15. "*Bison*" *alticornis* and O. C. Marsh's Early Views on Ceratopsians

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Abstract

Bison alticornis figures prominently in the history of North American dinosaur paleontology because O. C. Marsh bungled its original identification. Although he later realized his mistake and properly recognized that the specimen consisted of a pair of brow horns of a ceratopsian, this correction is generally downplayed at the expense of a good story about Marsh's rush to judgment. In reality, his original identification was plausible on the basis of the knowledge about dinosaurs at that time. Furthermore, archival records reveal that modern accounts about the type locality are wrong. The skull fragment in fact comes from a few kilometers from downtown Denver, Colorado.

Introduction

Salvage work at construction sites, as well as reconnaissance of exposures, has recently produced numerous dinosaurs specimens from the nonmarine Laramie, Arapahoe, and Denver Formations in the Denver metropolitan area, Colorado. The results of this

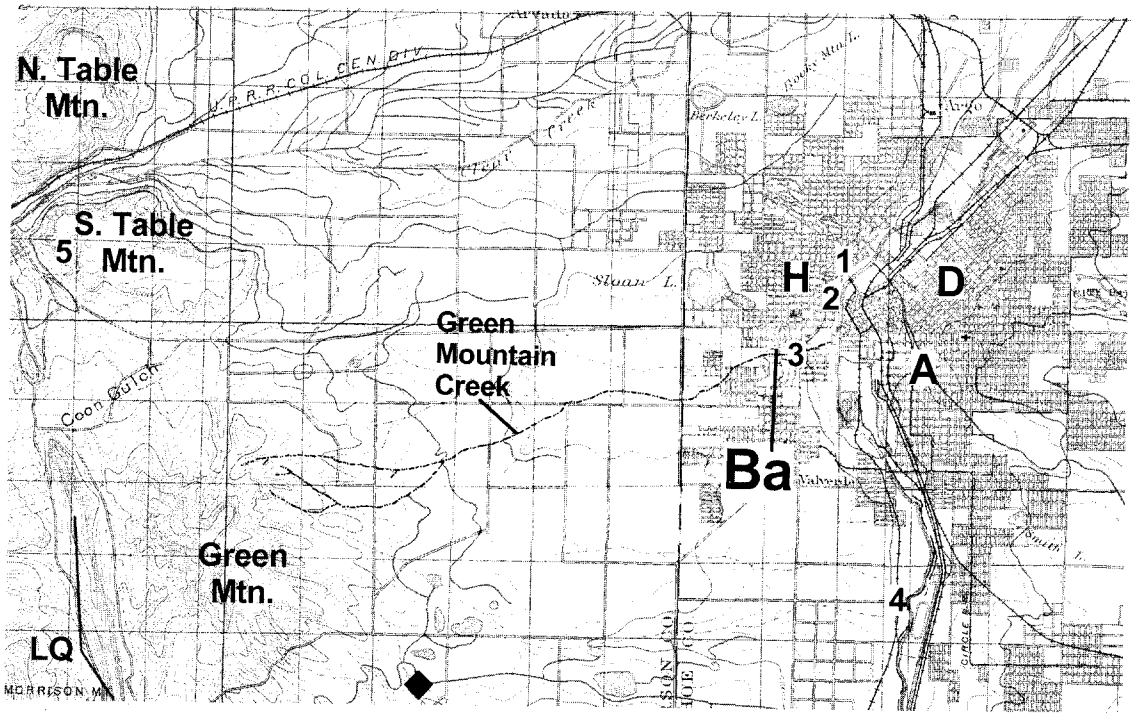

Figure 15.1. Map of the Denver area in 1888 showing Highland (H), Auraria (A), and Denver (D). Location of some of the major exposures mentioned by Cross (1888) are indicated: 1, ravine near St. Luke's Hospital; 2, along the cut bank of the South Platte River; 3, Windsor Addition (where "Bison" alticornis *was found; see Fig. 15.6); 4, banks opposite Jewell Park; 5, southwest corner of South Table Mountain (where the infamous* Tyrannosaurus rex *tooth was found). (As side notes, the Arthur Lakes quarries [LQ] in the Morrison Formation occur along the ridge west of Green Mountain, and* Ornithomimus velox *named by Marsh was also found; site indicated by solid diamond). Map adapted from Emmons et al. (1896: pl. 1).*

work are presented by Carpenter and Young (2002) in a larger work summarizing the Upper Cretaceous–Lower Tertiary stratigraphy and paleontology of the Denver Basin (Johnson et al. 2002; Johnson and Raynolds 2003). Archival work to locate previous dinosaur discoveries in the Denver region has revealed that there is much misinformation about many of the specimens collected and sent to O. C. Marsh of the Peabody Museum (Yale University) in the late 1800s, including the type locality for the famous "*Bison*" *alticornis*. The story as told by those involved is presented below.

Denver, Colorado, is today a large metropolitan city located on the prairie at the foot of the Rocky Mountains. It grew from three small towns, Denver, Auraria, and Highland, that sprung up in late 1858 at the confluence of the South Platte River and Cherry Creek (Fig. 15.1). Bedrock in the region which "form the surface about the city of Denver . . . may be conveniently and appropriately named the Denver Formation" (Cross 1888: 121). It consists predominately of brown mudstones and yellowish to orange andesitic sandstones and conglomerates. Brown (1943) identified the K-T boundary west of Denver on the southeast flanks of South Table Mountain (now part of the Jefferson County Open Space) on the basis of Paleocene mammals and fossil plants. The boundary has been found elsewhere in the basin primarily on paleomagnetic and palynomorphs (Hicks et al. 2003; Nichols and Fleming 2002).

