PLIOCENE (LATEST HEMPHILLIAN AND BLANCAN) VERTEBRATE FOSSILS FROM THE MANGAS BASIN, SOUTHWESTERN NEW MEXICO

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ABSTRACT—Two vertebrate faunas of Pliocene age, the Walnut Canyon and Buckhorn local faunas, are described from sediments of the Gila Group in the Mangas basin in northern Grant County, southwestern New Mexico. Stratigraphic sections and lithologic descriptions are provided for the three unnamed formations in the upper part of the Gila Group that produced these two faunas. The Walnut Canyon local fauna includes one major locality, the Walnut Canyon Horse Quarry, and three smaller sites located 5 km southeast of Gila. The fauna is composed of 12 species of mammals, including one lagomorph, one rodent, two carnivores, two horses, one peccary, three camels, one cervid, and one antilocaprid. The most common members of the fauna are the equids *Astrohippus stockii* and *Dinohippus mexicanus* and two genera of camelids (*Hemiauchenia* and *Alforjas*). The remaining species in the fauna are represented by very small samples. *A. stockii*, *D. mexicanus*, the canid *Vulpes stenognathus*, the tayassuid cf. *Catagonus brachydontus*, and the camelid *Alforjas* are typical of late Hemphillian (late Miocene and early Pliocene) faunas. Furthermore, the presence of *A. stockii*, *D. mexicanus*, and a true cervid are indicative of latest Hemphillian faunas. Two correlative latest Hemphillian faunas, the Yepómera fauna from Chihuahua in northern Mexico and the Palmetto fauna from the Bone Valley Formation in Florida, are earliest Pliocene in age (5.2– 4.5 Ma).

The Buckhorn local fauna incorporates 14 sites located between 3 and 10 km northwest of Buckhorn. The fauna is composed of 27 species of vertebrates, including one fish, one frog, one salamander, two snakes, six birds, one lagomorph, four rodents, four carnivores, two horses, one peccary, two camels, one ruminant, and one proboscidean. The abundance of aquatic vertebrates in several of the Buckhorn sites, in particular frogs (*Rana*) and birds, including a flamingo (*Phoenicopterus*), rails, and ducks, as well as the lithology of the sediments, suggest a lacustrine depositional environment. The mammals from the Buckhorn local fauna are clearly indicative of a Blancan (Pliocene) age, and several species permit a more precise placement within the Blancan. The presence of the small hipparionine horse *Nannippus* and a primitive species of the arvicoline rodent *Mimomys* and the absence of Neotropical immigrants, suggest a pre-late Blancan age (older than 2.5 Ma). The occurrence of the horse *Equus* (*Dolichohippus*) *simplicidens* and a large species of *Mimomys* (subgenus *Ogmodontomys*) excludes very early Blancan faunas. The evolutionary stage of the rodents *Mimomys* (*Ogmodontomys*) cf. *M. poaphagus* and *Repomys* cf. *R. panacaensis* is most consistent with a late early or early middle Blancan age (4.0–3.0 Ma) for the Buckhorn local fauna. Broadly correlative early or middle Blancan faunas are Cuchillo Negro Creek and Truth or Consequences in New Mexico, Clarkdale and Verde in Arizona, Rexroad in Kansas, and Panaca in Nevada.

INTRODUCTION

The first vertebrate fossil collected from the Mangas basin in southwestern New Mexico, a partial juvenile skull of the late Miocene rhinoceros *Teleoceras fossiger*, was found near the mouth of Dry Creek in southernmost Catron County and reported by the famous nineteenth century paleontologist Edward Drinker Cope (1884). After a hiatus of some 70 years, paleontological field work in this region resumed in the early 1950s and has continued until the present time. Neogene vertebrate fossils are now known from sediments of the Gila Group (also known as the Gila Conglomerate or Gila Formation) at numerous sites throughout the Mangas basin, particularly in the central portion of the basin near the towns of Buckhorn, Cliff, and Gila in northern Grant County. Strata of the Gila Group in the Mangas basin range in age from Miocene to Pleistocene based on radiometrically dated basalt flows and volcanic ashes, as well as biochronologic ages derived from fossil mammals.

