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A GEOCHRONOLOGIC AND BIOCHRONOLOGIC REEVALUATION OF THE COAL VALLEY FORMATION, LYON AND MINERAL COUNTIES, WEST-CENTRAL NEVADA

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ABSTRACT

The Coal Valley Formation of Lyon and Mineral Counties, Nevada, is well known for its fossil mammal faunas, which span the middle to late Miocene (Clarendonian to Hemphillian North American Land Mammal ages). Based on biochronologic, radioisotopic and tephrochronologic data, the prior correlation of the Coal Valley Formation in Smith Valley to the type section of the Coal Valley Formation in Coal Valley is reevaluated. A thick diatomaceous shale unit at the top of the type section of the Coal Valley Formation, referred to as the marker shale, was previously correlated to a thick diatomaceous shale unit in the upper part of the Coal Formation of Smith Valley. The shale unit in Smith Valley is informally named the Petrified Tree Canyon shale because these two shale units are not geochronologically equivalent. The shale unit in Smith Valley is younger than 6.98 Ma and the marker shale unit in the type section is dated at about 9.5 Ma. Three new faunas are recognized from the Coal Valley Formation: the late Clarendonian Pine Grove Flat Local Fauna; the Old Reese Road Local Fauna of possible Clarendonian age; and the early Hemphillian Pumpkin Hollow Local Fauna.

INTRODUCTION

The Wassuk Group consists of three formations, in ascending stratigraphic order: the Aldrich Station Formation, the Coal Valley Formation and the Morgan Ranch Formation (Axelrod, 1956; Gilbert and Reynolds, 1973; Golia and Stewart, 1984; Stewart and Reynolds, 1987). Outcrops of the Wassuk Group occur from Fletcher Valley northward through Coal Valley, the east Walker Valley and the eastern and northern flanks of the Pine Grove Hills to the southwest side of the Singatse Range in Smith Valley, and eastward to Pumpkin Hollow, an area encompassing about 1,250 km^2 (Figure 1). The Wassuk Group is comprised of fluvial and lacustrine sediments that were deposited in an extensive northwest trending basin during the middle to late Miocene (Axelrod, 1956; Gilbert and Reynolds, 1973; Golia and Stewart, 1984). The basin contained a large circumneutral eutrophic lake during the deposition of the Aldrich Station Formation, which accounts for it consisting predominately of lacustrine and marginal paludal deposits of diatomaceous shale, carbonaceous mudstone and siltstone and lithic arenite beds (Gilbert and Reynolds, 1973; Golia and Stewart, 1984). The Coal Valley Formation consists primarily of andesitic sandstone, pebble to cobble conglomerate, mudstone and siltstone along with several interbedded diatomaceous shale beds, which have been interpreted to mainly represent fluvial deposits typical of braided stream deposition with occasional periods of widespread lacustrine deposition (Gilbert and Reynolds, 1973; Golia and Stewart, 1984). The Morgan Ranch Formation consists primarily of matrix-supported conglomerate and arkosic sandstone interbedded with minor siltstone and carbonaceous shale beds, which have been interpreted to mainly represent alluvial fan deposits (Gilbert and Reynolds, 1973; Golia and Stewart, 1984).

The Aldrich Station and Coal Valley Formations are well recognized for their middle Miocene floras and middle to late Miocene faunas, respectively (e.g., Berry, 1927; Stirton, 1935, 1940; Wilson, 1935; Macdonald, 1949; Axelrod, 1956; Macdonald and Pelletier, 1956; Evernden and James, 1964; Evernden et al., 1964; Gilbert and Reynolds, 1973; Macdonald and Macdonald, 1976; Schorn and Shelton, 1991; Kelly, 1998a, 1998b, 2007, 2010, 2013; Kelly and Secord, 2009). In the Pumpkin Hollow area (Figure 1), the Wassuk Group has yielded a small assemblage of mammal fossils that has previously been only briefly mentioned in the literature (Stirton, 1935; Axelrod, 1956; Macdonald and Pelletier, 1958). Gilbert and Reynolds (1973) provided correlations of various stratigraphic sections of the Wassuk Group from Coal Valley to Smith Valley. The purpose of this report is to reevaluate some of the prior correlations of the Wassuk Group sections made by Gilbert and Reynolds (1973) based on biochronologic, radioisotopic and tephrochronologic evidence and to provide updated biochronologic accounts of the mammalian faunas from the Coal Valley Formation, including new faunas from of the northwest flank of the Pine Grove Hills and Pumpkin Hollow.

METHODS

Dental nomenclature for castorid rodents follows Stirton (1935) and for equids follows MacFadden (1984). Dental formulae follow standard usage with upper teeth designated by capital letters and lower teeth by lowercase letters. Cheek tooth positions for isolated horse teeth were determined using the method of Bode (1931). Open nomenclature qualifiers for taxa follow Bengtson (1988). Subdivisions of the Clarendonian (Cl1, Cl2, Cl3) and Hemphillian (Hh1, Hh2, Hh3, Hh4) North American Land Mammal ages follow Tedford et al. (2004). Local fauna as used here is not a strict or formal biostratigraphic unit, but follows Woodburne's (1987, 2007) definition as an assemblage of fossil vertebrates of specific taxonomic composition recovered from one site or several sites that are closely spaced stratigraphically and geographically (see also, Tedford, 1970; Walsh, 2000). Detailed locality data are available at the University of California Museum of Paleontology and the Natural History Museum of Los Angeles County.

Older published K/Ar radioisotopic dates were recalibrated using the International Union of Geological Sciences constants following the method of Dalrymple (1979). Older published $^{40}Ar/^{39}Ar$ dates were recalibrated relative to the new Fish Canyon Tuff sanidine interlaboratory standard at 28.201 Ma (Kuiper et al., 2008).

Abbreviations are as follows: apl, anteroposterior length, not including the cementum on equid teeth; $^{40}Ar/^{39}Ar$, Argon-Argon; CV, coefficient of variation; GPTS, Global Polarity Time Scale; K/Ar, Potassium-Argon; Ma, megannum (one million years in the radioisotopic time scale); mml, metaconid-metastylid length; msch, mesostyle crown height; N, number of specimens; pl, protocone greatest anteroposterior length; pw, protocone greatest transverse width; SD, standard deviation; trw, transverse width, not including the cementum on equid teeth. Institutional acronyms are as follows: LACM, Natural History Museum of Los Angeles County; LACM (CIT), California Institute of Technology specimens now housed in the vertebrate paleontology collection of the LACM; UCMP, University of California, Museum of Paleontology; UCMP V, UCMP vertebrate fossil locality.

GEOCHRONOLOGY

Axelrod (1956) provided the first detailed geological study of the Miocene sedimentary rocks exposed in the Coal Valley area of Lyon and Mineral Counties, Nevada, wherein he recognized the Wassuk Group, consisting of three formations, in ascending stratigraphic order: the Aldrich Station, Coal Valley and Morgan Ranch Formations. Outcrops of the Wassuk Group of Axelrod (1956) have been mapped from Fletcher Valley northward through Coal Valley, the East Walker Valley, the eastern and northern flanks of the Pine Grove Hills to the southwest side of the Singatse Range in Smith Valley and eastward to Pumpkin Hollow (Gilbert and Reynolds, 1973; Bingler, 1978; Stewart and Dohrenwend, 1984; Stewart and Reynolds, 1987). The geochronology of this area is supported by a number of radioisotopic dates from volcanic rocks, primarily basaltic, rhyolitic and andesitic flows and tuffs interbedded within sedimentary rocks (e.g., Evernden and James, 1964; Evernden et al., 1964; Gilbert and Reynolds, 1973; Robinson and Kistler, 1986; Swisher, 1992; Kelly, 2007, 2013; Kelly and Secord, 2009), and a tephrochronologic analysis of the type sections of the Aldrich Station and Coal Valley Formations in Coal Valley (Perkins et al., 1998). Gilbert and Reynolds (1973) clarified the formational boundaries of the Wassuk Group, reassigned the Smith Valley Beds of Macdonald (1949) and Axelrod (1956) to the Coal Valley Formation, and provided correlations of stratigraphic sections of the Wassuk Group from Coal Valley northward to Smith Valley.

Gilbert and Reynolds (1973) recognized several marker beds in the Coal Valley Formation, one of which was their marker shale, a thick sequence of white weathering tuffaceous siltstone and diatomaceous shale beds exposed in the highest stratigraphic level of the type section of the Coal Valley Formation in Coal Valley. Gilbert and Reynolds (1973) correlated their marker shale in Coal Valley to other shale beds exposed in outcrops of the Coal Valley Formation along the northeastern flank of the Pine Grove Hills, the southwest flank of the Singatse Range (= Petrified Tree Canyon section, this paper) and the north side of Wilson Canyon in Smith Valley (Figure 2). They also recognized an andesitic tuff marker bed, which they traced from the type Coal Valley Formation at the south end of Coal Valley to outcrops exposed in the middle and along the northeast side of Coal Valley. In Gilbert and Reynolds's (1973:fig. 5) "southwest flank of Singatse Range section," they noted that a biotite crystal tuff (= unnamed crystal vitric biotite dacite tuff of Evernden et al., 1964, = Smith Valley Tuff of Swisher, 1992, = Wilson Canyon Tuff of Kelly, 2013) and basalt breccia unit occurred near the middle of the section, about 250 m below the marker shale. This tuff had been K/Ar dated by Evernden et al. (1964) at 9.3 Ma (KA 485, 9.55 Ma corrected, 2σ errors not provided). Gilbert and Reynolds (1973) did not directly tie the andesitic

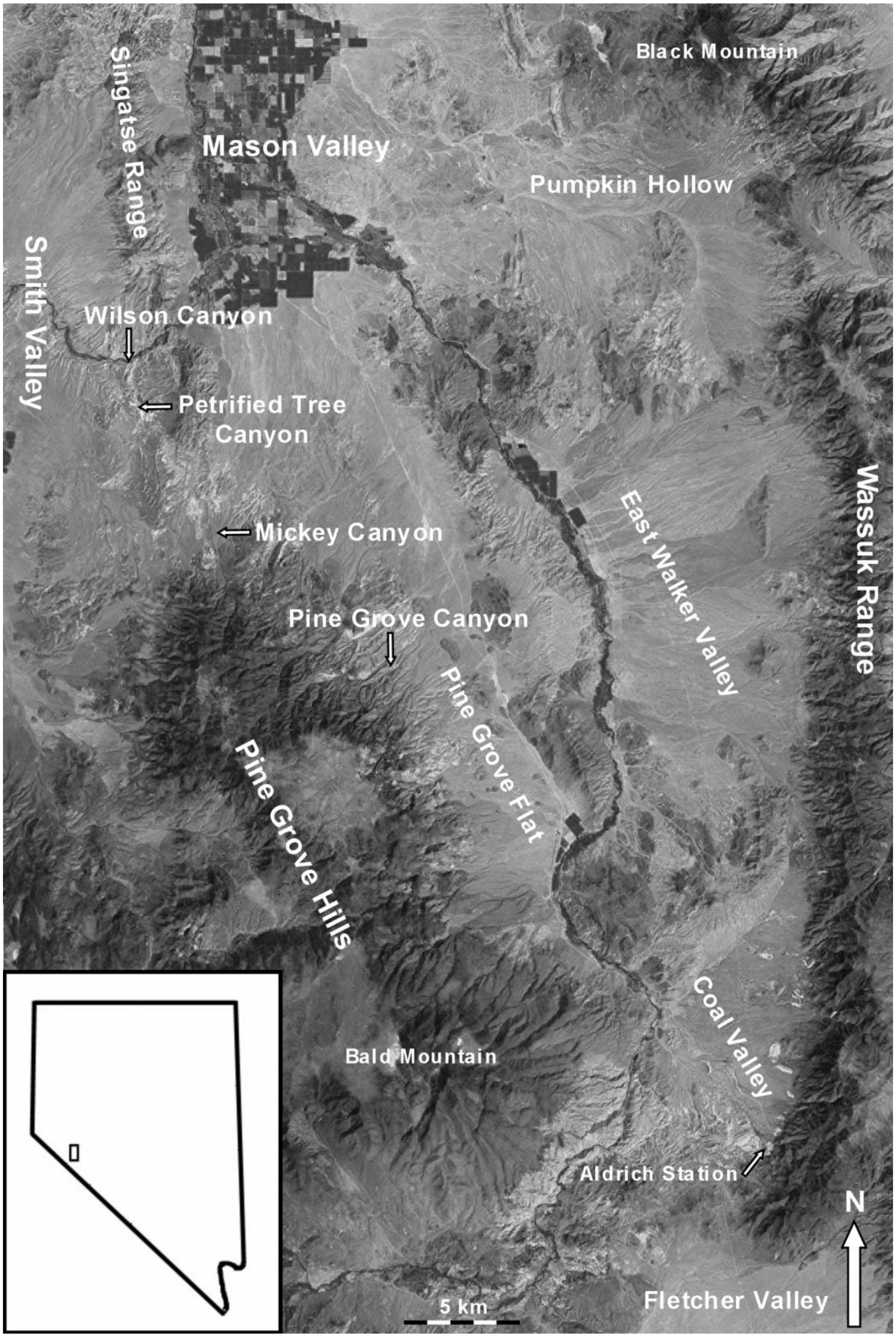

FIGURE 1. Aerial view of study area showing geographic locations of areas discussed in text that contain outcrops of Coal Valley Formation in Mineral and Lyon Counties, Nevada. Insert map shows location of study area in Nevada. Base aerial view from Google Maps.

tuff unit in their Coal Valley sections to the crystal tuff/ breccia unit in their "southwest flank of Singatse Range section" in Smith Valley, but their figure 5 implied these units were chronologically equivalent. This did not seem unreasonable at the time because they considered the Coal Valley Formation in their "Coal Valley (South) section" to span from about 11 to 9 Ma, which seemed compatible with the K/Ar date of the Wilson Canyon Tuff in the Coal Valley Formation of Smith Valley and their correlation of the marker shale units in both sections. However, Swisher (1992) redated the Wilson Canyon Tuff at 7.52 ± 0.08 Ma using the more accurate single crystal $^{40}Ar/^{39}Ar$ method. Swisher's age for the Wilson Canyon Tuff was further supported by $^{40}Ar/^{39}Ar$ dates of 7.08 ± 0.01 Ma and 6.98 ± 0.01 Ma for two pumice-bearing beds that occur in a stratigraphic interval from 160 to 130 m above the Wilson Canyon Tuff, respectively (Kelly, 2007; Kelly and Secord, 2009). Based on tephrochronology, Perkins et al. (1998) provided corroboration of a geochronologic span of about 11.5-9.5 Ma for the type section of the Coal Valley Formation in Coal Valley. The more accurate $^{40}Ar/^{39}Ar$ dates for the Wilson Canyon Tuff and those for the tuffs between the Wilson Canyon Tuff and the overlying thick shale unit in Smith Valley, along with supporting biochronologic evidence (see discussion below), indicate that the thick shale unit in Smith Valley is much younger (ca. ~6.8 Ma) than the marker shale of Gilbert and Reynolds (1973) in Coal Valley (Figure 3). The best exposures of this thick shale unit in Smith Valley occur in Petrified Tree Canyon (Figure 4), where the local section extends from the floor of the canyon, at about 600 m below the Wilson Canyon Tuff, to about 375 m above the shale unit. As such, this shale unit is informally named the Petrified Tree Canyon shale to differentiate it from the marker shale of Gilbert and Reynolds (1973), with its type section in Petrified Tree Canyon (Figures 3, 4). Exposures of the Petrified Tree Canyon shale can be traced from Petrified Tree Canyon northwestward to the southwest entrance of Wilson Canyon and southward to the north flanks of the Pine Groove Hills.

