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A REEVALUATION OF THE MAMMALIAN FAUNA FROM THE HALLELUJAH FORMATION, LONG VALLEY, LASSEN COUNTY, CALIFORNIA

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ABSTRACT

We describe a new mammalian fauna from the Hallelujah Formation of Long Valley in Lassen County, California, herein named the Hallelujah Junction Local Fauna. The fauna is comprised of the rhinoceros cf. *Teleoceras* sp., the horse *Dinohippus mexicanus*, the camel cf. *Hemiauchenia* sp., an indeterminate species of pronghorn antelope (Antilocaprinae), and an indeterminate genus of Gomphotheriidae or Mammutidae (Proboscidea). Based on a sample of mammalian fossils that are now lost, previous investigators considered the mammalian fauna from the Hallelujah Formation to be early to middle Blancan (early to middle Pliocene) in age, ranging from about 4.7 to 3.0 Ma. However, the occurrence of *D. mexicanus* and Rhinocerotidae in the new material indicates a latest Hemphillian age (latest Miocene to earliest Pliocene) for the upper part of the formation, ranging from 5.9 to 4.8 Ma.

INTRODUCTION

Outcrops of the Hallelujah Formation occur along the west and east sides of Long Valley, Lassen County, California (Louderback, 1906; McJannet, 1957; Burnett and Jennings, 1962; Van Couvering, 1962; Mergner, 1977; Cinque, 1979; Koehler, 1989; Grose and Mergner, 2000; Tenbrink et al., 2002; Henry et al., 2005, 2007; Trexler et al., 2009). In an unpublished proprietary report for Western Pozzalan Corporation (Goodman et al., 1974), James Firby of the University of Nevada, Reno, first reported the occurrence of vertebrate fossils from exposures along the west side of Long Valley, which he considered to be Blancan in age, ranging from about 4.7 to 3.0 Ma. Firby listed the following taxa from these localities: Leporidae, *Equus* sp. cf. *E. proversus*, Rhinocerotidae, *Playtgonus* sp., *Stegomastodon mirificus*, and Mammalia genus and species indeterminate. In an unpublished dissertation, Koehler (1989) mapped these localities and placed them within his upper sandstone member at about 10-20 meters above the contact with the middle member. Subsequent investigators have cited Firby's age determination for this fauna (Koehler, 1989; Grose and Mergner, 2000; Tenbrink et al., 2002; Henry et al., 2005, 2007). Despite extensive investigation, the fossils listed by Firby appear to be lost. However, the discovery of additional mammalian fossils from the upper sandy and middle members of the Hallelujah Formation exposed along the west and east sides of Long Valley (Figure 1) provides new insight into the age of this fauna, herein named the Hallelujah Junction Local Fauna. The purpose of this report is to provide a taxonomic description of this fauna and to reevaluate the age of the fossil mammal localities within the Hallelujah Formation.

GEOLOGIC SETTING

The Hallelujah Formation is comprised of conglomerate, sandstone, tuffaceous sandstone, diatomite, and diatomaceous siltstone. These deposits are interpreted to be of fluvial, fluvial-deltaic, and lacustrine origin (Koehler, 1989; Grose and Mergner, 2000; Tenbrink et al., 2002; Henry et al., 2005). Tenbrink et al. (2002) considered the deposition of the Hallelujah Formation to have begun before 8.0 Ma continuing until about 3.0 Ma, based on tephrochronology and the mammal-based age by Firby (in Goodman et al., 1974). Based on local fault displacement bounding Peterson Mountain along the east side of Long Valley, Tenbrink et al. (2002) noted also that as much as 550 m of section within the lower member of the Hallelujah Formation may be present