The Mangas basin (also referred to in the literature as the Mangas graben or Mangas trench) trends from northwest to southeast and is approximately 100 km in length, extending from south of Reserve in Catron County southeast to near Silver City in Grant County (Fig. 1). The basin is filled with 500 to 700 m of Neogene terrestrial sediments derived primarily from tilted and uplifted Oligocene and Miocene volcanic rocks exposed along its flanks (Leopoldt, 1981). Two major rivers transect the Mangas basin from east to west, the San Francisco River in the northern half of the basin and the Gila River in the central and southern part of the basin. Both of these rivers flow into southeastern Arizona.

The two largest vertebrate faunas so far discovered in the Mangas basin, the Walnut Canyon local fauna of earliest Pliocene age (latest Hemphillian) and the Buckhorn local fauna of medial Pliocene age (early or middle Blancan), occur in unconsolidated sediments in the upper part of the Gila Group in northwestern Grant County (Fig. 1). The Walnut Canyon local fauna is derived from a series of outcrops along the North Fork of Walnut Canyon about 5 km southeast of Gila. This fauna is composed of 12

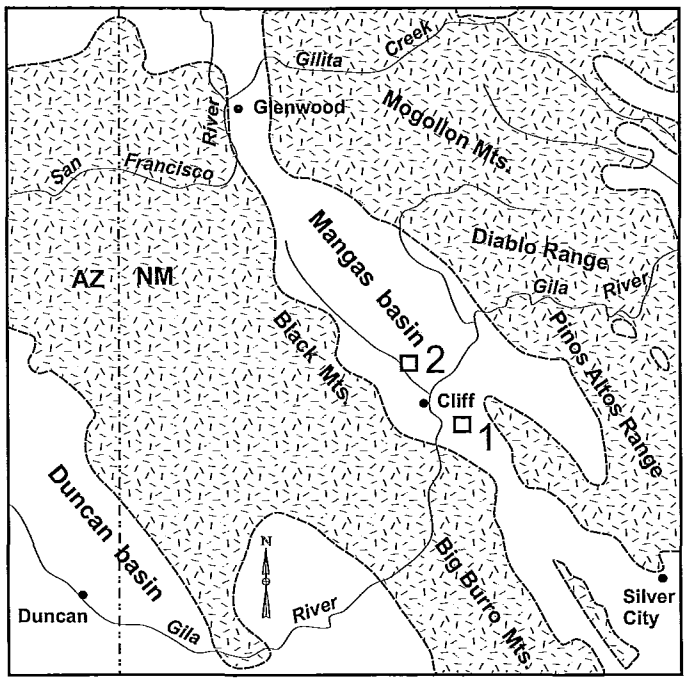


FIGURE 1. Map of the Mangas basin in Grant County, southwestern New Mexico showing locations of Walnut Canyon (1) and Buckhorn (2) local faunas.

species of mammals, the most common of which is the small horse, *Astrohippus stockii*, a species typical of latest Hemphillian faunas in the southwestern United States and northern Mexico. The Buckhorn local fauna, collected from badlands between 3 and 10 km northwest of Buckhorn, includes 16 species of mammals, as well as fish, frogs, salamanders, snakes, and at least six species of birds. A review of the Walnut Canyon and Buckhorn vertebrate faunas is the principal focus of this report.

We also provide preliminary descriptions of four formation-rank geologic units from the central portion of the Mangas basin, here informally termed formations A, B, C, and D, in ascending order. The outcrops we measured and described are in the general vicinity of the two areas where the major vertebrate sites are located, along the North Fork of Walnut Canyon about 5 km southeast of Gila and on the east side of Duck Creek about 3 km northwest of Buckhorn. Formal description and naming of these new formations will require further field work, but we feel it is important to provide preliminary descriptions of these units in order to establish the stratigraphic context of the Walnut Canyon and Buckhorn vertebrate faunas.

METHODS, MATERIALS, AND ABBREVIATIONS

The fossils described in this paper are housed in two vertebrate paleontology collections: the New Mexico Museum of Natural History and Science (NMMNH), Albuquerque, New Mexico and the Frick Collection, American Museum of Natural History (F:AM), New York. With the exception of the Frick Buckhorn site, all fossil sites discussed in this paper have been assigned NMMNH paleontology locality numbers (4-digit numbers preceded by L-). In addition to standard Township, Range, and Section, all NMMNH sites were located using a hand-held Global Positioning System (GPS) receiver that plots positions accurate to within 100 m or less, using Universal Transverse Mercator (UTM) grid coordinates and the NAD27 datum.

