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SHORT COMMUNICATION

NEW RECORDS OF RHINOCEROSES FROM THE RINGOLD FORMATION OF CENTRAL WASHINGTON AND THE HEMPHILLIAN-BLANCAN BOUNDARY

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Fossil specimens of two genera of rhinocerotids are here reported from the late Miocene to early Pliocene Ringold Formation of south-central Washington State. The metacarpal of *Aphelops* is the farthest northwest record of this Hemphillian rhino, the first authentic record of *Aphelops* from this state, and the first fossil mammal from the lower part of the Ringold section. An upper molar of *Teleoceras* is the first rhino specimen recorded from the White Bluffs Local Fauna (early Blancan). The presence of *Teleoceras* in a clear superpositional relationship above strata containing microtine rodents clarifies the stratigraphic and chronologic sequence of these biostratigraphically critical taxa near the Hemphillian-Blancan boundary and demonstrates their actual chronological overlap.

GEOGRAPHIC AND GEOLOGIC SETTING

The Ringold Formation is a continental basin-filling sedimentary stratigraphic unit in central Washington State. It is best exposed in bluffs along the Columbia River where the river passes through the Pasco Basin (Fig. 1). These late Miocene and early Pliocene sediments overlie flows of the Miocene Columbia River Basalt Group. Detailed geological descriptions of the area have been published by numerous authors (i.e., Newcomb, 1958; Brown and McConiga, 1959; Gustafson, 1978, 1986; Lindsey, 1996; Smith, Morgan, and Gustafson, 2000). Sedimentation commenced with the onset of basin development and basalt deformation sometime after the emplacement of the Elephant Mountain basalt flow at about 10 Ma. A complex set of fluvial and lacustrine depositional systems developed as the basin floor settled. The earliest sediments were deformed along with the basalt; higher (later) sediments show progressively less deformation (Brown and McConiga, 1959; Fig. 2). Exposed sediments in the White Bluffs along the east bank of the Columbia River show an irregularly fining-upward sequence beginning with coarse gravel (Taylor Flat conglomerate of Gustafson, 1978) overlain by finer fluvial sands and overbank deposits, in turn overlain by lacustrine deposits demonstrating three major episodes of significant ponding, interrupted and overlain by more fluvial deposits (Lindsey, 1996). Additional sediments underlie the main exposures but are only seen at the surface in a few basin-marginal areas.

Three local faunas (l.f.) have been described from the Ringold Formation in the White Bluffs, from levels indicated on Figure 2. The River Road l.f., from the Taylor Flat conglomerate, is considered late Hemphillian (Gustafson, 1977, 1978; Smith, Morgan, and Gustafson, 2000). The White Bluffs l.f. (Gustafson, 1978), from many localities in the fluvial sediments above the conglomerate and beneath the lacustrine levels, is dated as very early Blancan (Blancan I of Repenning, 1987). This local fauna can be divided into an upper level (here designated White Bluffs U l.f.) and a lower level (White Bluff L l.f.) that are separated in many places by a 1-m-thick volcanic ash marker bed, the White Bluffs tuff of Gustafson (1978). Highest in the section is the Blufftop l.f. (Gustafson, 1986; Smith, Morgan, and Gustafson, 2000), from fluvial sediments above the lacustrine levels, early Blancan (Blancan II of Repenning, 1987). Thus the Ringold Formation sediments span a period from the late Miocene through the early Pliocene that includes the boundary between the Hemphillian and Blancan North American Land Mammal Ages.

SYSTEMATIC PALEONTOLOGY

Family RHINOCEROTIDAE Gray, 1821
Subfamily ACERATHERIINAE Dollo, 1885
Genus *APHELOPS* Cope, 1874
APHELOPS cf. *A. MUTILUS* (Matthew, 1924)
(Fig. 3)

Specimen—University of Oregon Museum of Natural History (Condon Museum) F-31612. In 1979, during excavations for a basement, workmen came across this isolated bone. It was given to Randall Brown, a local geologist who was working on ground water problems in the area. Brown subsequently gave it to the Condon Museum.

