Symposium 4 (Friday, November 7, 2014, 8:30 AM)

A SPECTACULARLY PRESERVED EARLY PERMIAN DVINOSAUR (TEMNOSPONDYLI) FROM THE PARNAÍBA BASIN (BRAZIL) ILLUMINATES THE ANATOMY, FUNCTIONAL MORPHOLOGY, AND EVOLUTION OF AQUATIC LOCOMOTION IN THE CLADE

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Since 2011, fieldwork has been conducted in the early Permian Pedra de Fogo Formation (PFF) of the Parnaíba Basin to study its age, depositional environments, and vertebrate faunas. Discoveries include several articulated skeletons of a new temnospondyl. Phylogenetic analysis indicates that the species is a basal dvinosaur. The Brazilian dvinosaur has a well-ossified skeleton, and is characterized by a large head and ceratobranchials, a robust pectoral girdle, rhachitomous vertebrae with a large notochordal space, and caudal vertebrae and ribs that are modified into a rigid fin-like structure. Small limbs are present and include ossified stylopodial, zeugopodial, and autopodial elements. The Brazilian species shares an elongate body plan with the Permian and Early Triassic tupilakosaurids, but the structure of the vertebrae differs. The short, disc-like diplospondylous centra of tupilakosaurids resemble the centra of taxa such as whales and ichthyosaurs, which have inflexible vertebral columns. In contrast the vertebrae of the Brazilian species are more elongate and consist of a ring of bone that surrounded the notochord. We interpret this morphology as indicative of a highly flexible vertebral column. Together, these characters suggest a fully aquatic animal that was well adapted to anguilliform swimming. The large head may have been used in combination with powerful body movements for penetrating dense aquatic vegetation, but the limbs were better suited to fine movements and position holding. The phylogenetic placement of the new taxon implies that this general bauplan evolved before the origin of tupilakosaurids; further refinement within the clade included the evolution of a more rigid vertebral column. The PFF dvinosaur is a member of a complex lacustrine ecosystem characterized by several guilds of aquatic secondary consumers, and at least some localities seem to preserve mass death assemblages of the species. The PFF samples a previously unknown biogeographic province in western tropical Gondwana, and other members of the lacustrine community include a new trimerorhachid and the oldest and northernmost occurrence of a rhinesuchid.

Poster Session IV (Saturday, November 8, 2014, 4:15 - 6:15 PM)

THE BROMACKER LOCALITY: THE MOST IMPORTANT PALEONTOLOGICAL SITE OF LOWER PERMIAN TERRESTRIAL VERTEBRATE FOSSILS OUTSIDE OF NORTH AMERICA

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The early Permian Bromacker quarry, located in the middle part of the Upper Rotliegend Tambach Formation near Gotha, central Germany, is a highly prolific site that yields terrestrially adapted invertebrate, vertebrate, and plant fossils. In numbers of individuals, diversity of taxa, and quality of preservation, the vertebrates far surpass those of all other European sites combined of comparable age. Whereas the Bromacker taxa are unique to Europe, they are identical or very closely related to forms known elsewhere almost exclusively from the lower Permian of the U.S. To date, thirteen vertebrates, eight to ten invertebrates, four invertebrate and six vertebrate traces, and three to four plants have been identified. The unique commonality of all vertebrates with those of North America has been relevant in resolving important areas of inquiry: (1) accurately assessing the biostratigraphic position and age of the Tambach Formation and therefore the base of the Rotliegend; (2) providing the first irrefutable, biological evidence of a predrift, continuous landmass of Laurasia during the early Permian; (3) contributing significant, new information about the global distribution patterns of early Permian tetrapods across southern Laurasia; and (4) providing direct evidence that faunal interchange across southern Laurasia of many terrestrial species during this time was not impeded by biological, environmental, and physical barriers. Geological evidence indicates that the Tambach Basin during Tambach Formation deposition represented a 'truly upland' paleoenvironmental setting, which is supported by the Bromacker fossils and sediment marks: (1) first geological evidence of temperatures below zero near the equator (ice marks); (2) lack of any obligatory aquatic or semi-terrestrial forms (fish and most amphibians); (3) the amphibians, which include two to four dissorophoids and *Seymouria*, are widely viewed as highly adapted to an active, terrestrial existence; (4) presence of four taxa of terrestrial herbivores presumably capable of consuming high-fiber vegetation, which doubles that for any assemblage of comparable age; (5) minimal number of individuals counts indicate that the herbivores outnumber the two top predators by a ratio of 7:1; (6) using the same measurement herbivores represent nearly 50% and top predators 7% of the total population; (7) presence of large tetrapod burrows; and (8) presence of the ephemerally-adapted invertebrate Conchostraca.

Poster Session I (Wednesday, November 5, 2014, 4:15 - 6:15 PM)

VERTEBRATE FEEDING TRACE FOSSILS IN THE CEDAR MOUNTAIN FORMATION (LOWER CRETACEOUS), ARCHES NATIONAL PARK, UTAH (USA): BIRD, PTEROSAUR, OR UNKNOWN TRACEMAKER?