Today, there are few exposures of the Denver Formation in the metropolitan area due in large part to population growth. But con-

ditions were apparently very different in the 1800s, when the area was far less developed, as noted by geologist Edmond Cross in 1888 (121–122):

> There are many outcrops of these beds in and about the city of Denver, the most instructive ones being on the west bank of the [South] Platte, and in particular may be mentioned: The ravine crossing the Boulevard at St. Luke's Hospital, Highland; the banks of the tributary of the Platte which crosses the Windsor Addition; and outcrops on the river bank, in cuttings of the South Park Railroad and in gullies opposite Jewell Park. The "High Line" Ditch shows the Denver beds in many places between the [South] Platte and Cherry Creek, and numerous outcrops may be found in the banks of the chief ravines of the area between Cherry and Coal Creeks. . . . Other exposures to the west of Denver were on the western face of Green Mountain, in a ravine at its southwestern base . . . [and] . . . a slight depression . . . at the southwest end of South Table Mountain.

These areas occupied the region between Denver to the east and the foothills of the Rocky Mountains to the west (Fig. 15.1). In the intervening years, the landscape has been greatly modified, and few of these exposures exist today.

Institutional Abbreviations. DMNH: Denver Museum of Nature & Science (formerly Denver Museum of Natural History), Denver, Colorado; USNM: National Museum of Natural History (formerly United States National Museum), Washington, D.C.

Discovery of Dinosaurs Near Denver

Dinosaur bones in the Denver area were known for a long time, as noted by George Cannon (1888: 141), a high school teacher and geologist: "The majority of the exposures of the Denver beds are found in thickly settled neighborhoods, and, having been exposed for some thirty years to the ravages of numerous collectors and curiosity hunters, have doubtless been robbed of many accessible bones." One of those collectors was Edward L. Berthoud of Golden, Colorado, who wrote Marsh on December 6, 1873, "I find from my notes of 1867–68 a fossil bone bed that was discovered . . . when digging a well—at 45 feet in depth a fossil lower jaw fragment with cutting teeth of a ruminant that was sent to Smithsonian Mus[eum] in 1867" (Edward D. Berthoud, letter to Marsh, December 6, 1873). Berthoud also found what was apparently a ceratopsian horn, although it was not recognized as such at the time: "I have written to Prof. Lesquereux in reference to the fossil tusk" (Berthoud, letter to Marsh, December 6, 1873). Berthoud probably met Lesquereux in 1872 when the latter came to collect fossil leaves in the Dakota Formation near Golden, Colorado. Berthoud later send Marsh a large theropod tooth collected by

Arthur Lakes from South Table Mountain (Fig. 15.1), a basalt-capped mesa west of Denver. This tooth was apparently well known because several others made reference to it in letters to Marsh many years later:

> One of them (Cannon) says he was collecting when a student under Lakes, at Morrison in '77 or '78 and that a tooth was found in the Table Mountain beds (our Green Mountain series) and was sent to you. Can you remember anything about it or whether it was identifiable? (Samuel Emmons, letter to Marsh, July 15, 1886)

> The inclosed [*sic*] note may aid you in the identification of the tooth from South Table Mountain, I spoke about to you, during your recent visit in Denver. It was sent to you in the early part of '77. (George L. Cannon, letter to Marsh, November 22, 1886)

> In a cigar box you will find a large number of fragments found by Mr. [George L.] Cannon last summer on South Table Mountain . . . at the spot where the sabre-shaped tooth was obtained by Prof. Lakes, several years ago. (Whitman Cross, letter to Marsh, March 12, 1889)

The tooth has been relocated in the Peabody Museum collections and has been identified as that of *Tyrannosaurus* (Carpenter and Young 2002). It is the earliest discovery of that dinosaur and precedes the naming of that taxon by over three decades. Interestingly, given Marsh's penchant for creating new names, he did nothing with the tooth, possibly deeming it by this time of his career as unimportant. More recently, a partial *Tyrannosaurus* skeleton has been found in the southern Denver metro area (Carpenter and Young 2002).

In the late 1800s, the dinosaur bones being found had apparently been eroding out of the Denver Formation for a long time and concentrated as erosional lag:

> Some bones [were] found on the side of a slight depression in the Denver strata at the southwest end of South Table Mountain. . . . All of the important bones were found within a few feet of each other, and present a fresh unworn surface, with sharp angular edges when found broken. . . . The bones were evidently weathered out of the surrounding rock. (Cannon 1888: 142)

This site is apparently the large exposure where Berthoud made his collection; today it is grass covered. At another site,

> A large quantity of bones of a large herbivorous Dinosaur were recently obtained from a weathered surface of the Denver Sandstone east of Green Mountain within a space of one hundred square feet. . . . I can confidently assert that those bones not found in situ, but weathered out on

> the surface, or mixed with the loess and slightly drifted from the original source, have all been derived from a matrix of Denver Formation. (Cannon 1888: 143)

Most of the early dinosaur discoveries were by locals. A more concerted effort to collect dinosaur bones was made during the 1880s and 1890s as part of the U.S. Geological Survey study of the Denver Basin undertaken by Samuel Emmons, Whitman Cross, and George Eldridge.

