A MIDDLE EOCENE BRONTOTHERE (MAMMALIA; PERISSODACTYLA; BRONTOTHERIIDAE) FROM YELLOWSTONE NATIONAL PARK, WYOMING

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Abstract—A jaw fragment with a lower third molar of a small brontothere, *Palaeosyops* sp. cf. *P. laevidens*, was collected from a volcanic alluvial mudflow conglomerate from the Wapiti Formation of the Absaroka Volcanic Supergroup, on Mount Hornaday, in the northeastern section of Yellowstone National Park, Wyoming. *Palaeosyops laevidens* has been found in early middle Bridgerian (Br2, Middle Eocene) sites in the Green River Basin of Wyoming. The presence of a species assigned to *P. laevidens* in the Wapiti Formation of the Absaroka Volcanic Supergroup adds additional support to the proposed early middle Bridgerian age of the Wapiti Formation.

INTRODUCTION

Yellowstone National Park, located in the northwestern corner of Wyoming and adjoining areas of eastern Idaho and southern Montana, hosts millions of visitors each year who come to see both the scenic geologic heritage features and the abundant wildlife found within the park boundaries. The park was established in 1872 and represents America's first national park. However, few visitors are aware that Yellowstone also has a rich and diverse paleontological history that spans from the Cambrian to the Quaternary (Santucci, 1998; Tweet et al., 2013). Early and late Cenozoic volcanism has obscured much of the fossil history of Yellowstone National Park but also has helped preserve some of its more distinctive fossil resources. In particular, Eocene volcanism has preserved an extensive paleobotanical record that has provided important information of the paleoenvironment of this region of North America for the lower Eocene.

The Eocene Geology and Paleontology of Yellowstone National Park

The Eocene rocks of Yellowstone National Park pertain to the Absaroka Volcanic Supergroup. The supergroup is dominated by volcanic and volcaniclastic sedimentary rocks produced during the early and middle Eocene by a series of stratovolcanoes situated northwest to southeast across the park (Smedes and Prostka, 1972). The supergroup is divided into three successive groups, in ascending order the Washburn, Sunlight, and Thorofare Creek Groups, with several formations in each that have complex stratigraphic relationships (Smedes and Prostka, 1972). Paleontologically the most famous of these are the Sepulcher Formation and laterally equivalent Lamar River Formation of the Washburn Group. Outcrops of these formations within Yellowstone National Park have been known for their rich paleobotanical records since the late 1800s (e.g., Lesquereux, 1872; Knowlton, 1899). Petrified wood, foliage impressions and palynomorphs are well known in the Sepulcher and Lamar River Formations and the younger Langford Formation (Thorofare Group) indicating the presence of redwoods, maples, dogwoods, sycamores, magnolia, horsetails, cycads, ferns, and other plants adapted to warmer and more humid conditions than what we see at Yellowstone today (Dorf, 1960; Fritz, 1980). A striking example of the paleobotanical record at Yellowstone National Park can be seen at Specimen Ridge which contains numerous standing silicified tree stumps, representing multiple events of forests being buried by volcanic activities that occurred during the deposition of the Lamar River Formation (Dorf, 1960; Yuretich, 1980). Until recently, no invertebrate or vertebrate body fossils had been reported from the Absaroka Volcanic Supergroup. Here we report on the first vertebrate fossil, a brontotheriid jaw fragment, from the early middle Bridgerian Wapiti Formation of the Sunlight Group of the Absaroka Volcanic Supergroup at Yellowstone National Park.

MATERIALS AND METHODS

The specimen described here was collected by USGS biologist Craig Whitman in 1998 while doing carnivore survey work on Mount Hornaday, in Yellowstone National Park. The fossil is reposited in the Yellowstone National Park Heritage and Research Center in Gardiner, Montana. This specimen was initially identified as an indeterminate brontothere by Bill Wall of Georgia College and State University (YELL archives). Photographs were made using an Apple iPhone 12 and measurements made with digital calipers. Figures were edited and generated with Adobe Photoshop and Adobe Illustrator respectively.

Institutional Abbreviations: **AMNH**, American Museum of Natural History, New York; **YELL**, Yellowstone National Park Heritage and Research Center, Gardiner, Montana.