Locality—UOMNH 2720, latitude 46°13′35″N, longitude 119°16′51″W, Benton County, Washington (Fig. 1).

Description—A third metacarpal (Mc3) measuring 167 mm in length and 44 mm in proximal width. It closely resembles the equivalent bone of the Miocene rhino genus *Aphelops.*

Determining a specific identification is questionable from this single bone, although Prothero (2005) records only one species of *Aphelops* (*A. mutilis*) from the latest Miocene. Measurements for Mc3 listed by Prothero for *A. mutilis* (mean of six individuals) are L = 153 mm, PW = 48 mm, similar in width but slightly shorter than the Ringold specimen.

This is the first rhino specimen from levels of the Ringold Formation older than the Taylor Flat conglomerate, the first specimen of this genus from Washington, and is the oldest mammalian specimen yet known from post-basalt sediments in the Pasco Basin. Because of the unique stratigraphic position of this specimen, I do not include it in any of the previously described Ringold Formation local faunas.

Geology of UOMNH 2720 Site—The area is on the southwestern margin of the Pasco Basin, occupying a synclinal valley between two anticlinal ridges whose crests trend NW–SE. The northern ridge is relatively low. The southern ridge, Badger Mountain, is much higher and erosion has exposed the basalt strata in its core. Sediments in the area where the rhino fossil was found are not well exposed. A small exposure of Ringold sediment (characterized by substantial consolidation and minor iron-oxide staining) is still exposed near the discovery site. It is a fine-grained silt and clay, tan to slightly yellowish-brown, with poorly defined stratification. It resembles some sediments of the Facies association III (floodplain-overbank environment where pedogenic alteration occurred) as described in other areas of Ringold Formation exposure by Lindsey (1996). Total thickness of the Ringold sediments in the area may be up to about 30 meters. Brown (1979) correlates this deposit with the 'silts and clays' ('blue clays' or 'lower mud unit' of some descriptions) that form thick deposits in the central Pasco Basin and underlie the Taylor Flat conglomerate.

Age—The youngest basalt flow underlying Ringold sediments has a radiometric date of about 8.5 Ma, setting a maximum age for the deposits. Lindsay (1996) reports three radiometric dates