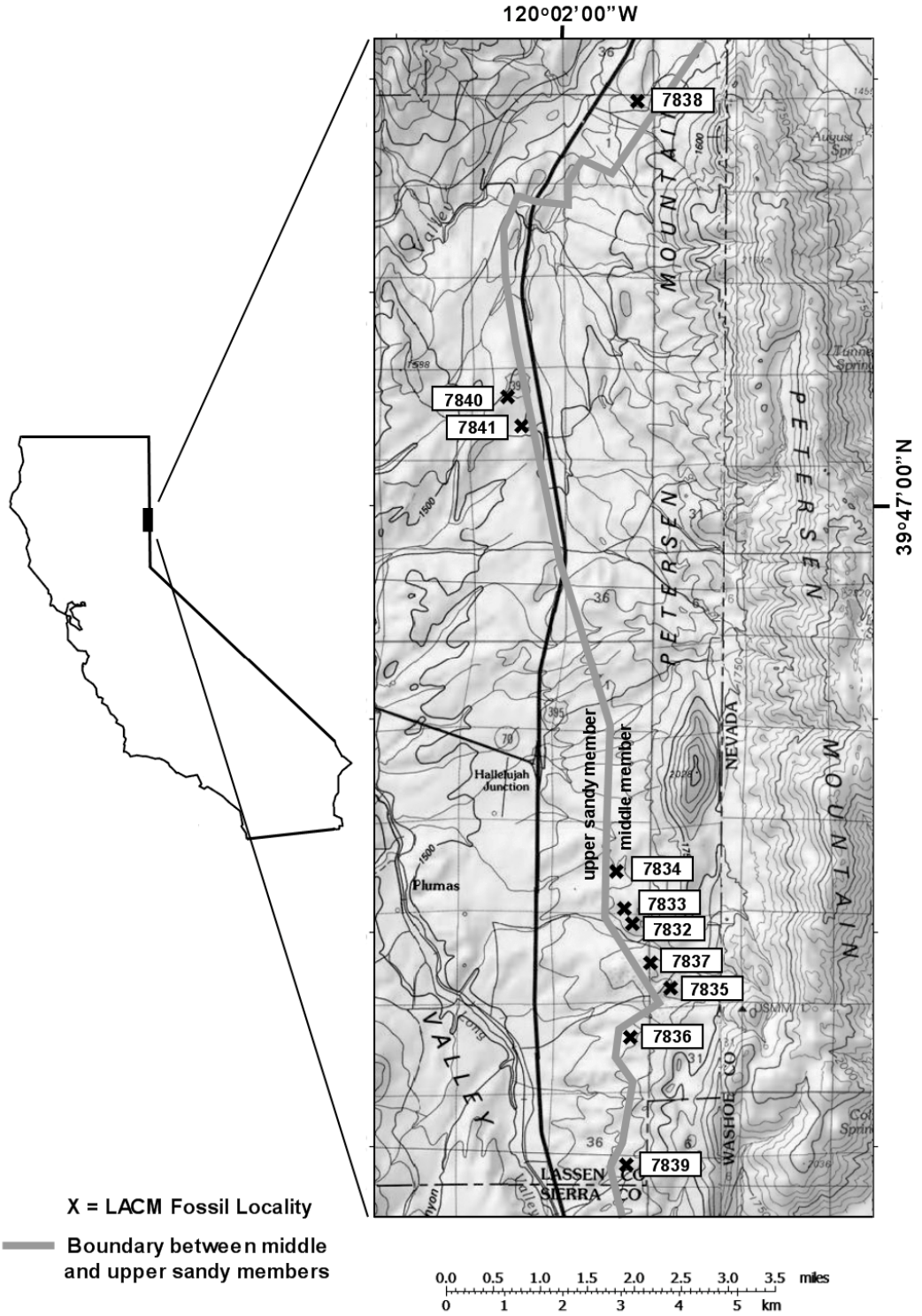

FIGURE 1. Outline map of California showing general location of study area and insert map showing location of LACM fossil localities in Long Valley, California. Gray line indicates boundary between the middle and upper sandy members. Base insert map is U.S. Geological Survey Susanville and Portola 30' x 60' series topographic map, scale =1:100,000.

below the 8.0 Ma tephrochronology date. Henry et al. (2005, 2007), noted that a basaltic andesite lava underlying the base of the Hallelujah Formation in east Long Valley was $^{40}Ar/^{39}Ar$ dated at 11.66 ± 0.25 Ma, providing a maximum age constraint for the formation.

Koehler's unpublished dissertation (1989) provided the first detailed lithostratigraphic analysis of the Hallelujah Formation wherein he divided the formation into three informal members; the upper sandy member, the middle member, and the lower sandy member (Figure 2). Because the exposures of the Hallelujah Formation in Long Valley lack widespread marker beds and are often isolated by intervening Quaternary alluvium, the thickness of each member is not precisely known (Koehler, 1989). According to Koehler (1989), the upper sandy member ranges from ~700 – 1,150 m thick and is composed of red-brown, tan and buff conglomerate and sandstone, and buff, dark-brown, red and green-gray tuffaceous siltstone, sandy siltstones, and lignitic siltstones. The middle member ranges from ~1,000 - 1,200 m thick and is composed of white to buff sandy siltstone, mudstone, and tuffaceous siltstone with interbedded red-brown to orange-brown and tan sandstone. Koehler (1989) did not provide an estimated thickness for the lower sandy member, but it is at least 900 m thick (Tenbrink et al., 2002). The lower sandy member is composed of medium brown, tan, red-orange to buff colored sandstone and conglomerate with minor amounts of brown to dark brown siltstone and mudstone. The upper and lower sandy members are primarily fluvial and fluvial-deltaic deposits, whereas the middle member is dominated by lacustrine deposits. The contact between the middle and upper sandy members is gradational. However, when exposed, the contact can be recognized by a change from the white to buff mudstones and tuffaceous siltstones of the middle member to the reddish brown sandstones of the upper member (Koehler, 1989). The middle member can also be recognized by the presence of white siltstone chips on the ground surface (Koehler, 1989).

The mammalian fossils described herein were recovered from seven localities (LACM 7832 – 7837, and 7839) within the upper tuffaceous sandstones of Koehler's (1989) middle member exposed along the east side of Long Valley in the vicinity of Hallelujah Junction and three localities (LACM 7838, 7840, and 7841) in the lower portion of the upper sandy member (Figures 1and 2). All of the localities within the middle member occur from 40 to 50 m below the contact with the upper member, whereas all the localities within the upper sandy member occur from 10 to 20 m above the contact. Localities LACM 7840 and 7841 are actually equivalent to two of the putative Blancan localities reported by Firby (in Goodman et al., 1974). Figure 2 shows a generalized stratigraphic section of the Hallelujah Formation with the relative positions of the fossil localities.

