Dinosauria and Fossil Aves Footprints from the Lower Cantwell Formation (latest Cretaceous), Denali National Park and Preserve

by Anthony R. Fiorillo, Paul J. McCarthy, Brent H. Breithaupt, and Phil F. Brease

Abstract

The Cantwell Formation (Late Cretaceous to Early Tertiary) is a thick rock unit that crops out in much of the central part of Denali National Park and Preserve (Denali). The lower part of this succession is dominantly comprised of fine-grained channel and floodplain sedimentary facies, including crevasse splay, crevasse delta, levee, and minor lacustrine and palustrine components. Floodplain deposits contain abundant evidence of weak pedogenesis, including root traces, blocky structure, iron oxide mottles and nodules, suggesting widespread poorly drained conditions in a highly aggradational setting. The upper Cantwell succession is largely volcanic. The lower Cantwell Formation correlates in age with the famous dinosaur-bearing rocks of the Prince Creek Formation of the North Slope of Alaska, as well as the dinosaur-bearing Chignik Formation of Aniakchak National Park in southwestern Alaska.

Several new Mesozoic-aged vertebrate fossil sites have been discovered in Denali. These sites are located in the Igloo Creek/Tattler Creek area and the northern side of Double Mountain. Some sites contain individual tracks while other localities contain hundreds of tracks. The most frequent footprint type found among all sites is the track of a medium-sized theropod. The tracks attributable to this animal measure 8-10 inches (20-25 cm) in length. Additional theropod tracks range from small tracks (4-5.5 in/10-14 cm in length) to very large tracks (over 20 in/50 cm in length). In addition to the more common theropod tracks, there are two sites that contain tracks attributable to hadrosaurs.

An exceptional site contains several hundred tracks attributable to a medium-sized wading bird. The morphology of the tracks indicates the substrate was still very wet when these birds walked on the surface. Nearly circular depressions attributable to probe-style feeding by these ancient shorebirds are also preserved at this site. These footprints demonstrate that the Cantwell Formation has great potential as a fossil vertebrate-bearing rock unit. Further, the assembling of Beringia through accretion began in the Cretaceous and these discoveries highlight the biological diversity of Beringia.

Introduction

A paleontological investigation of the Cantwell Formation (Late Cretaceous to Early Tertiary) in Denali National Park and Preserve has been initiated by the National Park Service. This thick rock unit crops out in much of the central part of Denali and is particularly visible along much of the eastern length of the park road. Here we summarize the preliminary paleontological and sedimentological results of this survey and briefly describe the first records of Mesozoic-aged fossil vertebrates from this rock unit.

Geologic Background

The Cantwell Formation is thousands of meters thick and is comprised of an upper, dominantly volcanic unit and a lower, dominantly fluvial sedimentary unit *(Kirschner 1994, Ridgway et al. 1997)*. Pollen analysis for the lower Cantwell Formation shows that these sedimentary rocks were deposited during the late Cretaceous (late Campanian or early Maastrichtian) *(Ridgway et al. 1997)*. Sedimentation was dominated by alluvial fan, braided stream and lacustrine settings *(Ridgway et al. 1997)*. Given that the southern margin of Alaska was near its current latitude during the Cretaceous *(Hillhouse and Coe 1994)*, the basin in which the Cantwell Formation was deposited was near its present latitude at the time of deposition as well.

The lower part of the Cantwell Formation is dominantly comprised of fine-grained channel and floodplain sedimentary facies. Floodplain deposits contain abundant evidence of weakly developed fossil soils (paleosols), including root traces, blocky structures, iron oxide mottles and nodules, suggesting widespread poorly drained conditions in a highly aggradational setting. Periodic larger floods deposited thin beds of coarse-grained conglomerate onto these fine-grained floodplains *(Ridgway et al. 1997)*. The lower Cantwell Formation correlates in age with the well known dinosaur-bearing rocks of the Prince Creek

Photo by Anthony R. Fiorillo

Figure 1. Right pes, or hind foot, impression of a medium sized theropod track from outcrop of the lower Cantwell Formation along Igloo Creek, Denali National Park.

Formation of the North Slope of Alaska, as well as the dinosaur-bearing Chignik Formation of Aniakchak National Park in southwestern Alaska.

There are two areas of interest in this report, the Tattler Creek/Igloo Creek area and the northern flank of Double Mountain. The Cantwell Formation in the Igloo Creek/Tattler Creek area can be characterized as consisting largely of sandstones and siltstones. There is a coarsening upward trend in this area that is likely evidence of a major river channel moving closer to the site. In addition there is evidence of regular sedimentation on floodplains punctuated by hiatuses with brief periods of soil formation. The Cantwell Formation along the northern flanks of Double Mountain has a thick sequence of finer grained sediments than those found in the Igloo Creek/Tattler Creek area. Ridgway et al. *(1997)* attribute these finer grained rocks to a marine influenced coastal lowland environment.

Footprint Discussion

As part of an ongoing paleontological survey of the Cantwell Formation, several Mesozoic aged vertebrate fossil sites have been discovered in Denali *(Fiorillo et al. 2006)*. Thus far the survey has discovered 20 fossil footprint localities. These sites are located in the Igloo Creek/Tattler Creek area and on the northside of Double Mountain. Some sites contain individual tracks while other localities contain hundreds of tracks. The most frequent footprint type found among all sites is the tracks of a medium-sized theropod *(Figure 1)*. The tracks attributable to this animal measure approximately 8-10 inches (20-25) cm in length. This length provides an estimated hip height of approximately 35 inches (90 cm) and a body length of approximately 10 feet (3 m) *(sensu Thulborn 1989)*. Additional theropod tracks range from small tracks (4-5.5 in/10-14 cm in length) to very large tracks (over 20 in/50 cm in length). In addition to the more common theropod tracks, there are two sites that contain tracks attributable to hadrosaurs.