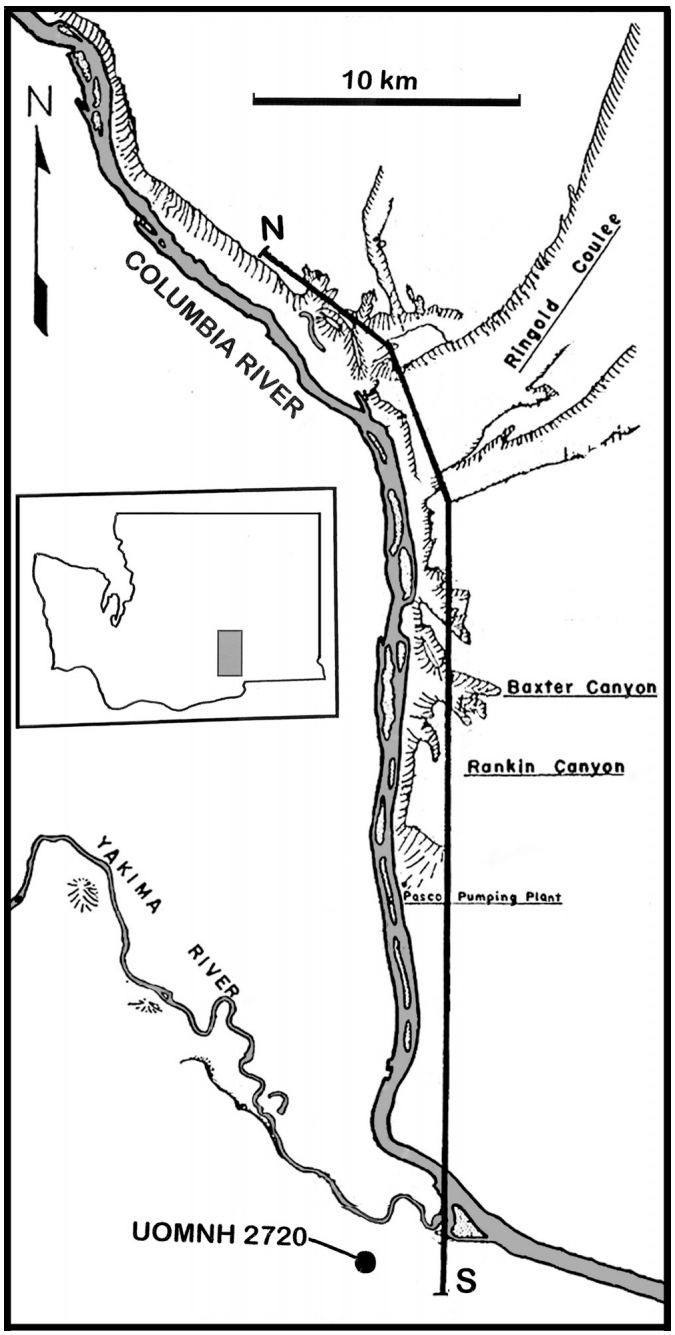

FIGURE 1. Map of part of the Columbia River Basin, showing location of *Aphelops* metacarpal discovery (UOMNH 2720) and line (N–S) of stratigraphic cross-section (Fig. 2) through the Ringold Formation. Inset map shows location of detail map in Washington State.

($^{40}Ar/^{39}Ar$) derived from volcanic ash in well cores in the 'lower mud unit' of the Ringold Formation elsewhere in the Pasco Basin of 6.79 ± 0.13, 6.67 ± 0.18, and 6.62 ± 0.09 Ma. Accepting the correlation of the Kennewick-area deposits by Brown (1979), these dates give the best available estimate for the age of this specimen, compatible with an early Hemphillian age (Hh2). Although the Ringold specimen could be younger, Tedford et al. (2004:218R) note that *Aphelops mutilis* first occurs in the Hh2 subage of the Hemphillian North American Land Mammal Age, correlated (their fig. 6.2) as between about 7.5 and 6.8 Ma.

Tribe TELEOCERATINI Hay, 1902
Genus *TELEOCERAS* Hatcher, 1894
TELEOCERAS HICKSI Cook, 1927
(Fig. 3)

Specimen—University of Washington Burke Museum, UWBM 92879.

Locality—UW C1399, White Bluffs along the Columbia River, Franklin County, Washington (one of several localities between Savage Island and Pasco Pump) above the White Bluffs tuff, White Bluffs U local fauna.

Description—Partial left M2 with well-preserved protoloph, missing the ectoloph and part of the metaloph (Fig. 3). The protoloph retains a well-developed antecrochet (characteristic of *Teleoceras*) and the metaloph has a strong crochet. Tooth morphology and size closely resemble those of a specimen of *Teleoceras hicksi* at a similar wear stage illustrated by Prothero (2005:fig. 4.43F).

Discussion—This specimen was collected sometime between 1957 and 1970 by William Shawver, but not identified until recently.

Significance of the Ringold *Teleoceras* Specimens—The new *Teleoceras* specimen from the upper level of the White Bluffs l.f. (UW C1399) is stratigraphically above the first (earliest) appearance of advanced microtine rodents in the Ringold Formation (1, Fig. 2). That microtine is *Mimomys sawrockensis* (specimens originally described as *Ophiomys mcknighti* Gustafson, 1978; revision follows Repenning, 2003) from locality UW A5927, which is approximately 25 m below the level at which the rhino tooth was found. Locality UW A5927 has been considered Blancan I in age (Repenning, 2003; Bell et al., 2004).

