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The Beckerdite Local Biota (Early Hemphillian) and the First Tertiary Occurrence of a Crocodilian from Kansas

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The Beckerdite local biota in Clark County, Kansas yields fossil plants, invertebrates, and vertebrates of late Miocene (early Hemphillian) age. The age of the site was determined by biostratigraphy. The genus *Osteoborus* limits the biota to Hemphillian age, and the presence of *Epicyon, Nimravides,* and *Procamelus* indicates that the biota is early Hemphillian because these latter taxa did not survive the mid-Hemphillian extinction event.

Taphonomic evidence suggests that the bones were exposed to weathering from four to 15+ years prior to burial. Selective preservation, favoring robust elements, is indicated. Evidence of water transport and carnivore processing is abundant. Based on studies at other fluvial sites, the time span of bone deposition at the site is from less than one to several thousands of years.

The Beckerdite local biota contains the first reported crocodilians from the Miocene of Kansas. Crocodilians have been reported previously in Oklahoma and Nebraska, so the find in Kansas fills in this taxon's biogeographic range in the Midcontinent during the late Tertiary. Additionally, the presence of crocodilians supports previous interpretations of the climate on the Great Plains during the late Miocene as being warm-temperate to subtropical.

INTRODUCTION

Miocene rocks and sediments of western Kansas have yielded numerous vertebrate fossils. Most localities of Miocene age that have been examined in any detail are located primarily in the northwestern or north-central regions of Kansas (Zakrzewski, 1988). Three Miocene sites are known from southwestern Kansas: the Fullerton Gravel Pit in Morton County, and the Swayze Quarry, and the Beckerdite local biota in Clark County (Fig. 1). The exact location of these sites are on file at the Sternberg Museum of Natural History. The two additional Miocene sites mentioned here are reviewed briefly here.

The Fullerton Gravel Pit is currently under investigation (Liggett and Zakrzewski, 1996). Preliminary identification indicates the presence of *Osteo-*

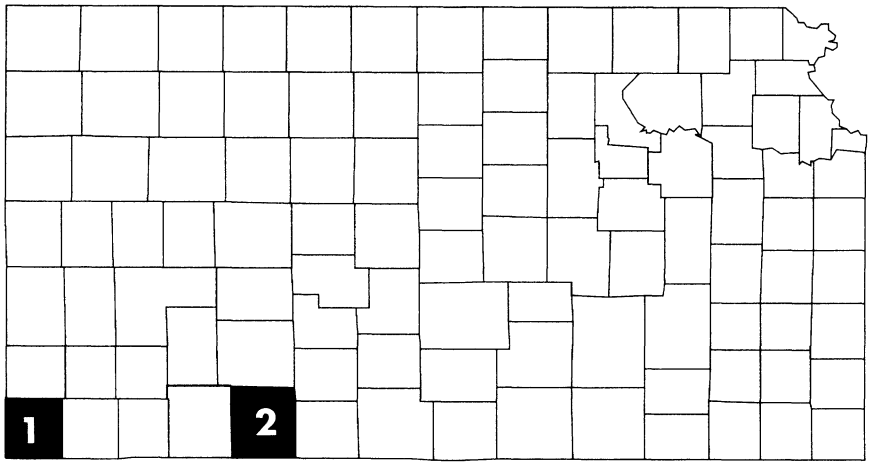

Figure 1. Map of Kansas with the two counties in southwestern part of state containing Miocene faunas highlighted: (1) Morton County, containing Fullerton Gravel Pit and (2) Clark County, containing Beckerdite local biota (l.b.) and Swayze Quarry. Exact locations of sites can be obtained from Sternberg Museum of Natural History.

borus, Protohippus, Megatylopus, and *Hemiauchenia,* and this assemblage suggests an early Hemphillian land mammal age.

George F. Sternberg excavated the Swayze Quarry in the 1930's for Childs Frick of the American Museum of Natural History. This early Hemphillian fauna has a high mammalian diversity, with 13 families being represented (personal correspondence from Richard H. Tedford to Richard J. Zakrzewski dated 18 July 1975). Most of the vertebrate fossils from the quarry are housed at the American Museum of Natural History, but some specimens are in the Sternberg Museum of Natural History. Selected taxa from the Swayze Quarry are reported in the literature (e.g., Hibbard, 1942; Baskin, 1982; MacFadden, 1984), however a complete faunal list has never been published.

The early Hemphillian Beckerdite local biota (l.b.) is significant because the locality preserves both plant and animal remains, the preservation of which allows a more complete paleoecological interpretation. The biota was collected from a poorly sorted, medium-grained, silty sand within the Ogallala Group. The sediments were deposited in a slow moving river (Liggett, 1994). The taxonomic list from the site (Appendix 1) includes algae (charophyte), grasses, hackberry, elm, and borages among the plants; ostracodes and gastropods among the invertebrates; urodelans and anurans among the amphibians; chelonians, lacertilians, and crocodilians among the reptiles; and canids, felids, antilocaprids, camelids, equids, rhinocerotids, gomphotherids, and rodents among the mammals. All specimens referred to in this paper

are from the Sternberg Museum of Natural History (FHSM) vertebrate paleontology (VP) collection.