The abbreviations for tooth positions in mammals are standard, with upper case letters for upper teeth and lower case letters for lower teeth: I/i (upper/lower incisors), C/c (upper/lower canines), P/p (upper/lower premolars), and M/m (upper/lower molars). It is difficult in some cases to determine the exact position of isolated horse teeth, in particular the P/p3 and P/p4 are often difficult to differentiate, as are the M/m1 and M/m2. If the tooth position can not be determined with certainty, both possible teeth are listed: (e.g., P3/P4 or m1/m2). The dental terminology for horse teeth follows MacFadden (1984a). Measurements throughout the paper are given in millimeters (mm). Detailed studies of the lower vertebrates were not undertaken because we lack extensive expertise in these groups and, in general, they do not provide much biochronologic information. However, the extensive material of frogs and birds from the Buckhorn local fauna certainly warrants further work.

The ages and boundaries for the Miocene, Pliocene, and Pleistocene epochs and their standard subdivisions follow Berggren et al. (1995). All ages are given in millions of years or Mega-anna (Ma). The ages and boundaries of the North American land-mammal ages (NALMA) and their subdivisions follow Tedford et al. (1987) for the Miocene and earliest Pliocene (Arikareean, Hemingfordian, Barstovian, Clarendonian, and Hemphillian) and Lundelius et al. (1987) and Repenning (1987) for the Pliocene and Pleistocene (Blancan and Irvingtonian). Definition of the terms "fauna" and "local fauna" follow Woodburne (1987, p. xiv). A fauna is "an assemblage of fossil vertebrates of specific taxonomic composition obtained from a number of geographically diverse sites," whereas a local fauna is "an assemblage of fossil vertebrates of specific taxonomic composition recovered from one or a few sites that are closely spaced stratigraphically and geographically."

GEOLOGIC SETTING

Late Cenozoic basin-fill sediments in at least eight basins in southwestern New Mexico and southeastern Arizona have usually been included in the Gila Conglomerate or Gila Group (Leopoldt, 1981). As originally defined by Gilbert (1875), the Gila Conglomerate included only coarse alluvial and fluvial basin-fill sediments of Neogene age exposed by the Gila River and its tributaries. Gilbert (1875) specifically mentioned deposits of the Gila Conglomerate in the Mangas basin along the San Francisco River in southwestern New Mexico, and in the Duncan and Safford basins in southeastern Arizona. Since its original description, the term Gila Conglomerate has been applied to the Neogene alluvial fills in most of the basins in this region.

Based on regional studies of the Gila Conglomerate, Heindl (1958) recognized that the individual basins in southwestern New Mexico and southeastern Arizona contained locally-derived sediments that were not genetically related to deposits of similar lithology and age in other nearby basins. Therefore, Heindl (1962, 1963) elevated the Gila Conglomerate to group status, and recommended that a separate lithostratigraphic nomenclature be developed for each basin in the region. In a review of the geology of the central portion of the Mangas basin, Leopoldt (1981) divided the deposition of Gila Group sediments in this basin into two phases, the older basin fill and younger basin fill. The older basin fill consists of sediments of early to middle Miocene age (20–10 Ma) dominated by approximately 250 m of coarse-grained, mostly highly-indurated, conglomerates and fanglomerates. A

