A review of dinosaurian body fossils from British Columbia, Canada

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A review of all dinosaurian body fossils from British Columbia, Canada

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Abstract -
Since the 1900s, dinosaur fossils have been discovered from Jurassic to Cretaceous age strata, from all across the prairie provinces of Canada and the Western United States, yet little material is known from the outer provinces and territories. In British Columbia, fossils have long been uncovered from the prevalent mid-Cambrian Burgess Shale, but few deposits date from the Mesozoic, and few of these are dinosaurian. The purpose of this paper is to review the history of dinosaurian body fossils in British Columbia. The following dinosaurian groups are represented: coelurosaurians, thescelosaurids, iguanodontians, ankylosaurs and hadrosaurs.

Introduction -
The first fossil excavations from British Columbia, Canada, were begun in 1909, when Charles Doolittle Walcott uncovered a deposit near the town of Field (Gould, 1989). This deposit, of Cambrian fauna, is located within the Canadian Rocky Mountain Parks, which were designated as a World Heritage Site in 1984. Though the Burgess Shale preserves many fossils of extinct organisms, the deposit predates dinosaurs by more than a quarter of a billion years.

In British Columbia, there are many formations during the Mesozoic, nearly all of which preserve dinosaurian traces, such as footprints, with a few also preserving pterosaurian traces (McCrea *et al.,* 2014). However, dinosaur bones were unheard of in British Columbia until 1971, when bones were discovered in the north of the province (Arbour & Graves, 2008). These included part of an arm and a leg from a cerapodan. However, dinosaur bones remained exceptionally rare until the early 2000s, when large deposits near the town of Tumbler Ridge were discovered (Arbour & Graves, 2008). Most recently, a nearly complete hadrosaur was discovered in the Tumbler Ridge deposits, which marks the most complete find in the province, as well as the first derived iguanodontian.

This is different from other western regions of North America, especially Alberta, where many hundreds or thousands of specimens have been discovered in Jurassic and Cretaceous deposits, with only minimal track or other trace fossils.

This paper reviews the few occurrences of dinosaurian fossils in British Columbia, and finds a likely reason for this marked lack of such bones.

The map illustrating the distribution of currently known dinosaur fossils in British Columbia (Figure 1) is based on https://commons.wikimedia.org/wiki/
File:Canada_British_Columbia_location_map_2.svg by ”Hanhil”, which has a CC-BY-SA 3.0 license.

Institutional abbreviations:
RBCM - Royal British Columbia Museum

Results -

On only a few occasions have dinosaurian fossils been discovered in British Columbia (Fig. 1). However, those that are known range from a single bone to a near complete skeleton, from the northeast of the province, to the southwest.

One of the earliest dinosaurian fossil deposits discovered in British Columbia was that of a cerapodan, which was described in depth by Arbour & Graves (2008) (Fig. 2). First found in 1971 by Kenny Larson, the bones were proposed either to be a basal ornithopod or pachycephalosaurian (Arbour & Graves, 2008). However, the features that were listed as shared with pachycephalosaurians were also shared with ornithopods, but not always the reverse. Thus, it seems likely that an ornithopod identity is more likely for the material. They were located when he discovered above-background levels of radiation, which was emanating from the bones. The specimen received the accession number RBCM.EH.2006.019. The material includes a right humerus lacking the distal end, a complete right radius, the distal portion of a left tibia, a left fibula lacking the proximal end, an astragalus, and multiple pedal bones, including an articulated series of phalanges and unguals. However, other bones were found, such as a flat bone that Arbour & Graves (2008) could not identify, as well as a nearly complete digit, and other unidentified bones found in the surrounding matrix. The unidentified flat bone (Fig. 2 G–H) was proposed to be a skull bone by Arbour & Graves (2008). As a skull bone, it seems most likely to be part of the skull roof or lateral skull. However, it is not the right proportions or even size for the orbital region, and thus seems to belong to a nasal, or other bone in association with the antorbital fenestra. All the bones are from mainland BC, specifically the late Campanian to early Maastrichtian aged Brothers Peak Formation (Arbour & Graves, 2008).

