The First Record of Dinosaur Footprints in the State of Washington, USA

ROSS, Marcus R., Dept. of General Math & Science, Liberty University, 1971 University Blvd, Lynchburg, VA 24502
MCLAIN, Matthew A., Dept. of Biological and Physical Sciences, The Master's University, 21726 Placerita Canyon Road, Santa Clarita, CA 91321

Abstract

Dinosaur remains from the western shoreline of Laramidia (near the modern-day Pacific Coast of North America) are rare and often isolated and/or fragmentary. The majority of the finds come from the southerly regions of Baja, Mexico and nearby southern California, with only a handful of dinosaur-bearing localities from central California to coastal Alaska. To date, the State of Washington has only produced one dinosaur fossil: a partial proximal left femur from a theropod recovered from the Upper Cretaceous (Campanian) Cedar District formation of the Nainamo Group at Sucia Island State Park.

Here we report the discovery of the first dinosaur track site from the State of Washington. The locality is along the eastern flank of the Cascade Mountains near the city of Ellensburg, and it consists of a series of buff sandstones and dark gray-to-black shaley mudstones exposed along a road cut. The dinosaur tracks are preserved as sand infills (natural hypichnial casts) atop the shaley mudstones in which the prints were made. Three dinosaur groups are represented by two complete and three partial tracks: one partial theropod pes, two partial and one complete ornithopod pes, and one complete ankylosaur pes with detailed skin impressions.

The locality's strata are assigned to the Upper Cretaceous on the basis of an isolated mosasaur tooth crown from a shale unit directly beneath the track-bearing sandstone. The recovery of this tooth also represents the first occurrence of mosasaur fossils from the State of Washington and confirms a marine depositional environment for the shale units. In addition to dinosaur tracks, sandstone layers contain cross-beds, ripple marks, worm burrows, and terrestrial plant material including both woody tissue and leaves. Frequent alternations of shale and sandstone indicate a dynamic nearshore environment.

Location and Stratigraphy of Study Area

The track-bearing outcrop is located in north-central Kittitas County, approximately 25 miles north of Ellensburg, WA within the Okanogan-Wenatchee National Forest (**Figure 1**). A roadcut exposed along US-97 consists of an alternating series of buff sandstones and dark gray-to-black shaley mudstones dipping steeply to the north (**Figure 2**). These alternating sediments represent terrestrial and nearshore sands and marine mudstones containing vertebrate body and trace fossils in addition to plant fossils of both woody tissue and leaves. Assignment of these sediments to the Upper Cretaceous is made on the basis of an isolated mosasaur tooth crown recovered from the shale unit directly below the track-bearing sandstone.

No Cretaceous strata have previously been identified in this region of the state. Rather, the terrestrial (dominantly fluvial) Swauk Formation is the primary sedimentary unit known to crop out in the study area. The Swauk Formation and its correlatives in central and northwestern Washington (the Chuckanut, Manastash, and Huntington formations) were previously thought to include Cretaceous sediments, but are now recognized as upper Paleogene through early Oligocene on the basis of radiometrics, palynoflora, plant macrofossils, freshwater mollusks, and mammal fossils (see Mustoe and Gannaway 1997 and Mustoe *et al.* 2007 for reviews).

Sediment of the Upper Cretaceous (Turonian through lower Maastrichtian) Nanaimo Group are exposed on the San Juan Islands (Washington, USA) and Vancouver Island (British Columbia, Canada) approximately 240 km northwest of the study area. The Nanaimo Group consists of conglomerates, sandstones, and mudstones interpreted as deposits of an offshore marine fan (Mustard 1994, Mustard *et al.* 1999). Cretaceous vertebrate fossils are known from both locations (Peecoock & Sidor 2015, Nicholls & Meckert 2002). While it is uncertain at this time if the sediments exposed at this site are an eastern extension of the Nanaimo Group or merely correlative, the presence of terrestrial vertebrate trace fossils confirm a dynamic nearshore depositional environment at this location.

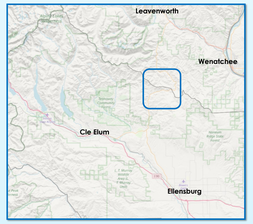

Figure 1. General location of study area. Map from mrdata.usgs.gov.

Figure 2. Outcrop exposure along US-97.

Preliminary Measured Section

A preliminary measured section is presented in **Figure 3**. Due to moderate snow cover during initial reconnaissance of the site, only 1.73 meters of sediments could be observed and measured. Our preliminary measured section is taken along a vertical line near the *in situ* footprints. Our section measures 1.73 meters in thickness. Sandstones in the upper portion of this section contain ripple cross-lamination and trough cross-bedding, while the lowest sandstone observed contains abundant plant fossils, trace fossils, and hypichnial casts of dinosaur footprints representing at least three groups (ankylosaurs, ornithopods, and theropods). An isolated mosasaur tooth was recovered from the lowest mudstone.

