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Comments on Dinosaurian Preservation in the Cretaceous of Alberta and Wyoming

by Charles M. Sternberg

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Résumé

Puisant dans son fabuleux bagage de connaissances sur les dinosaures du Crétacé supérieur, l'auteur présente ici des notes précieuses sur la conservation des hadrosaures, des cératopsidés et des stégocéras. Des observations méticuleuses *in situ* fournissent des renseignements nombreux sur l'apparence et les caractéristiques des animaux et de leur milieu.

Summary

The author draws upon his great fund of knowledge about dinosaurs of the Upper Cretaceous to present here some notes on the preservation of hadrosaurs, ceratopsians, and dome-headed dinosaurs. Careful observation of remains *in situ* provides considerable information on the appearance and characteristics of both the animal and its environment.

Biographical Note

In more than 60 years of fieldwork, Charles M. Sternberg has collected more dinosaurs than any other living man. Born and raised in Kansas, he began collecting specimens in the United States with his father, then moved to Canada in 1912 to join the staff of the National Museums. Since then he has collected on sites ranging from Nova Scotia to British Columbia; he is primarily known, however, for his fieldwork in Alberta and Saskatchewan. Recognition of his work has included an honorary LL.D. from the University of Alberta and fellowship in the Royal Society of Canada. Since his retirement from the Museums in 1951, Dr. Sternberg has resided in Ottawa.

Introduction

Over the course of the last 100 years many complete or nearly complete naturally articulated skeletons and great numbers of disarticulated bones of dinosaurs have been found. An observant collector of dinosaur remains learns much about these animals and about the environment in which they lived. Many years of collecting dinosaurs from the Upper Cretaceous beds of Alberta and from the Lance Formation of Wyoming have enabled me to make certain observations that may be of interest to others.

Plate 1

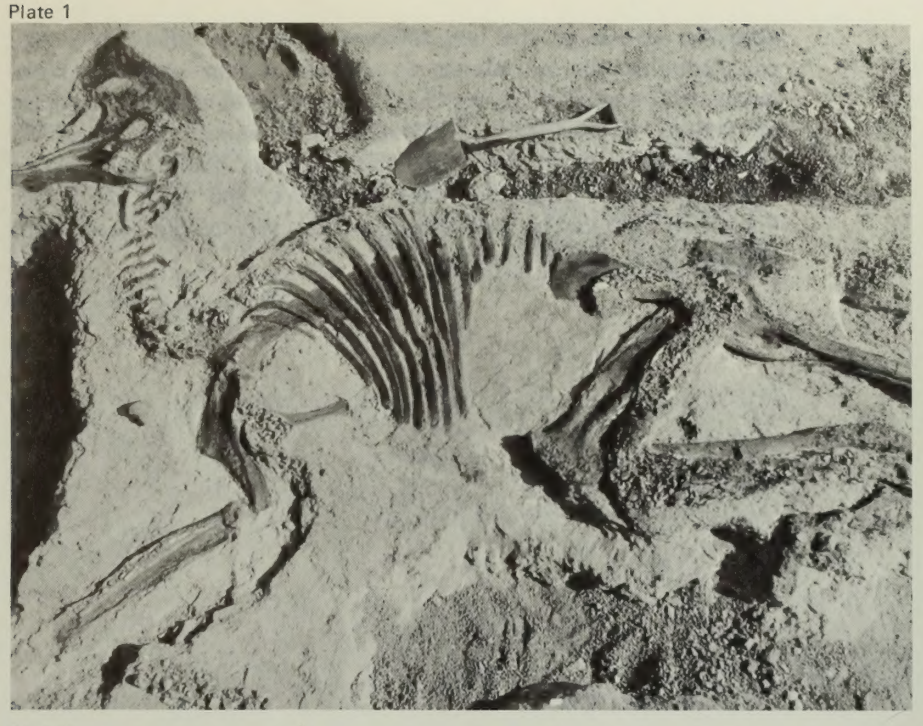

Plate 2

Plate 1

Naturally articulated skeleton of duck-billed dinosaur (*Lambeosaurus*) *in situ*, Oldman Formation, east of Manyberries, Alta.

