Paleontology of the Medora Public Fossil Dig Site (Paleocene: Sentinel Butte Formation), Billings County, North Dakota

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ABSTRACT

The Medora site is located in highly dissected badland terrain on an isolated knoll about 3 km east of Medora, Billings County, North Dakota. Vertebrate, invertebrate, and trace fossils are entombed in a thin < 5 cm thick black to rust colored carbonaceous (lignitic) mudstone within the Paleocene Sentinel Butte Formation. The bone bed is 6.5 m above the top of a reddish clinker (HT Butte Bed) that marks the contact between the underlying Bullion Creek and Sentinel Butte Formations (Ft. Union Group).

Several thousand fossils of a diverse vertebrate fauna have been recovered through excavation and screen-washing of sediments. This fossil assemblage consists mostly of disarticulated remains, although two partial semi-articulated skeletons of *Champsosaurus gigas* have been recovered. Teeth, vertebrae, limb bones, and scutes of the crocodile *Borealosuchus* are abundant. Fossil size indicates that some of the crocodiles were large, perhaps up to about 4 m in length. Skull parts, teeth, spines, vertebrae, and scales document the presence of several fish taxa including bowfin (*Amia*), gar (*Lepisosteus*), and pike (*Esox*). Freshwater turtles, at least two species of birds, and the giant salamander *Piceoerpeton* were also members of this freshwater community. Teeth and jaws of several species of mammals have also been collected at the site including *Titanoides*, *Neoplagiaulax*, and *Palaeoryctes cruoris*. Collectively these mammals indicate a Tiffanian (Ti_3) lineage zone for the site. Abundant crocodile and fish coprolites are also preserved. Freshwater bivalve and gastropod remains are found with the vertebrate fossils.

The sedimentology of the Medora site indicates initial deposition in a paludal environment that later became a ponded water habitat. Paleobotanical evidence from other nearby sites indicates that the setting was in a subtropical forest. Abundant bones and numerous, large, well preserved coprolites indicate that this was a feeding ground for crocodiles. Numerous depressions in the bone bed, interpreted to be crocodile foot prints, and broken bones in the site indicate that these large animals trampled and bioturbated the swampy area while scavenging for food.

Geology, Stratigraphy, and Depositional Setting of the Medora Site

The Medora site is located in highly dissected badland terrain on an isolated knoll about 3 km east of Medora (fig. 1). The fossils are entombed in a thin, < 5 cm black to rust colored carbonaceous (lignitic) mudstone within the Paleocene Sentinel Butte Formation (fig. 2). This fossiliferous carbonaceous mudstone is overlain by a thinly bedded, gray with rust-colored banding, variegated muddy siltstone that is about 1 m thick. These lithologies indicate initial deposition in a paludal (swampy) environment that later became a ponded water habitat.

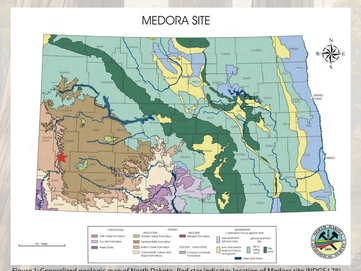

Figure 1: Generalized geologic map of North Dakota. Red star indicates location of Medora site (NDGS L78).

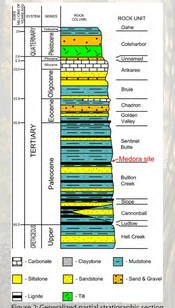

Figure 2: Generalized partial stratigraphic section of North Dakota indicating position of Medora site.

The origin of these sediments was mainly from rivers and streams flowing from the west. The thin organic, lignitic layer, where most of the fossils are entombed, is derived from aquatic plants living in the swampy environment and leaves, branches, etc. from trees and shrubs growing in and adjacent to the swamp. The bone bed is about 6.5 m above the top of a reddish clinker (HT Butte Bed) that marks the contact between the Bullion Creek and Sentinel Butte Formations (Fort Union Group) (fig. 3). Remains of the bear-like animal *Titanoides* along with those of *Neoplagiaulax*, and *Palaeoryctes* suggests a Tiffanian (Ti_3) lineage zone (60-56 million years ago) for this fossil site (Lofgren et al., 2004).