Although Gilbert and Reynolds (1973:fig. 3) geologically mapped all of the outcrops of the Wassuk Group along the northeastern flanks of the Pine Grove Hills, their "Northeast of Pine Grove section" only showed a portion of the entire section in this area, that is the section lying just above a fault and exposed along the north wall of lower Pine Grove Canyon and further north. This section contains a thick white tuffaceous siltstone and shale unit just above the fault, which Gilbert and Reynolds (1973) correlated to their marker shale in Coal Valley. South of the fault along the north side of Pine Grove Canyon and in a second

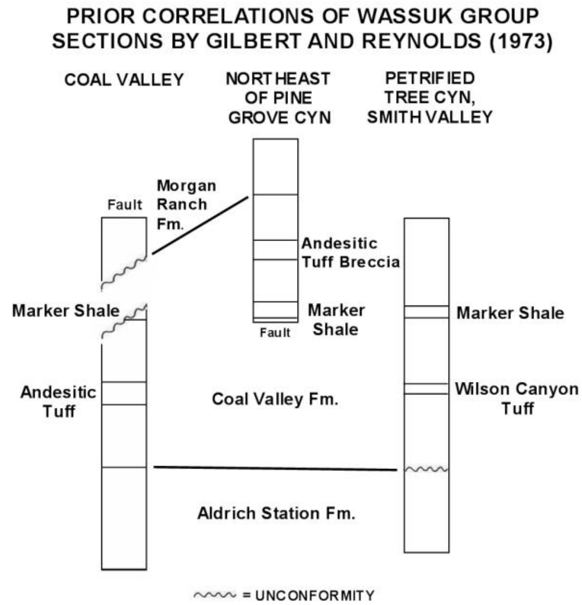

FIGURE 2. Correlations of Gilbert and Reynolds (1973) of schematic stratigraphic sections of Coal Valley Formation from the south side of Coal Valley northward through the northeast side of Pine Grove Canyon and to the east side of Smith Valley (Petrified Tree Canyon section = southwest flank of Singatse Range section of Gilbert and Reynolds, 1973).

canyon further south, more than 690 m of Coal Valley Formation are exposed. Several smaller faults are present in these outcrops along with a thick shale unit at about 435 m above the base, and two tuffs, which were K/Ar dated by the Berkeley Geochronology Lab (Gilbert and Reynolds, 1973; Robinson and Kistler, 1986). A tuff that occurs south of Pine Grove Canyon and just north of the Pine Grove Canyon Road at 38° 41' 53.20" N, 119° 4' 31.86" W was dated at 9.4 ± 0.4 Ma (KA 2439). A second, stratigraphically lower tuff exposed near the base of the local section of Coal Valley Formation at about 1,725 m southwest of the first tuff (KA 2439) and 720 m south of the of the Pine Grove Canyon Road at 38° 41' 9.0" N, 119° 5' 18.0" W, was dated at 10.5 ± 0.4 Ma (KA 2431) and 10.7 ± 0.5 Ma (KA 2432). Considering the radioisotopic dates from the Pine Grove Canyon sections, the thick, upper shale unit does correlate to the marker shale of Gilbert and Reynolds (1973) in the type section of the Coal Valley Formation in Coal Valley (Figure 3). This correlation is further supported by the occurrence of Clarendonian mammals from below the marker shale in the Pine Grove Canyon area (see discussion below).

On the west side of the Pine Grove Flat area, an isolated outcrop of Coal Valley Formation occurs about 3.6 km southeast of the Pine Grove Canyon Road that is unconformably overlain by a rhyolite flow K/Ar

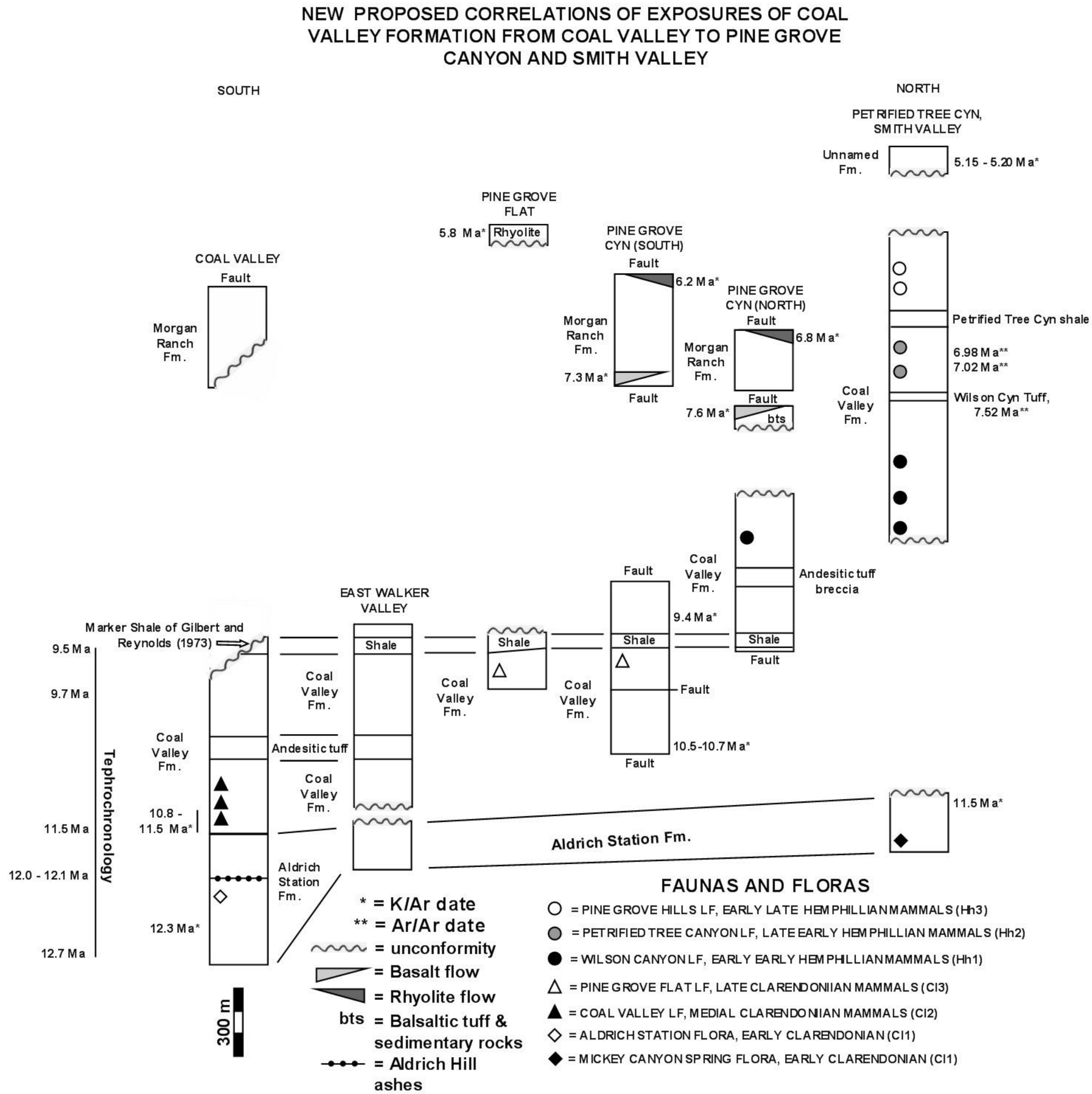

FIGURE 3. New proposed correlations of schematic stratigraphic sections of the Wassuk Group (Aldrich Station, Coal Valley and Morgan Ranch formations) from Coal Valley northward through the Pine Grove Flat and Pine Gove Canyon areas to the east side of Smith Valley (Petrified Tree Canyon) along with the relative stratigraphic positions of floras and faunas. Abbreviations are: CYN, canyon; Fm., formation; LF, local fauna.

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dated at 5.8 ± 0.7 Ma (KA 2494). The Coal Valley Formation at the Pine Grove Flat outcrop consists of about 175 m of andesitic sandstones and siltstones along with a thick white tuffaceous siltstone and shale unit at the top of the local section, which Gilbert and Reynolds (1973) mapped as the marker shale. The Pine Grove Flat outcrop of Coal Valley Formation yielded late Clarendonian mammals (see discussion below), which indicates that the thick, white tuffaceous shale unit at the top of the Pine Grove Flat section also correlates with the marker shale of Gilbert and Reynolds (1973) in Coal Valley (Figure 3).

The entire Pumpkin Hollow area has been geologically mapped (Bingler, 1978; Stewart and

Dohrenwend, 1984). What Axelrod (1956) regarded as deposits assignable to the Morgan Ranch Formation in Pumpkin Hollow were referred by Stewart and Dohrenwend (1984) to the Coal Valley Formation as redefined by Gilbert and Reynolds (1973). Stewart and Dohrenwend (1984) also identified outcrops of Aldrich Station Formation in the Pumpkin Hollow area. There are no direct radioisotopic dates for the Aldrich Station or Coal Valley Formations in the Pumpkin Hollow area, but a basalt flow that overlies outcrops of the Coal Valley Formation on the north side of Pumpkin Hollow was K/Ar dated at 7.5 ± 0.4 Ma (SQ16, USGS Menlo Park), which does provide a minimum age estimate for these outcrops (Figure 5). Thus, further refinement of an age assignment for the Coal Valley Formation in the Pumpkin Hollow area must rely on the biochronologic evidence (see discussion below).

BIOCHRONOLOGY

Coal Valley—Berry (1927) provided the first report of fossils from Coal Valley. He described the Coal Valley Flora from sediments exposed in Coal Valley that he attributed to an outlier of the Esmeralda Formation. As noted above, Axelrod (1956) recognized three new formations, the Aldrich Station, Coal Valley and Morgan Ranch Formations, which he assigned to the Wassuk Group. Axelrod (1956) provided detailed systematic accounts of the Aldrich Station Flora from the Aldrich Station Formation and reported on the occurrence of a Clarendonian assemblage of mammals, the Coal Valley Fauna, from the overlying type section of the Coal Valley Formation in Coal Valley.

The localities within the type section of the Coal Valley Formation that yielded the Coal Valley Local Fauna (Table 1 = Coal Valley Fauna of Axelrod, 1956), based on tephrochronology and radioisotopic dates, span an interval of about 11.5 to 10.7 Ma (Gilbert and Reynolds, 1973; Perkins et al., 1998), within the medial Clarendonian (Cl2). Axelrod (1956) and MacFadden (1984) reported the occurrence of the horse, *Hipparion tehonense* (Merriam, 1916a) in the Coal Valley Local Fauna, a species that first appears in the early (Cl1) Clarendonian South Tejon Hills Local Fauna of California (Tedford et al., 2004) and has also been recorded from the Clarendonian of Texas, Kansas, Nebraska and South Dakota (MacFadden, 1984). However, Stephen W. Edwards (per. communication, 2014, 2017) reviewed the identification of the smaller, hipparionine horse teeth from Coal Valley and recognized they do not represent *H. tehonense*, but instead may possibly represent a form related to *Neohipparion trampasense* (Edwards, 1982). Previously, the first occurrence of *Neohipparion trampasense* was from the late medial Clarendonian (Cl2) Xmas-Kat Quarries of Nebraska and it has also been documented from the late Clarendonian (Cl3) of California, the late Clarendonian to early Hemphillian (Cl3-Hh1) of Florida, and the early Hemphillian (Hh1) of Kansas (MacFadden, 1984; Hulbert, 1987b). Although unambiguous identification of hipparionine horse genera requires knowledge of the cranial morphology, including the structure of the facial fossa, which is unknown for the hipparionines from Coal Valley, investigators have demonstrated that detailed studies of the morphology of the cheek teeth can also be used to differentiate hipparionine taxa (e.g., MacFadden, 1984; Hulbert, 1987b; Woodburne, 2007). Hulbert (1987b) provided detailed descriptions and dental statistics of four samples of *N. trampasense* including the typotypic sample from the late Clarendonian (CL3) Kendall-Mallory localities, California, along with samples from the latest Clarendonian (Cl3) Love Site, Florida, the late medial Clarendonian (Cl2) Xmas-Kat Quarries, Nebraska, and the early Hemphillian (Hh1) J. Swayze and Arens Quarries, Kansas.

Two different hipparionine horses occur in the type Coal Valley Formation of Coal Valley that can be differentiated by size and occlusal morphology. The upper cheek teeth of the smaller Coal Valley hipparionine differ from those of *H. tehonense* by the following (MacFadden, 1984): 1) P2 distinctly more elongated anteroposteriorly relative to molar length; 2) more complex pre- and postfossette plications; 3) slightly greater anteroposterior elongation and slightly more acute anterior and posterior borders of the of the protocone; and 4) lacking a tendency for the protocone to connect with the protoloph during late wear. The cheek teeth of the smaller Coal Valley hipparionine (Figures 6A-Q) do exhibit similarities in occlusal morphology to *N. trampasense*, including the following: 1) cheek teeth notably tapered toward the base; 2) upper premolars larger than molars; 3) moderately complex pre- and postfossette borders, including a large pli protoconule on the molars that commonly extends to the lingual margin of the prefossette or slightly further; 4) an anteroposteriorly elongated protocone with the anterior and posterior margins sometimes pointed; 5) a strong, persistent pli caballin; 6) a deep hypoconal groove (= hypoglyph of Edwards [1982]); 7) ectoflexids relatively shallow on p3-4, not penetrating the isthmus between the metastylid and metaconid; and 8) ectoflexids on m1-3 deep, penetrating the isthmus between the metastylid and metaconid. However, the above dental similarities are also shared by a number of other hipparionine species. Moreover, where quarry samples or other large samples of hipparionine species have been documented, many of these characters exhibit a wide range of variation with some overlap in dimensions