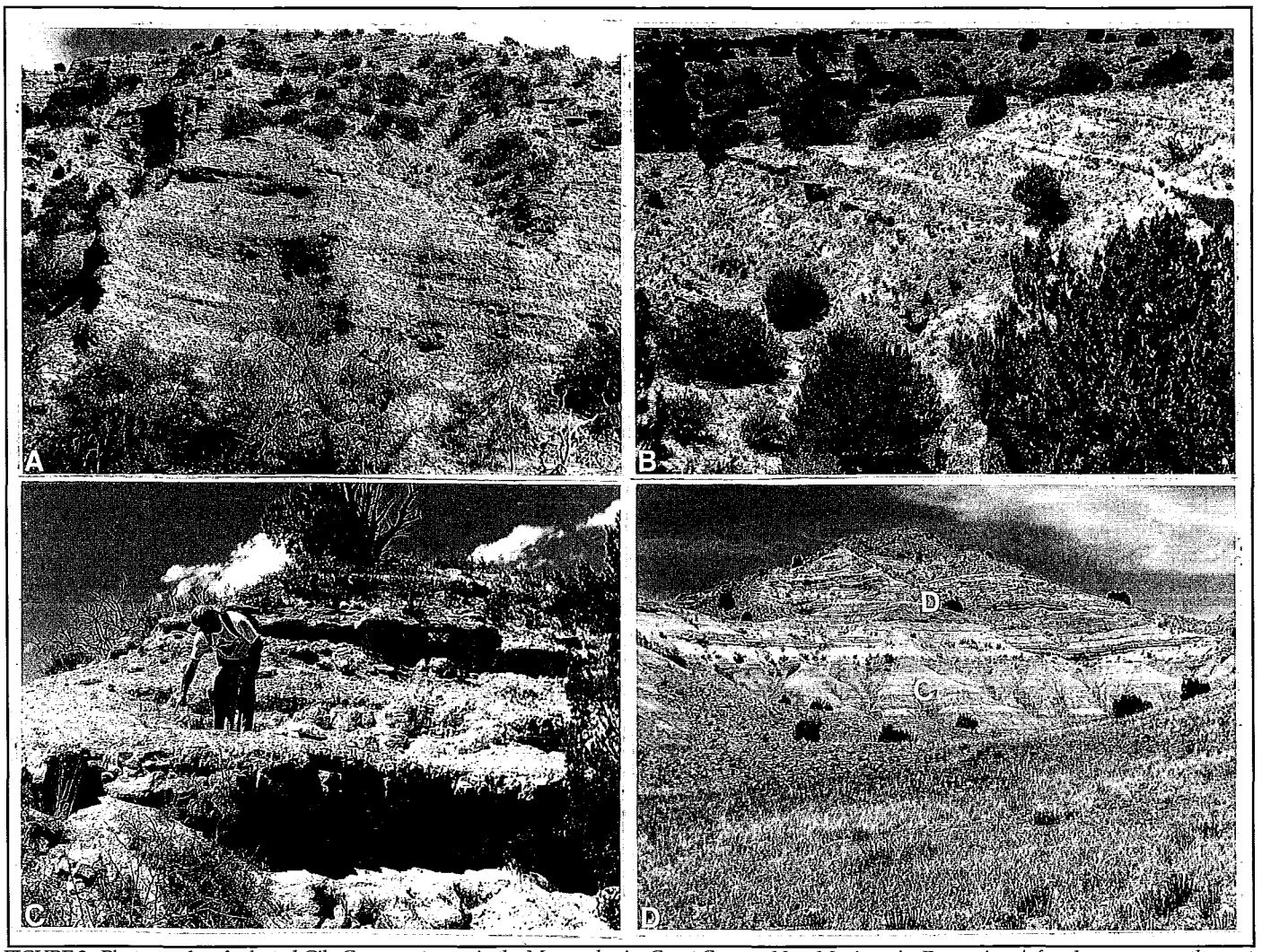


FIGURE 2. Photographs of selected Gila Group outcrops in the Mangas basin, Grant County, New Mexico. **A.** Formation A fanglomerates on the east side of the Gila River just south of the mouth of Mogollon Creek. **B.** Middle member of Formation B at the North Fork of Walnut Canyon showing ledgy tuffs and calcretes. **C.** Middle member of Formation B at the North Fork of Walnut Canyon, site of the Walnut Canyon Horse Quarry (NMMNH locality L-2922), person is standing on the fossiliferous unit. **D.** Formations C and D at the Duck Creek section northwest of Buckhorn.

younger basin fill of late Miocene to early Pleistocene age (10 to 1.5 Ma) is characterized by finer-grained, mostly unconsolidated, sediments ranging from pebble conglomerates and sandstones to siltstones, mudstones, and diatomites. Both Heindl (1962) and Leopoldt (1981) noted that a major unconformity separates the early Miocene indurated conglomerates of the older basin fill and the late Miocene to Pleistocene finer grained, mostly unconsolidated, sediments of the younger basin fill.

Leopoldt (1981) interpreted the younger basin fill deposits in the upper part of the Gila Group as products of an alluvial fan and playa lake depositional environment. In the Pliocene and early Pleistocene, a large lake apparently expanded to cover much of the central Mangas basin. The existence of this lake is substantiated by the presence of lacustrine sediments within the upper Gila Group in the vicinity of Buckhorn in Grant County, including diatomites (Stewart, 1988), as well as by the abundant occurrence of aquatic vertebrates in several units within the Pliocene Buckhorn local fauna. Prior to the early Pleistocene, the Mangas basin was a hydrologically closed system, but after that time external drainage opened the basin and the Gila River began to flow through the basin to the southwest into Arizona, much as it does today.