GEOLOGIC SETTING

The brontotheriid jaw fragment was collected from the upper slopes of Mount Hornaday from a volcanic alluvial mudflow conglomerate of the Wapiti Formation of the Sunlight Group, which is part of Absaroka Volcanic Supergroup (Fig. 1). The Wapiti Formation overlies the Willwood Formation at the type section, near Wapiti, Wyoming, and overlies the Lamar River Formation or Cathedral Cliffs Formation in the northwest section of Yellowstone National Park (Smedes and Prostka, 1972). In turn, the Wapiti Formation is overlain by the Trout Peak Trachyandesite, also of the Sunlight Group (Smedes and Prostka, 1972). The Wapiti Formation was originally defined by Nelson and Pierce (1968) as a sequence of andesitic volcaniclastic rocks and lesser amounts of interlayered lava flows of trachyandesite and minor dacite (Smedes and Prostka, 1972). In the Sunlight Creek and Crandall Creek regions of Yellowstone National Park, the Wapiti Formation consists primarily of dikes and intrusive features that grade outward into interfingering vent and alluvial facies rocks in the northeastern region of the park, which includes Mount Hornaday (Smedes and Prostka, 1972). To the southeast, near Wapiti, this formation grades laterally from predominantly

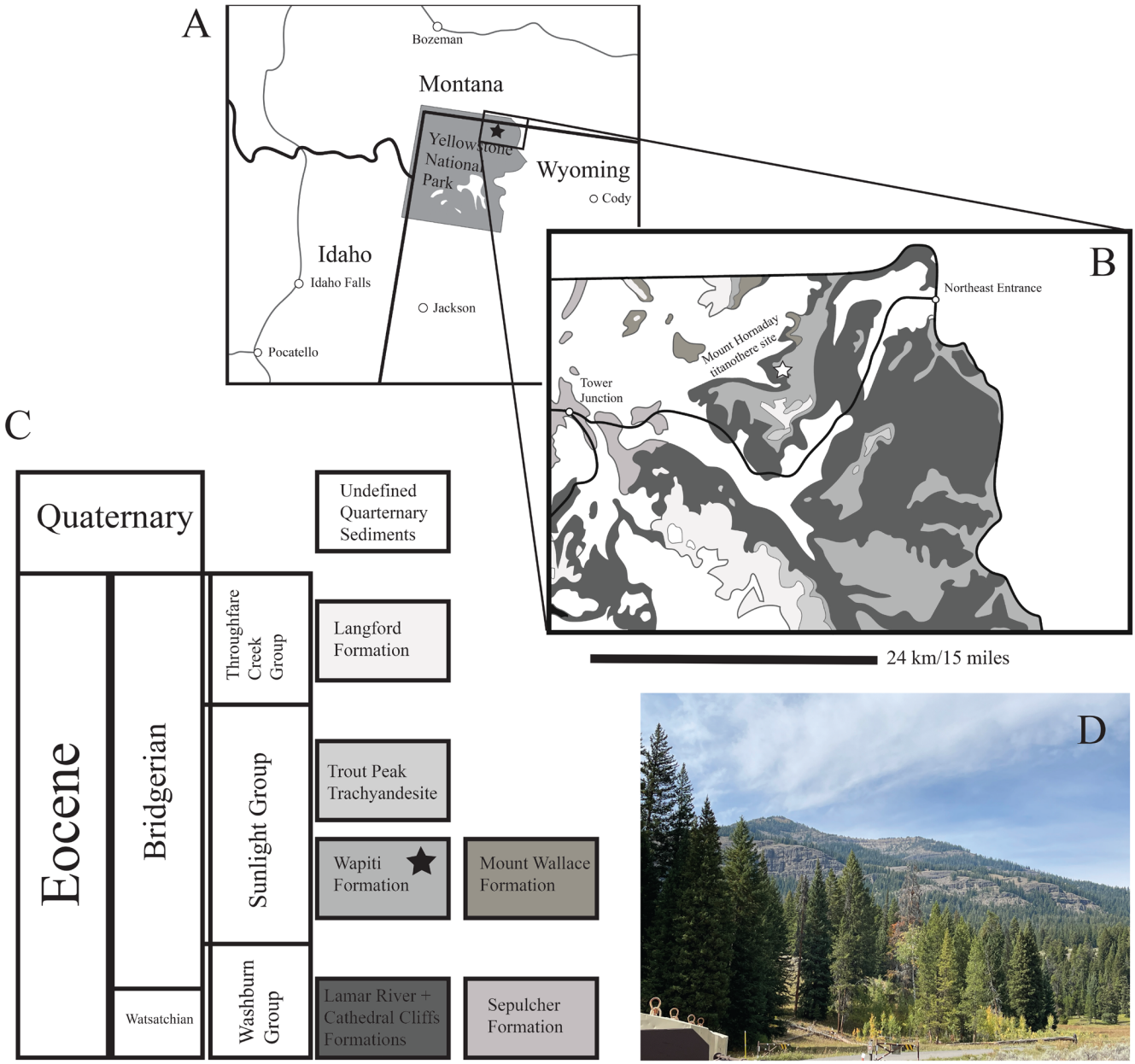


FIGURE 1. The relative location of the Mount Hornaday brontothere site within Yellowstone National Park and its relative stratigraphic position. **A**, The location of Yellowstone National Park in Idaho, Montana, and Wyoming; star indicating the region of interest. **B**, The geologic distribution of the Absaroka Volcanic Supergroup in the northeast corner of Yellowstone National Park and the approximate location of the Mount Hornaday brontothere site (white star) in the Wapiti Formation; geologic features are color-coded and correspond to stratigraphic information in fig. C. **C**, The stratigraphic distribution of the Absaroka Volcanic Supergroup groups and formations seen in fig B; star indicating the stratigraphic position of the Wapiti Formation and the age of the Mount Hornaday titanothere. **D**, Photo of Mount Hornaday (photo by JPH).