The previously lone rhino specimen from the Ringold Formation is a jaw of *Teleoceras hicksi* (Gustafson, 1977; species identification by Prothero, 2005) from the River Road local fauna. It was found in a sand lens in coarse gravel (locality UW C71, Taylor Flat conglomerate of Gustafson, 1978; unit E of the member of Wooded Island of Lindsey, 1996), about 60 m below the level of the new specimen. The Taylor Flat conglomerate is interpreted as a bar deposit of a major river with strong currents that were capable of carrying large cobble gravel from sources outside the Columbia Plateau, possibly from Idaho or British Columbia (Smith, Morgan, and Gustafson, 2000). The River Road local fauna consists of *Teleoceras hicksi*, the giant salmon *Onchorhyncus* (*Smilodonichthyes*) *rastrosus* (Cavender and Miller, 1972), a large camel, and an unidentified advanced deer. Based on the evidence of the presence of *Teleoceras hicksi* and *Onchorhyncus* (*Smilodonichthyes) rastrosus*, this fauna has been dated as Hemphillian (roughly 9 to 5 Ma; Tedford et al., 2004). Based on the evidence of the presence of advanced deer and of the stratigraphic position of this fauna just below the White Bluffs local fauna, the *Teleoceras* from UW C71 is dated as very late Hemphillian. This deposit (and its fauna) is younger than the 'lower mud level' Ringold dates referred to above (Lindsay, 1996), and is therefore less than 6.62 Ma. Hemphillian-Blancan boundary date estimates (discussed by Tedford et al., 2004) vary. By the youngest estimates, the boundary (and thus the age of the River Road l.f.) could be as young as 4.6–4.9 Ma.

Rhinocerotids are now known from a few North American fossil faunas younger than late Hemphillian (Woodburne et al., 2004; Janis et al., 2008). The disappearance of rhinos as common members of vertebrate faunas is so notable that this has been used as a datum point in the definition of the Hemphillian-Blancan boundary since the original Wood committee definition (Wood et al., 1941; see also Tedford et al., 2004:218, who continued to use extinction of rhinoceratids as a criterion). Bell et al. (in Woodburne, 2004) redefined this boundary as being at the first appearance of microtine or arvicoline rodents of the genera *Mimomys*, *Ophiomys*, or *Ogmodontomys*, at about 4.98 Ma.