> During the progress of the work a considerable number of bones were discovered by Mr. G. L. Cannon, jr., of Denver, and by Mr. Eldridge and the writer [Cross]. The collection of this material extended over a number of years [i.e., since the start of the project in 1881]. The fossils obtained were for the most part isolated bones or fragments, and all or nearly all of them were sent to Prof. O. C. Marsh for examination. (Cross 1896: 226)

The fossils were sent to Marsh in his role as the official vertebrate paleontologist for the U.S. Geological Survey. It was hoped that the fossils would shed light on the age of the formations in the Denver area:

> In the absence of any other determinable animal remains, any information you could give us relative to this tooth, or the supposed Megalosaurus tooth (if that is in your hands) would be of material assistance towards the clearing of the obscure chronology of this formation [i.e., Denver Formation]. (Cannon, letter to Marsh, November 22, 1886)

Discovery of *Bison alticornis*

In the spring of 1887, George Cannon found and excavated a pair of horns attached to a skull roof (Fig. 15.2A, B). As he was to later recount,

> While the horns were firmly imbedded in undisturbed Denver Group sandstones, a large portion of the skull, and the bases of the horns had fallen down a vertical bank, and were rescued from the muddy bank of Green Mountain Creek. Other portions may have been washed down the creek beyond hope of recovery. I was unable to spare time for excavation, and after bringing in to the [U.S. Geological] Survey, the pieces on the surface (marked, and separated as far as the circumstances of the case would permit) left the further work of excavating and shipment to them. (Cannon, letter to Marsh, June 29, 1887)

Cross shipped the specimen to Marsh, and it arrived at the Peabody Museum in New Haven, Connecticut, during the first week of May. It was assigned accession number YPM 1871E and arrived with several other specimens of dinosaur bones (YPM 1871A-D). Fresh broken surfaces alerted Marsh that not all of the

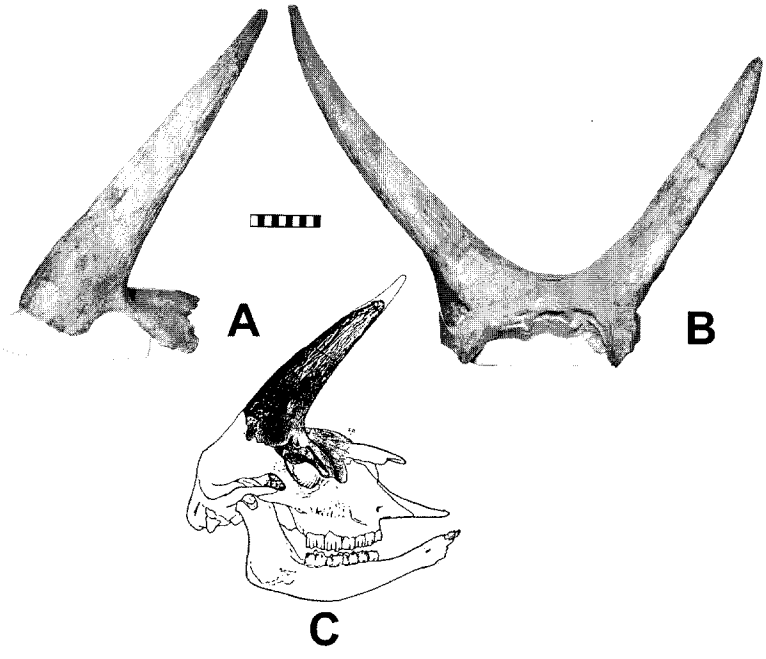

Figure 15.2. The Bison alticornis *horn cores (USNM 4739) in lateral (A) and anterior (B) views. That Marsh originally thought that these horns were of a giant bison is not unreasonable, as shown in this hypothetic reconstruction (C). Scale bar = 10 cm (A, B).*

specimen was recovered, and he sent a note to Whitman Cross via Samuel Emmons:

> I yesterday received a letter from Mr. Emmons enclosing a note from yourself in regard to the Denver buffalo skull. On the day before yesterday I went to the locality with Mr. Cannon and we dug out of the rock the rest of the horns, i.e. the tips and yesterday I went again to dig for the fragments you desired. By carefully examining all lose dirt & mud near by we found about 70 more pieces, mostly small, and these, together with the horn fragments, will be sent you by express. . . . Of the horns, I found the extreme tip of one, and nearly a foot in length of the other. . . . Several other fragments of horn are among those found yesterday. All fragments sent in this box undoubtedly belong to the skull. (Cross, letter to Marsh, May 10, 1887; these fragments were given the accession number 1883)

Marsh also wrote to Cannon asking him to look for more of the skull:

> As requested, have made a careful re-examination of the spot where the bison skull was found, obtaining nothing but a few worthless scales. . . . Cross . . . dug down the bank and carefully worked over the mud flat at its base, for some distance along the Creek. From my examination of this work I am satisfied that no further portions of this animal can be obtained. (Cannon, letter to Marsh, June 29, 1887)

Much of the skull was missing, and Marsh undoubtedly wanted more of it. However, as Cross explained to Marsh,

> The horns were imbedded in the rock, and the lower part of the skull, as found, was exposed. Doubtless a considerable part of the skull had been washed away. I examined the stream bed below and all the material which has recently been removed from the bank. I also dug into the rock surrounding the skull for several feet, but found no more bone matter." (Cross, letter to Marsh May 10, 1887)