volcanic breccia and conglomerate to predominately volcanic sandstone and siltstone (Smedes and Prostka, 1972). This finer-grained equivalent is also known as the Pitchfork Formation, and a thick wedge of Wapiti Formation is interbedded with the Pitchfork Formation along the Shoshone River (Hay, 1956; Nelson and Pierce, 1968; Gunnell et al., 1992).

The age of the Wapiti Formation was placed by Smedes and Prostka (1972) as early middle Eocene. It is stratigraphically above rocks of the Washburn Group regarded as dating to the early Bridgerian North American Land Mammal Age (NALMA), and interfingers with and is overlain by the Trout Peak Trachyandesite which produced potassium-argon dates of 48.0 ± 1.3 m.y.—middle Eocene (early middle Bridgerian) (Smedes and Prostka, 1972). The Sepulcher and Lamar River Formations are dated to the late Wasatchian to early Bridgerian NALMAs; the Lost Creek Tuff Member of the lower Sepulcher Formation is dated to 49.2 ± 1.5 m.y. (Smedes and Prostka, 1972). The Langford Formation is considered to be younger Bridgerian (Smedes and Prostka, 1972). Vertebrate and paleobotanical fossils from the laterally equivalent Pitchfork Formation are dated to the middle Eocene (Hay, 1956). Gunnell et al. (1992) described a number of vertebrate faunal assemblages (the Wapiti Valley local fauna) of the underlying Aycross and Willwood formations to the southeast of Yellowstone National Park. The upper sections of the Willwood Formation had faunal assemblages that represent latest Wasatchian (Wa7) and earliest Bridgerian (Br1a) while

the Aycross Formation contained characteristic early to middle Bridgerian (Br1b-Br2) taxa (Gunnell et al., 1992). If the stratigraphy and corresponding biostratigraphy of the Wapiti Valley local faunae (Gunnell et al., 1992) is correlative with the Hornaday Mountain site, then we interpret the Wapiti Formation as no older than middle Bridgerian (Br2).