Biostratigraphy of the Beckerdite L.B.

The inferred age of the fauna is based on the biostratigraphy of the fossil mammals. Material used for comparison is housed in the Sternberg Museum of Natural History, the University of Nebraska State Museum, and the American Museum of Natural History. Vertebrates from the site are represented primarily by postcranial material, some fragmentary, so generic identification was tenuous and specific identification mostly impossible. The genus *Osteoborus* limits the biota to the Hemphillian age, and the presence of *Epicyon, Nimravides,* and *Procamelus* indicates that the biota is most likely early Hemphillian (Fig. 2) because these latter taxa did not survive the mid-Hemphillian extinction event (Breyer, 1981; Webb, 1984; Tedford and others, 1987)

Vertebrate Taphonomy

A number of taphonomic conditions affected the fossils at the Beckerdite site. Many of the vertebrate fossils were weathered significantly before burial, with the majority of specimens assigned to weathering stages 3 to 5 of Behrensmeyer (1978). This degree of weathering is evidenced by sediment-filled cracks, paleoroot traces and cracks that show staining similar to the rest of the bone surface (indicating that the cracks are as old as the bone). Based on her work in Africa, Behrensmeyer (1978) showed that a minimum number of years between death and burial of an individual can be judged by the stage of weathering. In the situation of stages 3 to 5, the bones could have lain on the surface for at least four to 15+ years.

Some of the vertebrate remains show evidence of abrasion and edge rounding which occurred during water transport. Furthermore, bones that typically are transported easily by water or are durable (carpals, metapodials, limb bones, ribs, etc.) are well-represented in the collection. This rounding and winnowing indicates that the bones were transported from the site of death to the site of burial.

There are several juvenile or fetal rhinoceros bones (probably *Teleoceras*) from the site. Many of these bones show evidence of carnivore processing, including gnawed ends and tooth marks (for example VP-12651, VP-12656, and VP-12665).

The four lines of evidence (weathering cracks, selective preservation of robust skeletal elements, water-rounding of bone edges, and carnivore damage) can be used to summarize the taphonomic history of the site. After many of the animals died, their carcasses were processed by carnivores. Those elements without much meat, such as the feet, or which were otherwise robust, remained on the surface, drying and cracking for

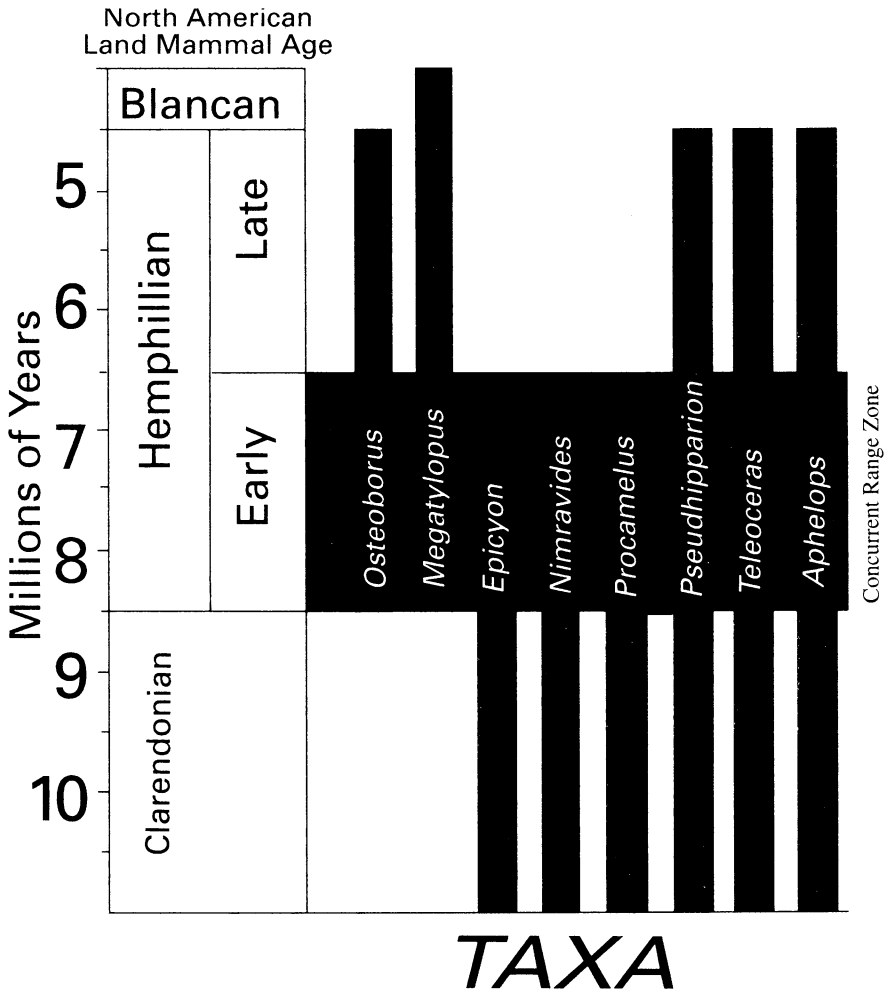

Figure 2. Biostratigraphic distribution of selected taxa from Beckerdite l.b. Taxon range zones obtained from Webb (1984), Tedford and others (1987), and Voorhies (1990).