Field and Laboratory Procedures

Because the fossils entombed in the mudstone are fragile and mostly small, delicate tools such as biological probes and small brushes are used to free them from the matrix (fig. 3). Larger and semi-articulated specimens are removed from the site using standard plaster casting techniques. Matrix was bulk sampled, disaggregated, and washed/processed through < 1/16 inch (1 mm) mesh screen to extract microfossils. Fossils are being prepared in the North Dakota Geological Survey, Johnsrud Paleontology Laboratory at the North Dakota Heritage Center in Bismarck and are being cataloged into the North Dakota State Fossil Collection at the Heritage Center.

Figure 3: Photo of the Medora site. Arrow points to the HT Butte Bed (red), marking the contact between the Bullion Creek Fm. (below) and the Sentinel Butte Fm. (above) of the Fort Union Group.

Paleontology

The fossil assemblage recovered so far from the Medora dig site consists of disarticulated remains of a diverse vertebrate fauna, freshwater mollusks, and trace fossils. Fossils of freshwater mussels are abundant at this site and often occur in clusters (fig. 4A), but even though the original shell material of these creatures is preserved, they are difficult to collect because they are so fragile. At least two species of freshwater snails, including *Campeloma*, and a much smaller species are also found at the site (fig. 4B). Some conifer cones have also been identified (fig. 4C). The only semi-articulated specimens found up to now are two partial skeletons of the champsosaur, *Champsosaurus gigas* (figs. 5A-C). Several isolated vertebrae, teeth, ribs, limb bones, and gastralia of this species have also been recovered.

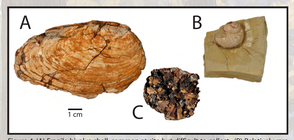

Figure 4: (A) Fragile bivalve shell, common at site but difficult to collect. (B) Relatively rare gastropod shell. (C) Rare, fragile conifer cone.

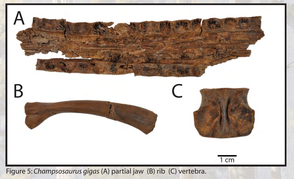

Figure 5: *Champsosaurus gigas* (A) partial jaw (B) rib (C) vertebra.

The largest animals living at the Medora site were crocodiles. Hundreds of crocodile teeth have been recovered as well as vertebrae, limb bones, and scutes. It is likely that the crocodile remains recovered from the Medora site are from *Borealosuchus*, the large, common, crocodile that lived in North Dakota at that time. The largest crocodile teeth we have recovered from the Medora site are 35 mm in length, suggesting that they were massive animals (fig. 6A), probably measuring as much as 4.5 m in length (figs. 6B-C). The crocodiles also deposited coprolites in the pond. Some of these coprolites, as big as Red River Valley potatoes, are another indication that the crocodiles were huge (fig. 7). Fossils, including gar scales and fish bones, are embedded in some of the coprolites.

Figure 6: Crocodylia (A) tooth, 4 cm in length. (B) scute (C) vertebra.

Figure 7: Crocodylia, coprolite, 16 cm in length.

The fish that lived in the Medora swamp included *Amia* (bowfin, Amiidae), *Lepisosteus* (gar, Lepisosteidae), and *Esox* (pike, Esocidae) (figs. 8-9). The remains of mammals, birds, lizards, and the giant, "Hellbender"-sized 1-meter-long salamander, *Piceoerpeton* (fig. 10A), indicate that these animals were also members of the interesting aquatic community at the Medora site. Turtle fossils, including carapace pieces, plastron pieces, limb bones and toe bones, representing at least two species, including *Plastomenus*, have also been recovered from the site (figs. 10B-D). A humerus from a duck-sized bird and fragments of coracoids from an American Robin- to Blue Jay-sized bird have been found (fig. 11). Screen washing has yielded numerous small mammal fossil teeth and jaws. Three jaws have been recovered so far. Small teeth from multituberculates and insectivorous mammal teeth have been identified from the screen-washed matrix (fig. 12). Remains from *Titanoides* and limb bones from a smaller (porcupine- to beaver-sized) mammal (fig. 13) have also been recovered.