Bridgerian Brontotheres

During the Bridgerian of the middle Eocene at least four genera of early hornless brontotheriids occurred in North America (Fig. 2). *Eotitanops* is one of the earliest and smallest, known from two species; *E. borealis* and *E. minimus* (Gunnell and Yarborough, 2000; Mihlbachler, 2008). *E. borealis* is from the index taxon for the lower Bridgerian (Br1a, Gunnell et al., 2009) of Wyoming, Colorado, and Baja California (Gunnell and Yarborough, 2000). *E. minimus* is known from the lower Bridgerian (Br1a; Gunnell et al., 2009) of Colorado and Wyoming including the Aycross Formation southeast of Yellowstone National Park (Gunnell and Yarborough, 2000). *Palaeosyops* was a common brontotheriid throughout the Bridgerian and is currently known from five species. The earliest species of *Palaeosyops* is *P. fontinalis* from the lower Bridgerian (Br1b, Gunnell et al., 2009) from Colorado and Wyoming, including the Aycross Formation southeast of Yellowstone National Park (Gunnell and Yarborough, 2000). *P. paludosus* and *P. laevidens* are both index taxa for the middle Bridgerian (Br2, Gunnell et al., 2009) of the Green River Basin of Wyoming. *P. robustus* and *P. laticeps* are from the upper Bridgerian (Br3, Gunnell et al., 2009) of the southern Green River Basin of Wyoming (Gunnell and Yarborough, 2000). *Telmatherium validus*, an upper Bridgerian brontothere from Wyoming, is also known from the Aycross Formation, southeast of Yellowstone