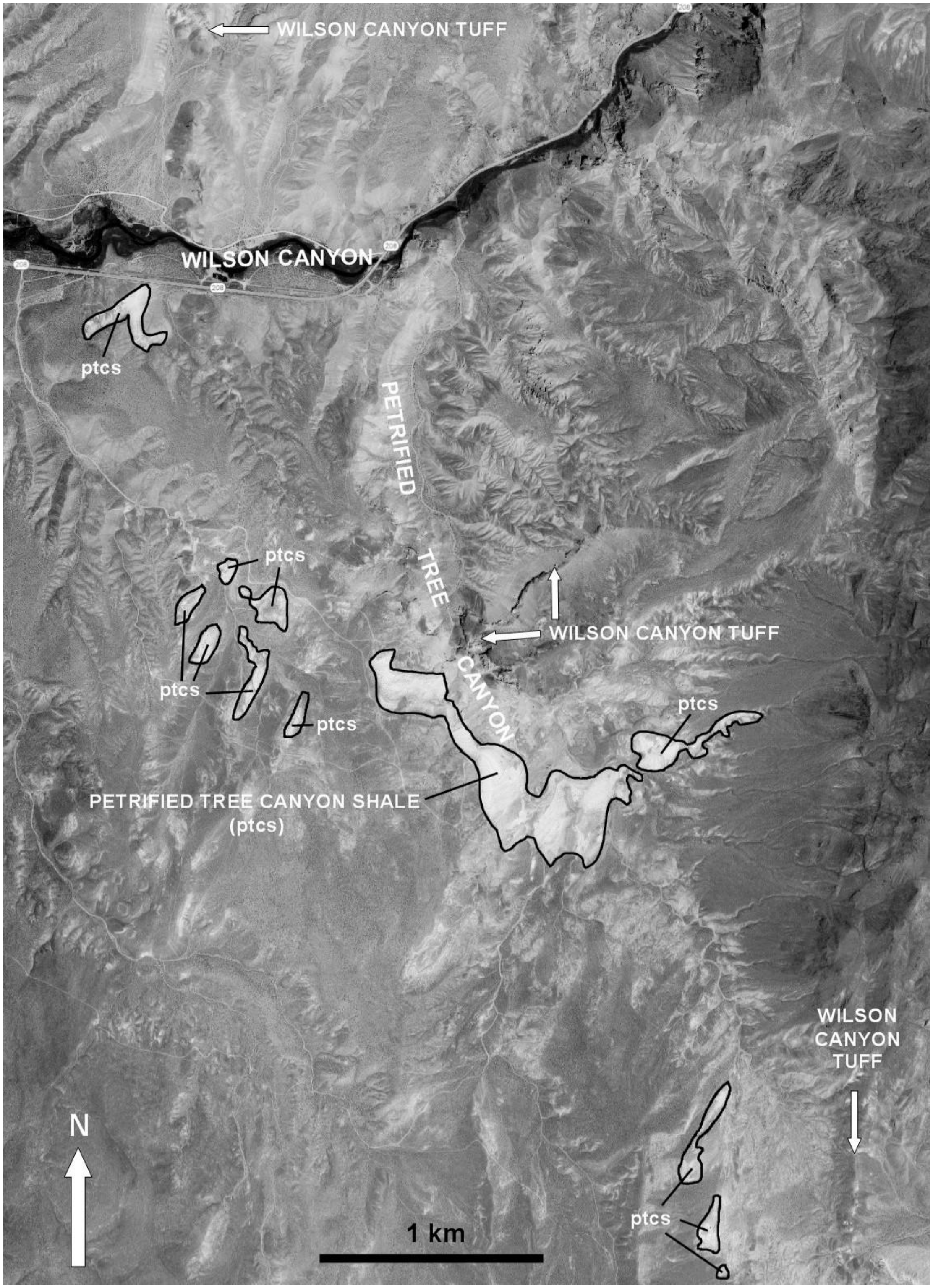

FIGURE 4. Aerial view of Petrified Tree and Wilson Canyons in Smith Valley, Nevada, showing geographic locations of outcrops of a thick diatomaceous shale bed, referred to in the text as the Petrified Tree Canyon shale, and the Wilson Canyon Tuff. Base aerial view from Google Maps.

(MacFadden, 1984; Hulbert, 1987b; Woodburne, 2007).

In order to speculate on the identification of the smaller hipparionine from Coal Valley, it is necessary to compare it with samples of *N. trampasense* and other similarly sized Clarendonian hipparionines. Except for two specimens (LACM 160247 and UCMP 40371), all other specimens of the small Coal Valley hipparionine are isolated teeth (Figure 6). UCMP 40371 consists of an associated LM1-2. LACM 160247 consists of an associated LP2, partial RP2 and RP3-M2 in early moderate wear (mesostyle crown height of P4 = 39.8 mm). The upper cheek teeth of LACM 160247 agree well in size and occlusal morphology with the other isolated, smaller hipparionine cheek teeth from the type section of the Coal Valley Formation and are regarded as conspecific. What stands out is that the premolars of LACM 160247 exhibit an occlusal pattern where the posterior lingual border of the protoloph and anterior lingual border of the metaloph are separated (not confluent) above the pli caballin. In other isolated premolars from Coal Valley, this occlusal pattern is also present on premolars in early to early moderate wear. For example, in P2, the pattern is incomplete (protoloph and metaloph separated) at a mesostyle crown height of 27 mm, but complete (protoloph and metaloph confluent above the pli caballin) by 24 mm crown height. In P3, the pattern is incomplete even when the mesostyle crown height has been worn down to 31 mm, and in P4 it is incomplete until a mesostyle crown of about 30 mm. This premolar occlusal pattern is common among species of *Cormohipparion*, but usually lacking in species of *Neohipparion* (MacFadden, 1984; Woodburne, 1996, 2007). In particular, the overall occlusal patterns of the teeth of LACM 160247 are very similar to the holotype teeth of *Cormohipparion quinni* Woodburne, 1996, including the incomplete connection of the lingual borders of the premolar protolophs and metalophs during early wear (MacFadden, 1984:fig. 21A; Woodburne, 1996:figs. 13C-D). However it should be noted that this incomplete premolar occlusal wear pattern has a wide distribution within Miocene Equidae, including older less derived taxa such as *Parahippus leonensis* Sellards, 1916, "*Merychippus*" *coloradense* (Osborn, 1918) and "*Merychippus*" *primus* Osborn, 1918 (MacFadden, 1984:fig. 56; Hulbert and MacFadden, 1991:fig. 7G; Woodburne, 2003:fig. 16.7), indicating that it is a pleisomorphy. In species of *Neohipparion*, except for the occasional occurrence of this wear pattern in P2 during early wear (e.g., MacFadden, 1984:figs. 20D and 72B), the confluence of the P3-4 protoloph and metaloph occurs immediately after wear begins (MacFadden, 1984; Hulbert, 1987b). Thus, it appears that the loss of the incomplete wear pattern in the premolars of species of *Neohipparion* is derived relative to its occurrence in species of *Cormohipparion*.

As noted above, the protocones of the small Coal Valley hipparionine are moderately anteroposteriorly elongated. This character is exhibited by species of *Neohipparion* and *Cormohipparion*, but usually more developed in *Neohipparion*, wherein the length of the protocone is proportionally longer relative to the length of the tooth throughout all wear stages (MacFadden, 1984; Hulbert,1987b). In the small Coal Valley hipparionine, the occlusal outline of the protocone at the beginning of wear appears long and narrow, as seen in LACM 160252 (Figures 6G-I, msch = 43.5 mm, pl = 7.24 mm, pw = 3.26 mm). However, the protocone length of LACM 160252 decreases to 6.61 mm at midway down the crown. In all of the other small Coal Valley hipparionine upper cheek teeth, whose wear stages range from early moderate to early late wear (msch = 24-40 mm), the protocone length did not vary significantly with wear (N = 21, mean P3-M2 pl = 7.04 mm, SD = 0.36, CV = 5.1). A comparison of the mean protocone length (pl) to mean tooth length (apl) of P3-4 and M1-2 of the small Coal Valley hipparionine, including only cheek teeth in early moderate to early late wear, to other species of *Neohipparion* and *Cormohipparion* is shown in Figure 7. The small Coal Valley hipparionine most closely resembles *C. quinni* in relative proportions of the mean protocone length to mean tooth length. The upper cheek teeth of the small Coal Valley hipparionine differ from those of *N. trampasense* by the following (Edwards, 1982; Hulbert, 1987b): 1) P2 protocone with a more oval occlusal outline and with an anterior spur present during early to moderate wear; 2) P2-4 connection of posterior protoloph border and anterior metaloph border incomplete during early to early moderate wear; 3) lower crowned (unworn M1 mesostyle crown height = ~45 mm versus 57~60 mm for *N. trampasense* samples from Nebraska and Florida); 4) P2-M2 anterior enamel border with tendency to be less plicated; 5) protocones less anteroposteriorly elongated (Figure 7, plus mean P3-4 pl = 7.07 mm, mean M1-2 pl = 6.97 mm versus 8.1 mm and 8.3 mm, respectively, for the topotypic sample of *N. trampasense*); and 6) P2-M2 connection between hypocone and metaloph more constricted. It should be noted that the topotypic sample of *N. trampasense* from Kendall-Mallory does not contain unworn upper cheek teeth, so the maximum M1 mesostyle crown height is undetermined. However, the tallest tooth in the Kendall-Mallory sample, which is in early moderate wear, has a mesostyle crown height of ~46 mm, indicating that the topotypic sample is likely slightly lower crowned than

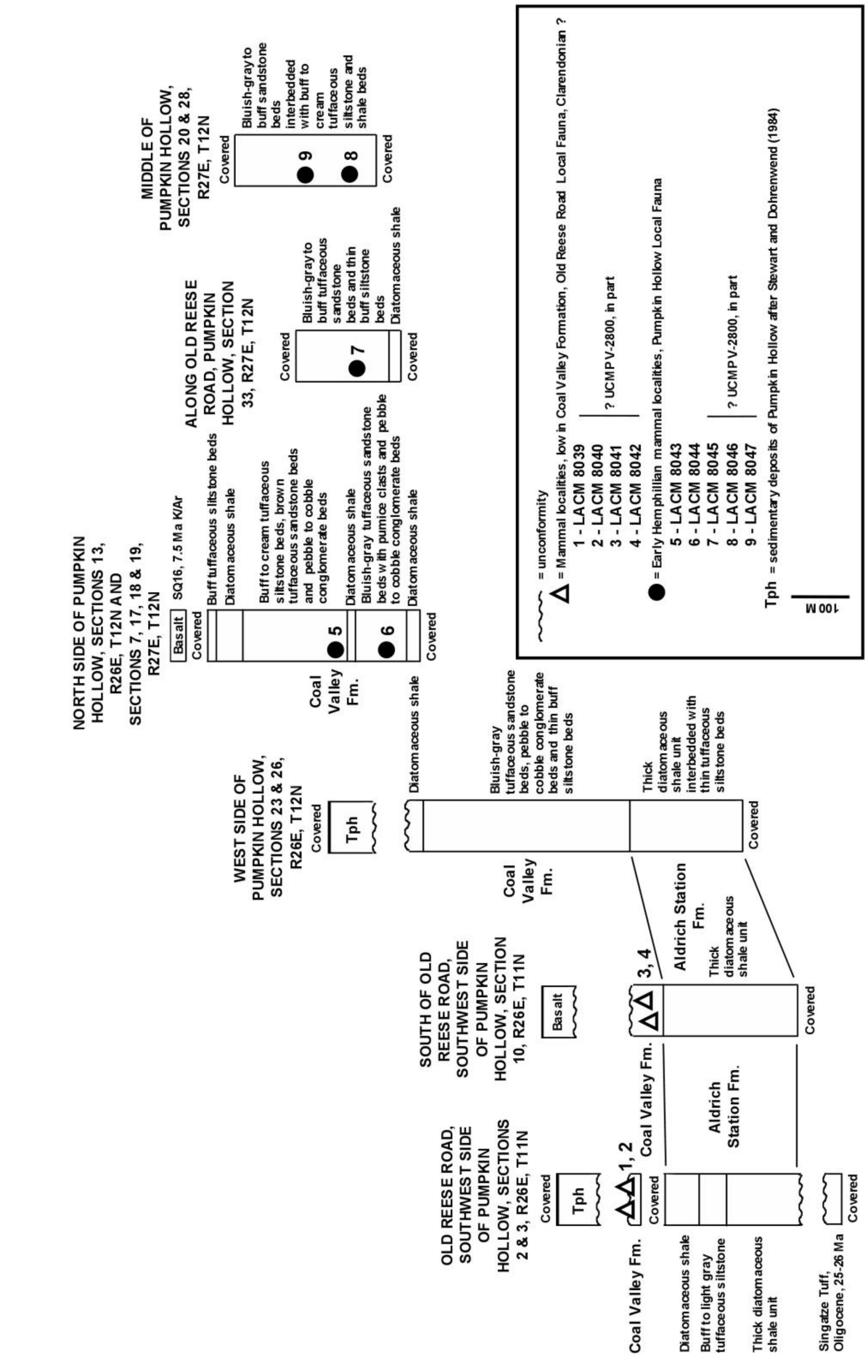

FIGURE 5. Schematic stratigraphic sections in the Pumpkin Hollow area of Lyon and Mineral Counties, Nevada, showing relative stratigraphic positions of the fossil mammal yielding levels in the Coal Valley Formation.

FIGURE 6. *Cormohipparion sp.*, cf. *C. quinni* from type section of Coal Valley Formation. A, associated LP2, partial RP2 and RP3-M2, LACM 160247. B, LdP2, UCMP 38279. C, RdP3 or 4, LACM 160251. D, RP3, LACM 160248. E, partial RP3, LACM 160249. F, LM1 or 2, UCMP 40373. G-I, RM1 or 2, LACM 160252. J and K, associated LM1 and 2, UCMP 40371. L-M, Rdp3 or 4, LACM 160254. N-O, Lp3 or 4, LACM 160253. P, Lm1 or 2, LACM 160256. Q, partial Lm3, LACM 160257. A-G, J-L, N and P-Q, occlusal views. H and O, labial views. I, posterior view. Scale bar = 5 mm. Photographs B, F, J and K courtesy of Stephen W. Edwards.

the Florida and Nebraska samples of *N. trampasense* (Stephen Edwards, personal communication, 2018). This slightly lower crown height would not be surprising because Hulbert (1987b) noted that the Kendall-Mallory specimens represent the least derived sample of *N. trampasense*, including more oval protocones with flat lingual borders on the upper check teeth and weaker, less persistent pli caballinids on the lower cheek teeth as compared with the younger samples of the species.

The lower cheek teeth of the small Coal Valley hipparionine (Figures 6L-Q) differ from those of the topotypic sample of *N. trampasense* from Kendall-Mallory and the other samples of the species reported by Hulbert (1987b:table 3) by having slightly shorter metastylid-metaconid lengths (mean p3-4 mml = 10.63 mm, mean m1-2 mml = 10.78 mm). The dental statistics for large samples of lower cheek teeth of *C. quinni* have not been reported in the literature. Otherwise, the lower cheek teeth of many hipparionine species have similar occlusal patterns (MacFadden, 1984), but those of the *Neohipparion* lineage exhibit a progressive transverse narrowing, that is the width becomes narrower relative to the length along with a progressive flattening of the labial enamel borders of the protoconid and hypoconid through time (Hulbert, 1987b). The lower premolars of the small Coal Valley hipparionine exhibit a slight flattening of the lingual borders of protoconid and hypoconid (Figure 6N), but not to the extent seen in the topotypic sample and other samples of *N. trampasense* (Edwards, 1982:fig. 6; MacFadden, 1984:figs. 74-75).

Although the cheek teeth of the small Coal Valley hipparionine are similar in size and occlusal morphology to those of *Cormohipparion quinni*, they differ as follows (Woodburne, 1996): 1) the protocones are more compressed transversely (less rounded occlusal outlines, e.g., mean M1-2 pw/pl = 0.466 versus 0.486 and 0.504 for topotypic sample from Devil's Gulch Quarry and sample from Railway Quarry A of *C. quinni*, respectively); 2) P2-M2 protocones remain separate from protolophs throughout wear; 3) P3-4 protocones lack anterior spurs during early wear; and 4) the widths lower premolars are narrower (less inflated transversely) relative to widths of the lower molars. All of these differences indicate that the small Coal Valley hipparionine is more derived than *C. quinni* (MacFadden, 1984; Woodburne, 1996, 2007).