In a 1996 review of fossils of British Columbia, Sampson & Currie reported an isolated pedal phalanx that was first found in 1979 (Fig. 3). It came from the Fernie region, where deposits of coal were mined. Found near the river, it was waterworn, meaning that it could have come from one of the many veins, from Late Jurassic to Early Cretaceous in age. Sampson & Currie noted that it was likely the first phalanx, based on the concave articular surface, and noted a possible identity as *Camptosaurus*, but stated that this identification was tentative (Sampson & Currie, 1996). However, based on comparison with the first pedal phalanges of *Camptosaurus*, *Allosaurus*, and hadrosaurs, the bone seems to likely be closer to *Camptosaurus* than the other compared taxa. Thus, I find a primitive iguanodontian identify most likely.

In the same edited volume as Sampson & Currie, Ludvigsen (1996) described a tooth from Vancouver Island (Fig. 4). During 1992 excavations for a pipeline across Trent River, Joe Morin of Courtney, and his son Mathew, were breaking apart chunks or Upper Cretaeous shale. While breaking these chunks up, Mathew identified a single tooth. The small, triangular tooth was later sent to the Royal Tyrrell Museum where Currie identified it a belonging to a theropod (Ludvigsen, 1996). Comparisons made by me with various other theropod teeth, such as those of abelisaurids, *Allosaurus*, *Tyrannosaurus*, and dromaeosaurids, have led me to a coelurosaurian identity for the tooth. As well, the tooth is likely from the Campanian based on the ages of the similar teeth, and the geologic age of the Trent River region of Vancouver Island.

In 2002, a pair of young boys floating down the Flatbed Creek stopped on the bank and uncovered the tracks of an ankylosaur, as well as a bone. Because of this, the Tumbler Ridge Museum Foundation prompted an expedition in the Tumbler Ridge area, to Quality Creek. At this location they discovered more fossils from rock that had slid down the cliffs beside the creek. One block contained vertebrae, a fibula, and a rib, as well as unidentifiable remains (McCrea & Buckley, 2004). Multiple other blocks were also found to contain bones, with a total of around 20 specimens found. The deposits are from the Kaskapau Formation, which is from the Turonian. Some preserved remains include an ankylosaurian scute, a theropod tooth, as well as ribs, five vertebrae, an unidentified phalanx, and a possible pelvic bone (Fig. 5). Based on the bones, it was suggested that a large ornithopod, an ankylosaurian, and a small theropod were all present in the formation (McCrea & Buckley, 2004; Rylaarsdam *et al.*, 2006). Discovered in 2008, excavation of a nearly complete hadrosaur from the Tumbler Ridge area was finished in 2013. These remains have not yet been described, and it is not my intention to provide further information prior to the published description of the material.

Discussion -

Even though hundreds of dinosaur footprints have been uncovered from across British Columbia, there are only around five different deposits preserving dinosaur body fossils. There two main possibilities for why this is so.

The first option is simply that deposits have not been located, even though they are in existence. This is possible, but probably not the only cause. In Alberta, fairly recent glaciers could have scraped off upper layers of sediment, exposing Mesozoic rock below (Sampson & Currie, 1996). However, some of these deposits are known to extend into British Columbia. For example, the Wapiti Formation extends into British Columbia, but only footprints are preserved on the British Columbian side of the border. The hypothesis of simple ignorance towards deposits is supported by the fact that in rockier, more vegetated British Columbia, finding these deposits or bones may be much more difficult (Sampson & Currie, 1996). Examples of this support comes from the Tumbler Ridge deposits, where the rock from cliff faces is exposed by lack of vegetation, yet is difficult to access because of the height of the cliff. Other evidence comes from the absence not only of dinosaurian fossils in British Columbia relative to Alberta, but also of other terrestrial vertebrate bones.