Plate 2

Naturally articulated skeleton of duck-billed dinosaur *(Lambeosaurus) in situ*, Oldman Formation, Sand Creek area, Dinosaur Provincial Park, Alta.

During Upper Cretaceous times conditions were favourable for the preservation of dinosaurian remains in deposits now referred to as the Oldman and Edmonton Formations, which are well exposed along the Red Deer River in Alberta. Throughout the millions of years that these deltaic and fluvial sediments were accumulating along the western edge of the Upper Cretaceous sea, a great variety of dinosaurs and other animals inhabited the area. The presence of plesiosaur bones throughout both formations and of beds containing brackish-water invertebrates in the Edmonton Formation shows that the area was close to sea level. It would appear that the land was settling at about the same rate as the sediment was building up. During one period, however, the land must have settled faster, because the marine strata of the Bearpaw Formation separate continental deposits of the Oldman and Edmonton Formations.

Duck-billed dinosaurs, or hadrosaurs, were probably the most numerous of the dinosaurs inhabiting this region and, as they lived in the shallow water of the deltas, their remains had a much greater chance of being properly buried and preserved than did those of dinosaurian forms that lived on dry land. This probably explains the great preponderance of well-preserved hadrosaur remains collected from the Oldman and Edmonton Formations. It seems that many animals were buried soon after death and before the natural relationships of the bones had been altered.

Articulated skeletons often lack the head, the neck, and the forelimbs. I believe that these animals died in the water and, when gases were generated in the body cavity, the carcass floated for some time. Head, neck, and forelimbs dropped off before the rest of the carcass settled to the bottom. Ossified tendons and powerful ligaments held the remainder of the skeleton together. The carcasses of other individuals settled to the bottom soon after death and were completely covered by sediments before any part was badly disturbed. As most of these skeletons were buried on their sides, much information can be gained about the normal articulation and the range of movement of the vertebral column, the skull, and the limbs. In hadrosaurs the vertebral column, from near the middle of the back to well beyond the middle of the tail, was strengthened by two or three sets of ossified tendons on either side of the neural spines. The tops of the spines form a straight line from beyond the pelvis to about the middle of the back. At this point the column turns downward toward the base of the neck, thus lowering the forepart of the body so that the short forelimbs reach the ground. The neck turns sharply upward from its base, and the skull attaches at about a right angle to the upturned neck. Evidence that this is the true position of the head is convincing: the occipital condyle is fixed, and the articulating surface points downward. All undisturbed skeletons lying on their sides show the neck and skull in this position (*see* Plate 1).

Several hadrosaur skeletons have been found lying on their backs. I believe that in such a case the bloated carcass floated upside-down with the head dragging under the shoulders. When the gases escaped from the body it sank to the bottom and was soon covered by sediment. In some cases the skin of the abdomen remained intact, and the weight of the sediment pressed it into the body cavity against the upturned ribs. In other cases the skin was broken and sediment completely filled the body cavity. The enveloping sediments ensured that the bones re-

mained in a natural position. In this type of preservation the forelimbs are above the body with the humerus pointing away from the body. The ulna and radius articulate with the humerus in basically the same manner as they do in horned dinosaurs.

While working with my father and brothers in the Lance beds of Wyoming in 1908-10, we collected two interesting so-called hadrosaur "mummies." The first, now in the American Museum of Natural History, was preserved on its back with the forelimbs above the skeleton and the head below the shoulders. It was encased in skin impression, the skin having collapsed into the body cavity. This animal must have died in the water. The second "mummy," now in the Senckenberg Museum in Frankfurt, was obviously buried in quite a different manner (Plates 3 and 4). It is evident that the animal bogged down in soft sediments, probably quicksand, and suffocated. The skeleton was preserved upright, with the beak pointing up and the head well above the body. One hind limb was doubled up beside the body, and the other was extended downward. Thus one hind foot was six to eight feet lower in the strata than the beak. The forefeet were forced up beside the body with the palmar surfaces up, showing the web (Lull and Wright 1942, Pl. 9).