It should be noted that *Cormohipparion quinni* has a complicated taxonomic history. Based on an isolated RP2 and partial LP3, Cope (1899) described *Hippotherium sphenodus* from the Pawnee Creek beds of Colorado, but failed to designate a type specimen between these two teeth. Later, Osborn (1918) reassigned *Hippotherium sphenodus* to *Merychippus* and designated the P2 as the lectotype and the P3 as the co-type. Woodburne et al. (1981) considered the teeth from Pawnee Creek to be conspecific with other well preserved hipparionine samples, some including skulls, from Nebraska, Colorado, New Mexico and California. Based on these more complete specimens, Woodburne et al. (1981) reassigned *M. sphenodus* to *Cormohipparion*, which was followed by MacFadden (1984). However, Woodburne (1996) reappraised the taxonomic status of *C. sphenodus*, where he considered the P2 lectotype, the P3 co-type of the species and certain additional teeth, along with a few specimens with the facial fossa partially preserved from the early late Barstovian Pawnee, Horse and Mastodon Quarries of the Pawnee Creek beds, as exhibiting dental and cranial morphologies that are more characteristic of *Merychippus* rather than *Cormohipparion*. Woodburne (1996) restricted these specimens to the species and reassigned them to *Merychippus sphenodus*. Woodburne (1996) then referred the well-preserved skulls and dentitions from the younger late Barstovian Devil's Gulch Horse Quarry of the Cornell Dam Member and the Railway Quarry A of the Crookston Bridge Member of the Valentine Formation, previously assigned to *C. sphenodus*, to a new species, *Cormohipparion quinni*. Woodburne (1996) did not address the taxonomic status of the specimens from California, which are only known from teeth and were previously referred to *C. sphenodus* (Woodburne et al., 1981; MacFadden, 1984). Subsequently, Woodburne (2007) also referred a skull from the medial Clarendonian MacAdams Quarry, Clarendon beds, Texas, to *C. quinni*, which was previously assigned by MacFadden (1984) to *C. sphenodus*. It should be noted that Woodburne (2007) informally subdivided the medial Clarendonian (Cl2) into an early medial Clarendonian (Cl2.1) for the time represented by the faunas from MacAdams Quarry, Minnechaduza (Nebraska), Big Spring Canyon (South Dakota), and the Hollow Horn Bear Quarry (South Dakota) and a late medial Clarendonian (Cl2.2) for the time represented by the faunas from the X-mas Kat (Nebraska), *Machaerodus* (Nebraska), Hans Johnson quarries (Nebraska), Ed Ross Ranch Quarry (South Dakota) and Gidley Horse Quarry (Texas). Woodburne (2007:25) regarded the MacAdams Quarry to be between 12.0 to 11.5 Ma in age. Thus, the chronologic range of *C. quinni* as recognized by Woodburne (1996, 2007) is late Barstovian to early medial Clarendonian.

The comparisons provided above demonstrate the difficulty of assigning a sample of cheek teeth to a hipparionine species. Overall, the small Coal Valley hipparionine exhibits more dental similarities to *C. quinni* than to *N. trampasense* or any other similarly sized Clarendonian hipparionine. However, as noted above, the small Coal Valley hipparionine does exhibit certain dental characters that suggest it may represent a distinct species, more derived than *C. quinni*. The taxonomic opinion of Stephen W. Edwards (per. communication, 2018) that the Coal Valley small hipparionine represents a species related to *N. trampasense*, but less derived, cannot be unambiguously ruled out without knowledge of the cranial morphology, including the facial fossa structure. However, the morphological data indicate that it more likely represents a species related to *C. quinni*. Thus, the small Coal Valley hipparionine is referred to *Cormohipparion* sp., cf. *C. quinni* to reflect this possibility.

The second hipparionine species from Coal Valley is only represented by a partial upper cheek tooth (ectoloph and fossettes) and a partial right dentary with Rp3 or 4 (Figure 8A). They differ from

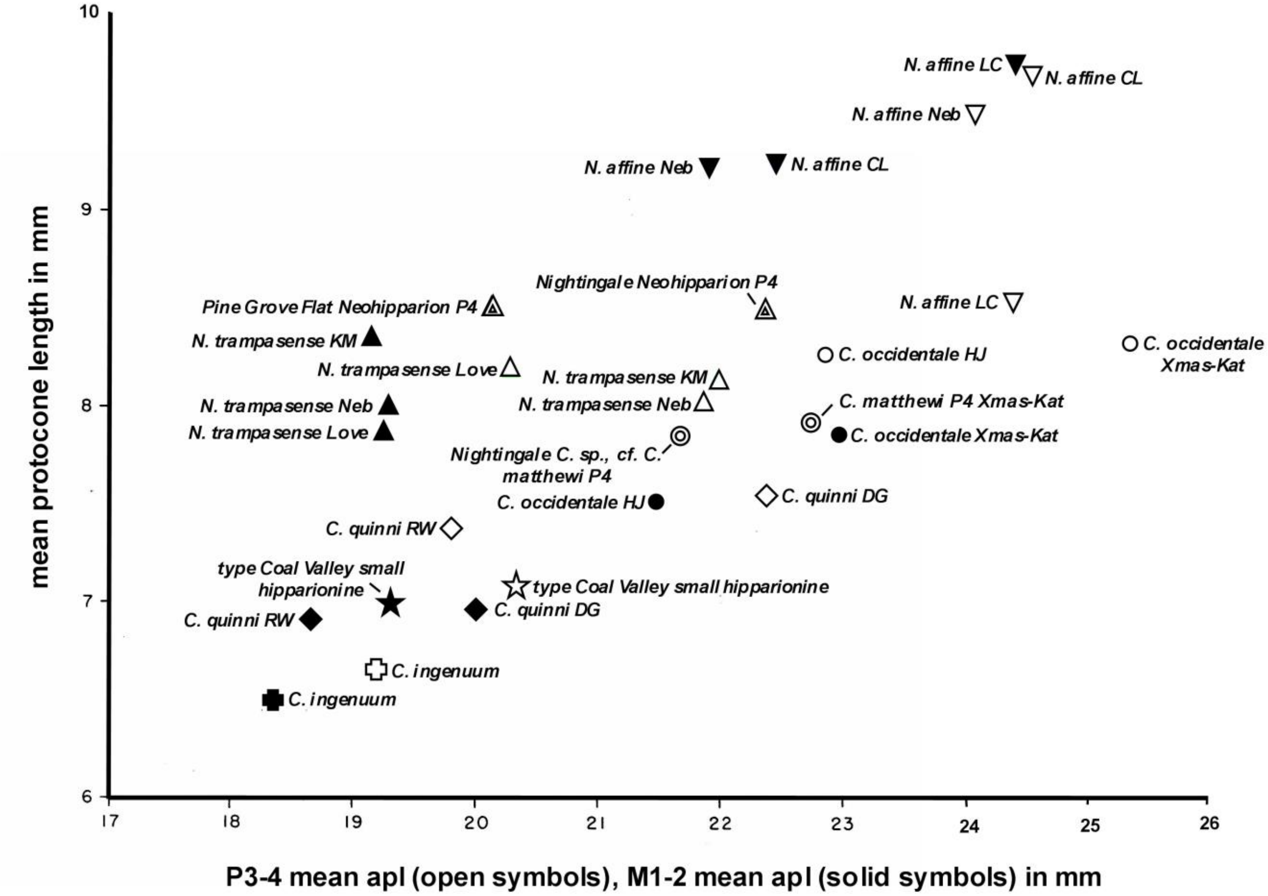

FIGURE 7. Graph comparing the mean P3-4 and M1-2 protocone lengths (pl) to mean P3-4 and M1-2 lengths (apl) in mm of selected hipparionine species (*Cormohipparion ingenuum*, *Cormohipparion quinni*, *Cormohipparion occidentale* sensu stricto, *Neohipparion trampasense* and *Neohipparion affine*), the small hipparionine from the medial Clarendonian type section of the Coal Valley Formation, the *Neohipparion* P4 (LACM 160243) from the late Clarendonian outcrop of Coal Valley Formation at Pine Grove Flat, a *Neohipparion* P4 (UCMP 38659) and a *Cormohipparion* sp., cf. *C. matthewi* P4 (UCMP 39327) from the late Clarendonian Nightingale Local Fauna of the lower member of the Truckee Formation, and the mean P4 apl and mean P4 pl of *Cormohipparion matthewi* from Xmas-Kat. Abbreviations for samples are: LC, Lapara Creek Fauna, Texas; CL, Clarendon beds (combined sample from Noble Ranch, Grant Lease and MacAdams Quarry), Texas; DG, Devil's Gulch Member, Valentine Formation, Nebraska; HJ, Hans Johnson Quarry, Ash Hollow Formation, Nebraska; KM, Kendall- Mallory Local Fauna, California; LOV, Love Site, Florida; Neb, combined sample *N. affine* from Clarendonian localities of Nebraska and South Dakota and combined sample *N. trampasense* from Xmas-Kat Quarries, Ash Hollow Formation, Nebraska; RW, Railway Quarry A, Crookston Bridge Member, Valentine Formation, Nebraska; Xmas-Kat, Xmas-Kat Quarries, Ash Hollow Formation, Nebraska. Measurements for *C. ingenuum* (Love Site, late Clarendonian) from Hulbert (1988), *C. quinni* from Woodburne (1996), *C. occidentale* sensu stricto and *C. matthewi* from Woodburne (2007), and *N. trampasense* and *N. affine* from Hulbert (1987b).

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those of *C.* sp., cf. *C. quinni* from Coal Valley by the following: 1) larger; 2) less complex plications of the prefossette and postfossette; 3) a shorter mesostyle radius of curvature (ROC = ~60 mm versus ROC for *C.* sp., cf. *C. quinni* of ~73 mm); 4) a relatively larger, more transversely expanded metastylid-metaconid complex; 5) slightly more rounded labial borders of the protoconid and hypoconid; 6) a small, weak pli caballinid; and 7) pre- and postfossettids with simple enamel borders (lacking plications). They also differ from the hipparionine specimens of the Pine Grove Flat Local Fauna referred to *Cormohipparion* sp., cf. *C. matthewi* (see below) by the following: 1) slightly larger size; 2) a metaconid that is larger than the metastylid; 3) the metaconid and metastylid are more expanded anteroposteriorly (mml = 15.82 mm); and 4) lacking an accessory stylid on the hypoconid. A generic diagnosis for these teeth is questionable, but they are most similar in size and occlusal morphology to those of *Cormohipparion* and likely represent an undetermined species of the genus.

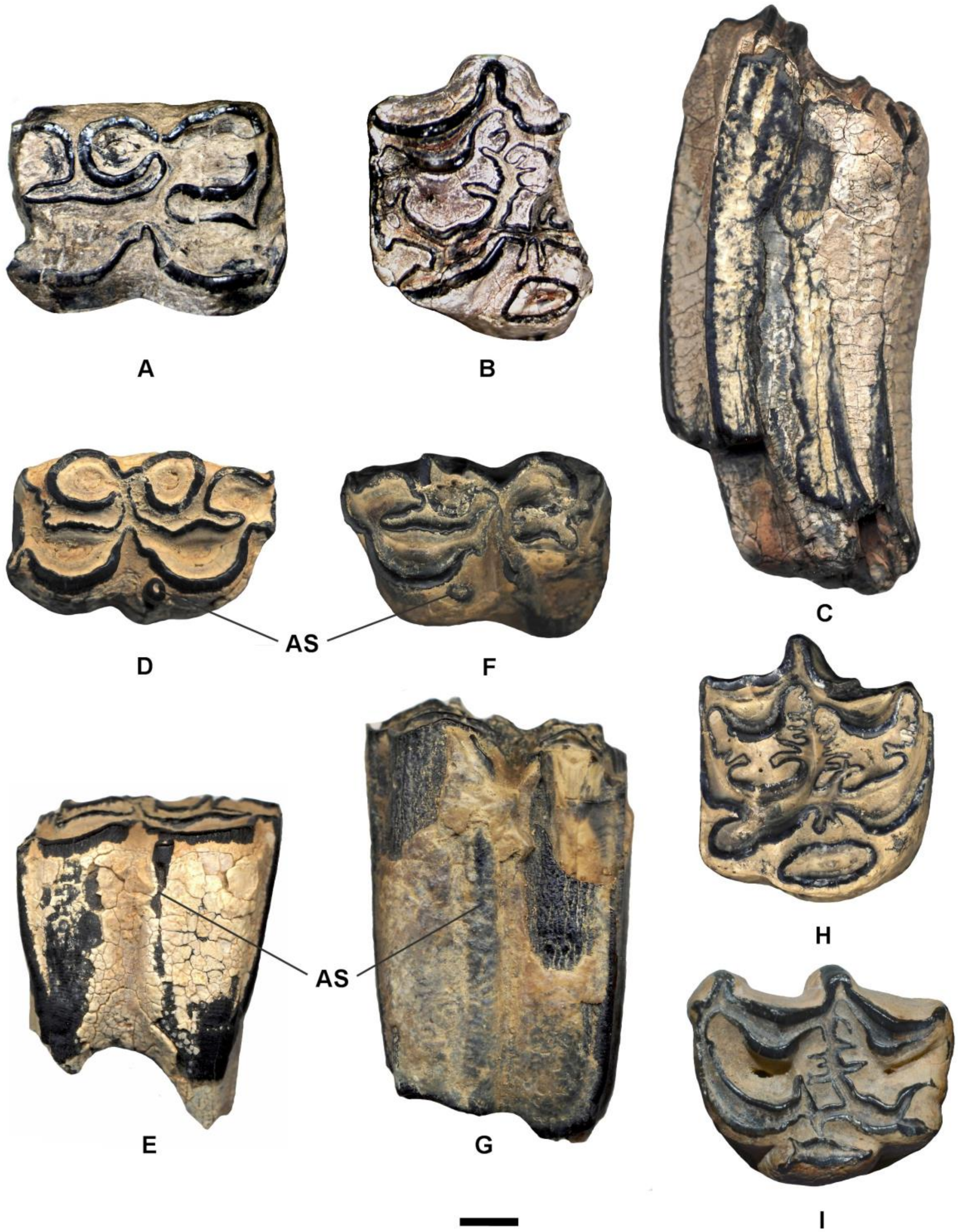

FIGURE 8. Equidae from Coal Valley Formation and lower member of Truckee Formation. A, cf. *Cormohipparion* sp., Rp4, LACM 160260, medial Clarendonian Coal Valley Local Fauna, type section of Coal Valley Formation. B-G, *Cormohipparion* sp., cf. *C. matthewi*: B-C, partial RP4, LACM 160244, late Clarendonian Pine Grove Flat Local Fauna, south of Pine Grove Canyon, Coal Valley Formation; D and E, Lm1 or 2, LACM 160261, late Clarendonian Nightingale Local Fauna, Truckee Formation; F and G, partial Rm1 or 2, LACM 160242, late Clarendonian Pine Grove Flat Local Fauna, Pine Grove Flat, Coal Valley Formation. H-I, *Neohipparion trampasense*: H, partial RP4, LACM 160243, late Clarendonian Pine Grove Flat Local Fauna, Pine Grove Flat, Coal Valley Formation; I, LP4, UCMP 38659, late Clarendonian Nightingale Local Fauna, Truckee Formation. AS, accessory stylid. A-B, D, F, H and I occlusal views. C, posterior view. E and G, labial views. Scale bar = 5 mm. Photograph 8I courtesy of Stephen W. Edwards.