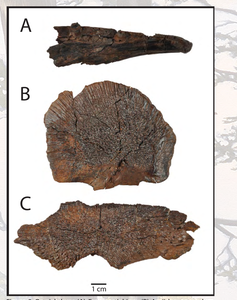

Figure 8: Osteichthyes (A) *Esox*, partial jaw (B) Amiidae, operculum (C) Amiidae, frontal.

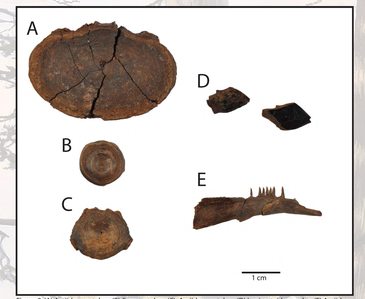

Figure 9: (A) Amiidae, vertebra (B) *Esox*, vertebra (C) Amiidae, vertebra (D) Lepisosteidae, scales (E) Amiidae, left maxilla.

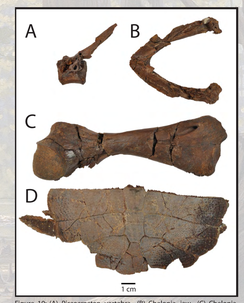

Figure 10: (A) *Piceoerpeton*, vertebra (B) Chelonia, jaw (C) Chelonia, humerus (D) Trionychidae, partial carapace.

Figure 11: (A) Aves, (duck-sized) humerus (B) Aves, (American Robin to Blue Jay - sized) partial coracoid.

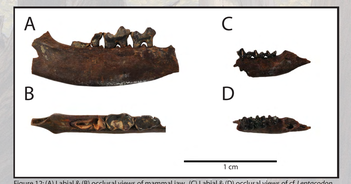

Figure 12: (A) Labial & (B) occlusal views of mammal jaw. (C) Labial & (D) occlusal views of cf. *Leptacodon*.

Figure 13: (A) *Titanoides*?, metapodial? (B) *Titanoides*, phalanx.

Figure 14: Paleocene mural depicting life in western North Dakota. Wall mural displayed at the North Dakota Heritage Center. Painting by Geoff Elson.

Paleoecology

The Medora swamp was a quiet, shallow water ecosystem that was teeming with life (fig. 14). Paleobotanical evidence from other sites of similar age in western North Dakota indicates that the setting was subtropical, hot and humid (Hoganson, 2006). This swamp was probably a temporary backwater of a larger lake, as suggested by the numerous, large predaceous fish *Esox*, *Amia*, and *Lepisosteus*, some of which grew to at least 67 cm in length. These fish, and the soft-shelled turtles, preyed on smaller fish, mollusks, and other small animals inhabiting the swamp. The forest canopy and underbrush around the swamp provided habitats for multituberculates, insectivores, and other mammals. Birds also frequented the swampy area. Other studies have revealed that trees and shrubs growing in western North Dakota at this time included the exotic subtropical trees *Taxodium* (Bald Cypress), *Magnolia*, *Platanus* (Sycamore), *Cercidiphyllum* (Katsura), *Ginkgo*, *Metasequoia* (Dawn Redwood), and palm (Erickson, 1999; Hoganson, 2006; DeVore et al., 2011) (fig. 15).

The Medora swamp was a feeding ground for crocodiles and champsosaurs. This is indicated by the disarticulated skeletons, crushed bone, and abundant crocodile coprolites in the site. The champsosaurs were primarily feeding on fish and the crocodiles were feeding on everything they could catch, probably including mammals that wandered too close to the water. Numerous depressions in the bone bed are interpreted to be crocodile footprints (fig. 16), and broken bones found at the site suggest that these large animals trampled and bioturbated the swampy area while scavenging for food. The Medora swamp would have been a putrid, smelly, disgusting place because of the decaying carcasses, rotting flesh, and abundant feces of the animals that fed on them.

Figure 15: Plantae, bark imprint from a tree branch.

Figure 16: Crocodylia? footprint. Arrows indicating location of claw marks.

References

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