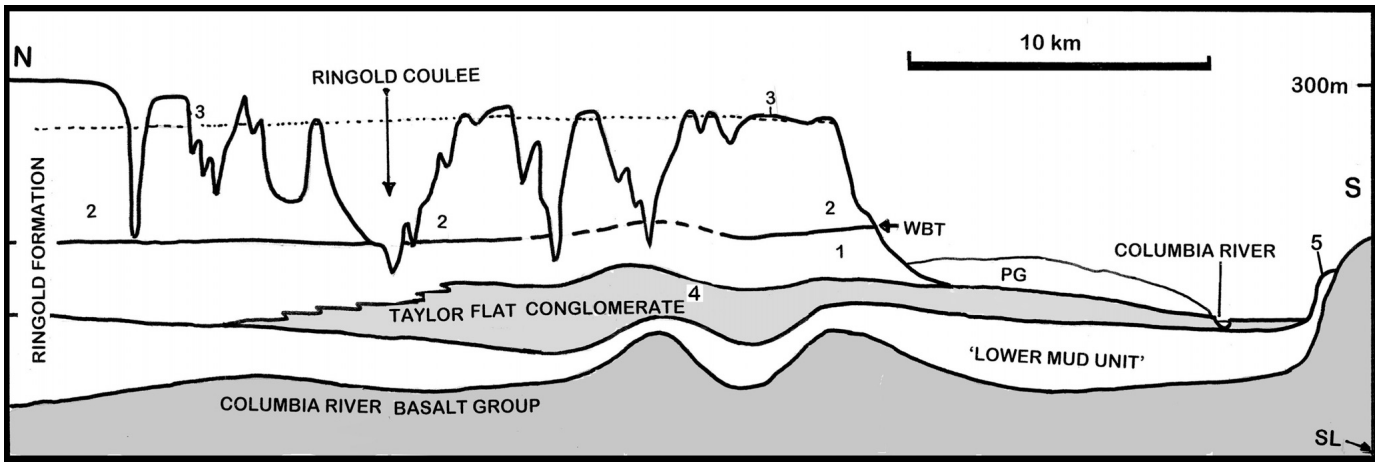

FIGURE 2. Stratigraphic cross-section (N–S) through the Ringold Formation, modified after Brown and McConiga (1960), along the line shown in Figure 1. Vertical scale exaggerated. **1**, Location of UW A5927, microtine locality (*Mimomys sawrockensis*), level of White Bluffs L l.f. **2**, Multiple localities, sources of White Bluffs U l.f., *Teleoceras* upper molar specimen found at this level. **3**, Multiple localities, sources of Blufftop l.f. **4**, Locality UW C71, level of River Road l.f. and source of *T. hicksi* jaw. **5**, Locality UOMNH 2720, *Aphelops* locality. **Abbreviations**: **PG**, Pleistocene gravel; **SL**, sea level; **WBT**, White Bluffs tuff, marker bed.