TABLE 1. Revised faunal lists of local faunas from the Coal Valley Formation and the Nightingale Local Fauna from the lower member of the Truckee Formation of Nevada.

Coal Valley Local Fauna, medial Clarendonian (Cl2)

Mammalia
- Carnivora
  - Mustelidae
    - *Plionictis* sp.
  - Canidae
    - *Epicyon* sp.
- Rodentia
  - Castoridae
    - *Hystricops* sp.
    - *Prodipoides* sp., cf. *P. dividerus*
- Proboscidea
  - Gomphotheriidae
    - cf. *Gomphotherium* sp.
- Perissodactyla
  - Rhinocerotidae
    - *Peraceras profectum*
  - Equidae
    - *Cormohipparion* sp., cf. *C. quinni*
    - cf. *Cormohipparion* sp. (large)
    - "*Pliohippus*" *tehonensis*
- Artiodactyla
  - Camelidae
    - cf. *Miolabis* sp.
    - cf. *Aepycamelus* sp.
  - Antilocapridae, genus undetermined

Pine Grove Flat Local Fauna, includes Pine Grove Flat localities (UCMP V71099, LACM 8048, 8049) and the south of Pine Grove Canyon localities (LACM 8050, 8051), late Clarendonian (Cl3)

Actinoptergyii
  - family indeterminate

Mammalia
- Proboscidea
  - Gomphotheriidae
    - *Gomphotherium* sp.
- Perissodactyla
  - Rhinocerotidae, genus undetermined
  - Equidae
    - *Cormohipparion* sp., cf. *C. matthewi*
    - *Neohipparion trampasense*
    - *Pliohippus* sp.
- Artiodactyla
  - Merycoidodontidae
    - *Merychyus major major*
  - Camelidae, genera undetermined
    - two species (one moderately large sp. and one smaller sp.)
  - Protoceratidae or Dromomerycidae,
    - genus undetermined (partial horn core)

Nightingale Local Fauna, including Brady Pocket, late Clarendonian (Cl3)

Actinopterygii
- Gasterosteiformes
  - Gasterosteidae
    - Stickleback, genus undetermined

Testudines
  - Testudinidae, genus undetermined

Aves
  - Phalacrocoracidae
    - *Phalacrocorax* sp., cf. *P. wetmorei*
  - Charadriidae
    - charadriid sp., genus undetermined
  - Alcedinidae
    - cf. *Megaceryle* sp.
  - Anatidae
    - *Anas* sp.

Mammalia
- Lipotyphla
  - Soricidae
    - *Alluvisorex* sp., cf. *A. chasseae*
  - Talpidae
    - *Scapanus* sp., cf. *S. tedfordi*
- Lagomorpha
  - Leporidae
    - *Alilepus hibbardi*
    - *Hypolagus fontinalis*
  - Ochotonidae
    - *Hesperolagomys* sp.
- Rodentia
  - Sciuridae
    - *Protospermophilus* sp.
  - Castoridae
    - *Prodipoides lecontei*
  - Mylagaulidae
    - *Hesperogaulus* sp., cf. *H. wilsoni*
  - Geomyidae
    - *Phelosaccomys* sp., cf. *P. shotwelli*
- Heteromyidae
    - *Perognathus minutus*
    - *Cupidinimus* sp.
- Carnivora
  - Mustelidae
    - *Limnonyx* sp.
  - Canidae
    - cf. *Leptocyon* sp.
- Proboscidea
  - Gomphotheriidae
    - *Gomphotherium* sp.
  - Rhinocerotidae
    - *Aphelops megalodus*
    - *Teleoceras major*
- Perissodactyla
  - Equidae
    - *Cormohipparion* sp., cf. *C. matthewi*
    - *Neohipparion trampasense*
    - *Pliohippus* sp.
- Artiodactyla
  - Merycoidodontidae
    - *Merychyus major major*
  - Camelidae
    - *Aepycamelus bradyi*
  - Antilocapridae
    - cf. *Cosoryx* sp.

Old Reese Road Local Fauna, includes localities LACM 8039-8042 and ?UCMP V2800 in part, Clarendonian?

Mammalia
- Rodentia
  - Castoridae
    - *Prodipoides* sp.
- Proboscidea
  - Gomphotheriidae, genus undetermined
- Perissodactyla
  - Equidae, genus undetermined
- Artiodactyla
  - Camelidae, genera undetermined

two species, one small and one very large

Pumpkin Hollow Local Fauna, includes localities LACM 8043-8047 and ?UCMP V2800 in part, early Hemphillian (Hh1 or Hh2)

Reptilia
Testudines, family undetermined
Mammalia
Lagomorpha
Leporidae
cf. *Hypolagus* sp.
Carnivora, family undetermined
Proboscidea
Gomphotheriidae, genus undetermined
Artiodactyla
Camelidae
Hemiuchenia sp.
Megatylopus or *Alforjas* sp.
Antilocapridae, genus undetermined
Perissodactyla
Rhinocerotidae
Teleoceras hicksi
Equidae
"*Dinohippu*s" sp., cf. "*D.*" *spectans*
?Cormohipparion sp.

Wilson Canyon Local Fauna, early early Hemphillian (Hh1)

Mammalia
Lagomorpha
Leporidae
Hypolagus vetus
Rodentia
Aplodontidae, genus undetermined
Sciuridae
Spermophilus argonautus
Geomyidae
Pliosaccomys dubius
Zapodidae
Pliozapus solus
Castoridae
Dipoides sp., cf. *D. stirtoni*
Cricetidae
?*Paronychomys antiquus*
Proboscidea
Gomphotheriidae
Gomphotherium sp.
cf. *Rhyncotherium* sp.
Carnivora
Canidae
Borophagus secundus
Eucyon davisi
Felidae
Machairodus sp.
Barbourofelis fricki
Mustelidae
Eomellivora sp.
Artiodactyla
Tayassuidae
Prosthenops oregonensis
Antilocapridae
Illingoceras alexandrae
Camelidae
Hemiauchenia sp.
Alforjas sp.
Megatylopus sp.
Perissodactyla
Rhinocerotidae
Aphelops malacorhinus
Equidae
"*Dinohippus*" sp., cf. "*D.*" *spectans*

Petrified Tree Canyon Local Fauna, late early Hemphillian (Hh2)

Actinoptergii
Cypriniformes
Cyprinidae
cf. *Lavinia* sp.
Catostomidae
Catostomus sp.
Amphibia
Anura
Hylidae
Hyla sp. (small)
Hyla sp. (large)
Ranidae
Rana sp.
Bufonidae
Bufo sp.
Pelobatidae
Scaphiopus sp.
Mammalia
Eulipotyphla
Soricidae
Cryptotis sp.
Limnoecus sp.
Lagomorpha
Leporidae
cf. *Hypolagus* sp.
Rodentia
Sciuridae
Spermophilus sp.
Heteromyidae
Perognathus sp., cf. *P. mclaughlini*
Geomyidae
Parapliosaccomys martini
Cricetidae
Paronychomys jacobsi
Postcopemys sp. A
Postcopemys sp. B
Bensonomys lindsayi
Proboscidea
Mammutidae
Mammut (*Pliomastodon*) *nevadensis* (= *Mammut* sp., *vide* Lambert and Shoshani, 1998)
Carnivora
Ursidae
Inarctos nevadensis
Canidae
Eucyon davisi
Mustelidae
Martes sp.
Artiodactyla
Tayassuidae
Prosthennops oregonensis
Camelidae
Hemiauchenia sp.
Alforjas sp.
Megatylopus sp.
Antilocapridae, genus undetermined
Perissodactyla
Rhinocerotidae
Teleoceras fossiger
Equidae
"*Dinohippus*" sp., cf. "*D.*" *spectans*

Pine Grove Hills Local Fauna, early late Hemphillian (Hh3)

Mammalia
- Edentata
  - Megalonychidae
    - *Megalonyx* sp.
- Proboscidea, family undetermined
- Carnivora
  - Ursidae
    - *Inarctos nevadensis*
  - Canidae
    - *Carpocyon* sp., cf. *C. limosus*
  - Felidae, genus undetermined
- Artiodactyla
  - Camelidae
    - *Pleiolama vera*
    - *Megatylopus* sp.
  - Dromomerycidae
    - cf. *Pediomeryx* sp.
- Perissodactyla
  - Equidae
    - *Dinohippus* sp. (small)
  - Rhinocerotidae
    - *Teleoceras* sp., cf. *T. hicksi*

A third horse species, "*Pliohippus*" *tehonensis*, from the type section of the Coal Valley Formation is represented by an isolated Lm2 (LACM 160259, Figures 9A-C). The taxonomic history of "*Pliohippus*" *tehonensis* is complicated. Merriam (1915) described *Protohippus tehonensis* based on an M1 or 2 (UCMP 21779) from locality UCMP V2751 in the South Tejon Hills, California. Merriam (1915) assigned a p3 or 4 (UCMP 21484) from Comanche Creek, Tejon Hills, California, to *Merychippu*s sp., but later (Merriam, 1916a) tentatively reassigned this tooth to *Protohippus tehonensis*. However, J. Howard Hutchison discarded the UCMP record for this specimen on July 9, 1969 due to a lack of provenance data. Stirton (1940) transferred *Protohippus tehonensis* to *Pliohippus*, which was followed by Drescher (1941), Savage (1955) and James (1963). However, Hulbert (1987a, 1993) first noted that this species likely represents a separate clade from *Pliohippus* sensu stricto, possibly related to the *Astrohippus-Dinohippus-Equus* clade and thus referred it to "*Dinohippus*" *tehonensis*. Kelly (1995) described *Heteropliohippus hulberti* from the Caliente Formation of California and noted certain synapomorphies of his new taxon with *Pliohippus tehonensis*, but since the facial morphology of the latter is unknown, he referred it to "*Pliohippus*." Based on cladistic analyses, Kelly (1995, 1998a) demonstrated that *H. hulberti* along with "*Pliohippus*" *tehonensi*s represent a clade that is the closest sister taxon to the *Astrohippus-Dinohippus-Equus* clade.

LACM 160259 is indistinguishable in size and occlusal morphology from the m1-2 of "*Pliohippus*" *tehonensis* (Merriam, 1915), including the following (Merriam, 1916a; Drescher, 1941; Savage, 1955; Kelly, 1995, 1998a): 1) the metaconid is larger than the metastylid, but both are small (metaconid/metastylid length = 9.15 mm at occlusal surface and 10.08 mm near the base) as compared with those of hipparionine lower molars; 2) a well-developed protostylid that extends from the base to about half way up the crown; 3) lacking a pli caballinid; 4) a deep ectoflexid; 5) rounded labial borders of the protoconid and hypoconid; 6) very shallow pre- and postfossettids with simple enamel patterns (lacking plications); and 7) a thick layer of cementum. Besides "*P*." *tehonensis*, the only other early to medial Clarendonian (Cl1-Cl2) horse that exhibits a combination of a pliohippine-like occlusal pattern and a distinct protostylid is *Heteropliohippus hulberti*. The Lm2 from Coal Valley can be easily distinguished from *H. hulberti* by its significantly smaller size and relatively narrower transverse width (Kelly, 1995, 1998a). Thus, the Lm2 from the type section of the Coal Valley Formation can be confidently assigned to "*P*." *tehonensis*.

In addition to the holotype upper molar of "*Pliohippus*" *tehonensis* of the South Tejon Hills Local Fauna (Merriam, 1915), Drescher (1941) referred two specimens (p2-4, LACM [CIT] 2617; m1-3, LACM [CIT] 2618) to the species from locality LACM (CIT) 303 in the South Tejon Hills. "*Pliohippus*" *tehonensis* is also know from UCMP V5304, Comanche Point Local Fauna (Savage, 1955). Stock (1935) assigned a partial dentary with dp2-4 and m1 (LACM [CIT] 1825) to "*P*." *tehonensis*. It came from a well core that was taken several miles northwest of Comanche Point. Whistler and Burbank (1992) reported the occurrence of "*Pliohippus*" *tehonensis* in the Dove Spring Formation of California, but later Whistler et al. (2009) reassigned all of the Dove Spring specimens to *Pliohippus tantalus* Merriam, 1913.

Originally, the localities that yielded the South Tejon Hills Local Fauna were stated to occur in the Santa Margarita Formation (e.g., Drescher, 1941; Savage, 1955), but these beds were reassigned to the non-marine Bena Gravel (or Bena Formation) by Dibblee and Warne (1970), which was followed by Bartow and McDougall (1984). The thin marine section of strata containing UCMP V5304, which underlies the Chanac Formation at Comanche Point and unconformably overlies the Bena Gravel, was retained in the Santa Margarita Formation (Barton and McDougall, 1984). Wilson and Prothero (1997) determined that the Comanche Point Local Fauna occurs near the boundary of Chron C5An and Chron C5r of the GPTS, which is dated at 12.01 Ma (early Clarendonian, Cl1), and the South Tejon Hills Local Fauna was extrapolated to occur lower down in Chron C5An (dated at 12.42-12.01 Ma). The stratigraphically higher North Tejon Hills Local Fauna from the Chanac Formation was at first thought to occur near the middle of Chron C5r (Wilson and Prothero, 1997), but a later assessment placed the fauna in Chron C4Ar (Prothero and Tedford, 2000), which is dated at about 9.7-9.0 Ma. The Black Hawk Ranch Local Fauna is the type fauna for the "late Clarendonian" Montediablan Stage and the South Tejon Hills Local Fauna along with the Comanche Point Local Fauna are the type faunas of the "early Clarendonian" Cerrotejonian Stage of Savage (1955). Savage (1955) also included the North Tejon Hills Local Fauna in the Montediablan. Prothero and Tedford (2000) placed the Black Hawk Ranch Local Fauna in the lower part of Chron C4Ar, dated at about 9.6 Ma.

James (1963) recognized two faunas from the Caliente Formation of Ventura and San Luis Obispo Counties, California, the Matthews Ranch Local Fauna and the Nettle Spring Local Fauna, which he considered early and late Clarendonian in age, respectively. "*Pliohippus*" *tehonensis* occurs in the Matthews Ranch Local Fauna (James, 1963; Kelly and Lander, 1992; Prothero et al., 2008). Prothero et al. (2008) provided magnetostratigraphic evidence that the Matthews Ranch Local Fauna occurs from Chron C5An to the lower half of Chron C5r of the GPTS, an interval dated at about 12.42-11.5 Ma, whereas the Nettle Spring Local Fauna occurs in the upper half of Chron C5r, an interval of about 11.5-11 Ma. Applying these data, Prothero et al. (2008) placed the boundary between Savage's (1955) Montediablan and Cerrotejonian Stages at about 11.5 Ma. However, recent faunal characterizations of the Clarendonian divide the age into three successive intervals: the early Clarendonian (Cl1) from about 12.5-12 Ma, medial Clarendonian (Cl2) from about 12-10 Ma, and late Clarendonian (Cl3) from about 10-9 Ma (Tedford et al., 2004; Kelly and Whistler, 2014). This would correlate the Cerrotejonian Stage to the early and early medial Clarendonian and Montediablan to the late medial and late Clarendonian. The use of the Montediablan and Cerrotejonian Stages were originally constructive in defining the "early and late Clarendonian" of the Pacific Coast when the middle Miocene mammalian biochronologic succession was not well understood, but these "stages" should be abandoned in favor of the slightly more refined faunal subdivisions of the Clarendonian presented by Tedford et al. (2004) and Whistler et al. (2009).