Stratigraphy

In its current usage, the Gila Group refers to Neogene clastic basin-fill deposits in most major basins in southwestern New Mexico and southeastern Arizona (e.g., Knechtel, 1936; Heindl, 1958, 1962, 1963; Dane and Bachman, 1965; Elston, 1976; Leopoldt, 1981; Lucas and Ingersoll, 1981; Cather et al., 1994). There is a real need to more precisely delineate the internal stratigraphy of the Gila Group. Mappable, formation-rank lithosomes need to be identified and defined in each of the Gila Group basins. For example, in the San Pedro Valley in southeastern Arizona, the Quiburis Formation of Miocene age (Heindl, 1963) and the St. David Formation of Plio–Pleistocene age (Gray, 1967) have been described as formations within the Gila Group. The Quiburis and St. David Formations are of particular significance because they have produced an important succession of late Hemphillian, Blancan, and early Irvingtonian

vertebrate faunas (Lindsay and Tessman, 1974; Johnson et al., 1975; Jacobs, 1977; Lindsay et al., 1984; Lindsay et al., 1990).

Leopoldt (1981) described the lithology and sedimentology of the Gila Group sediments in the central Mangas basin, but he did not propose a formal nomenclature for these units. In our preliminary studies of this same region, focusing on the Duck Creek–Table Butte area (T14–16S, R16–18W) in the vicinity of Buckhorn, Cliff, and Gila in northwestern Grant County, we identify four mappable lithostratigraphic units of the Gila Group. These lithostratigraphic units (described below) are here informally termed (in ascending order) formations A, B, C, and D. We intend to name these formations as formal lithologic units in a future paper.

Formation A—Leopoldt (1981) referred to rocks we informally term formation A as older basin fill. Trauger (1972) earlier called these beds the older part of the Gila Conglomerate. Finnell (1987) subsequently mapped it as older gravels of the Gila Conglomerate, a unit which includes the older and younger basin fills of Leopoldt (1981) and our formations A through D.

The most extensive exposures of formation A mentioned by Leopoldt (1981) are along the eastern edge of the Mangas basin in the general area of the confluence of Mogollon Creek with the Gila River (secs. 23–26, T14S, R17W; secs. 30–32, T14S, R16W; Canteen Canyon 7.5 minute quadrangle). Here, formation A (Fig. 2A) consists of well-indurated conglomerate and fanglomerate up to 400 m thick. Clasts are Oligocene volcanic rocks, mostly felsic. At several localities outside of the Mangas basin (Mogollon–Datil basin and Duncan basin), rocks similar to formation A are interlayered with basaltic andesites that yield K/Ar ages of 21–19 Ma, and thus this unit is probably early Miocene in age (Leopoldt, 1981). We have not yet undertaken detailed studies of formation A.

Formation B—Formation B represents most of the Gila Group sediments exposed in the central Mangas basin. Leopoldt (1981, pl. 1) mapped formation B as the basin-margin and transitional facies of the younger basin fill of the Gila Group. Formation B is at least 130 m thick, but a complete section has not been discovered (Leopoldt, 1981).

We measured an incomplete, 76-m-thick section of formation B along the North Fork of Walnut Canyon (secs. 7–8, T16S, R16W; Cliff 7.5 minute quadrangle), about 6 km southeast of Gila (Figs. 2B, 2C, 3B). This section is representative of Formation B. It is mostly composed of sedimentary breccia (50% of section), sandstone (21% of section), conglomeratic sandstone (14% of section), and siltstone (10% of section). Minor rock types include mudstone, calcrete, diatomite, and tuff (combined they are about 10% of the section). Pale orange and grayish orange pink are the dominant colors of the rocks in the measured section. Clasts and pebbles in the breccias and conglomerates are mostly felsic volcanic debris.

The measured section can be informally divided into three members: (1) a lower member of sandstone and sedimentary breccia at least 13 m thick (Fig. 3B, units 1–6); (2) a middle member with numerous tuff beds approximately 25 m thick (Fig. 2B; Fig. 3B, units 7–22); and (3) an upper member of cyclically bedded sedimentary breccias at least 38 m thick (units 23–26). The middle member is of particular interest here because it produces late Hemphillian mammals near its base (Figs. 2C, 3B).

