CONTINENTAL VERTEBRATES FROM THE LATE CRETACEOUS OF THE NORTH SLOPE, ALASKA

William A. Clemens, Museum of Paleontology, University of California, Berkeley, California 94720, USA

ABSTRACT

Discovery of fossil vertebrates and plants on the Alaskan North Slope provides a significant opportunity to analyze the composition and adaptations of a terrestrial biota to the demands of a Late Cretaceous, high-latitude environment. Currently, the largest collections of Alaskan Late Cretaceous (possibly early Maastrichtian) vertebrates are from strata of the Kogosukruk Tongue, Prince Creek Formation, exposed along the Colville River at about 70° N. latitude. This fauna lived at approximately 85° N. paleolatitude. Paleobotanical data suggest the climate at that time was cold temperate with probably relatively brief periods of winter freezing.

In addition to dinosaurs, this early Maastrichtian fauna includes several species of fish and at least four species of mammals. Even though several localities with different taphonomic histories have been sampled, no traces have been found of amphibians or nondinosaurian reptiles, which are abundantly represented in contemporaneous faunas in areas to the south. Almost all the lineages of Alaskan Maastrichtian terrestrial vertebrates identified so far became extinct at the end of the Cretaceous. Their adaptations to cold environments and long periods of darkness were not advantageous in surviving the environmental changes associated with the Cretaceous-Tertiary transition.

INTRODUCTION

Discoveries in both the Northern and Southern Hemispheres document the presence of dinosaurs and other terrestrial vertebrates at high paleolatitudes during the Jurassic and Cretaceous. A few years ago, knowledge of southern high-paleolatitude faunas was greatly expanded by discoveries of Early Cretaceous dinosaurs and other vertebrates in southeastern Australia (Rich and Rich, 1989). Until recently, only a few fragments of bones, footprints, and skin impressions documented the existence of dinosaurs at comparably high northern paleolatitudes (Russell, 1984). Knowledge of these northern high-paleolatitude faunas continues to increase as the result of a series of investigations of sites in Alaska, particularly fossiliferous deposits on the North Slope. Gangloff (this volume) summarizes the record of Mesozoic terrestrial vertebrates from Alaska. The collections from the Kogosukruk Tongue, Prince Creek Formation, currently provide the largest available sample of Mesozoic terrestrial life at northern high paleolatitudes.

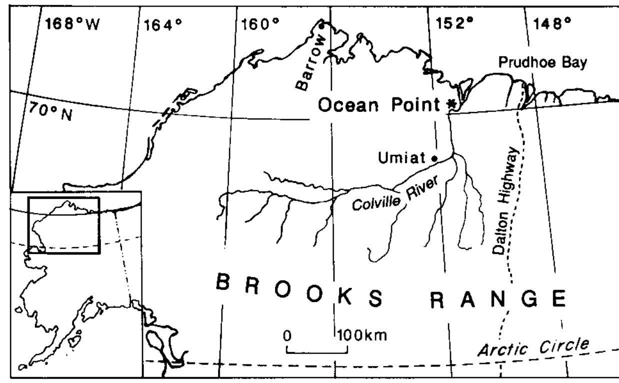

Fig.1. Location of study area (asterisk on main map). Alaskan North Slope includes northern slopes of Brooks Range and coastal plain of Arctic Ocean. Precise locality data are on file at the University of Alaska Museum, Fairbanks, and the Museum of Paleontology, University of California, Berkeley. (Reprinted from Clemens and Nelms, 1993.)

HISTORY OF RESEARCH

In 1961, the late Robert L. Liscomb, a geologist then working for Shell Oil Company, discovered dinosaurian bones weathering out of Cretaceous strata upstream from Ocean Point on the Colville River (Fig.1). Unfortunately, the following year he was killed in a rock slide while studying the Quaternary sediments on Middleton Island in the Gulf of Alaska. His field notes and collection of fossil vertebrates were maintained in the Shell Oil Company's archives, but their significance was not immediately appreciated.

Over two decades later, in 1984, H. W. Roehler and G. D. Stricker announced their discovery of evidence --footprints and skin impressions--of the presence of dinosaurs in Alaska during the Cretaceous.

In 1983, Richard V. Emmons of Shell Oil Company reviewed their company's paleontological collections from the lower part of the Colville River. He sent Liscomb's collection of vertebrate fossils to C. A. Repenning of the U.S. Geological Survey. Repenning recognized the fossils were the remains of dinosaurs and forwarded them to a leading expert on Mesozoic faunas, Wann Langston, Jr., of the University of Texas. This material was described and analyzed by K. L. Davies (1987).