The magnetostratigraphic data indicate that "*Pliohippus*" *tehonensis* is known elsewhere from the early Clarendonian through the early part of the medial Clarendonian, or about 12.4-11.5 Ma. The presence of "*P*." *tehonensis* in the Coal Valley Local Fauna appears to represent a slightly younger record for the species at somewhere between 11.5 to 10.8 Ma, but still within the medial Clarendonian (Cl2). Possible younger occurrences of the species in the San Francisco Bay area of northern California and elsewhere are currently being studied by Stephen W. Edwards (per. communication, 2017).

Northeastern flanks of the Pine Grove Hills—During the 1970s, field parties from the UCMP discovered mammal fossils in an isolated outcrop of Coal Valley Formation (locality V71099) exposed on the west side of Pine Grove Flat (Figure 1). Subsequently, additional fossils were recovered from this outcrop at localities LACM 8048 and 8049. The fossils came from siltstone and sandstone beds that occur from about 49 to 162 m below the marker shale (Figure 3). This mammal assemblage is here assigned to the Pine Grove Flat Local Fauna (Table 1).

The outcrop of Coal Valley Formation at Pine Grove Flat has yielded a small hipparionine species, which is represented by a RP4 (LACM 160243). It is referred to *Neohipparion trampasense* because it agrees well in size and occlusal morphology to the P4s of this species, including an elongated protocone (pl = 8.77 mm, pw = 3.59 mm), moderately complex pre- and postfossette plications, a doubled pli caballin, and a well developed pli protoconule that extends to near the lingual margin of the prefossette (Figures 7 and 8H). Macdonald (1956:fig. 11) documented the occurrence of *Neohipparion* sp. in the late Clarendonian Nightingale Local Fauna from the lower member of the Truckee Formation, Churchill County, Nevada, based on an isolated, barely worn upper cheek tooth (UCMP 38659) that he considered M2. However, this tooth has the parastyle and mesostyle broadly expanded near their bases and a prominent groove along the labial aspect of the parastyle, indicating that it likely represents a P4 (Bode, 1931). The Nightingale P4 is compatible in size and occlusal morphology to *N. trampasense* and is referred to the species (Figures 7 and 8I).

A second, larger hipparionine species is present in the Pine Grove Flat Local Fauna (Figures 8B-C, 8F-G). This appears to be the same species, originally referred to *Neohipparion* sp., cf. *N. occidentale* by Macdonald (1956) and later referred to *Cormohipparion* sp., cf. *C. occidentale* by Kelly (1998b), that occurs in the late Clarendonian Nightingale Local Fauna. For example, a Rm1 or 2 (LACM 160242, Figures 8F, 8G) from Pine Grove Flat exhibits the typical occlusal enamel pattern seen in species of *Cormohipparion* (MacFadden, 1984; Woodburne, 2007), including a large metaconid and metastylid that are well separated ("bow-tie" appearance), anteroposteriorly expanded pre- and postfossettids with moderate plications along their enamel borders, rounded labial borders of the protoconid and hypoconid, an expanded entoconid, a distinct protostylid, a moderately developed pli caballinid, and thick cementum. One additional distinctive character seen in LACM 160242 is an accessory stylid that is positioned at the anterolabial

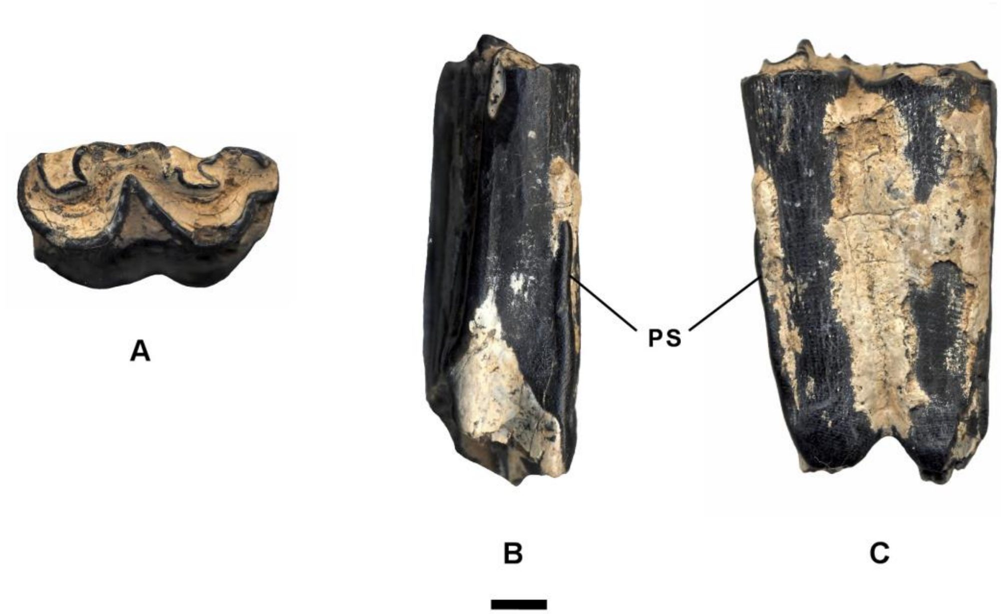

FIGURE 9. "*Pliohippus*" *tehonensis* from Coal Valley Formation, Coal Valley. A-C, Lm2, LACM 160259. PS = protostylid. A, occlusal view. B, anterior view. C, labial view. Scale bar = 5 mm.

corner of the hypoconid (Figures 8F, 8G). This stylid extends down to the base of the crown as a distinct ridge and is closely appressed to the anterolabial wall of the hypoconid. This stylid does not appear to be homologous to the ectostylid commonly seen in hipparionine deciduous premolars, where the ectostylid is positioned centrally between the protoconid and entoconid, and only extends up from the base of the crown for about one-third to one-half of the height of the crown. The presence of this accessory stylid in the Pine Grove Flat specimen might be interpreted as an aberrant developmental anomaly, but for the fact that an identical accessory stylid is present on a lower molar (LACM 160261, Figures 8D, 8E) from the late Clarendonian Nightingale Local Fauna (Macdonald, 1956; Kelly, 1998b). Moreover, both of these lower cheek teeth are clearly not deciduous and agree well in size and occlusal morphology, strongly suggesting they are conspecific.

Two localities (LACM 8050 and 8051) yielded a small sample of mammal fossils from thin, alternating buff to brown siltstone and pebble conglomerate beds, that occur stratigraphically at about 21 and 95 m below the marker shale unit in the Coal Valley Formation section exposed in a small easterly draining canyon, south of Pine Grove Canyon (Figure 3, Pine Grove Canyon South section). Several partial upper cheek teeth of a large hipparionine horse were recovered from these localities. As is the case of the lower molar from the Pine Grove Flat locality, a partial P4 from south of Pine Grove Canyon (Figures 8B-C) is indistinguishable in size and occlusal morphology from the upper premolars of the large hipparionine from the late Clarendonian Nightingale Local Fauna of the Truckee Formation (Macdonald, 1956; Kelly 1998b), including an oval protocone, moderately developed plications of the pre- and postfossettes, a very strong, doubled pli caballin, a wide hypoconal grove extending to the base of the crown, and thick cementum. This further supports a conspecific assignment of the large hipparionine specimens from the localities in the Coal Valley Formation at Pine Grove Flat and from south of Pine Grove Canyon, and the lower member of the Truckee Formation (Nightingale Local Fauna). Because the stratigraphic levels of the beds that yielded the specimens from Pine Grove Flat and south of Pine Grove Canyon are similarly positioned below the marker shale and they both contain the same species of horse, the specimens from south of Pine Grove Canyon are included in the Pine Grove Flat Local Fauna.

Although the larger hipparionine of the Nightingale Local Fauna was previously referred by Kelly (1998b) to *Cormohipparion* sp., *C. occidentale*, this informal species assignment needs to be reassessed in light of new insights provided by Woodburne (2007) regarding *C. occidentale*. Because the taxonomic history of *C. occidentale* is complicated, a brief review is presented here. Leidy (1856) named *Hipparion occidentale* from Clarendonian sediments exposed along the Little White River of South Dakota. Gidley (1903) erected a new genus, *Neohipparion*, and most later investigators (e.g., Stirton, 1940; Webb, 1969) reallocated *H. occidentale* to his new genus. Based on an analysis of cranial and dental characters, Skinner and MacFadden (1977) recognized a new genus, *Cormohipparion*, and designated *C. occidentale* as the type species, which was followed by MacFadden (1984; 1998). Based on a very detailed morphometric analysis, Woodburne (2007) recognized that the samples referred to *C. occidentale* actually represent a complex of species ranging from the early to late medial Clarendonian. He then divided this complex into six species: the type species *C. occidentale* sensu stricto and five new related species. Except for two species left in open nomenclature, *Cormohipparion* sp. from the Clarendonian of the Dove Spring Formation and *Cormohipparion* sp. from Clarendonian of the Punchbowl Formation of California, Woodburne (2007) did not address any of the other western occurrences of hipparionine samples that are similar to species in the *C. occidentale* complex. Woodburne's (2007) species diagnoses were based primarily on differences in the cranial morphology, but also included the degree of hypsodonty and some minor differences in the occlusal morphology of the cheek teeth. Unfortunately, the hipparionine samples from Pine Grove Flat and the Nightingale Local Fauna, lack cranial material. Of the six species that Woodburne (2007) recognized in the *C. occidentale* species complex, the Pine Grove Flat and Nightingale cheek teeth are most similar morphologically to those of *Cormohipparion matthewi* from the late medial Clarendonian quarries of Nebraska, including a similar crown height (unworn M1-2 mesostylar crown height = 45-46 mm), a doubled P3-4 pli caballin, a single M1-2 pli caballin, and similar complexity and distribution of plis on the pre- and postfossettes of the upper cheek teeth. Thus, the larger hipparionine of the Pine Grove Flat Local Fauna and the Nightingale Local Fauna is reassigned to *Cormohipparion* sp., cf. *C. matthewi* to reflect these dental similarities, but recognizing that without knowledge of the cranial morphology, a true specific identification is impossible.

The large-bodied oreodont *Merychyus major major* Leidy, 1858, is present in the Pine Grove Flat Local Fauna (E. Bruce Lander, per. communication, 2017) and in the late Clarendonian Nightingale Local Fauna of the Truckee Formation (Macdonald, 1956). For many years, Lander (e.g., 1977, 1998, 2005a, 2005b, 2008) has proposed that changes in body size within an oreodont lineage can be used to refine biochronologic correlations of faunas. Morgan et al. (2009) regarded *M. major major* to be the largest subspecies of the species. Lander (2008) and Morgan et al. (2009) regarded the occurrence of *M. major major* in a fauna as an indicator of a "latest" Clarendonian age. Lander (2008) regarded the late Clarendonian Montediablan Stage of Savage (1955), which is characterized by the Black Hawk Ranch Local Fauna along with the North Tejon Hills Local Fauna of California, to be latest Clarendonian, an interval that he placed from about 11.10 to 8.70 Ma. However, Prothero and Tedford (2000) placed the Black Hawk Ranch Local Fauna and the correlative North Tejon Hills Local Fauna in the lower part of Chron C4Ar of the GPTS, which is dated from about 9.79 to 9.11 Ma. Tedford et al. (2004) did not differentiate a late and latest Clarendonian, but just assigned the Black Hawk Ranch Local Fauna and the North Tejon Hills Local Fauna to the late Clarendonian (Cl3), an interval which they regarded to span from about 10 to 9 Ma. Despite whether one uses the qualifier latest or late Clarendonian, all investigators seem to be in agreement that the Black Hawk Ranch and North Tejon Hills Local Faunas represent the latter part of the Clarendonian. Here I follow Tedford et al. (2004) and regard the Black Hawk Ranch and North Tejon Hills Local Faunas as late Clarendonian (Cl3) in age.

A late Clarendonian (Cl3) age for the Nightingale Local Fauna, including the Brady Pocket Locality, is well established (Macdonald, 1956; Kelly, 1998b). Even though the Pine Grove Flat Local Fauna is taxonomically limited, it contains three species in common with the late Clarendonian Nightingale Local Fauna, supporting a late Clarendonian age assignment for the fauna. Moreover, the localities that yielded the fauna occur from 150 to 220 m below a tuff K/Ar dated at about 9.4 Ma (KA 2439), indicating a minimum age for the fauna, and from about 21 to 162 m below the marker shale, which, based on the tephrochronology of the type section of the Coal Valley Formation, is equivalent to an interval of about 10-9.5 Ma, or late Clarendonian.

North of Pine Grove Canyon, an exposure of Coal Valley Formation has yielded a small sample of early Hemphillian mammals. The fossil bearing beds at this exposure occur from ~200 to 150 m above the andesitic tuff breccia unit and below an unconformably overlying basalt flow K/Ar dated at ~7.6 Ma (KA2496), indicating these fossils are biochronologically equivalent to the Wilson Canyon Local Fauna in Smith Valley (Figure 3).

