletal elements. Observations of bone breakage and weathering prior to burial indicate exposure of the skeletal elements prior to burial. The development of mudcracks and extensive burrowing in the overbank siltstone facies is consistent with exposure and weathering of skeletal elements prior to burial. Continued discoveries of bone breakage support previous interpretations that invoked trampling of bones by large herbivores.

Poster Session I (Wednesday, November 2)

CHANGING OLD VIEWS WITH NEW TECHNOLOGY: USING XRF TO COMPARE BONE CHEMISTRY OF BIRDS WITH OTHER VERTEBRATES

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The rehabilitation of birds with broken bones, both wild and domestic, is problematic due to the tendency of bird bones to shatter on impact rather than fracture. In the veterinary literature, this characteristic is attributed to either elevated amounts of calcium within the apatite structure or a higher ratio of bone apatite to collagen within the skeleton. However, it has not been demonstrated which of these can be attributed the brittle behavior of bird bones. Alternatively, this characteristic may not be a result of differences in bone chemistry at all, but rather differences in the mechanical properties of bird bones caused by the pneumatization of much of the skeleton (in flight birds). Although recent studies have shown that bird bones are denser than bones of other vertebrates, the reason for this greater density is unknown. In this study, I use a ThermoScientific Niton XL3t XRF Analyzer to examine the chemistry of fish, reptile, mammal, and bird bones to test whether levels of calcium are elevated in birds compared to other vertebrate groups. Specimens consisted of the following areas of the skeleton: skull (fish, reptile, bird, and mammal), vertebrae (bird, reptile, and mammal), long bones (bird and mammal), and limb girdles (reptile, bird, and mammal). The samples included representatives of both wild and domestic species, as well as normal and pathologic bone tissue. Calcium was measured in overall parts per million (ppm).

Birds were found to have lower ppm of calcium in their bones compared to reptiles and mammals, with values closer to those seen in fish. These XRF data suggest that the brittle behavior of bird bones in response to trauma is not caused by elevated levels of calcium in the bones; however, further testing is necessary to assess whether apatite to collagen ratios differ in birds compared to other vertebrates.

Poster Session I (Wednesday, November 2)

PLESIOSAUR STRUCTURAL EXTREME FROM THE MAASTRICHTIAN OF ANGOLA

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An elasmosaurid plesiosaur (PA103) was recovered from the Mucuío Formation, Bentiaba, Namibe Province, southern Angola, and preserves the pectoral and pelvic girdles, cervical and dorsal vertebrae, and ribs. However, it is the pectoral girdle that shows several unique adaptations that are unparalleled in other plesiosaurs, including a highly atrophied dorsal process of the scapula, long longitudinal pectoral bar with extensive contacts between the coracoids anteriorly and posteriorly and between scapulae, presence of a left-right asymmetry of the coracoid ventral process, and widely expanded posterior portions of the coracoids. The reduced dorsal process indicates that the muscles required for terrestrial

locomotion atrophied during elasmosaur evolution. To test this hypothesis, pectoral girdle muscle topology and maximum-attachment areas were determined within a squamate and archosaur phylogenetic bracket, and the evolution of the pectoral girdle musculature among Sauroupterygia was traced and homologized. A Catalano-Goloboff phylogenetic morphometrics analysis (one landmark character, 14 landmarks) of forty Eosauropterygia taxa retrieved the Bentiaba specimen as derived among Elasmosauridae and supported the general tree topology reported previously from phylogenetic analyses based on anatomical characters other than landmarks. The myological reconstruction determined in this study serves as a basis for determining boundary conditions involved during muscle action. These results allowed construction of finite-element models derived from laser-scan data of the Bentiaba specimen. The Bentiaba specimen model results were contrasted with other basal plesiosaur pectoral girdles to determine the functional significance of the unique skeletal structure of the Angolan fossil. The Bentiaba specimen is a structural extreme; a compromise between the undesired consequences of having a large muscle attachment area and a geometry that minimizes stress within bones by also taking advantage of arthrological relationships with contiguous bones.