In 1965 I prepared a hadrosaur skeleton *in situ* for exhibition in the Dinosaur Provincial Park of Alberta (Plate 2). The carcass had settled on its back with the head under the left shoulder. It was covered initially to a depth of about 3 ft and all of the covered bones were in their natural position. However, the front limbs were pulled out of place and the distal ends of the long ribs were destroyed before final burial. Good skin impressions were found over the ribs of the left side. The body cavity was completely filled with sediments. Another skeleton found in 1915 in Alberta was preserved in a very similar manner.

Skulls of horned dinosaurs, or ceratopsians, are much more common than skeletons. I believe that the ceratopsians lived in swampy floodplains, away from open water, and most of them died on land where carnivores could tear apart the carcasses. The solidly constructed skulls would often be carried away by floods and covered by sediment. Isolated skulls, with large horncores but without lower jaws, were usually buried upside-down. Occasionally a ceratopsian died in the water, or the carcass was picked up by a flood soon after death and was buried in its entirety (*see* Plate 6). Of the three *Leptoceratops* collected from the Upper Edmonton Formation (Lance equivalent) in 1947 (Sternberg 1950), two seem to show that the animals had waded into soft mud, bogged down and been buried.

In a number of places in the Sand Creek area I have observed bone beds in which bones of a single species of ceratopsian are preserved. In these deposits other bones are rarely found. Often, considerable amounts of ironstone with rush impressions are in evidence, and the bones are scattered and broken as if they had been trampled. This would suggest that at times ceratopsians congregated in certain swampy areas from which other animals were excluded. One such bone bed, containing bones of *Styracosaurus*, is situated quite low in the strata of the Oldman Formation about 3 miles south of the Steveville ferry, on the east side of the Red Deer River. Most of the other horned dinosaur bone beds in this area contain the bones of the more common *Centrosaurus*. A bone bed containing bones of *Anchiceratops* was