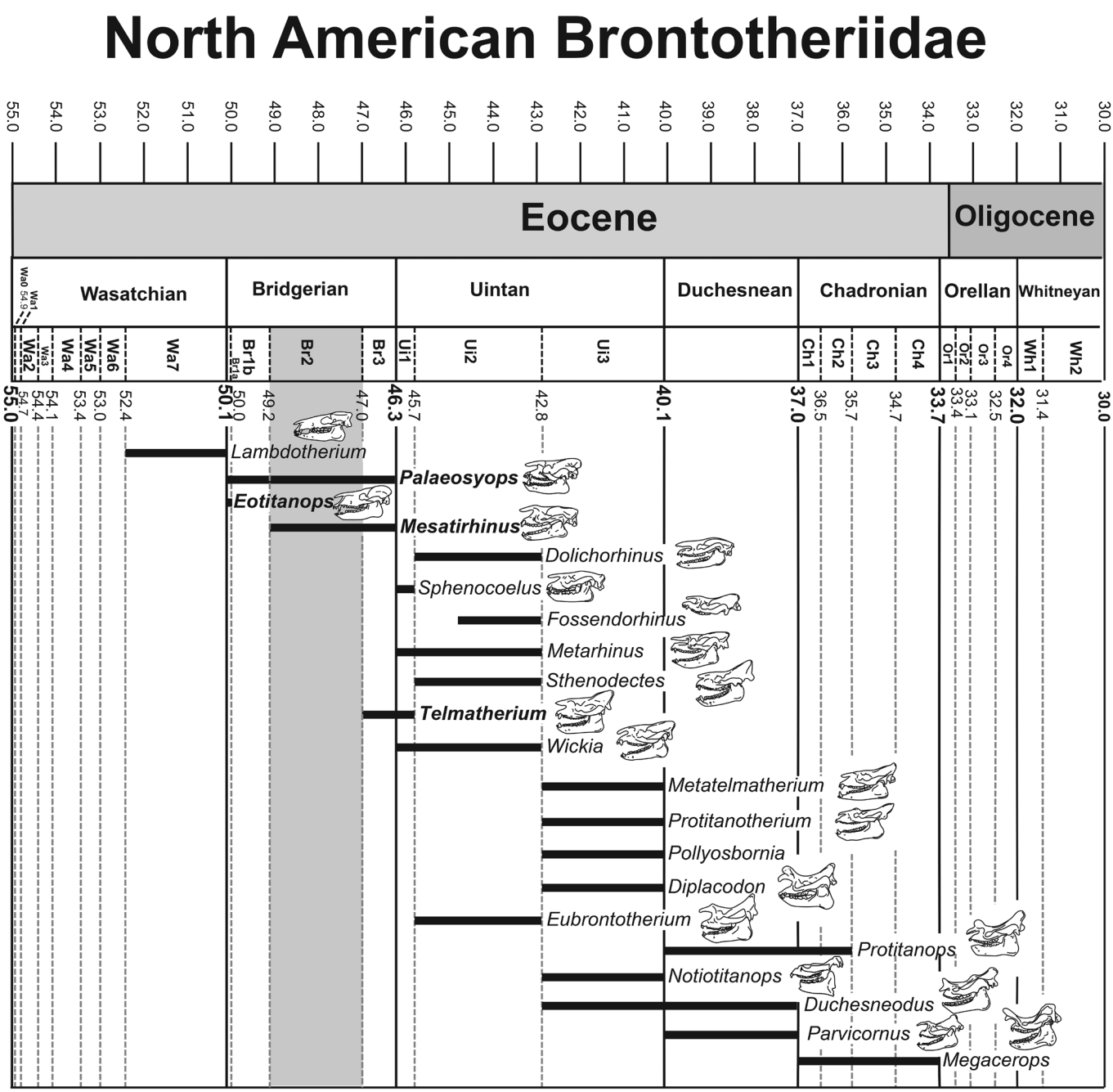


FIGURE 2. Biochronology of the Brontotheriidae with the middle Bridgerian (Br2) highlighted.

National Park (Mihlbachler, 2008). *Mesatirhinus junius* was a late Bridgerian to early Uintan brontothere of Wyoming and Colorado (Mihlbachler, 2008).

SYSTEMATIC PALEONTOLOGY
CLASS Mammalia Linnaeus, 1758
ORDER Perissodactyla Owen, 1848
FAMILY Brontotheriidae Marsh, 1873
SUBFAMILY Palaeosyopinae Steinmann and Döderlei, 1890
GENUS *Palaeosyops* Leidy, 1870
Palaeosyops sp. cf. *P. laevidens* Cope, 1873

Occurrence—Volcanic alluvial mudflow conglomerate from the Wapiti Formation, Absaroka Volcanic Supergroup, on Mount Hornaday, Yellowstone National Park, Wyoming.

Material—YELL 134174, a left m3, missing distal hypoconulid, and section of ramus (Fig. 3).

Description—The preserved tooth from Mount Hornaday represents a small brontotheriid with mesiodistal preserved length of 36.2 millimeters and a labiolingual width of 23.8 millimeters (Fig. 4). The hypoconulid has broken away but a remnant of the distal root is present. The crown shows little wear on the lophs. The lophs form a w-shaped pattern. A small labial cingulid is present on the mesial margin of the base of the crown. A small paraconid is present and moderately developed with a short mesiodistal ridge. The protoconid is relatively tall and narrow, approximately the same height as the hypoconid. The paralophid is a short crest, roughly half the length of the protolophid. The protolophid is a long thin crest forming between the protoconid and the metaconid. The v-shaped trigonid basin is shallow with a pentagonal basin at the center, formed by the rise of the paraconid, paralophid, protoconid and metaconid. The metaconid is relatively tall compared to the protoconid, hypoconid, and entoconid. A small metastylid is present. The cristid obliqua is a long narrow crest originating from the distal base of the metaconid and extends into the hypoconid. The entoconid is relatively small but is roughly at the same height of the protoconoid and hypoconid, bearing a distinct distal lingual ridge just prior to the hypoconulid. The v-shaped talonid basin is relatively shallow and is slightly wider than the trigonid basin.