Another possibility is that there is a preservation bias against fossilizing bones. This may be possible, as during the middle Late Cretaceous, the sea levels would have been higher than previously or subsequently, and thus more costal regions would have been closer to sea level. The Western Interior Seaway would have stretched across the north of the province, and many skeletons deposited in it would have flowed into Alberta. The constant sediment depositing would have prevented marshes forming in Alberta, which make fossil formation more likely, as marshy water is more acidic than fresh water, preventing most fossils from forming (Sampson & Currie, 1996). This hypothesis of preservation bias can be supported, as the Aptian–Albian age is known to be very productive, yet formations of that age in British Columbia only preserve footprints. Other support comes from the fact that apart from rare occurrences, known bones are relatively far away from the ancient shoreline, where there would have been less water to disturb and move the skeletons.

Conclusion -

Over a century of of fossil discoveries in British Columbia, few dinosaurian fossils are known. One of the main deposits for such bones is near Tumbler Ridge, near the border with Alberta. Other bones have been found in regions farther from the ancient shoreline, or in rare occurrences on British Columbian islands. Based on the known dinosaurian fossils in British Columbia, There must be a reason for a marked lack compared to Alberta. Of the two reasons, one being lack of known deposits even though they exist, and the other being a preservation bias towards footprints compared to bones, it is uncertain which is the likely cause of the comparative rarity of dinosaurian body fossils in British Columbia.

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Figure 1. The distribution of dinosaurian fossils throughout British Columbia. Red dots signify

approximate localities of dinosaurian fossils. The Burgess Shale is shown in black.