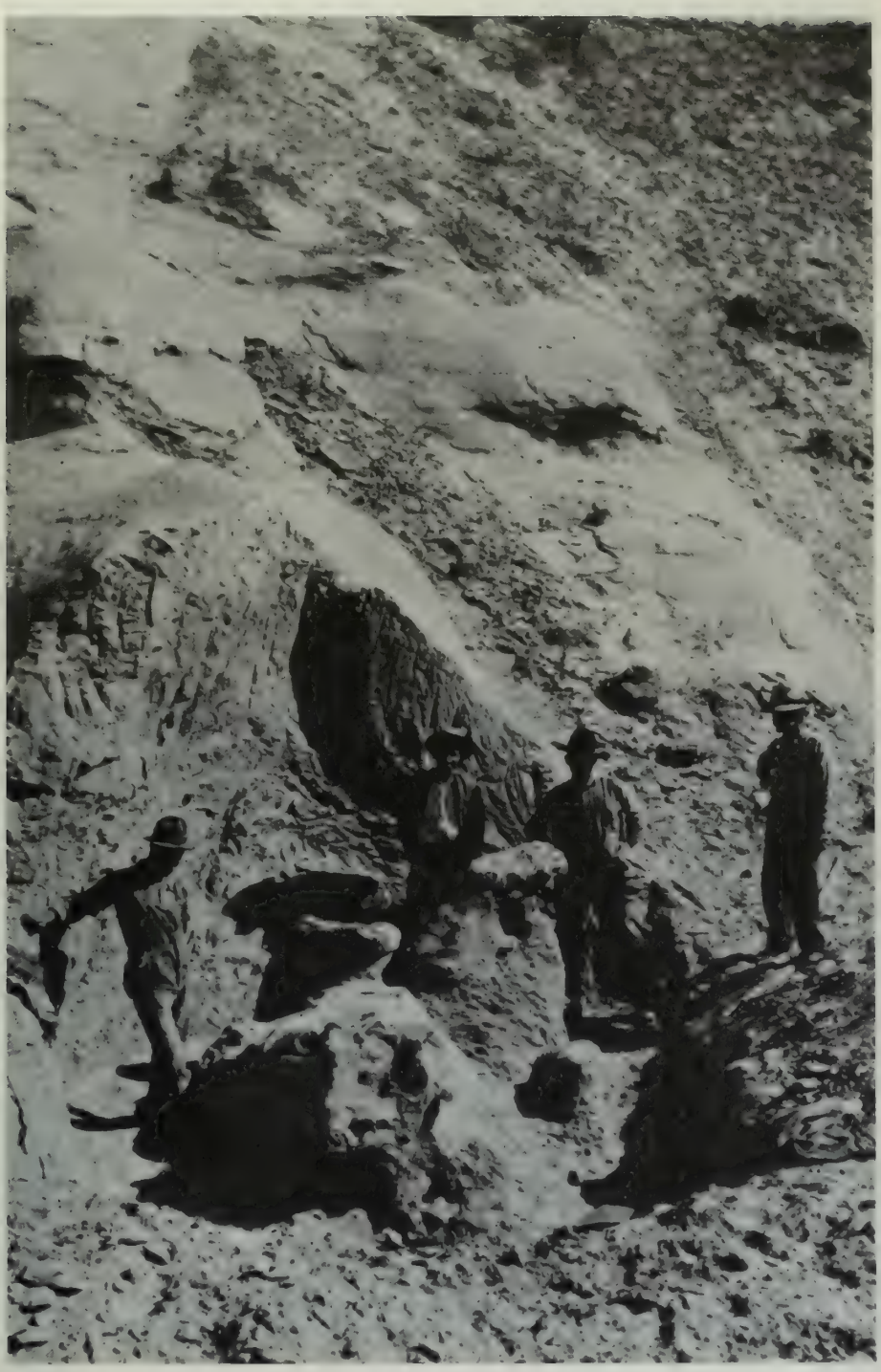

Plate 3
Hadrosaur skeleton *in situ*, Lance Formation, eastern Wyoming. Specimen now in Senckenberg Museum, Frankfurt.

found in the Lower Edmonton Formation northwest of Drumheller. In the Scabby Butte area in southern Alberta there was a bone bed containing the remains of a strange ceratopsian that had greatly thickened nasal and prefrontal bones and lacked horns (*Pachyrhinosaurus canadensis,* Sternberg 1951).

Other extensive bone beds contain disarticulated bones of many species and are quite distinct from the horned dinosaur bone beds. Evidence suggests that these disarticulated bones were washed up on shore much as driftwood is piled up on modern beaches. The heavy bones were often washed up to one level and the lighter ones, such as ribs, were pushed further up the beach. In such bone beds, bones of any of the animals that lived in the area may be found, along with those of upland forms that may have washed down the rivers. There is no certainty that any two bones found near each other in these beds belong to the same individual, or

Plate 4
Same as Plate 3. A, tip of beak; B, left forelimb; C, right forelimb.

indeed the same species, unless they are articulated.

We must assume that the armoured dinosaurs, or ankylosaurs, lived in very wet, swampy regions since almost all specimens are preserved upside-down. This very broad, low-slung animal with heavy plates of bone on its back would, when dead, float on its back. Eventually the carcass would sink to the bottom and be buried.

In 1921 I collected a nearly complete skeleton of a large carnivorous dinosaur that had apparently been washed into shallow water on its right side and then been covered with fine sand to a depth of about 18 inches. When it came to rest, the skeleton was completely articulated, but all the exposed parts, including the left side of the skull, were subsequently pulled apart and scattered. (*see* Plate 5).

The situation with the dome-headed dinosaurs *(Stegoceras)* (*see* Sternberg 1966, Figure 26) must be viewed in quite a different light from that of the

Plate 5
Partly articulated skeleton of large carnivorous dinosaur, Oldman Formation, Sand Creek area, Alta.

forms discussed above. We can assume that the animal inhabited upland areas since most specimens consist only of the thickened solidly-constructed skull-cap or dome, with all edges worn smooth as if they had been rolled down a stream. Only one complete skull, with a few bones, has been collected, although well over a hundred skull-caps have been found. This animal may have been extremely common but, since it lived on the upland, there was much less chance of the bones being properly buried and preserved.

It is hoped that collectors will always take special care to note the manner in which dinosaur specimens were buried. Direct observation in the field yields much more information on the possible skeletal position and habits of the animal than speculation in the laboratory. Any reconstruction of a dinosaur must be based upon detailed and accurate observation of the remains and their position in the sediments.

Plate 6
Completely articulated skeleton of *Anchiceratops*, lower Edmonton Formation, southwest of Rumsey, Alta.

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