Satisfied that no more of this specimen was to be found, Marsh named and described the horns as *Bison alticornis* in October 1887, noting that it "indicates one of the largest of American bovines, and one differing widely from those already described" (Marsh 1887: 323). This identification was meant with skepticism by Cannon even before Marsh had published his pronouncement,

> I need not say that the occurrence of such opposite and unexpected types [dinosaur and bison] in this formation will stimulate me to devote all the time I can spare from my business to the seach [*sic*] for material that may elucidate the present most complicated chronology of this group [Denver Group]. (Cannon, letter to Marsh, May 21, 1887)

Marsh was reluctant to change his mind about the specimen, even after receiving another, smaller pair of horns from the Judith River Formation of Montana that he named *Ceratops montanus* in December 1888 (Marsh 1888). Not until he received a partial skull of a ceratopsian, which he named *Triceratops horridus,* did he reconsider (Marsh 1889a: 334), but even then the acknowledgment appears in a footnote, "The specimen figured in vol. xxxiv, p. 324, may prove to belong to the same genus." As if to excuse his misidentification, he notes, "As previously stated, the posterior pair of horns-cores of this family are hollow at the base, and in form and surface markings are precisely like those of *Bovidae.* The resemblance is so close that, when detached from the skull, they cannot be distinguished by any anatomical character" (Marsh 1889a: 335).

It is true that there is considerable superficial similarity between the horns of bison and ceratopsians (Fig. 15.3). In both, there is a sinus cavity at the base of the horn core and the horn core surface is marked by an extensive network of vascular grooves providing a blood supply to the keratinous sheath. It was only in context of a more complete skull that Marsh was able to understand the convergent nature of the horn cores.

Marsh's Early Views of Ceratopsians

Actually, Marsh's ideas about ceratopsian bones changed several times as he received more and more specimens from the West. As Marsh received various dinosaur specimens, he usually wrote back to the collectors informing them of the identity of the fossils. We

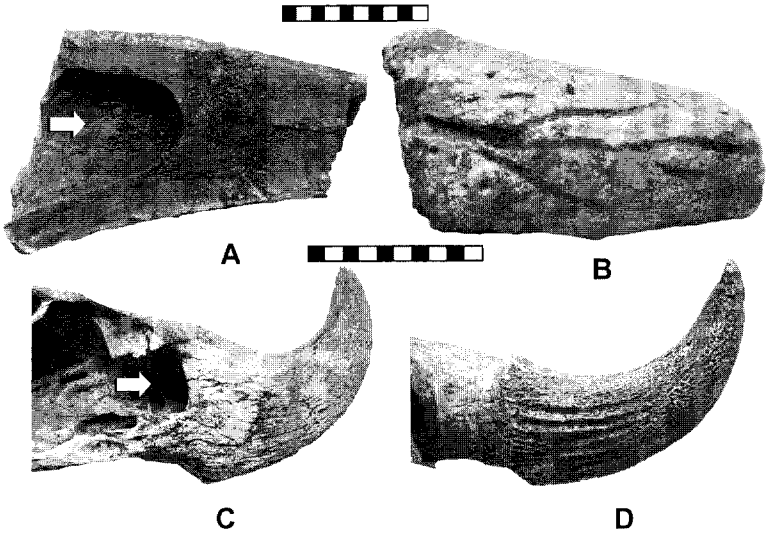

Figure 15.3. Similarities noted by Marsh between a ceratopsian horn core (A, B; DMNH 34392) and that of a bison horn core (C, D; DMNH 46724) include the hollow base (A, C arrows) and the grooved outer surface (B, D).

have few of these letters from Marsh, but we can glean some idea of his thinking from various publications of the period. Thus, from Cannon, we note that Marsh originally considered some of the fragmentary bones from the Denver area as stegosaur: "Mr. George H. Eldridge, of the [U.S. Geological] Survey, obtained from the Willow Creek beds [(i.e., Arapahoe Formation)] a number of . . . stegosaurian . . . bones" (Cannon 1888: 143). That this was indeed Marsh's opinion of these bones is confirmed when he later wrote that same year, "The present genus [*Ceratops*] appears to be nearly allied with *Stegosaurus* of the Jurassic. . . . They indicate a close affinity with *Stegosaurus,* which was probably the Jurassic ancestor of *Ceratops.* . . . The remains at present referred to this genus [i.e., *Ceratops*], while resembling *Stegosaurus* in various important characters" (Marsh 1888: 477, 478).

Why did Marsh first identify some of the bones as belonging to *Stegosaurus,* a seemingly ludicrous idea today? In the late 1880s, the only quadrupedal dinosaurs well known to Marsh were various Jurassic sauropods and *Stegosaurus.* The Denver bones lacked the characteristic features of sauropods (e.g., large size, pneumatic vertebrae) but did have some resemblance to the bones of stegosaurs. For example, the humerus of stegosaurs and ceratopsians are relatively short and robust as compared to body length, the processes on the vertebrae to which the ribs attach are angled upward in order that the ribs might accommodate a rotund belly, the femur is straight-shafted and oval in cross section, and the toes are short and end in wide hooves (Fig. 15.4). Given that Marsh received hundreds of complete *Stegosaurus* bones, including partial skeletons beginning in 1879 (Carpenter and Galton 2001), the similarities of the isolated and fragmentary Denver bones to the more complete *Stegosaurus* bones were more obvious than their differences. As Marsh pointed out several times:

> The vertebrae, and the bones of the limbs and of the feet, are so much like the corresponding parts of the typical *Stegosaurus* from the Jurassic, that it would be difficult to separate the two when in fragmentary condition, as are most of those from the later formation [i.e., Cretaceous strata]. (Marsh 1889a 335)
>
> The humerus is large and robust, and similar in form to that of *Stegosaurus*. . . . The tibia is of moderate length, and resembles that of *Stegosaurus*. In one individual, at least, the astragalus is firmly coossified with the distal end of the tibia, as in *Stegosaurus*. (Marsh 1890b: 420–421)
>
> The *Ceratopsidae* resemble, in various points, the *Stegosauria* of the Jurassic, especially in the vertebrae, limbs, and feet. (Marsh 1891: 176)

Most of these similarities are heavyweight adaptations superimposed on distant phylogenetic relationships (i.e., ceratopsians and stegosaurs are more closely related to each other than either is to the sauropods). If there were any doubts in Marsh's mind about the identifications of the Denver fossils in 1887, they were probably dispelled by the long, tapering bones covered by a network of grooves for blood vessels sent to him. Except for their large size, these ceratopsian horns superficially do resemble *Stegosaurus* tail spikes (Fig. 15.4A, B).

After naming *Bison alticornis,* Marsh considered the possibility that some of the bones (primarily the horn cores) were not bison: "The bison-like horn-cores . . . probably belong to a member of this group [i.e., ceratopsians] . . . As they agreed in all anatomical characters with the remains of cavicorn mammals from that formation [i.e., Pliocene strata in the Denver area], they were referred to the genus *Bison,* under the name *B. alticornis*" (Marsh 1889b: 174–175). However, Marsh abandoned this position after a few years when he was convinced by Whitman Cross (1889) that the horn cores from the Denver area came from Cretaceous strata: "The writer has since learned that they were found in the Denver beds, which although regarded as Tertiary, are probably Cretaceous. Under these circumstances, this well-marked species may be known as *Ceratops alticornis,* until additional remains make certain its true nature" (Marsh 1889b: 175).

It was about this time that Marsh was also receiving ceratopsian specimens from Wyoming, which only reinforced his new interpretation, "Remains of the same reptile [i.e., *Ceratops montanus*], or one nearly allied, had previously been found in Colorado, in deposits of about the same age, by Mr. G. H. Eldridge, also of the U.S. Geological Survey" (Marsh 1891: 478). Although Marsh continued to draw parallels between the bones of ceratopsians and stegosaurs (e.g., Marsh 1890a, 1890b, 1891), he accepted that *Bison alticornis* was indeed a ceratopsian when he summarized the dinosaurs of the Denver Basin in 1896 (Marsh 1896).