Formations C and D—Leopoldt (1981, pl. 1) mapped formations C and D as the basin-center facies of the younger basin fill of the Gila Group. We measured a representative section of this unit (Figs. 2D, 3A) about 1 km east of Duck Creek and 4 km northwest of Buckhorn (sec. 29, T14S, R18W, Buckhorn 7.5 minute quadrangle). Trauger (1972) suggested that this entire interval may be up to 300 m thick, but Leopoldt (1981) could only document a maximum thickness of about 150 m. Our incomplete section is about 57 m thick (Fig. 3A).

Formations C and D are mostly lacustrine deposits, but they are two lithostratigraphically distinct, mappable units. We measured 27 m of formation C, most of which is mudstone (76% of measured section). Lesser rock types are sandstone (15% of

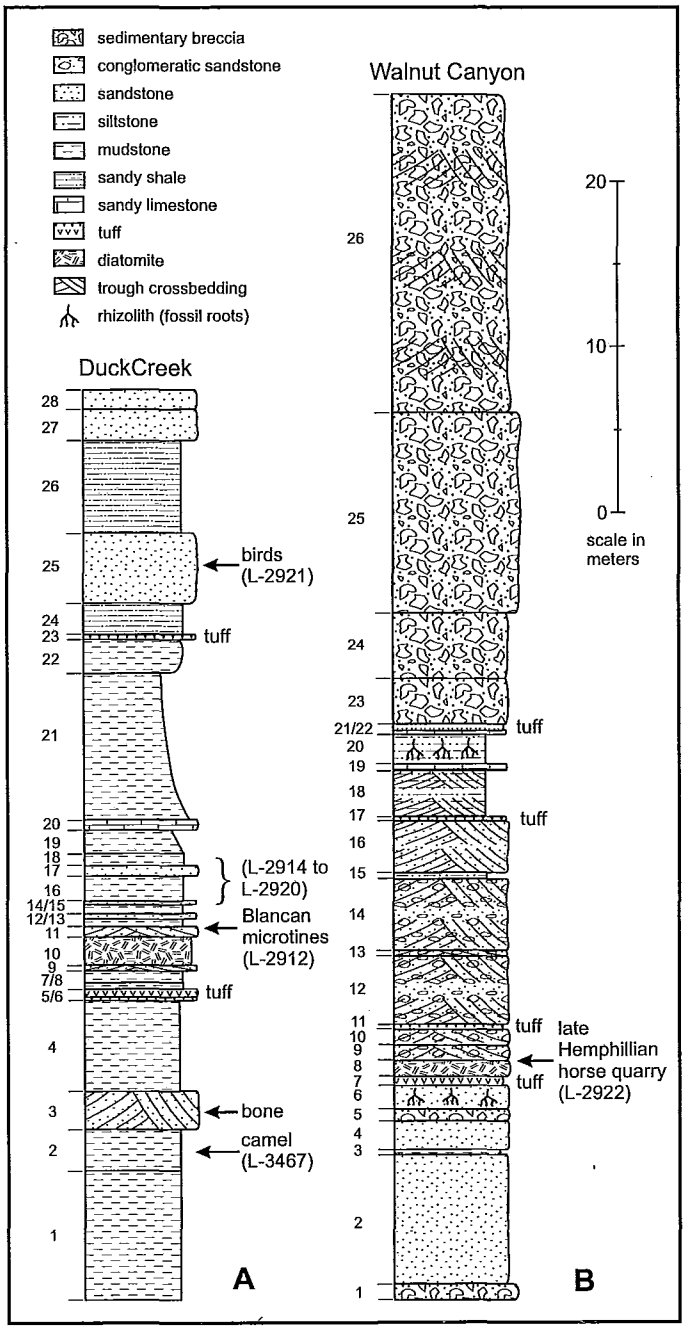


FIGURE 3. Stratigraphic sections of three unnamed formations (formations B, C, D) containing Pliocene vertebrate fossils, located in the central part of the Mangas basin in Grant County, New Mexico. A. Measured stratigraphic section of part of formations C and D on the east side of Duck Creek northwest of Buckhorn. B. Measured stratigraphic section of part of formation B on the North Fork of Walnut Canyon east of Riverside. See Appendix for description of numbered units.

section), diatomite (7% of section), and tuff (2% of section). Dominant colors are yellowish gray and greenish or olive gray, giving the unit an overall greenish hue. In contrast, most of the 28-m-thick section we measured of formation D is composed of sandstone (65% of section) and sandy shale (27% of section). Minor rock types are mudstone, limestone, and tuff (combined 8% of section). Dominant colors are orange pink and light brown, so that the unit has a terra cotta color overall. Formations C and D can be distinguished by gross lithological features (mudstone-dominated versus sandstone/sandy shale-dominated) and color (green versus terra cotta). Their contact is gradational and conformable, but it is mappable. Both formations produce fossil vertebrates of Blancan age.