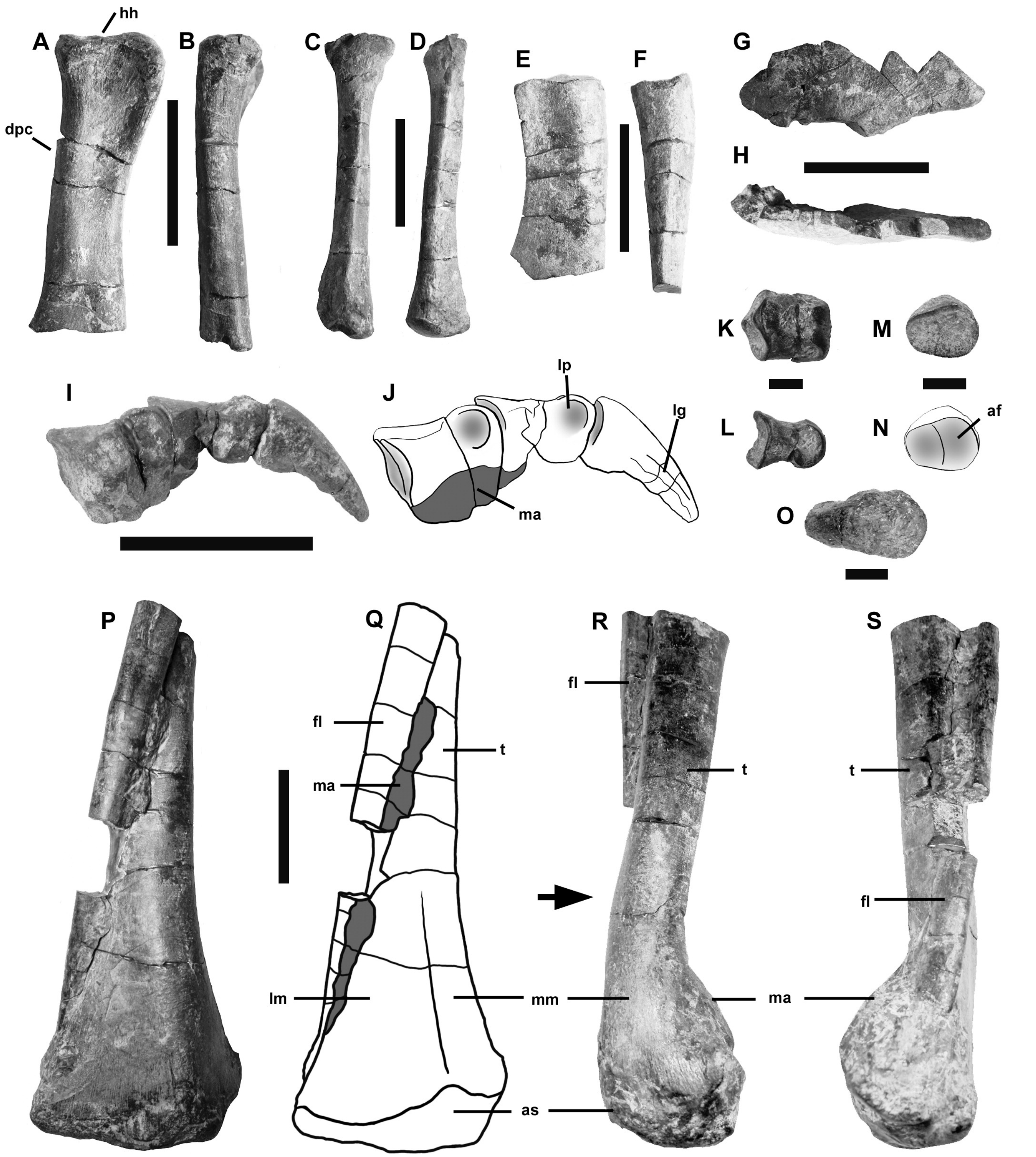

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Figure 2. The material from Sustut Basin, RBCM.EH.2006.019, an unidentified ornithopod (from Arbour & Graves, 2008). Right humerus in (A) medial view and (B) anterior view. Right radius in (C) medial view and (D) posterior view. Indeterminate bone in (E) medial or lateral view and (F) anterior or posterior view. Indeterminate bone in (G) "side" view and (H) "top" view. (I) Articulated phalanges, digit II, right pes, in lateral view. (J) Outline drawing of (I) showing details. Penultimate phalanx, digit IV, right pes, in (K) dorsal view and (L) lateral view. Ungual, digit IV, right pes, in (M) proximal view and (O) dorsal view. (N) Outline drawing of (M) showing articular facets. Distal part of left tibia and fibula in (P) posterior view, (R) medial view, and (S) lateral view. (Q) Outline drawing of (P) showing details. The arrow indicates the pronounced distal curvature in the tibia. In A–J and P–S, scale bars = 5 cm; in K–O, scale bars = 1 cm. af, articular facet; as, astragalus; dpc, deltopectoral crest; fl, fibula; hh, humeral head; lg, lateral groove; lm, lateral malleolus; lp, lateral pit; ma, matrix; mm, medial malleolus; t, tibia. From Arbour & Graves (2008), fig. 2. Original Copyright Canadian Science Publishing. This image is reproduced in this manuscript under Fair Use, in order to review the relevant literature. The original copyright holder retains all rights and copyrights to this image.