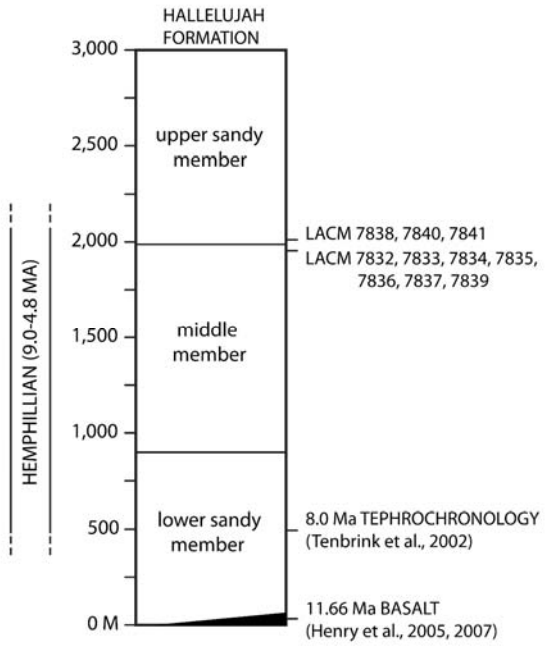

FIGURE 2. Generalized stratigraphic section of the Hallelujah Formation of Long Valley, California, showing positions of vertebrate fossil localities and portion of formation assigned to the Hemphillian North American Land Mammal age. Localities LACM 7838, 7840, and 7841 occur in upper sandy member from 10 to 20 m above the contact with the middle member. Localities LACM 7832 - 7837 and 7839 occur in middle member from 40 to 50 m below the contact with the upper sandy member. Mean estimated thickness of each member after Koehler (1989) and Tenbrink et al. (2002).

METHODS

Measurements of teeth and appendicular elements were made to the nearest 0.1 mm with a vernier caliper. All horse dental specimens were measured following the standards set forth by Eisenmann et al. (1988). Horse dental terminology follows MacFadden (1984a). All other specimens were measured at their greatest dimensions. Upper teeth are designated by uppercase letters and lower teeth by lower case letters. Metric abbreviations and dental formulae follow standard usage. All radioisotopic ages include ±2σ, except those that were published without any citation for their deviation. North American Land Mammal Ages are informal biochronologic units initially established by the Wood committee (Wood et al., 1941). Their usage

was most recently summarized in a book edited by Woodburne (2004). The use of biochrons was summarized by Lindsay (2003). Subbiochrons or subbiozones (e.g., Hh4) of the Hemphillian North American Land Mammal age follow Tedford et al. (2004).

All taxonomic identifications were determined by the authors using published accounts and comparative material in the vertebrate paleontology collections of the Natural History Museum of Los Angeles County, the Museum of Paleontology, University of California, Berkeley, and the W. M. Keck Science and Mineral Engineering Museum, University of Nevada, Reno. All specimens reported herein were originally part of the collection of the W. M. Keck Science and Mineral Engineering Museum at the University of Nevada, Reno. Subsequently, the specimens were donated to the collection of the Department of Vertebrate Paleontology, Natural History Museum of Los Angeles County, where they are now housed. Detailed locality data are available at this institution.

Abbreviations and institutional acronyms are as follows: A-P, anteroposterior; Ar/Ar, Argon/Argon; IVCM, Imperial Valley College Museum; L, left; LACM, Natural History Museum of Los Angeles County; Ma, megannum in the radioisotopic time scale; N, number of specimens; R, right; ROC, radius of curvature; TR, transverse.

SYSTEMATIC PALEONTOLOGY

Class Mammalia Linnaeus, 1758
Order Perissodactyla Owen, 1848
Family Rhinocerotidae Owen, 1845
Genus *Teleoceras* Hatcher, 1894
cf. *Teleoceras* sp.

Referred Specimens—From locality LACM 7838: partial left premolar, LACM 154962. From locality LACM 7832: partial edentulous dentary, LACM 154933. From locality LACM 7837: cheek tooth fragment, LACM 154961. From locality LACM 7840: assoc. cheek tooth fragments, LACM 154965.

Discussion—The partial left premolar (LACM 154962, Figure 3A-B) is damaged with the lingual portion of the trigonid wall and the posterior portion of the talonid missing. The talonid is wider than the trigonid and labial and lingual cingulids are lacking. Measurements of LACM 154962 are A-P = 40.4 mm and TR = 23.6 mm. Based on the occlusal outlines of other Hemphillian Rhinocerotidae (Prothero, 2005), the original size of the premolar before damage is estimated to have been about A-P = 42 mm and TR = 25 mm. The partial edentulous dentary (LACM 154933) has two alveoli present for a lower premolar with an alveolar A-P measurement of 36.5 mm.

In size and morphology, the lower premolar and the edentulous dentary indicate the presence of a small rhino in the fauna, most similar to *Teleoceras.* During the late Hemphillian, two small species of *Teleoceras* were present, *Teleoceras hicksi* Cook, 1927 and *Teleoceras guymonense* Prothero, 2005. The Long Valley specimens probably represent one of these species. The cheek tooth fragments (LACM 154961 and 154965) are not generically diagnostic, but demonstrate the presence of Rhinocerotidae at localities LACM 7837 and 7840.

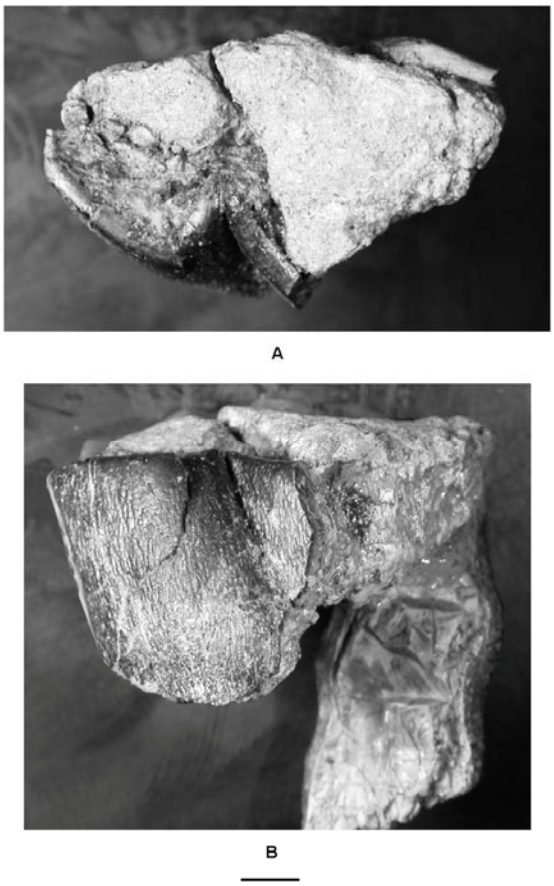

FIGURE 3. cf. *Teleoceras* sp., partial left premolar, LACM 154962. A, occlusal view. B, labial view. Scale = 5 mm.

