tions, namely the "Basal" Formation, "Lower" Formation and "Upper" Formation. Although these terms are unsuitable for formation names, they were given as the official names by Matsumoto (1939) and have not been revised since then. The "Basal" Formation and the "Upper" Formation are considered non-marine, and the "Lower" Formation is considered brackish and shallow marine deposit. The acanthoceratid ammonite *Eucalycoceras* sp. cf. *E. spathi* is known from the "Lower" Formation, suggesting the middle Cenomanian in age, and it is generally considered that the age of the "Upper" Formation is late Cenomanian to early Turonian.

Several vertebrate sites in the "Upper" Formation yield isolated small bones and teeth and fragments of larger bones. These remains are tentatively identified as the following vertebrate taxa: neopterygian fish, the turtles *Adocus* sp., *Shachemys* sp., *Basilemys* sp., anosteirine, trionychid and *Tienfucheloides* sp. cf. *T. undatus*, neosuchian crocodyliform, azhdarchid pterosaur, and aublysodontine tyrannosaurid, therizinosauroid, velociraptorine dromaeosaurid, ankyrosaurid and hadrosauroid dinosaurs. A fragmentary jaw and teeth of a eutherian mammal have also been found.

This vertebrate fauna is similar to the Bayn Shire and Iren Dabasu faunas of the early Late Cretaceous, and the fauna is clearly different from those of the Early Cretaceous and Campanian-Maastrichtian age. Although early Late Cretaceous vertebrate faunas have been known from Mongolia, China and the Middle Asia, the fact that such vertebrate fossil assemblage was present in Japan suggests that the same fauna had extended to the eastern margin of Asia.

SEQUENCE OF CLOSURE OF NEUROCENTRAL SUTURES IN *CAMARASAURUS* (SAUROPODA) AND IMPLICATIONS FOR PHYLOGENY IN REPTILIA

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A series of *Camarasaurus* (Dinosauria: Sauropoda) specimens in different ontogenetic stages allows determination of the sequence of closure of neurocentral sutures in the vertebral series. Juvenile *Camarasaurus* exhibit highly fused centra and neural arches in the mid- and posterior caudals, no suture lines are seen. However, all presacral, sacral, and anterior caudal (from no.1 to about no.6) vertebrae are unfused, and suture lines between centra and anterior caudal ribs are still seen up to the subadult stage. The time at which the sutures close is likely variable among individuals, but a typical sequence exists: (1st) mid-post caudals, (2nd) anterior caudals of caudal ribs, (3rd) neural arch of anterior caudals, (4th) cervicals (from anterior ones) or sacrum (both neural arch and sacral ribs), and (5th) dorsals. I observed the same pattern in some Archosauromorpha taxa. For example, the order of fusion in mature crocodilians (e.g., *Alligator* and *Crocodilus*) is similar to subadult *Camarasaurus*. The timing of closure is also relatively late in some carnosaurian theropods (e.g., *Coelophysis* and *Godzillasaurus*); on the other hand, the vertebral sutures of extant birds are already closed before hatching. Interestingly, some large-bodied turtles, such as chelids (e.g., *Chelus fimbriatus*) and cheloniids (e.g., *Eretmochelys imbricata*) clearly show visible sutures between the neural arches and centra even in the adult stage; however, juveniles of some small-bodied emydids (e.g., *Terrapene ornata*) have closed sutures. I never saw visible neurocentral sutures in *Sphenodon* or Squamata, even in juveniles of large bodied-taxa (e.g., pythons, komodo monitors, and mosasaurs). These data suggest the pattern and tempo of suture closure are due to phylogenetic position in Reptilia as well as body size, rather than simply the ontogenetic age of individuals.

PRELIMINARY MAGNETOSTRATIGRAPHIC ANAYLSIS OF THE UPPER CRETACEOUS KAIPAROWITS FORMATION, SOUTHERN UTAH

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The Kaiparowits Formation, located within the recently established Grand Staircase-Escalante National Monument of south-central Utah, harbors one of the most important Late Cretaceous vertebrate assemblages in the world; it includes an abundance of turtles, fish, crocodylians, dinosaurs (plus dinosaur egg shell), and mammals. This 850 m thick, structurally uncomplicated unit records relatively continuous deposition of mostly fine-grained fluvially derived sediments along the western margin of the Cretaceous Interior Seaway. Thus, the Kaiparowits Formation is ideally situated, both spatially and temporally, to address questions regarding North American vertebrate biodiversity, Mesozoic mammal biostratigraphy, and latitudinal faunal variations. However, as important as the Kaiparowits Formation is for understanding Late Cretaceous life in North America, its age is known only in a very general sense—a late Campanian age is assumed on the basis of palynomorph and mammalian studies, although conflicting studies suggest the possibility of early Maastrichtian. To refine the age of the Kaiparowits Formation, a pilot magnetostratigraphic study was conducted over ~90 m of this unit. Site mean directions obtained from five class I sites are indicative of normal polarity, whereas 14 additional sites are class III. Although magnetic reversal was not observed over the interval studied, precluding our attempt to temporally refine this portion of the Kaiparowits Formation, the study did result in the determination that 1) rocks of this portion of the Kaiparowits Formation are amenable to paleomagnetic analysis; 2) thermal demagnetization appears to be the most suitable technique; and 3) the normal polarity suggests correlation with chrons C33n, C32r2.1n, or C32n. Given the intentionally preliminary nature of this study, it is hoped that additional upcoming paleomagnetic studies of the Kaiparowits Formation will soon result in a high-resolution temporal framework.