Age of the Gila Group in the Mangas basin

Radiometrically-dated basalt flows that intertongue with basal Gila Group sediments in the Mogollon–Datil basin northeast of the Mangas basin and in the Duncan basin to the southwest along the New Mexico–Arizona border range in age from about 21 to 19 Ma, suggesting that Gila Group deposition began in the early Miocene. A latest Miocene basalt dated at 5.5 Ma, and two late Pliocene air-fall volcanic ashes dated at 2.13 and 2.01 Ma, occur in the upper part of the Gila Group (Leopoldt, 1981). None of these radiometrically-dated units are directly associated with vertebrate fossils, but they do place general time constraints on the deposition of Gila Group sediments in the Mangas basin.

Vertebrate fossils of at least five different ages help to constrain the age of the Gila Group. The oldest vertebrate fossil known from the Gila Group in New Mexico (Tedford, 1981) is an oreodont similar to *Promerycochoerus carrikeri*, a species typical of the early Miocene (late Arikareean, about 20 Ma). The Gila oreodont is not from the Mangas basin, but was collected from a volcaniclastic sandstone low in the Gila Group on the western slope of the Black Range in western Sierra County. The age of this fossil is in agreement with the early Miocene age for the onset of deposition of the Gila Group provided by several dated basalt flows mentioned above. A partial skull of the rhinoceros, *Teleoceras fossiger*, from Dry Creek in southern Catron County (Cope, 1884) is indicative of a late Miocene age, either late Clarendonian or early Hemphillian (10–7 Ma). The Walnut Canyon local fauna of latest Hemphillian age (earliest Pliocene, 5.2–4.5 Ma) and the Buckhorn local fauna of early to medial Blancan age (late early or early late Pliocene, 4.0–3.0 Ma) provide the strongest available evidence for the age of the upper part of the Gila Group in the Mangas basin. Leopoldt (1981) reported a Pleistocene fauna from southern Catron County, supposedly from sediments in the Gila Group. We have not had the opportunity to examine these Pleistocene fossils, nor the strata from which they were collected.

WALNUT CANYON LOCAL FAUNA

One primary locality, the Walnut Canyon Horse Quarry, and several minor sites are included in the Walnut Canyon local fauna, here proposed as a new name. The sites comprising the Walnut Canyon local fauna are all located approximately 5 km southeast of the town of Gila and 6 km east of the Gila River in northern Grant County, southwestern New Mexico (Fig. 1). These sites occur over an area of less than 1 km^2 and within a stratigraphic interval less than 10 m thick in the middle member of our formation B in the upper Gila Group (Figs. 2B, 2C, 3). The Walnut Canyon local fauna is composed of 12 species of mammals indicative of a latest Hemphillian age (earliest Pliocene).

Vertebrate fossils were first found in Gila Group strata along the North Fork of Walnut Canyon in the early 1970s by members of the Brown family, the owner's of the property (Leopoldt, 1981). J. E. Cunningham of Western New Mexico University showed two horse teeth from this site to W. S. Strain of the University of Texas at El Paso who identified them as two species of *Pliohippus*, identifications later cited in Cunningham (1974). At that time, species now placed in the genera *Dinohippus* and *Astrohippus* were commonly referred to *Pliohippus*. Dustin Hunt donated several complete horse teeth and one camel bone from the Walnut Canyon site to the Delaware Museum of Natural History. Lillian and Wesley Brown donated several bones and teeth from this site to the NMMNH.

Leopoldt (1981) and Tedford (1981) reported vertebrate fossils from the Walnut Canyon Horse Quarry, although they did not refer to the locality by that name. Tedford mentioned the presence of *Astrohippus stockii* and *Dinohippus* sp. from this locality, and based on their occurrence assigned a late Hemphillian age to the Walnut Canyon site. Leopoldt listed these two horses, as well as several additional mammalian taxa (identified by R. H. Tedford and G. E. Lewis), including leporid a tayassuid, and two camelids. Table 1 is a current faunal list of the 12 taxa of mammals identified from the Walnut Canyon local fauna. Rhinoceroses and proboscideans are absent from Walnut Canyon, as are all groups of lower vertebrates.