Family Equidae Gray, 1821
Genus *Dinohippus* Quinn, 1955
Dinohippus mexicanus Lance, 1950

Referred Specimens—From locality LACM 7832: partial RM1 or 2, LACM 154929; RM3, LACM 154930; upper cheek tooth fossette, LACM 154932; partial Rdp3 or 4, LACM 154931; partial Lm2 and associated Lm3, LACM 154927; partial Lm3, LACM

154928. From LACM 7833: upper cheek tooth fragment, LACM 154940; Lm1 or 2, LACM 154937; Lm1 or 2, LACM 154938; partial Rm3, LACM 154939; partial metatarsal and associated partial splint, LACM 154942; first phalanx, LACM 154943. From locality LACM 7834: partial right astragalus, LACM 154946. From locality LACM 7835: partial left upper cheek tooth, LACM 154950; partial dentary fragment (symphysis), LACM 154949; partial metatarsal, LACM 154952; partial metapodial, LACM 154951; partial first phalanx, LACM 154953. From LACM 7836: partial left tibia and associated partial astragalus, LACM 154955; first phalanx, LACM 154956. From LACM 7837: partial RP3 or 4, LACM 154959; associated partial RM2 and RM3, LACM 154958; associated Lp2-3, LACM 154957; partial Rp3 or 4, LACM 154960. From LACM 7839: partial first phalanx, LACM 154963. From LACM 7840: partial dentary with Rp2, LACM 154970.

TABLE 1. Measurements (in mm) of upper teeth of *Dinohippus mexicanus* from Long Valley. Additional abbreviations are: a, approximate; MCH, mesostyle crown height; PA-P, greatest anteroposterior protocone length; and PTR, greatest transverse protocone width.

Specimen /Position	A-P	TR	MCH	PA-P	PTR
LACM 154959/RP3 or 4	30.8	28.3a	69.5	7.5	5.6
LACM 154929/RM1 or 2	—	23.3a	40.9	—	—
LACM 154958/RM2	—	—	34.5	—	—
LACM 154958/RM3	33.0	23.9	23.7	10.0	5.1
LACM 154930/RM3	31.1	28.9	38.9	12.2	5.8
LACM 154950/partial tooth	—	—	57.3	—	—

TABLE 2. Measurements (in mm) of lower teeth of *Dinohippus mexicanus* from Long Valley. Additional abbreviations are a = approximate and MTCH = metastylid crown height.

Specimen /Position	A-P	TR	MTCH
LACM 154970 /Rp2	36.7	18.9	35.7a
LACM 154957/Lp2	33.7	15.8	31.4
LACM 154957/Lp3	30.4	19.1	34.9
LACM 154937/Lm1 or 2	29.7	15.9	57.3
LACM 154938/Lm1 or 2	33.0	15.7	62.7
LACM 154927/Lm2	—	—	61.3
LACM 154927/Lm3	35.7	15.1	63.8
LACM 154928/Lm3	—	14.7	59.5
LACM 154939/Rm3	—	15.8	57.6

Description—The upper cheek teeth (Figure 4) are characterized by having the following: 1) hypsodonty (early wear mesostyle crown height >60 mm); 2) moderate curvature (ROC = 70 - 76 mm, N = 4); 3) an elongated protocone with a moderate anterior

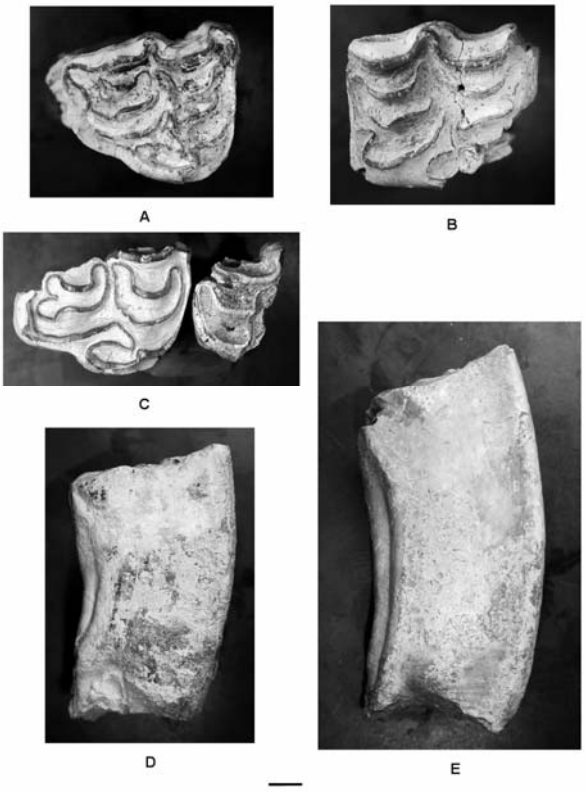

FIGURE 4. *Dinohippus mexicanus*, upper teeth from Long Valley. A and D, RM3, LACM 154930. B and E, RP3 or 4, LACM 154959. C, partial RM2-3, LACM 154958. A-C, occlusal views. D-E, anterior views. Scale = 5 mm.

projection and lingual enamel that varies from convex (LACM 154930 and 154958) to a slight lingual indentation (LACM 154959); 4) a protocone that is well connected to the protoloph; 5) simple fossette enamel patterns (few or no plications); 6) the parastyle and mesostyle are moderately well-developed, whereas the metastyle is reduced; 7) the pli caballin varies from weakly developed to absent; 8) the hypoconal groove extends down the crown to the base of the tooth; 9) thick cement (2.5 - 3.0 mm); and 10) relatively large size. Measurements of the upper cheek teeth are presented in Table 1.