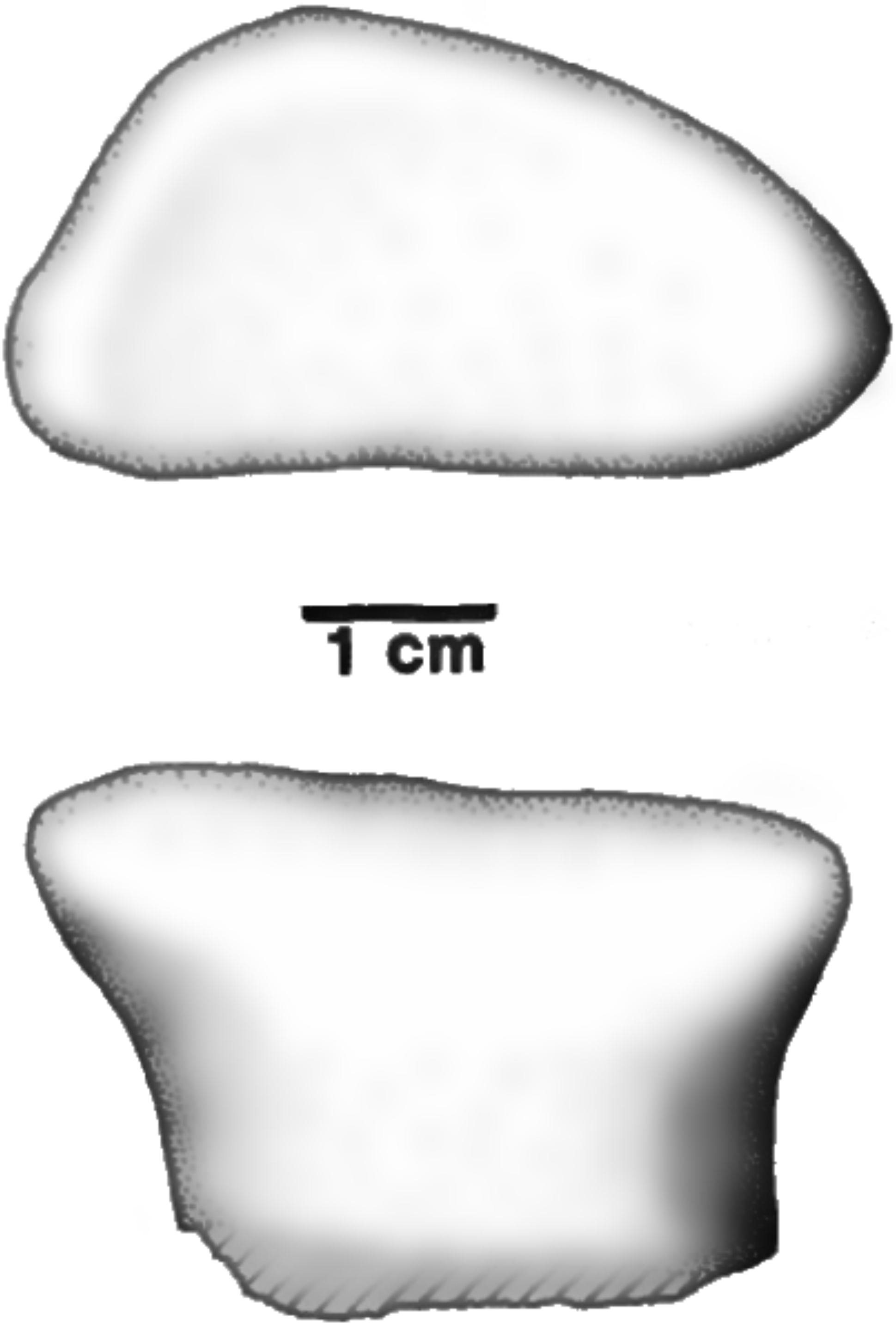

Figure 3. Fossilized manual phalanx of an ornithopod dinosaur from Fernie, southeastern British Columbia, in proximal and dorsal views. Scale bar equals 1 cm. From Sampson & Currie (1996) fig. 12.1. Copyright UBC Press. This image is reproduced in this manuscript under Fair Use, in order to review the relevant literature. The original copyright holder retains all rights and copyrights to this image.