Smith Valley—Wilson (1936) described a small sample of rodents recovered from the eastern side of Smith Valley. On the basis of these specimens, he named the Smith Valley Fauna. Axelrod (1956)

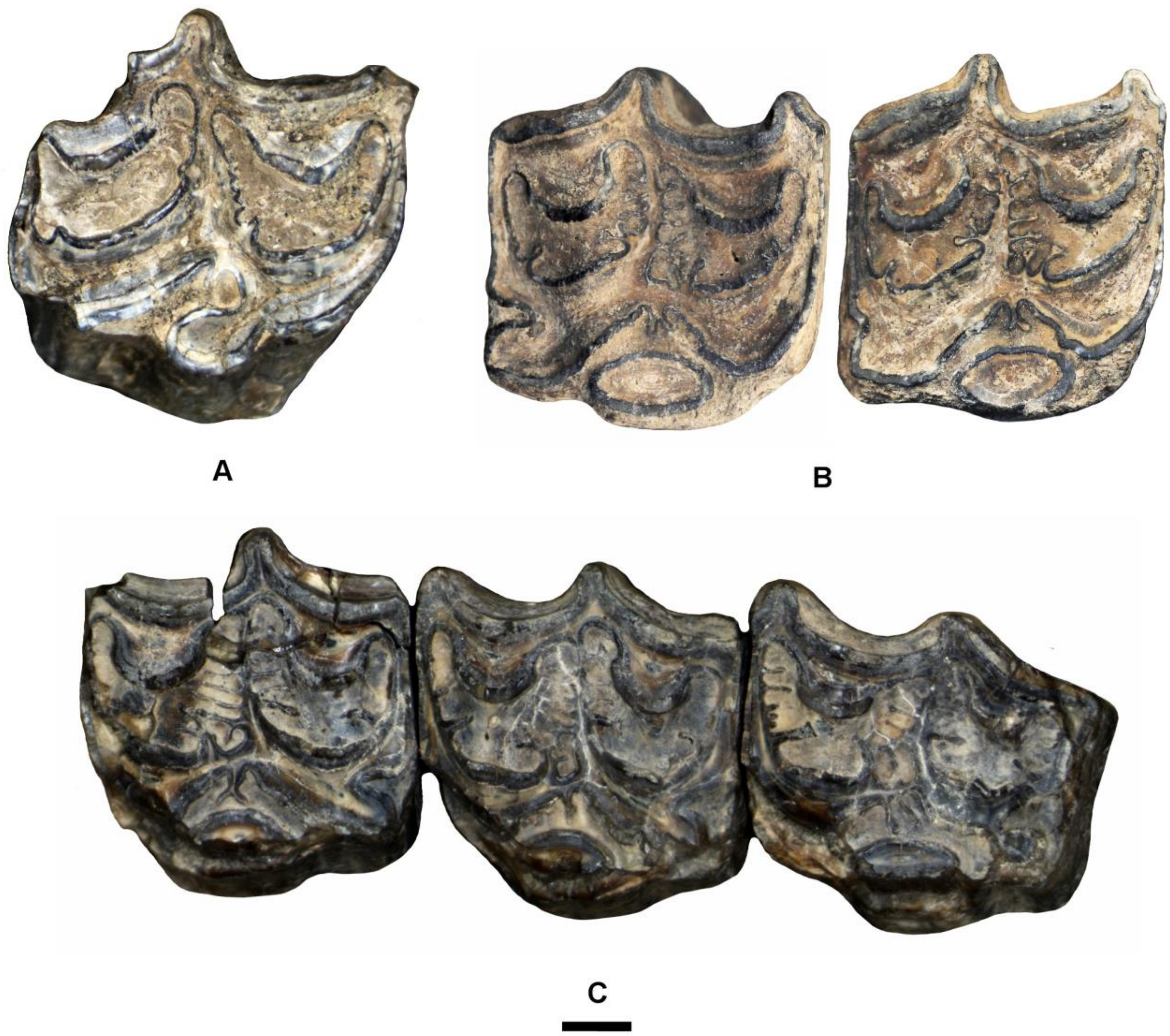

FIGURE 10. Equidae from Coal Valley Formation, Pumpkin Hollow. A, "*Dinohippus*" sp., cf. "*D.*" *spectans*, partial RM1 or 2, LACM 160238. B-C, ?*Cormohipparion* sp.: B, associated RM1-2 (well worn), LACM 160236; C, associated LM1-3 (moderate wear), LACM 160237. All occlusal views. Scale bar = 5 mm.

provided a discussion regarding the Smith Valley Fauna from the Smith Valley beds and the Yerington Fauna (see also, Stirton, 1935, 1939; Macdonald and Pelletier, 1940) from sediments exposed in Pumpkin Hollow, southeast of Yerington. Macdonald (1959) described a much larger assemblage of Hemphillian mammals from a number of new localities in the Smith Valley beds along the eastern side of Smith Valley, which he included in the Smith Valley Fauna of Wilson (1936). Stewart and Reynolds (1973) reevaluated the Coal Valley Formation and included the Smith Valley beds in the formation. Kelly and Secord (2009) first recognized that the Smith Valley Fauna of Macdonald (1959) actually represents three superposed Hemphillian mammal assemblages of different ages. Subsequently, Kelly (2013) formally abandoned Macdonald's (1959) concept of the Smith Valley Fauna and recognized three new local faunas from Smith Valley: the early early Hemphillian (Hh1) Wilson Canyon Local Fauna, the late early Hemphillian (Hh2) Petrified Tree Canyon Local Fauna, and the early late Hemphillian (Hh3) Pine Grove Hills Local Fauna (Table 1).

Pumpkin Hollow—In Pumpkin Hollow, the Aldrich Station and Coal Valley Formations usually occur as isolated outcrops, widely separated from each other (Bingler, 1978; Stewart and Dohrenwend, 1984). In only two outcrops does the Coal Valley Formation directly overlie the Aldrich Station Formation. One outcrop occurs about 4.8 km (3 miles) north of the Old Reese Road in Sections 23 and 26, R26E, T12N, where the Coal Valley Formation appears to conformably overlie the Aldrich Station Formation. Unfortunately, except for petrified wood, this exposure has not yielded any identifiable mammal fossils. The second exposure occurs about 0.63 km (0.39 miles) south of the Old Reese Road in Section 10, R26E, T11N, where the Coal Valley Formation also appears to conformably overlie the Aldrich Station Formation. Two localities (LACM 8041 and 8042, Figure 5) that occur very low in the Coal Valley Formation at the outcrop in Section 10 have yielded a small sample of fossils mammals, including two different camels (appendicular elements representing a small and large species), gomphothere enamel cheek tooth fragments and equid cheek tooth fragments. Two additional localities (LACM 8039 and 8040), which are stratigraphically positioned very low in the formation in isolated outcrops of the Coal Valley Formation along the Old Reese Road in Section 3, R26E, T11N, have yielded mammal fossils. Unfortunately, no age diagnostic mammals have been recovered from localities LACM 8039, 8040, 8041 and 8042. Two localities (LACM 8043 and 8044) in outcrops of the Coal Valley Formation along the northern border of Pumpkin Hollow have yielded fossil mammals of early Hemphillian age. These outcrops occur about 5.6 to 6.4 km (3.5 to 4 miles) north of the Old Reese Road in Section 13, R26E, T12N and Sections 7, 17, 18 and 19, R27E, T12N. Three additional localities in the Coal Valley Formation (LACM 8045, 8046 and 8047) of Pumpkin Hollow have also yielded fossil mammals of early Hemphillian age. Figure 5 provides preliminary schematic sections of selected outcrops of Aldrich Station and Coal Valley Formations in Pumpkin Hollow showing the relative stratigraphic levels of the localities that yielded fossil mammals.

The first collection of fossil mammals from Pumpkin Hollow came from UCMP V2800. The provenance of locality UCMP V2800 has a complicated history. In 1928, the philanthropist Annie Montague Alexander, who helped establish the University of California Museum of Paleontology, and her friend Louise Kellogg, collected 39 fossil mammal specimens from deposits exposed in Pumpkin Hollow, southeast of the town of Yerington, Nevada. Their collecting area was subsequently given the UCMP locality number V2800. The original locality catalogue description written by Curtis J. Hesse on July 1, 1931 was ".25 mile South to 1.5 miles North of Old Reese Road, Lyon Co., Nevada-May 18-25-1928 Alexander & Kellogg." The original locality label also has some hand written annotations. On October 4, 1948, J. R. Macdonald wrote "along drainage to east of Stosnider Fish Pond on Old Reese Road. Trace of road goes through Sec 10, 11, 12 of R26E, T11N. Exposures are scattered through volcanics & quaternary fill." Additional annotations, whose authorships are unknown, include "Hemphillian," "Coal Valley Fm?," and "Yerington quad." Also, Sec "10, 11, 12" of Macdonald's 1948 annotation was crossed through in pencil, but his "R26E, T11N" was circled in red pen with an "OK" and "DES" next to the circle, also in red pen. The initials "DES" are presumably those of Donald E. Savage. Historical maps show that the Old Reese Road never passed through Sections 10, 11 and 12, R26E, T11N, but instead traversed along a route that approximately paralleled the northern boundaries of these sections at about 0.48 to 1.6 km (0.30 to 1 mile) to the north. Isolated, unfossiliferous outcrops of Aldrich Station Formation are present in the northwest 1/4 and the northeast 1/4 of Section 11, whereas Section 12 is lacking any Wassuk Group outcrops. A large, almost continuous exposure of Aldrich Station Formation occurs on the flanks of an unnamed westerly draining canyon along the boundary between Sections 3 and 10, R26E, T11N. Poorly exposed outcrops of Coal Valley Formation overlie the Aldrich Station Formation on the south side of this unnamed canyon and contain localities LACM 8041 and 8042.

Stirton (1935:439, figs. 117-118) described two castorid teeth, a P4 and p4 from UCMP V2800, which he referred to *Eucastor* cf. *lecontei* (Merriam, 1896). Although Stirton (1935) listed both premolars as having the same UCMP specimen number (UCMP 31577), each specimen is currently assigned its own number (p4 = UCMP 31577, P4 = UCMP 45576). Stirton (1935) listed UCMP V2800 as occurring "17 miles south of Yerington at lower end of western side of Reese River Canyon, R27E, T12N," which would place the locality in Mineral County, not Lyon County. Stirton (1939) considered the mammal assemblage from UCMP V2800 to be Hemphillian in age. Macdonald and Pelletier (1958) referred to UCMP V2800 as the "Yerington Locality" and its location description matched Macdonald's 1948 annotation on the original locality catalogue label, but with the addition of "Map: USGS Wellington Quadrangle, 1890" (= USGS Wellington, Cal-Nev Quadrangle, 1:24,500, dated Nov 1893). Macdonald and Pelletier (1958) also provided a faunal list for UCMP V2800 and considered the fauna Hemphillian in age. Axelrod (1956:35, fig.4) referred to the mammal assemblage from UCMP V2800 as the Yerington Fauna and regarded it as Hemphillian in age. Axelrod (1956) also stated that the fauna "was collected along the Old Reese Road on the east side of the East Walker River just east and south of where the Lyon-Mineral County line crosses the river" from deposits that he assigned to the Morgan Ranch Formation. It should be noted that the boundaries between Lyon County and Mineral and Esmeralda Counties were modified by the Nevada Legislature several times (1883, 1904, 1933). Prior to 1933, the boundary between Mineral County and Lyon County did cross the East Walker River in Section 4, R26E, T11N (see USGS Wellington Cal-Nev Quadrangle, 1:24,00, 1893, 1931 edition), but in 1933 the county boundaries were modified, with a portion of Mineral County annexed to Lyon County, and since then the boundary between Lyon and Mineral County never crosses the East Walker River. From the above historical accounts, the geographic location of the collecting area of UCMP V2800 is uncertain. However, the most consistent fact appears to be that the collecting area or areas occur somewhere along the Old Reese Road, in either R26N, T11N or R27, T12N, or possibly in both. Moreover, considering that Alexander and Kellogg spent eight days (May 18-25, 1928) collecting in Pumpkin Hollow and that most of the exposures of Coal Valley Formation are limited to small isolated outcrops along or near the Old Reese Road, it would not be surprising if they prospected for fossils in more than one of these outcrops.

Currently, the Old Reese Road is still a passable dirt road that extends eastward from its junction with the East Walker River Road across the southern half of Pumpkin Hollow and then turns southeasterly, crossing the Wassuk Range through the Reese River Canyon to terminate at its intersection with Nevada Highway 95. In hope of relocating UCMP V2800, all exposures along the entire Old Reese Road were surveyed. From its intersection with the East Walker River Road, the Old Reese Road extends eastward through Section 3, R26E, T11N, where five, small poorly exposed outcrops of Coal Valley Formation occur, most of which are less than a few meters in elevation. Although these exposures of Coal Valley Formation are separated by Quaternary alluvium from each other and from a small outcrop of Aldrich Station Formation near the southeast boundary of Section 3, it is clear that they are positioned stratigraphically very low in the Coal Valley Formation of Pumpkin Hollow, not far above the Aldrich Station Formation. Fragmentary mammal fossils are common in two of these five exposures (localities LACM 8039 and 8040), including partial camel appendicular elements, equid and gomphothere cheek tooth fragments, and a partial rodent ulna. Going east, the Old Reese Road then passes through a fairly large isolated outcrop of Aldrich Station Formation exposed in Sections 1 and 2, R26E, T11N. A few other very small outcrops of Aldrich Station Formation occur about 3.2 km (2 miles) north of this outcrop with most of the intervening surface covered by much younger sedimentary deposits, referred to as the sedimentary deposits of Pumpkin Hollow by Stewart and Dohrenwend (1984) and Quaternary alluvium. Stewart and Dohrenwend (1984) regarded these younger sedimentary deposits to possibly correlate with the unnamed formation, K/Ar dated at about 5.2 Ma (KA2491, KA2513), that unconformably overlies the Coal Valley Formation in eastern Smith Valley (Gilbert and Reynolds, 1973). The Aldrich Station Formation has been K/Ar dated elsewhere at about 12.7-11.5 Ma (Gilbert and Reynolds, 1973; Robinson and Kistler, 1986; Perkins et al., 1998), indicating a latest Barstovian to early medial Clarendonian age. Based on tephrochronology, Perkins et al. (1998) regarded the Aldrich Hill ashes 1 and 2 within the Aldrich Station Formation to be 12.07 and 12.01 Ma, respectively. The early Clarendonian Aldrich Hill Flora occurs below these ashes in the type section of the Aldrich Station Formation in Coal Valley. The large outcrops of Aldrich Station Formation that occur along and south of the Old Reese Road in Sections 1, 2, 3, 10 and 11, R26E, T11N, are unfossiliferous. From here, the Old Reese Road extends eastward through outcrops of the Singatse Tuff, the Mickey Canyon Tuff and Quaternary alluvium and then crosses the boundary between Lyon and Mineral Counties. At about 6.4 km (4 miles) east from the Aldrich Station Formation outcrop, the Old Reese Road crosses over an outcrop of Coal Valley Formation, exposed in Section 33, R27E, T12N. Abundant fossil bone and tooth fragments occur throughout this outcrop on both sides of the road. Additional isolated exposures of Coal Valley Formation occur from 1.6 to 2.4 km (1 to 1.5 miles) north of this outcrop along the flanks of a westerly draining canyon in Section 28, R27E, T12N. These isolated exposures of Coal Valley Formation also yield abundant fossil mammal bone and tooth fragments. The Old Reese Road then continues east and southeast for 6.4 km (4 miles), where it leaves Pumpkin Hollow and enters the head of the Reese River Canyon. No other outcrops of Coal Valley Formation occur along this 6.4 km section of the Old Reese Road.

Thus, exposures of the Coal Valley Formation occur in two areas along the Old Reese Road (Section 3, R26E, T11N and Section 33, R27E, T12N) and in one area south of the Old Reese Road (Section 10, R26E, T12N), whereas the Aldrich Station Formation occurs in one area along the road (Sections 1, 2 and 3, R26E, T12N) and one area south of the road (Sections 10 and 11, R26E, T11N). Assuming that Alexander and Kellogg collected their fossils from outcrops exposed somewhere along the Old Reese Road in Pumpkin Hollow, and presuming that they collected from about 0.40 km (0.25 mile) south to 2.4 km (1.5 miles) north of the road, then the outcrops of Coal Valley Formation that yielded abundant fossil bone fragments in Sections 28 and 33, R27E, T12N, are compatible with the original description of their collecting area, at least in part. An exception to this may be two castorid premolars, which as stated above, Stirton (1935) referred to *Eucastor* cf. *lecontei*. However, Stirton (1935) also noted these premolars may possibly represent a different species of *Eucastor* Leidy, 1858, because they are larger than those of *E. lecontei*. The two, well-worn premolars exhibit the following (Stirton, 1935): 1) rooted; 2) p4 internal striids not extending to base of crown; and 3) P4 with a long hypostria, a short mesostria, a large parafossette and a small metafossette. In order to speculate on the generic status of the premolars from Pumpkin Hollow, a brief review of certain Barstovian through Hemphillian castorids is presented below.