Poster Session I (Wednesday, November 2)

A MORPHOMETRIC ANALYSIS OF THE MANDIBULAR PREMOLARS AND MOLARS OF SOUTH AFRICAN AUSTRALOPITHECUS

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Considerable debate has focused on whether there are high levels of variation in size and morphology in *Australopithecus africanus*, current taxonomic attributions of a variety of South African australopithecine specimens, the number of species represented within the Makapansgat and Sterkfontein samples of *A. africanus*, and the phylogenetic relationships of currently recognized South African australopithecine taxa. Analyses of mandibular premolar and molar shape variation are presented in order to assess the patterning and degree of size and morphological variation in the dentition of currently recognized South African australopithecine taxa.

Dental landmark coordinates were digitized in TpsDig2 using occlusal photographs of the mandibular premolars and molars of South African taxa from Kromdraai, Swartkrans, Sterkfontein, Taung, and Makapansgat. Landmarks were recorded for the cusp tips for unworn specimens and semi-landmarks were recorded for the overall occlusal outlines for both moderately worn and unworn specimens. These coordinate data were imported into Morphologika where generalized Procrustes analysis and principal components analysis were performed. Analyses of the overall occlusal shape of the mandibular premolars and molars and cusp tip positioning were executed on the samples of unworn teeth. Analyses were repeated for the entire sample of worn and moderately worn specimens, excluding cusp tip landmarks, in order to further examine results with larger sample sizes. Analyses of both worn and unworn samples indicate that the occlusal morphology of mandibular premolars and molars does not pattern well with current taxonomic attributions of South African australopithecines and reflect considerable overlap in size and morphological variation among currently recognized species. These results suggest that confident assignment of isolated mandibular premolars and molars of South African australopithecines to a particular species is problematic and may further confound efforts to reconstruct the phylogenetic relationships of these taxa on the basis of dental morphology.

Poster Session IV (Saturday, November 5)

TAPHONOMIC FILTERS OF AGE GROUPS OF THE ANKYLOSAURID DINOSAUR PINACOSAURUS

ARBOUR, Victoria, University of Alberta, Edmonton, AB, Canada; CURRIE, Philip, University of Alberta, Edmonton, AB, Canada

The ankylosaurid *Pinacosaurus* is known from several bonebeds from Mongolia and China. These specimens largely represent juveniles, based on their small size, lack of body osteoderms other than cervical rings, and unfused neurocentral sutures. The individuals in each of these sites probably died and were buried in a short interval of time. At Bayan Mandahu in China, the skeletons are preserved upright with limbs tucked under the body, and were buried during a sandstorm or by a dune-sourced alluvial fan. The presence of aligned, closely associated articulated skeletons suggests that this represents a social group. The Alag Teeg bonebed in Mongolia exhibits characteristics associated with miring, including plunging limbs and preferential preservation of limb elements. Although this could represent an accumulation of individuals independently drawn to the same resource, the Bayan Mandahu bonebed supports the interpretation that the Alag Teeg bonebed also represents a group. A new review of the Alag Teeg material shows that an individual more than twice the size of the juveniles, with closed neurocentral sutures, was present in the bonebed. This adult may have been part of the group of juveniles, may have been independently drawn to the same resource, or may have been mired at a later time. Drought assemblages, with many animals drawn to a dwindling water supply, tend to have trampled, disarticulated elements, unlike the taphonomy of Alag Teeg. Modern examples show that social groups can be preserved in short periods of time via miring. It is likely that the adult *Pinacosaurus* was mired at the same time as the juveniles, and was probably part of the group. Comparison with the extant phylogenetic bracket suggests that parental care can explain the presence of the adult with multiple juveniles. Ostriches form juvenile groups guarded by adults, and extant crocodylians guard large groups of offspring for about one year. Juvenile *Pinacosaurus*, lacking osteo-

derms and a fully-developed tail club, may have benefited from the presence of an adult. The absence of an adult at Bayan Mandahu may indicate that the adult(s) were able to escape the catastrophic accumulation of sand.