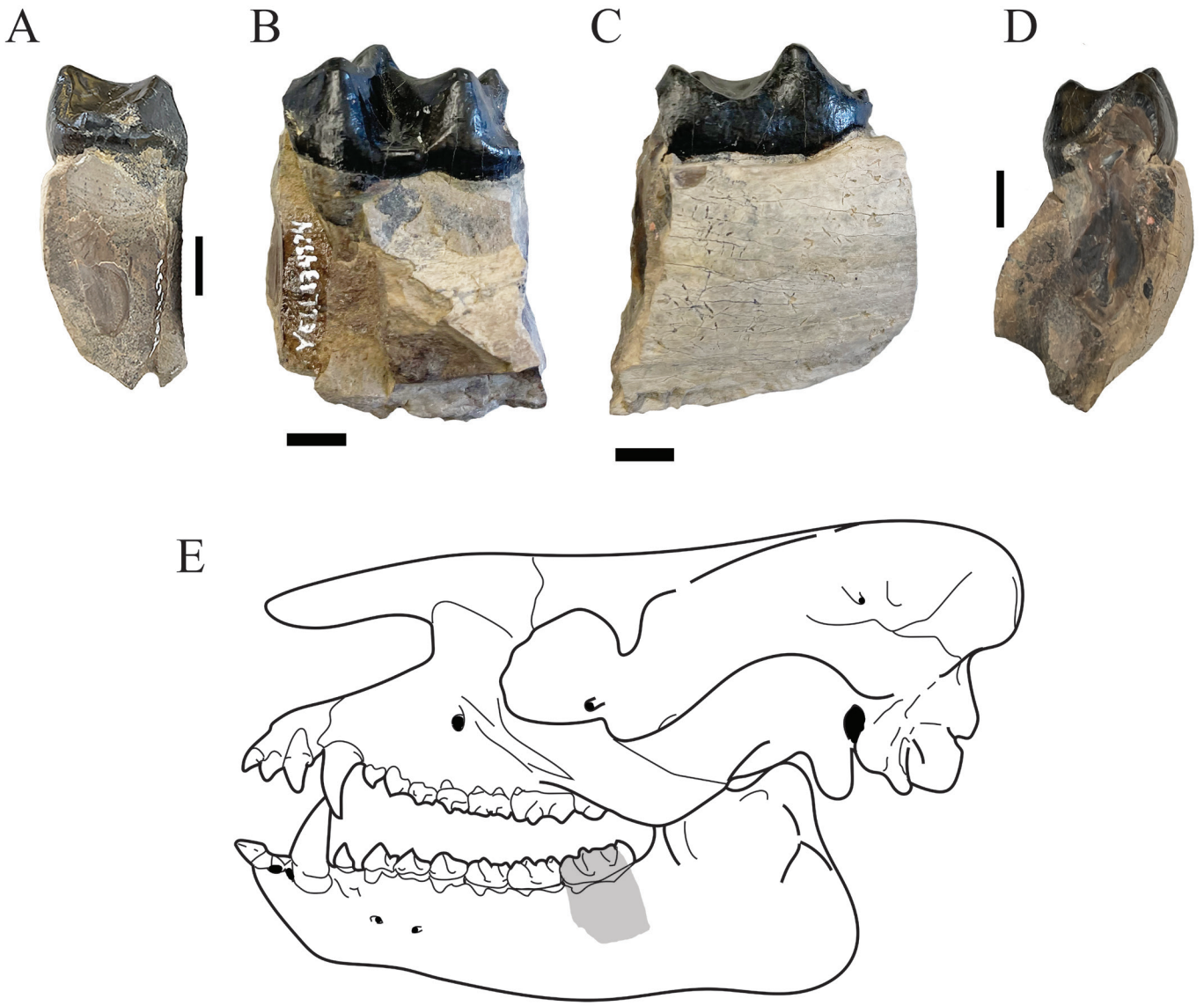


FIGURE 3. YELL 134174, partial left m3 and jaw fragment of *Palaeosyops* sp. cf. *P. laevidens*, from Mount Hornaday, Yellowstone National Park. **A**, anterior, **B**, lateral, **C**, medial, **D**, posterior; scale is 1 cm. **E**, skull and jaw of *Palaeosyops laevidens* showing the position of YELL 134174 in gray (image redrawn and modified from Osborn, 1929).