Korth (2007) erected a new castorid genus, *Prodipoides*, and reallocated five species that were previously assigned to *Eucastor* to his new genus, including *E. lecontei*, which resulted in *Eucastor* being only represented by the type species, *E. tortus* Leidy, 1858. *Eucastor tortus* is known from the middle to late Barstovian, whereas species of *Prodipoides* are known from the early to late Clarendonian (Korth, 2007). *Eucastor* differs primarily from *Prodipoides* by its smaller size, lower crowned cheek teeth, shallower p4 lingual striids, and certain differences in its cranial and incisor morphology that appear to be adaptations to a fossorial, tooth-digging lifestyle (Korth, 2007). Korth (2007) considered *Prodipoides* likely to be ancestral to *Dipoides* Jager, 1835, and noted that the late Clarendonian *Dipoides tanneri* Korth, 1998, appears morphologically transitional between typical species of *Prodipoides* and *Dipoides*. *Dipoides* differs from *Prodipoides* by having higher crowned, more prismatic cheek teeth with deeper striae/striids, along with certain differences in the cranial morphology (Korth, 2007). Although most species of *Dipoides* have open-rooted, ever growing cheek teeth, in *D. tanneri* the premolars develop roots during very late wear stages (Korth, 1998). Macdonald (1959) described five castorid specimens from the near the base of the Coal Valley Formation (= early Hemphillian [Hh1] Wilson Canyon Local Fauna of Kelly [2013]) in the Mickey Canyon area of Smith Valley. He referred these specimens to *Dipoides* sp. and noted they are most similar morphologically to *Dipoides stirtoni* Wilson, 1934, from the Hemphillian Rome Fauna of Oregon. The cheek teeth of *Dipoides stirtoni* are high crowned and prismatic with deep striae/striids, but with the parastriid shorter than the mesostriid on p4, similar to that in *D. tanneri* (Wilson, 1934; Shotwell, 1955; Korth, 1998). Wilson (1934) noted that of 89 cheek teeth of *D. stirtoni* he examined, 87 were open-rooted and two had closed roots. The well-worn cheek teeth of the *Dipoides* specimens from Smith Valley have closed roots (Macdonald, 1959) while the very worn premolars from Pumpkin Hollow have distinct roots (Stirton, 1935:figs. 117-118), similar to those of species of *Prodipoides*. These differences suggest that the Pumpkin Hollow specimens are less derived than the Smith Valley specimens and *D. stirtoni*. In both the Pumpkin Hollow and Smith Valley samples, the p4 internal striids (mesostriid and metastriid) do not extend to the base of the crown, similar to those of *P. lecontei* and *D. tanneri*.

A second castorid with rooted cheek teeth, *Hystricops* Leidy, 1858, occurs in the medial Clarendonian Coal Valley Local Fauna and in the late Clarendonian Nightingale Local Fauna (Macdonald, 1956; this paper). *Hystricops* has also been recorded from the late Clarendonian and Hemphillian of Oregon, and the late Barstovian and late Clarendonian of Nebraska (Shotwell, 1963; Shotwell and Russell, 1963; Korth, 1998, 2017; Flynn and Jacobs, 2008). The premolars from Pumpkin Hollow can be easily distinguished from those of *Hystricops* by their much smaller size, lack of inflated (bulbous) labial and lingual walls of the primary cusps and deeper striae/striids, resulting in less fossette/fossettid development during late wear (especially the para- and metafossettes and para- and hypofossettids).

The premolars from Pumpkin Hollow likely represent *Prodipoides*, but could possibly represent a transitional taxon like *D. tanneri*. Whether the Smith Valley specimens represent *D. stirtoni* or a form slightly less derived cannot be determined without a much larger sample, including teeth in various stages of wear, for comparison. *Prodipoides* and *D. tanneri* are restricted to the Clarendonian (Korth, 1998, 2002, 2007). If the Pumpkin Hollow premolars represent a taxon that is at a similar stage of evolution as these taxa, then that presents a problem because all of the other taxa from UCMP V2800 support a Hemphillian age for the fauna. The outcrops of Aldrich Station Formation in Pumpkin Hollow can be confidently assigned to the Clarendonian and the stratigraphically low outcrops of Coal Valley Formation overlying the Aldrich Station Formation in Section 3, R26E, T11N and Section 10, R26E, T11N are also likely Clarendonian in age based on the stratigraphic relationships of these formations in other areas of Lyon County. Therefore, the question arises, could the premolars have actually come from a much lower stratigraphic level in the Coal Valley Formation than that from which all of the other specimens of UCMP V2800 came, such as the isolated outcrops of Coal Valley Formation along the Old Reese Road in Section 3, R26E, T11N or south of the road in Section 10, R26E, T11N. The other less likely possibility is that the castorid premolars did come from the same fossil bearing horizon as all of the other mammals of UCMP V2800 and they represent a geochronologic range extension for *Prodipoides* into the early Hemphillian.

Unfortunately, determining which of these scenarios is correct will require the discovery of additional castorid specimens with precise knowledge of their provenance in Pumpkin Hollow. Axelrod (1956) based his Yerington Fauna on the taxa from UCMP V2800, but because UCMP V2800 could include mixed samples of fossils from widely separated stratigraphic levels within the Coal Valley Formation of Pumpkin Hollow, his faunal name is abandoned here. For now, the above castorid premolars are tentatively assigned to *Prodipoides* and, along with the fragmentary mammal fossils from the stratigraphically lowest exposures (localities LACM 8039-8042) of the Coal Valley Formation in Sections 3 and 10, R26E, T11N, are assigned to the Old Reese Road Local Fauna, to recognize their possible Clarendonian age.

The taxa from localities LACM 8043-8047, and, except for the castorid premolars, all of the other taxa from locality UCMP V2800 are compatible with a Hemphillian age (Table 1) and are here assigned to the Pumpkin Hollow Local Fauna. In particular, the occurrence of the equine horse, "*Dinohippus*" sp., cf. "*D.*" *spectans* (Cope, 1880) in the Pumpkin Hollow Local Fauna best supports an early Hemphillian age (either Hh1 or Hh2). The specimens of "*Dinohippus*" sp., cf. "*D.*" *spectans* from Pumpkin Hollow are indistinguishable morphologically from those of "*D.*" sp., cf. "*D.*" *spectans* from the Coal Valley Formation of Smith Valley (Kelly, 1995, 1998a, 2013; Kelly and Secord, 2009) and represent the same species. In Smith Valley, "*D.*" sp., cf. "*D.*" *spectans* occurs in the early early Hemphillian (Hh1) Wilson Canyon Local Fauna and the late early Hemphillian (Hh2) Petrified Tree Canyon Local Fauna (Kelly, 2013). The type locality for "*Dinohippus*" *spectans* is the late early Hemphillian (Hh2) Rattlesnake Formation of Oregon (Merriam et al., 1925; Enlows, 1976). Based by magnetostratigraphy and Ar/Ar dating, the Rattlesnake Formation has been correlated to Chrons C3Bn to C3Br2n of the GPTS, or about 7.3-6.9 Ma (Martin and Fremd, 2001; Prothero et al., 2006; Samuels and Zancanella, 2011).

A second horse, a hipparionine, is present in the Pumpkin Hollow Local Fauna (Figures 10A-C). It is represented by two specimens: an associated RM1-2 in late wear (LACM 160236) and an associated LM1-3 (LACM 160237) in moderate wear. These molars exhibit the following characters: 1) large size (mean M1-2 apl = 24.03 mm); 2) moderately elongated protocones (mean M1-2 pl = 8.83 mm) that are isolated from the protolophs; 3) highly plicated posterior prefossette and anterior postfossette borders, with two or more plications on the pli protoconule; 4) moderately plicated anterior prefossette and posterior postfossette borders; 5) a strong, doubled pli caballin; 6) a hypoconal groove extending to near the base of the crown; and 7) thick cementum. The molars of the Pumpkin Hollow hipparionine are equal in size and similar in occlusal morphology to those of *Neohipparion leptode* Merriam, 1915, from the early Hemphillian Thousand Creek beds of Nevada, but differ by having the protocones slightly less transversely flattened (mean M1-2 pw/pl = 1.79 versus mean M1-2 pw/pl = 2.35 for *N. leptode*) and less anteroposteriorly elongated (mean M1-2 pl = 8.83 mm versus mean M1-2 pl = 9.63 mm for *N. leptode*). The type locality of *N. leptode* is the Thousand Creek Beds of northern Nevada (Merriam, 1915; Merriam and Stock, 1928; Stock, 1951). Based on tephrochronology, Perkins et al. (1998) dated the Thousand Creek Beds to about 8.0-7.5 Ma, supporting an early Hemphillian (Hh1 or Hh2) age for the Thousand Creek Local Fauna. *Neohipparion leptode* has also been recorded from early Hemphillian of California, Kansas, Oklahoma and Texas (MacFadden, 1984, 1998; Hulbert, 1987b; Kelly and Stewart, 2008).

Based on isolated molars, Merriam et al. (1925) reported the occurrence of four different hipparionines in the Rattlesnake Formation: "*Hipparion*" *sinclairi* (= *Hippotherium sinclairi* Wortman, 1882); "*Hipparion occidentale*" (= *Cormohipparion occidentale* sensu lato of MacFadden, 1984); "*Hipparion*" *leptode* = (*Neohipparion leptode*); and *Hipparion anthonyi* Merriam, 1916b. The holotype of *Hippotherium sinclairi* is from the Rattlesnake Formation at Cottonwood Creek, Oregon, whereas the holotype of *Hipparion anthonyi* is from the late Clarendonian at Ironside, Oregon (Wortman, 1882; Merriam, 1916b; MacFadden, 1984). Both of these taxa were supposedly characterized by their highly plicated pre- and postfossette borders and, in *H. anthonyi*, a double or tripled pli caballin. However, MacFadden (1984) regarded both species as nomina dubia because they are only known from very small samples of isolated teeth. The hipparionine molars from Pumpkin Hollow are equal in size and similar in occlusal morphology to those from the Rattlesnake Formation that Merriam et al. (1925) assigned to *H. occidentale*, including complexly plicated pre- and postfossettes and doubled plis caballin, but differ by having slightly more elongated protocones (mean pl = 8.83 mm versus 8.20 mm for the Rattlesnake upper molars). As noted above, Woodburne (2007) reevaluated the systematics of the *Cormohipparion occidentale* species complex, wherein he divided the complex into *C. occidentale* sensu stricto and five new related species. Although specifically indeterminate, the Rattlesnake specimens of "*C. occidentale*" do appear to represent a large hipparionine species likely related to those of the *C. occidentale* complex.

Confident generic and specific identification of the hipparionine of the Pumpkin Hollow Local Fauna cannot be made without knowledge of its facial fossa structure. In size, it agrees well with both *N. leptode* and the large hipparionine from the Hemphillian Rattlesnake Formation, but in occlusal morphology, it appears to be slightly more similar to the Rattlesnake hipparionine. Thus, the Pumpkin Hollow hipparionine is left in open nomenclature and assigned to ?*Cormohipparion* sp. Hopefully in the future, more complete hipparionine specimens will be discovered from Pumpkin Hollow that will further clarify its systematic status.

In addition to the above horses, Prothero (2005) reported the occurrence of *Teleoceras hicksi* Cook, 1927, from UCMP V2800, which is known elsewhere from the late early Hemphillian through the late late Hemphillian (Hh2-Hh4).

CONCLUSIONS

Gilbert and Reynolds (1973) identified a thick tuffaceous diatomaceous shale unit at the top of the type section of the Coal Valley Formation in Coal Valley, which they named the marker shale because it could be traced northward to outcrops of Coal Valley Formation in the Pine Grove Flat and Pine Grove Canyon areas. Gilbert and Reynolds (1973) also correlated their marker shale to a thick diatomaceous shale unit within the upper part of the Coal Valley Formation exposed in Wilson Canyon, Petrified Tree Canyon and on the north flanks of the Pine Grove Hills in Smith Valley. However, biochronologic and radioisotopic data indicate the thick shale unit in Smith Valley is significantly younger than their marker shale of the type section of the Coal Valley Formation and, therefore, is here informally named the Petrified Tree Canyon shale, based on its exposure within the Petrified Tree Canyon section (Figures 3, 4).

Eight local faunas are recognized from the Coal Valley Formation of Lyon and Mineral Counties, Nevada (Table 1). The Coal Valley Local Fauna from the type section of the Coal Valley Formation in Coal Valley is, based on biochronologic, radioisotopic and tephrochronologic data, medial Clarendonian (Cl2) in age, or ~11.5-10.7 Ma. The late Clarendonian (Cl3) Pine Grove Flat Local Fauna occurs from ~49 to 162 m below the marker shale in the Pine Grove Flat outcrop and from ~21 to 95 m below the marker shale south of Pine Grove Canyon. It contains *Cormohipparion* sp., cf. *C. matthewi*, *Neohipparion trampasense* and *Merychyus major major*, taxa also present in the late Clarendonian (Cl3) Nightingale Local Fauna from the Truckee Formation of west-central Nevada. A late Clarendonian age for the Pine Grove Flat Local Fauna is also supported by its stratigraphic position below the marker shale, in an interval estimated to be between ~10 and 9.5 Ma based on tephrochronology (Perkins et al., 1998), and by a tuff K/Ar dated at ~9.4 Ma overlying the marker shale on the south side of Pine Grove Canyon. The original collection of fossil mammals from the Coal Valley Formation of Pumpkin Hollow came from UCMP V2800. The provenance of UCMP V2800 is uncertain and its fossil mammals may have come from different isolated outcrops and stratigraphic levels of Coal Valley Formation in Pumpkin Hollow. Two stratigraphic horizons in the Coal Valley Formation of Pumpkin Hollow yield fossils. One is very low, near the base of the formation, and the other occurs from about the middle to the upper third of the formation (Figure 5). The mammal fossils from the localities that are very low in the Coal Valley Formation of Pumpkin Hollow are assigned to the Old Reese Road Local Fauna and are possibly Clarendonian in age. The mammal fossils from the stratigraphically higher localities in the Coal Valley Formation of Pumpkin Hollow are assigned to the Pumpkin Hollow Local Fauna and include "*Dinohippus*" sp., cf. "*D.*" *spectans*, a taxon that indicates a probable early Hemphillian age (Hh1 or Hh2) for the fauna. In addition, a large hipparionine (?Cormohipparion sp.) is present in the Pumpkin Hollow Local Fauna, which is most similar to the large hipparionine species from the late early (Hh2) Hemphillian Rattlesnake Formation. *Teleoceras hicksi* is also present in the Pumpkin Hollow Local Fauna, which is known elsewhere from the early to late Hemphillian (Hh1-Hh4). The early early Hemphillian (Hh1) Wilson Canyon Local Fauna, the late early Hemphillian (Hh2) Petrified Tree Canyon Local Fauna and the early late Hemphillian (Hh3) Pine Grove Hills Local Fauna from the Coal Valley Formation of Smith Valley were previously characterized by Kelly (2013). The presence of early Hemphillian (Hh1) mammals in the Coal Valley Formation exposed about 2 km north of Pine Grove Canyon, stratigraphically well above the marker shale and an andesitic tuff breccia, indicates that this level is a correlative of the early Hemphillian Wilson Canyon Local Fauna of Smith Valley (Figure 3).

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