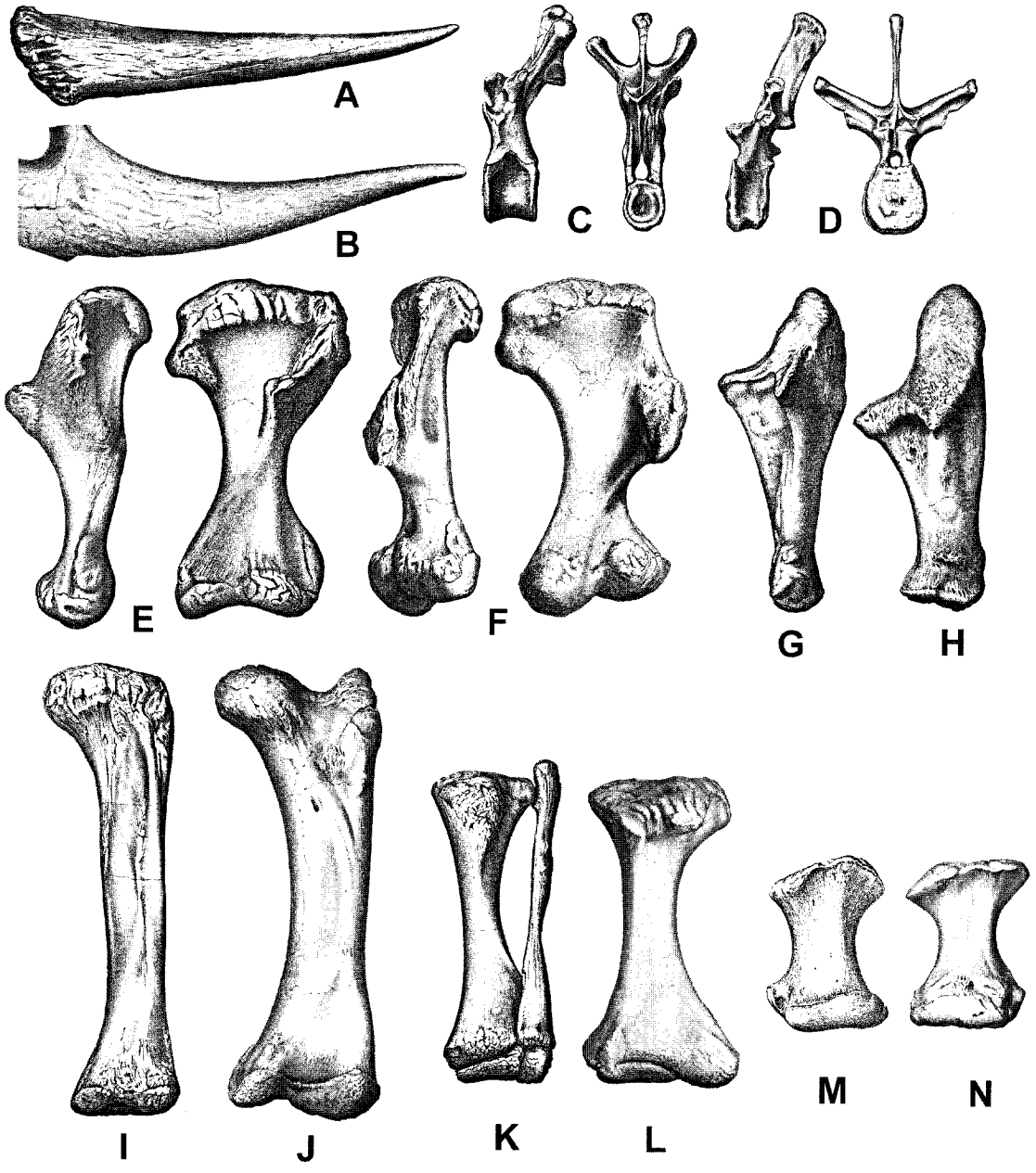

Figure 15.4. As noted repeated by Marsh, there is superficial similarities between the bones of ceratopsians and stegosaurs. (A) Stegosaurus *tail spike versus (B)* Triceratops *brow horn; dorsal vertebra of (C)* Stegosaurus *versus (D)* Triceratops; *humerus of (E)* Stegosaurus *versus (F)* Triceratops; *ulna of (G)* Stegosaurus *versus (H)* Triceratops; *femur of (I)* Stegosaurus *versus (J)* Triceratops; *tibia of (K)* Stegosaurus *versus (L)* Triceratops; *metatarsal of (M)* Stegosaurus *versus (N)* Triceratops. *Most of the ceratopsian specimens Marsh received from the Denver area were fragmentary, and the similarities are even more striking.* Stegosaurus *images are from Ostrom and McIntosh (1966) and* Triceratops *from Hatcher et al. (1907).*

Bison alticornis and the Great Lignite Debate

Why was the specimen of *Bison alticornis* so important scientifically when it was found? The answer comes from a letter from Whitman Cross to Marsh: "I hope you may be able to identify this interesting remains [i.e., *Bison alticornis*], fully, and am sure it will be of great significance for Denver geology" (Cross, letter to Marsh, May 10, 1887). At the time, the stratigraphy of the western United States was just being unraveled. One problem, however, concerned the "Great Lignite Debate" that was occurring between paleobotanists and vertebrate paleontologists. The Great Lignite Debate stems from the fact that many of the Upper Cretaceous and Lower Tertiary formations superficially resemble one another, being drab, tan to brown mudstones, tan lenticular sandstones, and numerous lignitic beds. At first all of these sedimentary rocks were called the Laramie Formation, but problems began to arise because of conflicting vertebrate and plant fossil evidence. As Hayden (1874: 27) stated, "The main question, then, is this: Are the vertebrate paleontologists, Cope and Marsh, justified in regarding the entire Lignite group as Cretaceous from the evidence furnished by the vertebrate remains?" Paleobotanists, on the other hand, considered the upper portion of the "Lignite group" as lower Eocene (what we now call the Paleocene) (see Waage 1975 for a historical perspective on the Great Lignite Debate). Cross (1889: 278) succinctly asked, "Do the Willow Creek [Arapahoe] and Denver Formations belong to the Laramie Group, or are they of later age?"—that is, are these formations Upper Cretaceous or Tertiary? The vertebrates from the Denver Basin are among the earliest dinosaurs discovered in the American West (summarized by Carpenter and Young 2002)—hence their importance at the time.

Marsh unwittingly contributed to the confusion regarding age of the Denver Formation (hence the "Lignite" group) when he wrote,

> Among the large number of extinct mammals recently received at the Yale Museum from the West, are several of especial interest, as they serve to mark definite horizons in the Tertiary deposits east of the Rocky Mountains. . . . The remains of this species [i.e., *Bison alticornis*] are found in the sandstones of the Denver Group, at the eastern base of the Rocky Mountains, where they indicate a well-marked horizon, which may be called the Bison beds. These deposits are more recent than the Equus beds, and are probably late Pliocene. (Marsh 1887, 323–324)

Obviously a single fossil cannot delineate "a well-marked horizon." Marsh was indirectly referring to "Other remains were obtained by G.H. Eldridge of the [U.S. Geological] Survey, and sent to the writer [i.e., Marsh] for examination" (Marsh 1887: 324). Most of these "other remains" are uncataloged at the National Museum of Natural History and include numerous fragments of ceratopsian horns.

