

NEW CRETACEOUS THEROPOD MATERIAL FROM PATAGONIA

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Associated remains of an amazing theropod have been recovered from the Bajo Barreal Formation (?Cenomanian) of Chubut, Argentina, including much of a large ungual phalanx of digit II of the left pes and an incomplete right metatarsal II. The ungual is similar to that of the enigmatic theropod *Megaraptor* from slightly younger deposits in Neuquén. It is transversely compressed with grooved lateral and medial surfaces, with the medial groove more dorsal than the lateral. The flexor tubercle is dorsoventrally low, and the articular surface is keeled. The metatarsal is distally robust. It is much more massive than metatarsal III of *Megaraptor*, suggesting heavier construction of the pes.

A second, smaller theropod specimen was previously discovered from the Bajo Barreal, consisting of a dorsal vertebra, three caudal centra, a complete rib, a partial metatarsal II, and manual and pedal unguals. The pedal elements have the same basic morphology in both of the Bajo Barreal predators, suggesting that they pertain to the same taxon. The dorsal vertebra shares features with that of *Deinonychus*, such as a high neural arch, widely spaced, suboval articular facets, a low neural spine, a marked hapidocoel, and a short, low-angled centrum with a small pleurocoel. The neural arch has three large and deep caudal pneumatic fossae. However, metatarsal II does not have the distal, deep groove present in dromaeosaurids. The phylogenetic relationships of the Bajo Barreal theropod must thus remain uncertain pending the recovery of additional material.

THE BIOSTRATIGRAPHIC AND TAXONOMIC DISTRIBUTION OF COLORADO MOSASAURS

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Mosasaurs in Colorado date back to 1897, although most material has been recovered in the latter half of the twentieth century. Material is known from the Late Cretaceous (early Campanian-early Maastrichtian) Mancos and Lewis Shales of western Colorado, and the Niobrara Chalk, Pierre Shale, and Fox Hills Sandstone of eastern Colorado, with most specimens coming from the Pierre Shale. The majority of the material has been recovered from eastern Colorado. Remains are known for both irusellosaurine (*Tylosaurus* and *Platecarpus*) and Mosasaurine (*Clidastes* and *Prognathodon*) mosasaurs. *Mosasaurus* was reported in 1917, but its presence cannot be confirmed as the material attributed to the genus is missing.

Tylosaurus proriger is known from the Smoky Hills Member of the Niobrara Chalk and the Pierre Shale. A tylosaurine specimen has recently been recovered 45-60 meters from the top of the Pierre Shale in Trinidad, extending the stratigraphic range of Colorado tylosaurines into the late Campanian. *Platecarpus tympaniticus* is as yet only identified from the Smoky Hills Member of the Niobrara Chalk, *Clidastes propyhton* only from the Sharon Springs Member of the Pierre Shale, *Prognathodon stadmani* from the Mancos Shale "B" Member (*Scaphites hippocrepis* zone), and *Prognathodon ovetoni* from the Hygeine Sandstone Member of the Pierre Shale, Lewis Shale, and Fox Hills Sandstone. Colorado mosasaur material represents some of the most westward ranging of Western Interior Seaway mosasaurs, and may help establish shore-trending biogeographical zones.

TAPHONOMY OF AN ICHTHYOSAUR FROM THE JURASSIC SUNDANCE FORMATION

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In July 1998, we collected an ichthyosaur from the Redwater Shale Member of the Sundance Formation, Natrona County, Wyoming. The remains include an articulated skull and lower jaw, the anterior half (at least) of the vertebral column, the pectoral girdle and numerous ribs. The skull was disconnected from the vertebral column, and rested at a steep angle to it, nearly perpendicular to bedding. The partially articulated pectoral girdle was displaced to the dorsal side of the vertebral column, suggesting that the carcass may have been scavenged. Neither forelimbs nor hindlimbs were found. The surface of some ribs and vertebrae are covered with borings, suggesting that the specimen was exposed on the sea floor for some time before burial. The skull and vertebrae are encased in calcareous concretions, a common mode of preservation in the Redwater Shale. At least two generations of cementation have been identified in the concretions. When preparation is finished, the specimen may prove to be one of the most complete ichthyosaurs known from the Jurassic of North America.

UPPER JURASSIC DINOSAURS OF LOURINHÁ (PORTUGAL)

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The Upper Jurassic dinosaur fauna from Portugal is quite rich and there are two main sites: Lourinhã (70 km North of Lisbon) and Guimarães (near Leiria) both of Kimmeridgian/Tithonian. In Lourinhã the known theropods are *Lourinhanosaurus antunesi* (Allosauroidae), and *Ceratosaurus* sp., while several bones ascribed to *Megalosaurus insignis* (nomen dubium) are *Lourinhanosaurus*. All *Megalosaurus* spp. from Portugal should be regarded as *nomina dubia*. The saurpods *Brachiosaurus atalaiensis* (Brachiosauridae), *Lourinhasaurus alenquerensis* and *Dinheirosaurus lourinhanensis* (Diplodocidae) were described from material of Lourinhã. The presence of *Pelorosaurus*, *Cetiosaurus* and *Pleurocoelus valdensis* can not be recognised in Portugal because it was supported by insuff-

icient material. The ornithischians known are *Dracopelta zbyzsewskii* (Ankylosauridae), *Dacentrurus armatus* (Stegosauridae) and ? *Camptosaurus* sp. However the last genus must be confirmed with more material. Small ornithischians as ? *Hypsilophodon* sp., *Phyllodon* sp. and *Trimucrodon cuneatus* are known by dental material. Eggshells of sauropod(?), and eggs and embryos of basal neotetanurine were found. It is important to clarify that the half of "egg" ascribed to *Dacentrurus armatus* by Lapparent and Zbyzsewski is not an egg but a geological structure. Two small tracks with theropod footprints were found near the shore but one of those big blocks was moved or destroyed by the sea before being removed to a museum.