Symposium 2 (Wednesday, November 2, 11:00 am)

FAUNAL REMAINS FROM EL FIN DEL MUNDO ARCHAEOLOGICAL SITE, SONORA, MEXICO

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At present, the Sonoran Desert is one of the driest regions in North America. However, within the last 20,000 years, accounting for the maximum last glacial and warming events, conditions varied significantly, allowing for permanent water ponds and running water. Those conditions, then, supported a mammal community that included tapirs (*Tapirus bairdii*), mylodonts (*Paramylodon harlani*), and gomphotheres (Gomphotheriidae), among others. Such evidence has been found at the archaeological site of El Fin del Mundo (The End of the World), a Clovis site located in the central portion of the State of Sonora, in the Sonoran Desert. Two major bone beds were exposed: one around 12,000 years BP (upper bone bed), which included the human occupation and parts of two juvenile gomphotheres, plus tapir and mylodont, buried by diatomaceous lake sediments; and a second, older level (lower bone bed), characterized by sandy spring-derived alluvium, and which included temperate animals, such as bison (*Bison* sp.), camels (*Camelops* sp.), and horses (*Equus* sp.). Those two faunules are clearly separated in time. The upper one may indicate a warm, humid forested habitat. The lower stratum must have formed under different climatic conditions, indicated by animals from cold, dry habitats, such as grasslands, including bison, camels, horses, hare, and woodrat. Further analyses are warranted to support the preliminary inferences about faunules composition, and to document the taphonomic history of the site.

Poster Session II (Thursday, November 3)

EQUUS FROM THE MIDDLE IRVINGTONIAN FAIRMEAD LANDFILL LOCALITY, MADERA COUNTY, CALIFORNIA

ASAMI, Rebecca, Department of Earth & Environmental Sciences, California State University, Fresno, CA, USA; IBARRA, Yesenia, Department of Earth & Environmental Sciences, California State University, Fresno, CA, USA; SCOTT, Eric, San Bernardino County Museum, Redlands, CA, USA; DUNDAS, Robert, Department of Earth & Environmental Sciences, California State University, Fresno, CA, USA

The middle Irvingtonian Fairmead Landfill site in Madera County, California preserves a diverse fauna collected from fluvial channel, overbank, and lacustrine deposits of the upper unit of the Turlock Lake Formation. The age of the locality is 0.78 Ma to 0.55 Ma. The fauna is dominated by large herbivorous mammals, with *Equus* representing two-thirds of identified specimens. The horses include individuals of all ontogenetic ages, from juveniles to aged adults. The considerable Fairmead Landfill collection provides ample material for comparison to other Pleistocene horses throughout North America. Metatarsals from the Fairmead Landfill were measured and compared to *Equus* from the following sites: *Equus* sp., Irvington, California; *E. "occidentalis"*, McKittrick and Rancho La Brea, California; *E. scotti*, Rock Creek, Texas; *Equus* sp., Dalhart Horse Quarry, Texas; *E. conversidens*, San Josecito Cave, Mexico; *E. ferus*, Natural Trap Cave, Wyoming; and *Equus* sp., Natural Trap Cave, Wyoming. Horses from the Fairmead Landfill site fall in the low end of the *E. "occidentalis"* / *E. scotti* distribution and in the upper end of the *E. conversidens* / *E. ferus* range. In addition to postcranial metrics, mandibles were examined for the presence or absence of infundibula, a character useful in distinguishing among horse species. The presence of infundibula in lower incisors of *Equus* at Fairmead Landfill indicates that these horses are neither *E. "occidentalis"* nor *E. conversidens*, since both these species lack infundibula in the lower incisors. This suggests the horse species from Fairmead Landfill may be either *E. scotti* or *E. ferus*, both of which possess infundibula. The infundibulum of the right 3rd incisor is open posteriorly, which also occurs in both *E. scotti* and Pleistocene North American *E. ferus*.

Technical Session XII (Friday, November 4, 2:00 pm)

PHYLOGENETIC MAPPING OF TRAITS OF THE AVIAN ALTRICIAL-PRECOCIAL SPECTRUM, AND ITS IMPLICATIONS FOR INFERRING EARLY AVIALAN LIFE HISTORY

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Extant birds can be classified according to development of offspring along an altricial-precocial spectrum, with fully-functional, feathered individuals at one end (precocial) and helpless, blind, naked chicks at the other (altricial). However, evolution of the various reproductive strategies along this spectrum has been difficult to understand because few studies have placed these data in phylogenetic context. I separated the common division of the precocial-altricial spectrum into seven character states to map life-history data onto both molecular and morphological avian phylogenies. The two trees imply different results: the former suggests that altriciality was evolved independently at least four times (by Passeriformes, Coraciiformes, Cuculiformes, and Apodiformes), while the latter implies a single origin. Both outcomes underscore the need for an avian phylogeny that integrates morphological and molecular data.