The ramification of Marsh identifying the Denver Formation as Pliocene was to add confusion to the already murky Great Lignite Debate and threw doubt into the use of vertebrate fossils to resolve the debate. As Cannon wrote:

> The Denver and the Willow Creek [i.e., Arapahoe Formation] Groups (Tertiary) have recently yielded a number of vertebrate fossils that promise to seriously modify various existing palaeontological beliefs, e.g., the supposed extinction of the Dinosauria at the close of the Cretaceous, the supposed value of vertebrate remains in the accurate solution of chronological problems, or the supposed inability of the highly specialized forms of the higher Vertebrata to survive any marked change of surroundings.
>
> In both of the above formations, forms hitherto regarded as typical of various epochs ranging from the upper Jurassic [i.e., stegosaur] to the latest Pliocene [i.e., bison] . . . have been discovered in the same stratum in identical states of preservation and under conditions that, but for the anachronisms involved in such a statement, would be regarded as positive proof of the existence of all forms represented by the fossils at the time of deposition of the sediment forming these beds. . . .
>
> The admission that Dinosaurs have survived until the Miocene destroys the value of all conclusion based on the supposed infallibly Mesozoic characters of the fossil forms involving the reopening of the great controversy relative to the age of the Western lignites. (Cannon 1888: 140, 146)

Cross was willing to accept a Tertiary age for the Denver Formation after concluding that the fossil plants described by Lesquereux were stratigraphically unreliable, although he was hesitant to accept a Pliocene age: "In view of the stratigraphical relations it seems probable that this conclusion [i.e., Pliocene age for the Denver Formation], will need to be modified somewhat when the various Tertiary Formations of this region have been correlated with others of known position" (Cross 1888: 132–133). Later, he wrote,

> Were it not for the presence of the fossil described by Prof. Marsh as *Bison alticornis,* the whole weight of the evidence [i.e., paleobotanic and stratigraphic] would be in favor of assigning the Willow Creek and Denver Formations—assuming that they are post-Laramie—to the earliest Tertiary possible. On account of this fossil, however, Prof. Marsh has stated that the strata containing it are "probably late Pliocene." But the bison specimen was dug out of solid typical Denver sandstone at the same general horizon which has yielded all the other Denver vertebrates [i.e., dinosaurs] yet found. This conflict is not yet explained. (Cross 1889: 279)

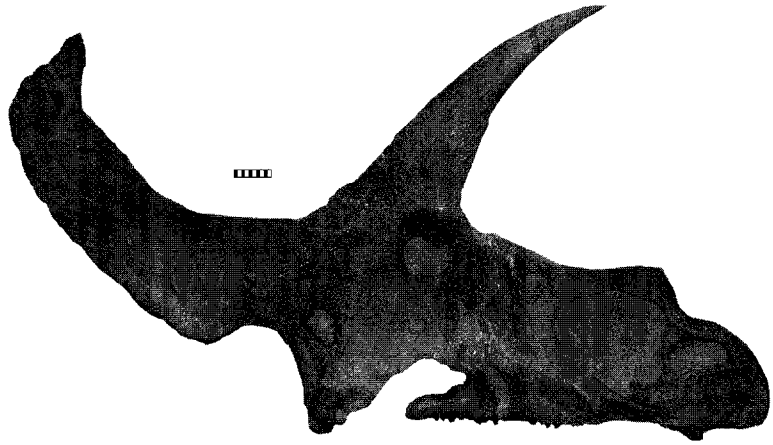

Figure 15.5. Confirmation that Triceratops *(DMNH 48617) does occur in the Denver area was made over a hundred years after Marsh named* Bison alticornis. *This skull was found in November 2003 and is from the Denver Formation near Brighton, Colorado, near where Eldridge collected numerous isolated ceratopsian bones (uncataloged at the National Museum of Natural History).*

Marsh was understandably irritated by the implied criticism, but his receipt of several complete *Triceratops* skulls required him to concede that *Bison alticornis* was actually a ceratopsian (Marsh 1889b). Later, he wrote,

> The geological horizon of these strange reptiles [ceratopsians] is a distinct one in the upper Cretaceous, and has now been traced nearly eight hundred miles along the east flank of the Rocky Mountains. It is marked almost everywhere by remains of these reptiles, and hence the strata containing them may be called the Ceratops beds. They are fresh-water or brackish deposits, which form a part of the so-called Laramie, but are below the uppermost beds referred to that group. (Marsh 1889c: 501)

Although there was some challenge of Marsh's use of the term "horizon" (e.g., Cross 1896), his conceding that *Bison alticornis* was a ceratopsian and therefore Upper Cretaceous did much to begin to resolve the Great Lignite Debate. Confirmation that *Triceratops* does occur in the Denver area was finally made in 2003 with the discovery of a partial skull (Fig. 15.5) in the Denver Formation.

Where Was *Bison alticornis* Found?

As a result of the historical importance of *Bison alticornis,* the location of the discovery is of great significance to vertebrate paleontology and Cretaceous stratigraphy. Marsh (1887: 324) states the specimen came from "the banks of Green Mountain Creek near Denver." But since Green Mountain Creek (now called Lakewood Gulch) is over 14.6 km long from its confluence with the South Platte River to the base of Green Mountain, the locality has always been vague. This vagueness may be why at least one vertebrate paleontologist referred to the site as being on Green Mountain (Lewis 1960).