NEW DINOSAUR BONE BED FROM THE PRINCE CREEK FORMATION, COLVILLE RIVER, NATIONAL PETROLEUM RESERVE-ALASKA

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Work completed in 1998 has defined a new dinosaur bone bed. The site is located on a bluff at the head of a gully along the west bank of the Colville River, 1.7 kilometers north of Kikak Creek and 43 kilometers south of Ocean Point. Fragmentary bone has been collected at the mouth of the gully since 1988. Bone specimens collected in-situ and as float indicate that a least four taxa are present. These include tyrannosaurids, dromaeosaurids, hadrosaurids and the ceratopsian *Pachyrhinosaurus*. This ceratopsian comprises 90% of the material identified to date. The *Pachyrhinosaurus* bone elements are of sub-adult proportions. This may be the earliest record of this taxon in North America.

The bone-bearing bed crops out 2 to 3 meters from the top of the bluff and extends along the bluff rim for 45 meters. Thickness of the bed ranges from 30 centimeters to 1 meter. Bone concentrations vary within this unit. In some parts of the bed, concentrations are greater than 20 bones/square meter (indicating a bone bed), in other parts, less than five. Skeletal elements are contained in a highly indurated matrix with isolated occurrences in less indurated zones. All bones show some degree of pre-burial weathering and desiccation. Weathering features define two classes of bones, those that are highly weathered and those that exhibit only slight pre-burial weathering. Evidence of abrasion is rare. No evidence of trampling has been observed. All large bone elements exhibit permafrost induced fractures. Most bones show evidence of post-burial fractures due to loading and regional tectonic deformation.

A DIVERSE VERTEBRATE ICHNOFAUNA FROM THE LOWER CRETACEOUS (ALBIAN) GATES FORMATION NEAR GRANDE CACHE, ALBERTA

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Since the early 1990's, twelve vertebrate tracksites have been reported in a 25km² area within the Smoky River coal mine near Grande Cache, Alberta. Footprints are uncovered during removal of coal of the Number 4 coal seam within the Grande Cache Member. Most of these tracksites have only one ichnotaxon of footprint present (*Tetrapodosaurus*). However, the W3 tracksite boasts a diverse vertebrate ichnofauna.

The footprints at the W3 site occur on a steep footwall, accessible only with the use of climbing equipment. To date, at least seven vertebrate ichnogenera have been recognized from the W3 footwall. The composition of the vertebrate ichnofauna present on the W3 footwall include the dinosaurian ichnogenera *Tetrapodosaurus*, *Gypsichnites*, *Irenesauripus*, *Ornithomimipus* and *Irenichnites*. Two avian ichnotaxa are also present, one of which is currently being described and which comprises over 60% of the documented ichnofauna. The W3 footwall displays an estimated 6000 footprints and over 100 tracks, most of which are found on three successive bedding planes. During the summer of 1998, 1200 footprints covering just over 500 square meters were mapped and measured.

Some talus blocks with avian footprints (*Aquatilavipes swiboldae*) were collected at the base of the W3 footwall and may well have originated from there. Very small mammal footprints were found in association with the *A. swiboldae* prints and are currently being described. This is the first record of Mesozoic mammal footprints from Alberta and the smallest pre-Tertiary mammal footprints to be discovered.

AN ANALYSIS OF BONE ORIENTATION AT THE CLEVELAND-LLOYD DINOSAUR QUARRY USING VECTOR SUMMATION: A NEW SPIN ON AN OLD TECHNIQUE

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The Cleveland-Lloyd Dinosaur Quarry in Emery County, Utah is one of the most important dinosaur quarries in North America. The quarry contains a diverse, late Jurassic fauna representing 11 dinosaur species. Over 10,000 bones have been excavated and mapped since the quarry was first worked in the late 1920s. Approximately 80% of the identified fossils are from *Allosaurus fragilis*. It has been suggested that the quarry represents a predator trap or bog that existed along lake margins, as evidenced by the dense concentration of bones that are embedded in calcareous claystone and reputedly scattered randomly.

This study examines bone orientation at Cleveland-Lloyd using a quantitative method that is common in geology, vector summation. Vector summation compares the variance of vectors in a uniform circular distribution (i.e., a distribution in which all vectors have equal probability of representation) to the variance observed in the orientation of bones (the measured circular distribution). Vector summation was used to test the hypothesis that the bones at Cleveland-Lloyd are randomly oriented, i.e., the variance of the measured circular distribution does not vary significantly from the variance of a uniform circular distribution. Preliminary results indicate that the bones at the Quarry are in fact non-randomly oriented. A non-random pattern typically indicates the influence of fluvial processes. However, hypothe-