4–15+ years. At some point, the bones were delivered by fluvial processes to the site of burial and ultimate fossilization. Some elements were transported for some distance, becoming slightly rounded in the process, whereas others (such as the fetal rhino bones) may have a local origin. The duration of the time-averaged sequence is not known; however, Kidwell and Behrensmeyer (1993) estimated that fluvial systems such as this can represent a time span of less than one year to several thousands of years.

Figure 3. Crocodilian dermal scute from Beckerdite l.b. (VP-12693). Bar scale is marked in centimeters.

Crocodilian Material

The recovery of crocodilian remains from the Beckerdite l.b. adds further significance to the site. Several tooth fragments (VP-3191, VP-4721, VP-6586, and VP-6781) are broken apical cusps measuring 9 to 18 mm from base to tip and 5 to 10 mm in diameter at their widest points. In addition, two dermal scutes were collected. One scute (VP-5790) is broken, and measures 30 × 26 mm. The other scute (VP-12693) is complete (Fig. 3), and measures 60 × 56 mm. The surfaces of both scutes show the typical pitted, crocodilian texture. Crocodilian remains are reported from late Tertiary rocks in Oklahoma (Woodburne, 1959) and Nebraska (Voorhies, 1971; Martin, 1984), but the Beckerdite l.b. is the first Tertiary site to yield such fossils from Kansas.

Discussion

Both browsing and grazing animals are present at the site, and the presence of grasses as well as trees like hackberry and elm indicates a mixed plant community. From the late Oligocene through the Miocene, grasslands spread across central North America (Thomasson and Voorhies, 1990). The late Miocene paleoenvironment on the Great Plains has been characterized as an open grassland with occasional patches of trees, and a warm-temperate to subtropical climate with moderate rainfall (Thomasson, 1990; Thomasson

and others, 1990). This warm climate extended at least as far north as southern Saskatchewan (Holman, 1971).

Supporting evidence for this environmental interpretation in Kansas is offered by the crocodilian fossils from the Beckerdite l.b. Crocodilians suggest a warm-temperate to subtropical climate (Woodburne, 1959) based on their Recent subtropical distribution (Bertin and Burton, 1987), and inhabit rivers, lakes, and swamps, having abundant vegetation (Woodburne, 1959). In addition to their climatic implications, the presence of crocodilians in this biota suggests the existence of a stable body of water and the presence of suitable prey animals in the general vicinity. This interpretation is consistent with the depositional environment of the Beckerdite site suggested by sedimentologic and fossil floral evidence.

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APPENDIX

Taxa from the Beckerdite local biota

Floral List

Division Charophyta
  Class Charophyceae
    Order Charales
      Family Characeae
        Chara cf. *C. globularis* Thuill
Division Magnoliophyta
  Class Liliopsida
    Order Cyperales
      Family Gramineae
        Berriochloa minuta Elias
        B. amphoralis Elias
  Class Magnoliopsida
    Order Urticlaes
      Family Ulmaceae
        Celtis sp.
    Order Lamiales
      Family Boraginaceae
        Biorbia fossilia (Berry) Cockerell

Faunal List

Phylum Arthropoda
  Class Ostracoda
    Order Podocopina
      Family Cyprididae
        Potamocypris n. sp.
      Family Candonidae
        Candona cf. *C. lactea* Baird
Phylum Mollusca
  Class Gastropoda
    Order Pulmonata
      Family Zonitidae
        cf. *Hawaiia minuscula* (Binney)
        cf. *Helicodiscus parallelus* (Say)
Phylum Chordata
  Class Amphibia
    Order Urodela
      Family, Genus, et sp. indet.
    Order Anura
      Family, Genus, et sp. indet.
  Class Reptilia
    Order Chelonia
      Family, Genus, et sp. indet.
      Family Testudinidae
        Geochelone sp.
    Order Crocodylia
      Family, Genus, et sp. indet.
    Order Squamata
    Suborder Lacertilia
      Family, Genus, et sp. indet.
  Class Mammalia
    Order Carnivora
      Family Canidae
        Osteoborus sp.
        Epicyon sp.
      Family Felidae
        Nimravides catacopis (Cope)
    Order Artiodactyla
      Family Antilocapridae?
        Genus et sp. indet.
      Family Camelidae
        Megatylopus sp.
        Procamelus sp.
    Order Perissodactyla
      Family Equidae
        Pseudhipparion sp.
      Family Rhinocerotidae
        Teleoceras sp.
        Aphelops sp.
    Order Proboscidea
      Family Gomphotheriidae
        Genus et sp. indet.
    Order Rodentia
      Family, Genus, et sp. indet.