The next summer, 1984, two U.S. Geological Survey field parties (led by Elizabeth Brouwers and David Carter) located the area where Liscomb had made his discoveries and collected small samples of dinosaurian bones. Recognizing the scientific significance of these discoveries, George Gryc of the U.S. Geological Survey facilitated the organization and funding of a field party consisting of paleontologists and geologists from the University of Alaska and the University of California, Berkeley. In 1985, exploratory excavations were made in what is now termed the Liscomb bone bed (Clemens and Allison, 1985). Prospecting nearby outcrops of the Prince Creek Formation resulted in discovery of vertebrate fossils, including bones, teeth, and skin impressions, at three additional stratigraphic levels.

Field research was continued in 1987 when a series of quarries was excavated along the exposure of the Liscomb bone bed. Emphasis was placed on assessing the taxonomic diversity of the bone bed. Prospecting in the immediate area, Howard Hutchison discovered a fragmentary but articulated hip region of *Edmontosaurus*. This specimen, along with a string of three articulated caudal vertebrae and part of a second hip region found in the jumble of bone preserved in the Liscomb bone bed, are the only clearly articulated segments of dinosaurian skeletons yet discovered in the area (L.G. Nelms and R. Gangloff, pers. commun., 1993).

In the same year, Parrish et al. (1987) reported the discovery of a few, fragmentary Cretaceous vertebrate fossils along the Colville River. Most of their localities are well upstream and stratigraphically lower than the beds exposed in the vicinity of the Liscomb bone bed.

At the beginning of the 1988 field season, Andrea Krumhardt, Howard Hutchison, and Mark Goodwin spent 10 days floating the river from Umiat to Ocean Point. Through most of their trip, no complete vertebrate fossils were found in place in the river banks. Approximately 5 miles south (upstream) from the exposures of the Liscomb bone bed, they discovered a series of channel fillings containing fragments of bone. Large samples of these lag deposits were collected.

In early August 1988, the other members of the field party reached the Ocean Point area and continued work on the Liscomb bone bed. In addition to significantly increasing the collection of dinosaurian remains, L. Gayle Nelms began collecting detailed data for a taphonomic analysis of the Liscomb bone bed. About 1 mile upstream, Howard Hutchison discovered a skull of the ceratopsian dinosaur, *Pachyrhinosaurus*, at a stratigraphic level that had not previously yielded vertebrate fossils. Through the following winter and spring, the samples of the channel fillings were screen washed and the coarser fractions concentrated. These concentrates yielded remains of teleost fish, teeth of hatchling dinosaurs, and teeth of mammals.

In the 1989 season, the field party divided its efforts between collecting more samples of the lag deposits at the microvertebrate site and working at the Liscomb bone bed. The excavations of the bone bed were particularly designed to collect taphonomic data.

Field research along the Colville River in the summers of 1987, 1988, and 1989 was underwritten by a grant from the Division of Polar Projects, National Science Foundation, and support from the University of Alaska Museum and Museum of Paleontology, University of California, Berkeley.

During the summer of 1990, a small field party led by L. Gayle Nelms and supported by a grant from British Petroleum to the University of Alaska Museum returned to the Colville River. The field party completed collection of data for Nelms' taphonomic study of the Liscomb bone bed.

Starting in the summer of 1991, field work in the area has been continued by groups directed by Roland Gangloff and sponsored by the University of Alaska Museum with an Eisenhower Mathematics and Science Grant administered by the State of Alaska, Department of Education.

Concurrently, during the late 1980's, field parties from the U.S. Geological Survey continued their research projects in the Ocean Point area. These included detailed stratigraphic and sedimentological analyses of the Prince Creek Formation and studies of its invertebrate paleontological and paleobotanical records. A preliminary summary of these studies was presented by Brouwers et al. (1987).

GEOLOGICAL AND PALEOENVIRONMENTAL CONTEXTS

On the Alaskan North Slope, outcrops of a thick accumulation of Cretaceous nonmarine and marine strata occur along the valley of the Colville River (Phillips, 1990). The fossil localities discussed here are in nonmarine sediments of the Kogosukruk Tongue, Prince Creek Formation, exposed in the banks of the Colville River at about 70° N. latitude (Fig.1). Most of the dinosaurian remains collected were derived from the Liscomb bone bed, but additional material was found at other stratigraphic levels in overbank, pond, and channel filling deposits. More than 4,000 identifiable vertebrate fossils have been recovered and appear to document a single fauna.

Frederiksen's (1991) analyses of the palynological record of sections including many of the vertebrate fossil localities indicated a Maastrichtian, probably early Maastrichtian, age. Radiometric age determinations reported by Conrad et al. (1990) of ~69 Ma support this interpretation. (J.D. Obradovich [pers. commun., 1993] analyzed rare crystals of sanidine from one of the volcanic units studied by Conrad et al. [1990] and obtained an older age determination, 72.9 Ma. Depending upon the definition of the Maastrichtian/ Campanian boundary adopted, this age determination suggests correlation with the early Maastrichtian if not the late Campanian.) The fauna vertebrate shows similarities to the characterizing assemblages of the

Lancian and Edmontonian ages recognized in Alberta, but not enough evidence is available to make a more precise correlation.