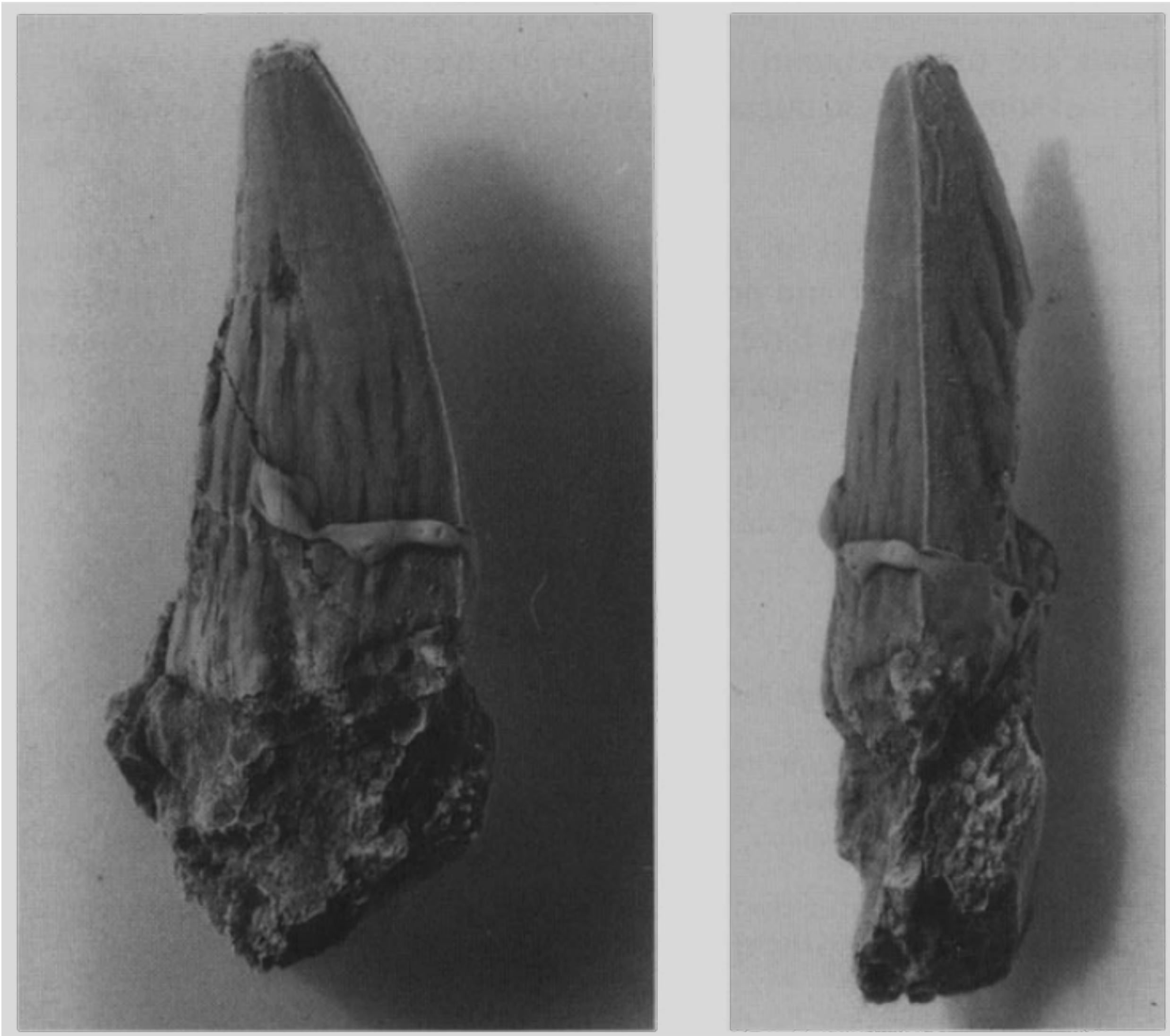

Figure 4. Theropod tooth from Trent River, Vancouver Island, British Columbia, in lingual and anterior views. Total tooth length ~1cm (Ludvigsen, 1996). From Ludvigsen (1996) fig. 13.8. Copyright UBC Press. This image is reproduced in this manuscript under Fair Use, in order to review the relevant literature. The original copyright holder retains all rights and copyrights to this image.

Figure 5. Several dinosaur bones from the Tumbler Ridge deposits in the hard sandstone matrix. Scale bar = 10cm. From McCrea & Buckley (2004), fig. 5a. Copyright Alberta Palaeontological Society. This image is reproduced in this manuscript under Fair Use, in order to review the relevant literature. The original copyright holder retains all rights and copyrights to this image.

Figure 6. Life restoration of the Sustut Basin ornithopod, with unknown proportions based on *Parksosaurus*, with integument based on *Kulindadromeus*. Illustration by the author. Scale bar = 1 meter.

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