The lower cheek teeth (Figure 5) are characterized by having the following: 1) hypsodonty (early wear metastylid crown height >60 mm); 2) the metaconid and metastylid are moderately separated with the occlusal enamel outline of the metaconid usually round and that of the metastylid varying from round to slightly angular; 3) a linguaflexid that is usually V-shaped; 4) a pli caballinid and protostylid are usually absent; 5) simple fossettid enamel borders; 6) a shallow premolar ectoflexid, not penetrating the

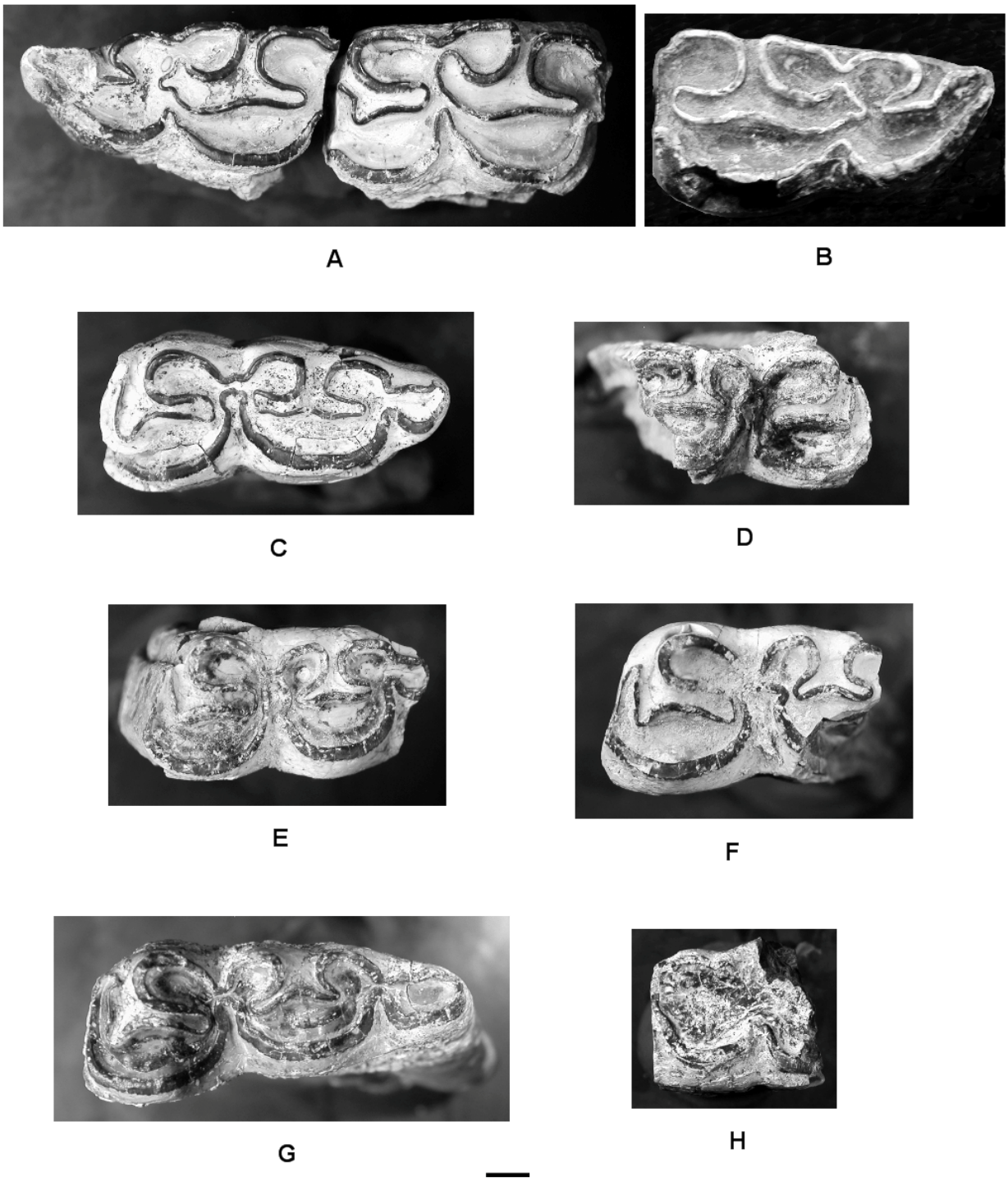

FIGURE 5. *Dinohippus mexicanus*, lower teeth from Long Valley. A, Lp2-3, LACM 154957. B, Rp2, LACM 154970. C, Lm1 or 2, LACM 154938. D, partial Rm3, LACM 154939. E, Lm1 or 2, LACM 154937. F, partial Lm3, LACM 154928. G, Lm3, LACM 154927. H, partial Ldp3 or 4, LACM 154931. All occlusal views, scale = 5 mm.

isthmus between the metaconid and metastylid, whereas the molar ectoflexid is deep, penetrating the isthmus and extending lingually to very near the linguaflexid; and 7) the labial borders of the protoconid and hypoconid are relatively flattened. Measurements of the lower cheek teeth are presented in Table 2.