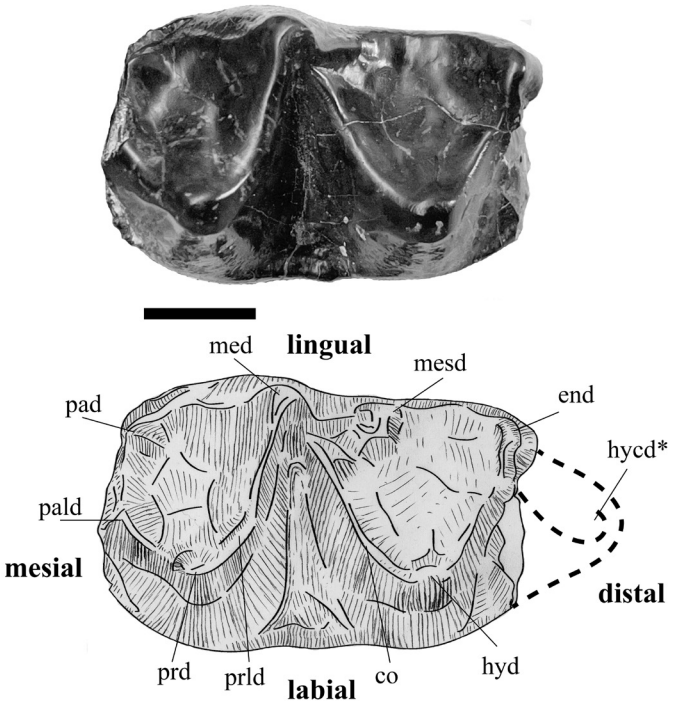


FIGURE 4. Oral view of YELL 134174, *Palaeosyops* sp. cf. *P. laevidens*, from Mount Hornaday, Yellowstone National Park. Above, a photograph of the specimen; below, a line diagram with the dental landmarks labeled. Scale is 1 cm. **Abbreviations co**- cristid obliqua, **hyd**- hypoconid, **hycd***- hypoconulid (missing), **end**- entoconid, **med**- metaconid, **mesd**- metastylid, **pad**- paraconid, **pald**- paralophid, **prld**- protolophid, **prd**- protoconid.

Remarks—The tooth and jaw fragment from Mount Hornaday can be confidently assigned to a brontothere by the w-shaped loph pattern which is noted for the upper and lower molars for the Brontotheriidae (Osborn, 1929; Mihlbachler, 2008). *Lambdotherium*, a small early Eocene (Wasatchian) perissodactyl from North America, also shares this w-shape loph pattern on its dentition; however, its taxonomic status as a brontotheriid is still debated and its small dentition size makes this a less likely candidate for the Yellowstone taxon (Lucas and Holbrook, 2004; Mihlbachler, 2008). The Bridgerian age of the Wapiti Formation in the Absaroka Volcanic Supergroup offers at least four candidate brontothere genera for the Yellowstone specimen (Fig. 5): *Eotitanops*, *Palaeosyops*, *Mesatirhinus*, and *Telmatherium* (Gunnell and Yarborough, 2000; Mihlbachler, 2008). These four taxa are known from Bridgerian sites in the northwestern region of Wyoming near Yellowstone National Park.

We describe YELL 134174 as a lower left m3 of *Palaeosyops* based on the presence of a pronounced though small paraconid, and the presence of a distinct distal lingual ridge on the entoconid which ends just prior to the hypoconulid, which we have observed in all five recognized species of *Palaeosyops*. The m3 of *Eotitanops*, *Mesatirhinus*, and *Telmatherium* lack a pronounced small paraconid and the distal lingual ridge. The m3 of *Mesatirhinus* and *Telmatherium* are proportionately more labiolingually narrow compared to YELL 134174, *Eotitanops*, and *Palaeosyops*. In addition, the position of the protoconid and hypoconid in *Mesatirhinus* and *Telmatherium* is closer to the labial margin of the crown compared to that seen in YELL 134174, *Eotitanops*, and *Palaeosyops*. We tentatively assign YELL 134174 to *Palaeosyops laevidens* as it has a pentagonal-shaped basin at the center of the trigonid basin and trigonid