AN ADDITIONAL RECORD OF A POLYCOTYLID PLESIOSAUR FROM THE UPPER CAMPANIAN OF NORTH AMERICA

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A partial polycotylid (Reptilia: Plesiosauria) paddle was discovered as surface float on land administered by the Arkansas Game and Fish Commission, in Hempstead County, Arkansas. The paddle originated from the Marlbrook Marl, ca. 5 to 7 m below contact with the Saratoga Chalk. The Marlbrook Marl is considered Upper Campanian in age based upon ammonite zones in the underlying Annona Chalk and overlying Saratoga Chalk. This specimen and a partial skeleton reported from the Upper Campanian of Saskatchewan represent the two youngest known occurrences of Polycotylidae in North America. Other vertebrate material recovered from this stratigraphic interval includes sharks, bony fishes, turtles, and mosasaurs.

The polycotylid specimen consists of a femur, fibula, centrale, a complete distal tarsal row, two supernumerary ossifications, and numerous phalanges. The femur exhibits four distinct facets on the distal margin, indicating at least two supernumerary ossifications present in the epipodial row. Elements below the epipodial row are extremely foreshortened, more so than in the derived polycotylids *Dolichorhynchops osborni* and *Polycotylus latipinnis*, and much more so than in *Trinacromerum bentonianum*. This condition is remarkable because it expands upon what is known about the progressive foreshortening of polycotylid limb elements through time. This morphological trend can be followed from the earliest known Cenomanian polycotylids, which have comparatively elongate paddle elements, to the culmination of extremely foreshortened elements in this Upper Campanian specimen.

The Arkansas material compares best with the type and referred specimens of *Dolichorhynchops osborni*, both in terms of size and morphology. However, *Dolichorhynchops* is known from the Middle Turonian through the Early Campanian, and thus the youngest known occurrence is ca. ten million years older than the present specimen. The discovery and description of more polycotylid material from the Upper Campanian may reveal that the Arkansas specimen represents an undescribed taxon.

TAPHONOMY OF MARINE VERTEBRATES FROM THE NACO FORMATION (MIDDLE PENNSYLVANIAN), CENTRAL ARIZONA

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A diverse assemblage of chondrichthyan teeth, spines, and dermal denticles is known from the Middle Pennsylvanian (Desmoinesian) Naco Formation in central Arizona, where they occur with an extensive invertebrate fauna of brachiopods, bryozoans, and echinoderms. Study of the vertebrates at one site near Kohls Ranch, Arizona, suggests that these fossils display a taphonomic history independent of the associated invertebrate fauna. The main outcrop consists of four lithologically distinct 1-2 meter thick limestone lenses interbedded with mudstones. Vertebrate material is concentrated within specific bedding planes within only one of these limestone beds. All specimens display rounding and abrasion, and some vertebrates are so highly abraded into "bone pebbles" that their original morphology is completely obliterated. Similar abrasion is not seen in the locality's invertebrate fauna, which includes articulated crinoids, edrioasteroids, and echinoids. Siliciclastic grains that could cause abrasion are extremely rare in the sediments. We hypothesize that most, if not all, of the vertebrate material originated from a near-shore environment where they were abraded by wave action in the sediment. At some point, possibly during a storm surge, these specimens were transported out to more distal marine environments, and deposited in their current location. The taphonomy of this site represents a model for other concentrations of isolated vertebrate elements in marine depositional settings.

ABNORMAL, MULTILAYERED TITANOSAUR (DINOSAURIA: SAUROPODA) EGGS FROM *IN SITU* CLUTCHES AT THE AUCA MAHUEVO LOCALITY, NEUQUEN PROVINCE, ARGENTINA

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All previous reports of abnormal, multilayered Mesozoic eggshells pertain to taxonomically unidentified eggshell fragments or isolated eggs. We report the first systematic study of eggshell abnormalities from *in situ* clutches of a known taxon within Dinosauria, specifically the Titanosauridae. Examination of 393 *in situ* clutches, referable to titanosaur sauropod dinosaurs, from Upper Cretaceous rocks in northwestern Patagonia, Argentina, reveals that six clutches contain both normal and abnormal, multilayered eggs within the same clutch. One complete clutch of 30 eggs contains 27 normal eggs and 3 mutlilayered eggs, distributed in three levels. The three abnormal eggs occupy the highest level within the clutch, are adjacent to one another, and represent the last eggs laid by the female sauropod. All normal eggs within the six clutches exhibit megaloolithid calcite structure, while the multilayered eggs show three distinct types of abnormal morphology. Type I consists of two superimposed eggshell layers of comparable thickness, both with typical megaloolithid eggshell structure. Calcite nucleation sites are present within remnants of permineralized membrane that separates the inner from the outer eggshell layer. Type II morphology displays two superimposed eggshell layers: the inner eggshell exhibits normal structure, while the outer eggshell is thinner, lacks basal nucleation sites, and exhibits unusually large tubercles, compared to normal eggs within the same clutch. In the absence of nucleation sites, the inner eggshell provides a template for the calcite crystalline structure of the overlying abnormal shell, and optical continuity is often apparent between the superimposed layers. Type III morphology consists of three or more superimposed shell layers, with normal calcite structure restricted to the innermost eggshell. The multiple, outer shell layers are laminar and incomplete, often separated by permineralized membrane, or exhibit diminutive surface ornamentation.