The metatarsal (Figure 6D) is relatively robust with a well-developed keel on the distal articular surface. The splint bone (Figure 6D) is large and tapers distally to a point, typical of those of monodactyl horses. The other appendicular elements (Figure 6A-C) are robust, indicating a moderately large size.

Discussion—The dental, cranial, and appendicular morphologies of *Dinohippus mexicanus* have been well characterized (e.g., Kelly, 1998b; MacFadden 1984b, 1986, 2006; MacFadden and Carranza-Castañeda, 2002). In size and cheek teeth occlusal morphology, the equid specimens from Long Valley are indistinguishable from those of *D. mexicanus* and are referred to this species.

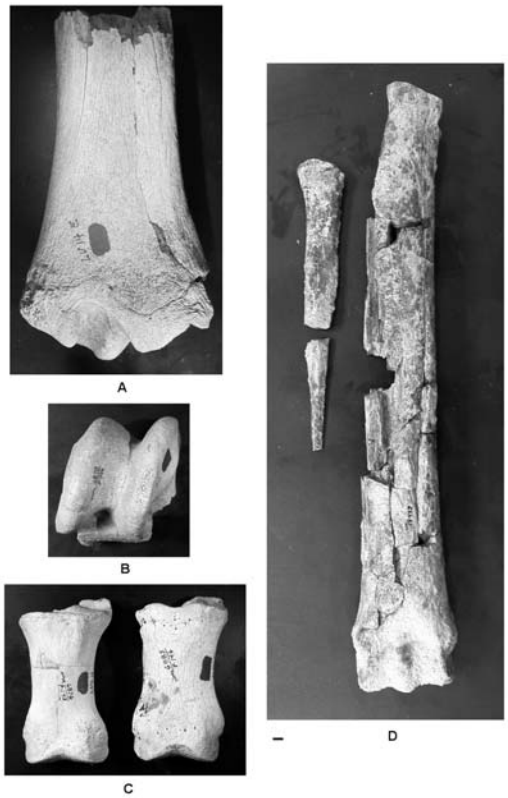

FIGURE 6. *Dinohippus mexicanus*, postcranial elements from Long Valley. A, partial distal tibia, LACM 154955, anterior view. B, partial astragalus, LACM 154946, anterior view. C, proximal phalanges, LACM 154943 (left) and LACM 154956 (right), anterior views. D, associated partial metatarsal (anterior view) and partial splint (lateral view), LACM 154942.

Order Artiodactyla Owen, 1848
Family Camelidae Gray, 1821
Genus *Hemiauchenia* Gervais and Ameghino, 1880
cf. *Hemiauchenia* sp.

Referred Specimen—From locality LACM 7833: partial dentary with p3 roots and associated cheek tooth fragments, LACM 154936. From locality LACM 7834: partial astragalus, LACM 154945. From locality LACM 7840: LACM 154964, upper left molar fragment.

Discussion—The partial astragalus consists of the lateral half (Figure 7C-D). It measures 64.0 mm in height. The partial dentary has the two roots of p3 and the anterior portion of the diastema. A p2 was not present. The p3 alveolar A-P is 14.0 mm. The upper molar fragment consists of the anterolabial corner of the tooth and documents the occurrence of a small camel at locality LACM 7840 in the upper sandy member.

The astragalus is moderately small and indistinguishable in size and morphology from those of *Hemiauchenia* from Hemphillian aged deposits of the Coal Valley Formation in Smith Valley, Nevada (per. observation). In *Hemiauchenia*, the p2 is absent and the p3 is two rooted (Gregory, 1942; Hibbard, 1963, Webb, 1974; Kelly, 1998a). The p3 alveolar length of LACM 154936 is also within the observed range of those of *Hemiauchenia* (Webb, 1974). The upper molar fragment represents a moderately small camel, similar in size to *Hemiauchenia vera* (Matthew, in Matthew and Osborn, 1909). All of the camel specimens appear to represent *Hemiauchenia*, but until more diagnostic material is available, these specimens are only tentatively referred to this genus.

Family Antilocapridae Gray, 1966
Subfamily Antilocaprinae Brooke, 1876
genus and species indeterminate

Referred Specimen—From locality LACM 7836: partial first phalanx, LACM 154954.

Discussion—The specimen consists of a partial first phalanx (Figure 7A-B) with portions of the medial and lateral sides of the proximal articular surface missing. The measurements are A-P = 48.1 mm and distal width = 17.5 mm.

The phalanx is morphologically typical of those of the subfamily Antilocaprinae, but also exhibits some similarity to those of Cervidae. The earliest appearance of the New World Cervidae is *Eocoileus gentryorum*, from the latest Hemphillian Palmetto Fauna from the upper Bone Valley Formation of central Florida

(Webb, 2000; Bell et al., 2004). Other North American cervids make their first appearance in the early Blancan (Webb, 1998, 2000; Bell et al., 2004). Based on the dimensions of the distal condyles of the metapodial of *E. gentryorum* (Webb, 2000), the Long Valley first phalanx is much too large to represent this species. Records of the Antilocaprinae are numerous in Hemphillian faunas from North America (Janis and Manning, 1998). The Long Valley specimen appears to represent a moderate sized member of the Antilocaprinae.