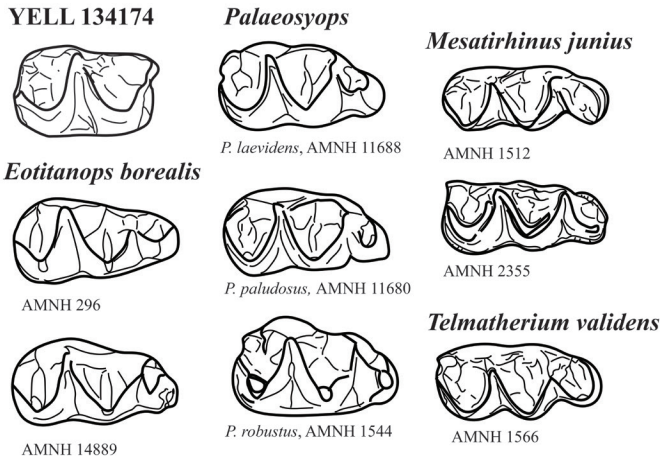


FIGURE 5. Line drawings of lower third molars of Bridgerian brontotheriids in comparison with YELL 134174. Teeth not drawn to scale.

labial lophs in a more u-shape compared to *P. paludosus* and *P. robustus*.

DISCUSSION AND CONCLUSIONS

Biochronologic correlation—Bown (1982) provided a preliminary paleontological inventory of the Aycross Formation from the southeast Absaroka Range. Bown (1982) described material referred to the brontothere *Palaeosyops fontinalis* and the uintathere *Bathyopsis middleswarti* from the Owl Creek-Grass Creek area, which were considered index taxa for "Bridger A" (Br1a-Br1b). Correlation with the type area of the Aycross Formation demonstrates more expansive biostratigraphic ranges in the Duncan Ranch fauna (Bown, 1982; Wood et al., 1936). Three distinct assemblages from different levels of the Acyross Formation contained occurrences of *Eotitanops borealis* (Br1a), *Palaeosyops* sp. cf. *P. major* (= *P. paludosus*; Br2), and *Uintatherium* sp. cf. U. *mirable* (= *U. anceps*; Br3-Ui2) (Bown, 1982; Wood et al., 1936). Other notable occurrences in the Duncan Ranch Fauna included *Patriofelis ferox* (Br2-3), *Hyrachyus* sp. cf. *H. modestus* (Br1a-Br3), and *Telmatherium* sp. cf. *T. validum* (= *T. validus*; Br3). If this faunal assessment is reliable, then the Aycross Formation has yet to produce a biochronologic fauna younger than late Bridgerian (Br3).

Gunnell et al. (1992) have provided the only representative local fauna with proximity to the Wapiti Formation as well as the Hornaday Mountain site. The Wapiti Valley faunae are comprised of 5 levels of local faunae (Wapiti I-V) (Gunnell et al., 1992). The Wapiti V local fauna is situated in the "Bridger B" of the Aycross Formation, which contains a characteristic middle Bridgerian (Br2) fauna, based on the occurrence of the index taxon *Smilodectes gracilis* (Gunnell et al., 1992). However, no fauna has been previously recovered from the Wapiti Formation, which could infer that this unit should contain taxa representing middle Bridgerian or younger biochronologic zone. Gunnell et al. (2009) produced a refined and formalized biostratigraphy of the latest Wasatchian (Wa7) to the late Uintan (Ui3) in the Green River Basin. The biochronology represented in the Green River Basin reinforced previous interpretations by Bown (1982) and Gunnell et al. (1992), in particular the interpretation of the Wapiti V local fauna as middle Bridgerian (Br2) (Gunnell et al., 2009). Gunnell and Yarborough (2000) noted that *Palaeosyops laevidens* was currently found only in the early beginnings of the middle Bridgerian (Br2). If our interpretation of YELL 134174 as *Palaeosyops* sp. cf. *P. laevidens* hold true, this makes the Yellowstone brontothere an important index taxon, providing biochronologic age support for the Wapiti Formation at the

Mount Hornaday site as at least middle Bridgerian (Br2), as proposed from geologic evidence from previous work (Smedes and Prostka, 1972).

Aside from the few, aforementioned reports, there seems to have been no further exploration into the paleontological significance of the Aycross Formation and associated units. Considering the good preservation of YELL 134174, it might be worthwhile to further explore the area further. A new paleontological survey of the western and northwestern Absaroka Mountains could reveal more significant fossils and localities that can help expand knowledge of the Paleogene faunae of the Yellowstone area.

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