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Abundant linear grooves on sandstone bedding planes of the Ruby Ranch Member of the Cedar Mountain Formation (Lower Cretaceous) in Arches National Park (Utah, USA) are interpreted as feeding traces made by a beaked vertebrate, such as a bird or pterosaur. These grooves have regular lengths (15.7 ± 2.0 mm), widths (3.4 ± 0.3 mm), and depths (1.5 ± 0.7 mm; n = 30), indicating a common origin related to the behavior and anatomy of their tracemakers. The trace fossils are either: solitary, bundled together as parallel groups of 4-8 grooves, or form semi-circular to circular patterns of 35-70. Bundles forming arc-like patterns are 13-15 cm wide. Grooves are on the same surface with runzelmarken, invertebrate trails, tridactyl theropod tracks, and a didactyl dromaeosaurid track.

Forms and patterns of these features do not correspond to any known inorganic structures or invertebrate traces, nor traces made by fish. Thus they are considered as trace fossils made by either birds or pterosaurs. Runzelmarken and laminations imply that algal films bound sedimentary surfaces and helped to preserve these trace fossils and their associated theropod tracks. Hence the grooves may have been grazing traces, in which tracemakers gouged just underneath and parallel to algal films by using hard body parts, such as beaks. If so, beaks would have been 3-4 mm wide and groove lengths would have been linked to beak length and neck movement. The diameter of the semi-circular and circular patterns suggests that the tracemakers were relatively small vertebrates. Arc-like patterns of clustered grooves could have been made by the tracemaker standing in one spot or shifting laterally to systematically mine the surface. However, no pes tracks were observed in direct association with these grooves. Hence the traces also may have been formed while the tracemakers floated in shallow water just above sedimentary surfaces.

Poster Session III (Friday, November 7, 2014, 4:15 - 6:15 PM)

BONE MASS AND AIR SPACE PROPORTION OF PTEROSAURS

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High-resolution computed tomography (CT) scanning is becoming more common to visualize fossils in three-dimensions, especially fragile, compressed, or hard to prepare specimens. However, the application of CT approaches to pterosaur fossils has so far been uncommon; work to-date has focused mainly on the cranial and axial skeleton of *Anhanguera* and *Rhamphorhynchus*, gathering qualitative information (for coding and general specimen description) rather than quantitative measurements for biomechanical and flight studies.

Quantitative data from CT scans of pterodactyloid pterosaur wing bones and previously published scans of pterodactyloid axial skeletons and wing bones are reported here to evaluate bone masses and pneumaticity. Bone mass is estimated using the bone volume calculated from the CT scans multiplied by estimated density, while pneumaticity is quantified using air space proportion (ASP) - the ratio of the air space in a bone to the total volume. ASP can be evaluated throughout the bone in order to document any variation or changes within a single bone.

Estimating the masses of large pterosaurs has been widely debated. Bone mass estimates presented here are substantially larger than previous ones, which suggests that contrary to previous proposals, pterosaurs may not share the relationship seen in birds between skeletal mass and total mass. In addition, our estimates for ASP vary within a single bone, being generally higher at the ends of the bone than in the shaft. This observation has major implications for previous pneumaticity estimates based on single cross-sections through bone in archosaurs including birds, sauropods and pterosaurs. Generally these ASP estimates are taken from measurements of broken shafts of long bones, yet the ends actually show higher ASP, which means that pneumaticity may previously have been systematically underestimated. Our measurements of ASP for different sizes of pterosaurs suggests that it increases with size, which may be related to increased bending stiffness in response to the greater flight pressures related to large size.

Poster Session IV (Saturday, November 8, 2014, 4:15 - 6:15 PM)

A NEW BALAENOPTERID (CETACEA, MYSTICETI) FROM THE UPPER MIOCENE EASTOVER FORMATION, VIRGINIA

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A new balaenopterid species is described from the vertebrate paleontology collections of the University of Texas. The new specimen was originally recovered in a salvage project in the state of Virginia by staff at William and Mary College in 1987, and was later moved to Texas with a member of the original project. This whale was discovered in sediments of the Upper Miocene aged Eastover Formation. This formation has historically produced numerous cetacean fossils, though the mysticete (baleen whale) material has been limited by poor preservation and lack of description.

Despite partial crushing and major disarticulation from a backhoe, roughly 90% of the specimen was recovered, including a basicranium, fragments of the rostrum, vertebrae, ribs, and a majority of both flippers and mandibles. One tympanic bulla is still present in situ.

The new specimen is clearly a member of Balaenopteridae, based on possession of balaenopterid characteristics such as a slender, anterolaterally directed zygomatic processes of the squamosal, dorsoventrally flattened supraorbital process of the frontal, shape of cornoid process of the mandible, hatchet-like proximal process of the ulna, and hourglass-shaped phalanges. The specimen represents a distinct species due to the unique combination of morphological characteristics, such as the position of the foramen pseudovale within the squamosal and pterygoid, the exposure of the alisphenoid, and periotic and tympanic bullae features. The interdigitation of the bones of the temporal wall is a distinguishing characteristic among balaenopterids and in this specimen a distinct round exposure of the alisphenoid is present. Also present is a long exposure of the squamosal into the temporal region. Preliminary phylogenetic analysis positions the new fossil taxon within Balaenopteridae, in contentious relation to other extinct members of the clade.

This specimen also represents a young individual due to the spongy and unfused state of the epiphyseal plates of the long bones and vertebrae. Cetacean ontogeny has been an