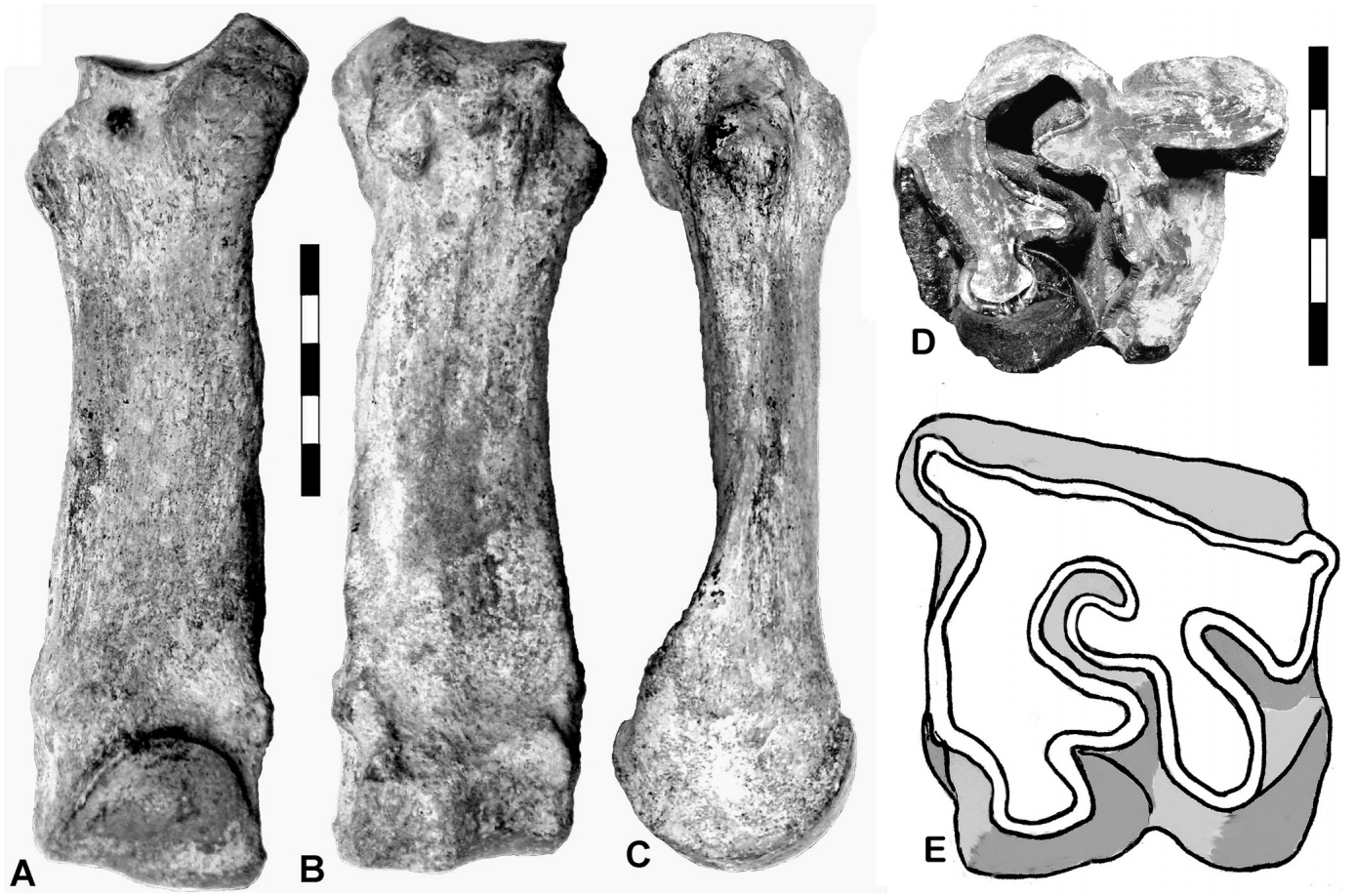

FIGURE 3. Left, *Aphelops* metacarpal 3 (UO F-31612); **A**, dorsal, **B**, ventral, and **C**, right lateral views, scale bar for **A**, **B**, and **C** equals 5 cm. **D**, partial M2 of *Teleoceras* (UWBM 92879). **E**, occlusal view of complete M2 of *Teleoceras hicksi*, drawn from a photograph in Prothero, 2005, for comparison; scale bar for **D** and **E** equals 5 cm.

Tedford et al. (2004) place the boundary at a slightly younger date, ca. 4.6–4.9 Ma. Other post-Hemphillian faunas containing rhinos are rare; some are questionable or lack stratigraphic context. The list includes the following:

1. The Beck Ranch fauna of Texas (Madden and Dalquest, 1990) produced a piece of an upper molar, probably referable to *Teleoceras*. The fauna is otherwise Blancan, currently thought to be middle Blancan (about 3.5 Ma). Madden and Dalquest accept the single partial tooth as part of this fauna; Prothero (2005) casts doubt on this interpretation, suggesting that the tooth was reworked from older sediments. If correctly dated as mid-Blancan, this would be the youngest rhino known from North America.
2. The Pipe Creek sinkhole fauna of Indiana (Farlow et al., 2001; Martin et al., 2002) includes both unquestionable *Teleoceras* and microtine rodents (*Ogmodontomys*). The fauna comes from a sinkhole deposit in Paleozoic limestone and has no Cenozoic stratigraphic context; moreover, the locality is geographically far from most equivalent-aged deposits and may be ecologically distinct.
3. The Saw Rock Canyon fauna of Kansas. Prothero and Manning (1987) report *Teleoceras* from this fauna ('Sawrock l.f.') but do not refer to any cataloged specimens. This fauna includes the type locality for *Mimomys sawrockensis* and is therefore Blancan by current definition.

Some other faunas dated as near the Hemphillian-Blancan boundary are considered Hemphillian at least partly on the basis of the presence of rhinos. For example, the Palmetto fauna of Florida (Webb et al., 2008) has rhinos (*Teleoceras hicksi*) but no small rodents. Other taxa of the Palmetto fauna (i.e., the lagomorphs) are similar to those in the White Bluffs l.f. Moreover, the fauna includes the earliest advanced cervid in North America; only the Ringold cervid *Bretzia pseudalces* is similar in age. The type locality for *B. pseudalces* is in the lower part of the White Bluffs local fauna.

It has become apparent that the mere presence of *Teleoceras* in a fauna is not sufficient in itself to indicate a Hemphillian age for that fauna. All records of rhinos younger than Hemphillian age are of the genus *Teleoceras* (Janis, 2008), which may have survived much longer than previously thought.

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