The vertebrate fauna lived at about 85° N. paleolatitude (Spicer and Parrish, 1990). The environment of the area was characterized by long periods (>3 months) of winter dusk and darkness. At this time, the North Slope was within the range of the northern polar broad-leaved deciduous flora (Spicer, 1989). Trees were limited to local high grounds and more elevated areas; the dominant ground cover was low herbaceous plants and bushes. Mean annual temperature was in the range of 2-8 °C (Spicer and Corfield, 1992).

VERTEBRATE FAUNA

The hadrosaurian *Edmontosaurus* sp. is the most abundantly represented dinosaur. Significantly, elements of the skeletons of adults are rare; most of the bones are from juveniles and young adults. *Pachyrhinosaurus* sp., a ceratopsian, is known from a single skull. Isolated teeth and other skeletal elements document the presence of *Troodon*, a tyrannosaurid, and a dromaeosaurid (R. Gangloff, pers. commun., 1993). Minute, isolated teeth of hatchling hadrosaurians, hypsilophodonts, and dromaeosaurids have been found in the channel lag deposits.

The most common mammal is a marsupial, probably a pediomyid. *Cimolodon* cf. *C. nitidus* and an as yet unidentified genus represent the Multituberculata. Finally, a few teeth are from a eutherian, *Gypsonictops* sp. Isolated teeth and/or fragmentary bones document the presence of sharks, a sturgeonlike fish, and one or more kinds of teleost fishes.

Comparison of this fauna with approximately contemporaneous faunas to the south reveals some marked differences. Common elements of these southern faunas that are not represented in the fauna from the North Slope include the gar, *Lepisosteus*; amphibians; and nondinosaurian reptiles, for example, turtles, crocodilians, and champsosaurs (Archibald and Bryant, 1990). Their absence does not appear to be a result of taphonomic biases. Probably these aquatic and terrestrial vertebrates were not members of the latest Cretaceous fauna of the North Slope or were present in much lower abundances than in faunas to the south in middle paleolatitudes (Clemens and Nelms, 1993).

DISCUSSION

As currently known, the probably early Maastrichtian terrestrial vertebrate fauna of the North Slope consists of a limited assemblage of taxa that are the same as or closely related to species found in approximately contemporaneous faunas to the south. Providing we are not being misled by taphonomic biases, the available sample indicates that some dinosaurs and mammals were able to inhabit areas inhospitable for amphibians and nondinosaurian reptiles.

Recent research suggests that, metabolically, at least some nonavian dinosaurs were unlike modern reptiles and possibly were endothermic. Data from histological analyses of bones of *Edmontosaurus* from Alaska by L.G. Nelms and the great abundance of young individuals in the samples from the North Slope support this interpretation. They suggest that at least some of the dinosaurs remained at high paleolatitudes throughout the year (Clemens and Nelms, 1993). The small size of the contemporaneous mammals, which might well have been endothermic, indicates that they, too, were year-round residents.

Short-term periods of catastrophic cold and darkness at the Cretaceous-Tertiary (K-T) boundary produced by the impact of a bolide and/or volcanism have been suggested by some workers as the primary causes of the extinction of dinosaurs, other than birds. This hypothesis leads to the prediction that Cretaceous animals adapted to cold and darkness would tend to survive such an environmental disruption but those not adapted to such rigorous environmental regimes would suffer higher levels of extinction.

Assuming the rigors of a cold climate and winter darkness excluded ectothermic amphibians and nondinosaurian reptiles from the North Slope in the Maastrichtian, it follows that the taxa of dinosaurs and mammals composing this fauna were better adapted to these climatic extremes. In spite of these adaptations, all lineages of Maastrichtian dinosaurs and mammals known from the Alaskan North Slope became extinct at the close of the Cretaceous.

Many lineages of dinosaurs and mammals, as well as ectothermic amphibians and nondinosaurian reptiles, were present in approximately contemporaneous, North American, middle-paleolatitude faunas. Here, nonavian dinosaurs and some lineages of mammals became extinct by the end of the Cretaceous. In contrast, ectothermic amphibians and nondinosaurian reptiles had a relatively high rate of survival into the Tertiary (Archibald and Bryant, 1990). This pattern of survival and extinction strongly argues against hypotheses invoking the effects of short-term, catastrophic, periods of extreme cold and darkness as causes of extinctions of nonavian dinosaurs and other organisms, extinctions employed to mark the end of the Cretaceous.

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