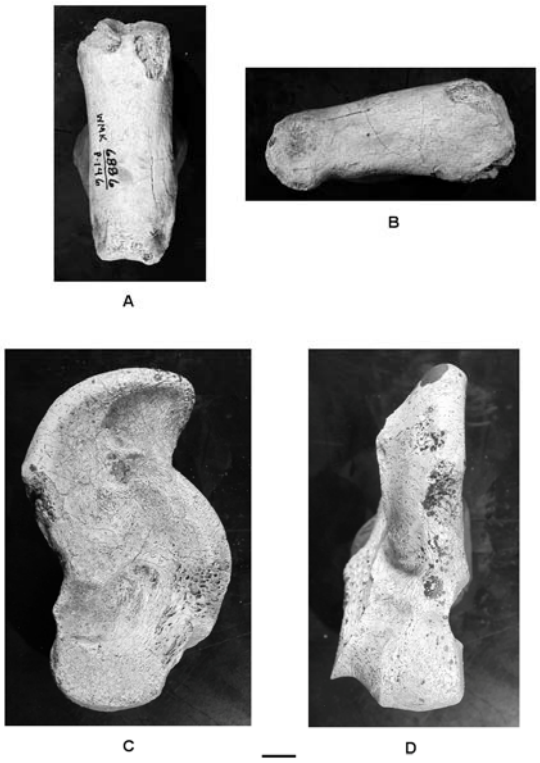

FIGURE 7. Artiodactyla from Long Valley. A-B, Antilocaprinae, genus and species indeterminate, proximal phalanx, LACM 154954, anterior (A) and lateral (B) views. C-D, cf. *Hemiauchenia* sp., partial astragalus, LACM 154945, lateral (C) and anterior (D) views. Scale = 5 mm.

Order Proboscidea Illiger, 1811
Family Gomphotheriidae Hay, 1922 or Mammutidae Hay, 1922
genus and species indeterminate

Referred Specimens—From locality LACM 7832: associated cheek tooth enamel fragments, LACM 154934; associated tusk fragments, LACM 154935. From locality LACM 7833: cheek tooth enamel fragment, LACM 154944. From locality LACM 7834: cheek tooth enamel fragment, LACM 154947. From LACM 7835: partial tarsal, LACM 154948.

Discussion—The fragmentary dental specimens and the partial tarsal can only be identified as either Gomphotheriidae Hay, 1922 or Mammutidae Hay, 1922, but they are significant because they document the occurrence of Proboscidea in the fauna.

Firby (in Goodman et al., 1974) identified *Stegomastodon mirificus* from the lower part of the upper sandstone member of the Hallelujah Formation. Confirmation of his identification cannot be made because the fossils are now missing. *Stegomastodon* is known from the late Hemphillian to the early Irvingtonian of North America, about 6.0 to 0.8 Ma (Lambert and Shoshani, 1998; Bell et al., 2004), and could conceivably have been present in the fauna. However, the newly discovered cheek tooth fragments do not exhibit the plate-like structure seen in the cheek teeth of *Stegomastodon*, but are more similar to the bunodont, rounded conules seen in the cheek teeth of *Gomphotherium* or *Mammut*.

CONCLUSIONS

The Hallelujah Formation of Long Valley, Lassen County, California has yielded a small assemblage of mammalian fossils herein referred to the Hallelujah Junction Local Fauna. The fauna is comprised of cf. *Teleoceras* sp., *Dinohippus mexicanus*, cf. *Hemiauchenia* sp., Antilocaprinae genus and species indeterminate, and Gomphotheriidae or Mammutidae. Additional taxa that may be present in the fauna, which were identified by Firby (in Goodman et al., 1974) in the original collection of fossils from the Hallelujah Formation that are now lost, include Leporidae and Tayassuidae.

The last appearance of Rhinocerotidae occurs in deposits of latest Hemphillian age (subbiozone or subbiochron Hh4 of Tedford et al., 2004) and rhinos were extinct in North America by earliest Blancan time (Bell et al., 2004; Prothero, 2005). Only two previous occurrences of Rhinocerotidae in the early Blancan have been reported (Madden and Dalquest, 1990; Farlow et al., 2001). Prothero (2005) regarded Madden and Dalquest's (1990) report of a partial rhino tooth to be reworked material from nearby Hemphillian deposits. Prothero (2005) stated "that it is more parsimonious to assume that this one tooth scrap has been reworked than to assume that hundreds of Blancan localities all over North America have failed to fossilize one rhino specimen while they were still living on this continent." Farlow et al. (2001) described an assemblage of mammals from a quarry in Indiana, the Pipe Creek Sinkhole biota, which included species typical of the latest Hemphillian and earliest Blancan.

Because the fauna came from a sinkhole within a Paleozoic limestone, there was no other independent geological method to determine the age of the fauna except to compare it with other faunas from North America. Farlow et al. (2001) considered the fauna to be either latest Hemphillian or earliest Blancan in age. However, based on a detailed analysis of the rodents from the Pipe Creek Sinkhole and the presence of *Teleoceras*, Martin et al. (2002) assigned the assemblage to the latest Hemphillian, at slightly more than 5.0 Ma. In addition, other recent investigations of formations in the Great Basin that span the Hemphillian/Blancan boundary and include radioisotopic, paleomagnetic, and tephrochronologic corroboration, indicate that the last appearance of the Rhinocerotidae occurs in deposits of latest Hemphillian age (e.g., Kelly 1994, 1997, 1998a, 2000; Trexler et al., 2000; Muntean, 2001; Lindsay et al., 2002; Jefferson and Lindsay, 2005; Cashman et al., 2009; Garside and Rigby, 2009; Kelly and Secord, 2009). The presence of cf. *Teleoceras* sp. in the Hallelujah Junction Local Fauna indicates that the fauna is no younger than latest Hemphillian.