The second area of study, on the north side of Double Mountain, has, in addition to the tracks of the medium-sized theropod, produced hundreds of tracks attributable to medium-sized wading birds, approximately the size of a modern Willet or American Avocet. The morphology of these fossil tracks shows a thin, web-like connection between the toes that starts at the base of the tracks and extends approximately a third to halfway towards the ends of the toes. Whereas it might appear that these features represent webbing between the toes of these Cretaceous birds, these types of marks in modern shorebirds is indicative of a substrate that is relatively deep mud *(Elbroch and Marks 2001),* hence these Cretaceous birds likely walked on a similar surface. There are also numerous small, nearly circular depressions, approximately 0.12 in (3 mm) in diameter, on the same bedding plane. These features are likely the feeding traces of these shore birds. Bill lengths of modern shorebirds vary in order to exploit various depths in the mud and sand for different food items such as worms, bivalves, and crustaceans *(Gill 1989),* but diet can include items other than invertebrates. The sanderling (*Calidris alba*), for example, consumes seeds, plant buds, algae and mosses in addition to invertebrates *(Richards 1988)*. Though there is evidence of invertebrate

bioturbation in the finely laminated sediments containing these bird tracks at Double Mountain, more precise determination of potential food items for these Cretaceous birds is unavailable at this time.

Summary

Denali National Park and Preserve is an exciting, rich, new area for dinosaur studies. The Cantwell Formation within the park contains the first record of dinosaurs in the Alaska Range. This record consists of tracks of small, medium, large, and very large-sized theropods, as well as hadrosaurs. In addition, the Cantwell Formation contains the first record of fossil Aves. Further, this occurrence of fossil birds records feeding behavior in these presumed ancient shorebirds. Combined this new suite of Mesozoic fossil vertebrate sites add to the understanding of biodiversity in Alaska during the Cretaceous at the beginning of the land bridge referred to as Beringia *(Hopkins 1967, Fiorillo in press)* because the Cantwell Formation correlates with other rock units in Alaska that produce dinosaur remains such as the Prince Creek Formation of northern Alaska *(Parrish et al. 1987; Fiorillo and Gangloff 2000, 2001; Gangloff et al. 2005)* and the Chignik Formation of southwestern Alaska *(Fiorillo and Parrish 2004)*. Thus, further work will provide the opportunity for a more detailed regional paleoecological and paleoenvironmental understanding of an ancient high latitude terrestrial ecosystem on a greenhouse Earth.

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References

Elbroch, M., and E. Marks. 2001.
Bird Tracks and Sign.
Stackpole Books. Mechanicsburg.

Fiorillo, A.R. in press.
Cretaceous dinosaurs of Alaska: Implications for the origins of Beringia. In *The Terrane Puzzle: new perspectives on paleontology and stratigraphy from the North American Cordillera*
edited by R.B. Blodgett and G. Stanley.
Geological Society of America. Special Paper.
Boulder, Colorado.

Fiorillo, A.R., B. Breithaupt, and P.J. McCarthy. 2006.
Dinosauria and Aves fossil footprints from the lower Cantwell Formation (Upper Cretaceous), Denali National Park, Alaska.
Journal of Vertebrate Paleontology,
Supplement 65:61A.

Fiorillo, A.R., and R.A. Gangloff. 2000.
Theropod teeth from the Prince Creek Formation (Cretaceous) of northern Alaska, with speculations on arctic dinosaur paleoecology.
Journal of Vertebrate Paleontology 20:675-682.

Fiorillo, A.R., and R.A. Gangloff. 2001.
The caribou migration model for Arctic hadrosaurs (Ornithischia: Dinosauria): a reassessment.
Historical Biology 15:323-334.

Fiorillo, A.R., and J.T. Parrish. 2004.
The first record of a Cretaceous dinosaur from western Alaska.
Cretaceous Research 25:453-458.

Gangloff, R.A., A.R. Fiorillo, and D.W. Norton. 2005.
The first pachycephalosaurine (Dinosauria) from the paleo-arctic of Alaska and its paleogeographic implications.
Journal of Paleontology 79:997-1001.

Gill, F.B. 1989.
Ornithology.
W.H. Freeman. New York.

Hillhouse, J.W., and R.S. Coe. 1994.
Paleomagnetic data from Alaska.
In *Geology of Alaska, The Geology of North America,* v. G-1, edited by G. Plafker and H.C. Berg.
Geological Society of America. Boulder, Colorado.
Pp. 797-812.

Hopkins, D.M. (ed.). 1967.
The Bering Land Bridge.
Stanford. Stanford University Press. P. 495.

Kirschner, C.E. 1994.
Interior basins of Alaska. In *Geology of Alaska, The Geology of North America,* v. G-1,
edited by G. Plafker and H.C. Berg.
Geological Society of America. Boulder, Colorado.
Pp. 469-493.

Parrish, M.J., J.T. Parrish, J.H. Hutchinson, and R.A. Spicer. 1987.
Late Cretaceous vertebrate fossils from the North Slope of Alaska and implications for dinosaur ecology.
Palaios 2:377-389.

Richards, A. 1988.
Shorebirds: a complete guide to their behavior and migrations.
Gallery Books. New York.

Ridgway, K.D., J.M. Trop, and A.R. Sweet. 1997.
Thrust-top basin formation along a suture zone, Cantwell basin, Alaska Range: implications for the development of the Denali fault system.
Geological Society of American Bulletin 109:505-523.

Thulborn, R.A. 1989.
The gaits of dinosaurs. In *Dinosaur Tracks and Traces*
edited by D.D. Gillette and M.G. Lockley.
Cambridge University Press. Cambridge. Pp. 39-50.