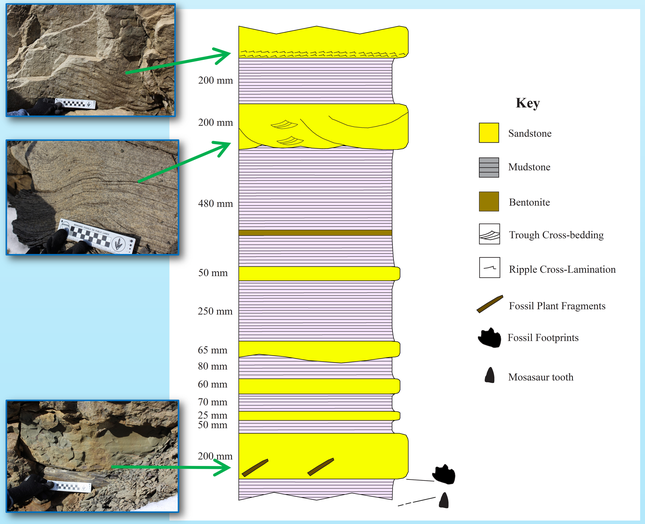

Figure 3. Measured stratigraphic column at the Washington dinosaur track site. Features of sandstone units shown at left.

Dinosaur Footprint Casts

To date, only one dinosaur fossil has been recovered in the State of Washington: a partial proximal left femur from a theropod recovered from the Upper Cretaceous (Campanian) Cedar District formation of the Nainamo Group at Sucia Island State Park (Peecook & Sidor 2015).

The new fossils reported here represent significant first discoveries and increase the documented dinosaur diversity within Washington. Footprints were made in on exposed marine-deposited muds and subsequently infilled with sand, forming natural hypichnial casts. Three casts were previously removed from the outcrop and two additional casts were identified *in situ* at the outcrop. These casts represent the following three dinosaur groups:

- **Ankylosaur**—One complete cast of the right pes featuring four digits and exceptional detail with distinct scale impressions on the heel pad (**Figure 4**).
- **Theropod**—One partial cast recovered from the outcrop featuring a well-preserved Digit III and partial preservation of Digits II and IV, and one *in situ* partial track (**Figure 5**).
- **Ornithopod**—One complete cast recovered from the outcrop, one partial cast recovered from the outcrop, and one possibly complete cast located at the outcrop (**Figure 6**).

Mosasaur Tooth Crown

In addition to the footprint casts, an isolated mosasaur tooth crown (**Figure 7**) was recovered from the shale below the cast-bearing sandstone. The tooth crown is 14mm high, slightly laterally compressed, and possesses non-serrated carinae on the anterior and posterior margins. There are nine small concave facets on the labial surface and eleven concave facets on the lingual surface.

The small size and distinctive shape lends assignment to the mosasaurine *Kourisodon* (Nicholls and Meckert 2002), though the tooth does not display a pronounced posterior curvature. The type of this genus, *K. puntledgensis,* was recovered from the Upper Santonian Pender Formation of the Nanaimo Group in Vancouver Island (Nicholls and Meckert 2002) and *K.* sp. Is reported from the Upper Campanian Hiketa Formation of the Izumi Group at Shikoku Island, Japan (Tanimoto 2005).

Figure 7. An isolated tooth of cf. *Kourisodon* recovered from the lower shale unit below the dinosaur track-bearing sandstone. Scale bar = 2 cm.

Plant & Trace Fossils

While vertebrate fossils were the focus of our preliminary reconnaissance, the outcrop contains a substantial amount of plant material and invertebrate trace fossils as well.

Plant material consists of preserved woody tissue and leaves in the sandstone units. (**Figure 8**, upper). Orientations within fossil-bearing beds range from horizontal to vertical. Trace fossils include both horizontal and vertical burrows (**Figure 8**, lower)

Figure 8. Leaf fossil (upper) and trace fossils (lower) from the track-bearing sandstone.

Figure 4. Ankylosaur footprint cast with well-preserved digits marked (left) and detail of footpad scale impressions (right). Scale bar in cm.

Figure 5. Partial theropod track cast in top (left) and oblique (center) views. Possible *in situ* theropod cast (right). Scale bar in cm.

Figure 6. Complete ornithopod track cast (left), possible partial cast (center images) and complete(?) *in situ* cast (right). Scale bar in cm.

Acknowledgements

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