Dinohippus mexicanus was first described by Lance (1950) from the latest Hemphillian Yepómera Local Fauna of Mexico. It has also been recorded from the latest Hemphillian of Florida, New Mexico, and Texas (e.g., Johnson and Savage, 1955; Quinn, 1955; Lindsay, 1984; MacFadden, 1984b, 1986; Carranza-Castañeda, 1989; Morgan and Sealey, 1995). Tedford et al. (2004) list *D. mexicanus* as one of the characterizing taxa of the latest Hemphillian. Only two occurrences of *Dinohippus* have been reported from the Blancan of North America: cf. *Dinohippus* sp. from the Anza-Borrego area of southern California (Downs and Miler, 1994) and *D. mexicanus* from the Tecolotlán Basin of Jalisco State (Jal Teco), central Mexico (MacFadden and Carranza-Castañeda, 2002). Downs and Miller (1994) referred four isolated upper molars from late Hemphillian deposits at Anza-Borrego and a partial mandible (IVCM 537, with Li1-2, Lp2-m3 and Ri1-c) from the middle Blancan Hueso Formation to cf. *Dinohippus* sp. The teeth of the partial mandible reportedly exhibited dental characters found in both *Dinohippus* and early *Equus*. Subsequently, Scott (2006) noted that the primitive dental characters in the partial mandible referred to cf. *Dinohippus* sp. by Downs and Miller (1994) are equivocal. Scott (2006) further noted that a new specimen, a partial maxilla with associated teeth from the Arroyo Diablo Formation (dated to 3.8-3.6 Ma) at Anza-Borrego, also exhibits morphological characters similar to both *Equus simplicidens* and *Dinohippus*. He concluded that definitive generic assignments cannot yet be made for these two Blancan specimens from the Anza-Borrego area.

MacFadden and Carranza-Castañeda (2002) tentatively identified *Dinohippus mexicanus* from Blancan deposits at Las Gravas, within the Jal-Teco7 sequence, based on isolated teeth. They reported that teeth of early *Equus* also occur in the same beds. Subsequently in a paper describing numerous late Neogene fossil faunas and localities in Mexico, Carranza-Castañeda (2006) concluded that the Jal Teco 7 locality at Las Gravas is late Blancan in age. His age determination was based on a radioisotopic date of 2.6 ± 0.2 Ma and the presence of the peccary *Platygonus*, the camel *Hemiauchenia blancoensis*, and a species of *Equus* having molars with less progressive characters than those of *Equus simplicidens*. Presumably, these are the same equid molars from the Jal Teco 7 locality that MacFadden and Carranza-Castañda (2002) had tentatively referred to *Dinohippus mexicanus*. Furthermore, Carranza-Castañeda (2006, fig. 5) now states that *D. mexicanus*, along with *Teleoceras*, only occur in the latest Hemphillian of the Tecolotlán Basin. This age determination was based on $^{40}Ar/^{39}Ar$ dates of 4.95 ± 0.02 and 4.89 ± 0.16 Ma from about the middle and the upper parts, respectively, of the late Hemphillian sequence in the Tecolotlán Basin. This sequence is separated by an unconformity from the overlying strata that contain the late Blancan fauna. Moreover, Carranza-Castañeda (2006) now considers the many additional faunas of central Mexico where *D. mexicanus* has been recorded to be latest Hemphillian in age. Thus, there are no credible occurrences of *Dinohippus mexicanus* in the Blancan.

The fossils previously identified by Firby (in Goodman et al., 1974), which are now lost, included Rhinocerotidae and *Equus* sp. cf. *E. proversus*. These fossils reportedly came from the lower part of the upper sandy member about 10-20 m above the contact with the middle member (Koehler, 1989). The presence of Rhinocerotidae from this part of the upper sandy member and the rhino specimens reported here from the upper sandy member indicate that the original fauna could not be any younger than latest Hemphillian. Based on a meager dental sample from the Etchegoin Formation of the North Coalinga area, California, "*Equus proversus*" was originally described by Merriam (1916) as *Pliohippus proversus*. Because the holotype and topotypic sample are not adequate to provide a specific diagnosis for this species, *P. proversus* in now regarded as a *nomen dubium* (Kelly, 1998b). The new horse premolar (LACM 154970) identified here as *D. mexicanus* is from the same area and stratigraphic level as Firby's specimens. Moreover, *Equus* is not known to co-occur with Rhinocerotidae and does not appear in the fossil record elsewhere until

the early Blancan (Downs and Miller, 1994; Bell et al., 2004). Therefore, it is probable that the lost equid material from the west side of Long Valley belonged to *Dinohippus mexicanus*, rather than *Equus*.

Hemiauchenia is a common taxon in Hemphillian to Rancholabrean faunas of North America (Honey et al., 1998). The remaining taxa recorded in the Hallelujah Junction Local Fauna, an indeterminate antilocaprid and indeterminate proboscidean, do not provide any additional information about age of the fauna.

In summary, the presence of *Dinohippus mexicanus*, which appears to be restricted to the latest Hemphillian, along with the co-occurrence of Rhinocerotidae, indicate a latest Hemphillian age (subbiozone or subbiochron Hh4, latest Miocene to earliest Pliocene) for the Hallelujah Junction Local Fauna, ranging from about 5.9 to 4.8 Ma. Our analysis of the new sample of fossils from the upper part of the middle member and lower part of the upper sandy member provides a more accurate age determination for this portion of the Hallelujah Formation in Long Valley. Furthermore, the 8.0 Ma tephrochronologic age determination within the lower sandy member and the occurrence of latest Hemphillian mammals from the lower part of the upper sandy member indicates that this stratigraphic interval of the Hallelujah Formation spans most of the Hemphillian.

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