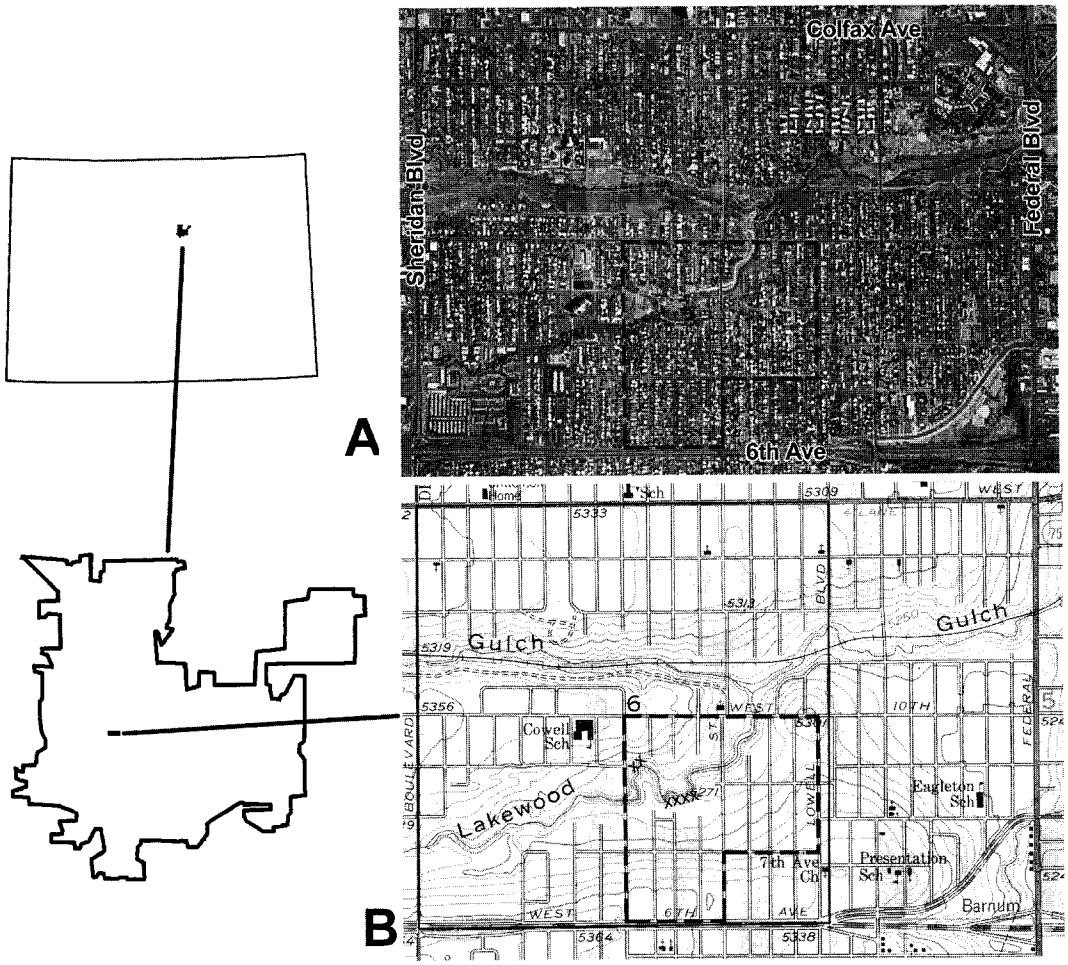

Figure 15.6. West Denver showing the location of the Windsor Addition of 1888. (A) Satellite photograph showing major features compared with a (B) topographic map (1957 edition). On the basis of the present topography of the area, the most likely places "Bison" alticornis *came from are marked with x's, although landscaping may have obliterated the actual spot (note that the meandering loop shown in [B] has been cut off by artificial rechanneling in [A]). The strip of land in Lakewood Gulch is an extension of Sanchez Park. Satellite photo modified from Google Earth; topographic map is from the Fort Logan Quadrangle.*

Cannon, who found the specimen wrote to Marsh stating that the specimen came "within a few miles of this city [i.e., Denver]" (Cannon, letter to Marsh, May 21, 1887). Cross noted that "This skull was found in the bank of a small stream about 3 ft. above the water" (Cross, letter to Marsh, May 10, 1887). Cross (1896: 227) noted that the specimen "was found in place near the Platte River, in Highlands" and had written earlier that the specimen was discovered "in a bank of typical Denver sandstone in the Windsor addition to the Town of Highland" (Cross 1888: 132). An 1888 map of Denver that shows subdivisions indicates that the Windsor addition occupied the southeast quarter of Section 6, Township 4 South, Range 65 West (Fig. 15.6B).

By using these data, it is possible to narrow the type locality for *Bison alticornis* Marsh 1887 to a 840-m section of Lakewood Gulch, about 4.5 km from the center of downtown Denver. Here, most of Lakewood Gulch is a broad valley bordered by residential areas. Assuming that some trace of the erosional bank, which pro-

duced the skull, still remains as topographical high along the Gulch, then two areas have been identified. These are at the west end of Lakewood Gulch at 39 39°43'48"N, 105°02'28"W and 39°43'52.5"N, 105°02'35"W (Fig. 15.6B). Although these two spots offer the best topography today from which the skull might have been excavated, no physical evidence of digging remains. There is the possibility that the actual site was obliterated long ago as the landscape was modified for human use.

Conclusions

"Bison" alticornis is more than an historical sidebar because it caused great confusion during a crucial time when the age of what are now known as Upper Cretaceous–Lower Tertiary beds of the western United States was being determined. It wasn't until Marsh reconsidered the identity of the horns of *Bison alticornis* as those of a horned Cretaceous dinosaur did part of the problem become solved. Even so, it was many more years until our current understanding of Upper Cretaceous and Lower Tertiary stratigraphy was resolved.

The location for the discovery of *B. alticornis* is most likely to have been along a cut bank along Lakewood Gulch (formerly Green Mountain Creek), about 4.5 km from downtown Denver.

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