Paul Sealey visited the Walnut Canyon site in 1989 and obtained permission from the landowners, Lillian and Wesley Brown, to collect fossils for the NMMNH. He excavated fossils from the Walnut Canyon Horse Quarry in 1989, and again in 1993. He also collected fossils from several other sites located less

TABLE 1. Fossil mammals from the latest Hemphillian Walnut Canyon local fauna, Grant County, New Mexico.

Order Lagomorpha
- Family Leporidae
  - genus and species indeterminate

Order Rodentia
- family, genus, and species undetermined

Order Carnivora
- Family Canidae
  - *Vulpes stenognathus*
- Family Felidae
  - genus and species indeterminate

Order Perissodactyla
- Family Equidae
  - *Astrohippus stockii*
  - *Dinohippus mexicanus*

Order Artiodactyla
- Family Tayassuidae
  - cf. *Catagonus brachydontus*
- Family Camelidae
  - *Hemiauchenia* sp.
  - cf. *Alforjas* sp.
  - giant camelid, *Megacamelus* or *Megatylopus*
- Family Cervidae
  - genus and species indeterminate
- Family Antilocapridae
  - genus and species indeterminate

than 1 km south of the Walnut Canyon Horse Quarry, most of which contained isolated fragmentary bones and/or teeth of horses. One of the sites yielded a mandible of a fox, *Vulpes stenognathus*, and several specimens of a cervid. Gary Morgan became interested in the Walnut Canyon Horse Quarry and visited the site with Sealey in July 1994 and again in November of that year. Sealey, Morgan, and several additional collectors have conducted excavations in the bone-producing layer in the Walnut Canyon Horse Quarry on six different occasions. Most of the easily dug sediments have been removed from this site, and future work at the quarry will require extensive removal of overburden.

Walnut Canyon Localities

The Walnut Canyon Horse Quarry (NMMNH locality L-2922) is the richest localized concentration of vertebrate fossils so far discovered in the Mangas basin. The site occurs on a low ridge and in the vertical wall of a stream bank along the east side of the North Fork of Walnut Canyon in the NW¼ NE¼ SE¼ NE¼ sec. 7, T16S, R16W; UTM zone 12, 3646200N, 731000E on the Cliff USGS 7.5 minute quadrangle (provisional edition, 1990). The fossils are preserved in an unconsolidated to partially-lithified diatomaceous mudstone (unit 8 of formation B in the Walnut Canyon measured section, see Figs. 2B, 2C, 3B and Appendix). The fossiliferous unit is directly underlain by a highly indurated, welded tuff (unit 7) that forms a prominent marker bed throughout the Walnut Canyon area.

In September 1993, Paul Sealey collected a mandible of the fox *Vulpes stenognathus* and an isolated upper molar of a cervid, as well as several bones of *Astrohippus* and a tooth of *Dinohippus*, from near the top of a small hill on the east side of the North Fork of Walnut Canyon about 0.5 km south of the Walnut Canyon Horse Quarry. Neither the fox nor the cervid have been found at the main horse quarry. This second site (NMMNH locality L-2926) is in the SE¼ NE¼ SE¼ sec. 7, T16S, R16W, UTM zone 12, 3645600N, 731100E on the Cliff quadrangle. The fossils from site L-2926 were derived from a light-colored mudstone similar in lithology to the bone-bearing bed at site L-2922, but located about 5 m higher in the section.

SYSTEMATIC PALEONTOLOGY

Class MAMMALIA
Order LAGOMORPHA
Family LEPORIDAE
genus and species indeterminate

Referred Material—NMMNH P-26739, isolated upper molar. NMMNH locality L-2922.

Discussion—Isolated leporid teeth, particularly upper cheek teeth, are notoriously difficult to identify (White, 1987). Most of the taxonomy of rabbits is based on the p3 and to a lesser extent P2, neither of which is present in the Walnut Canyon sample. Therefore, identification of the leporid from the Walnut Canyon local fauna must await the discovery of further material. The leporid genera *Hypolagus*, *Lepoides*, *Nekrolagus*, and *Notolagus* are present in late Hemphillian faunas (Lindsay et al., 1984; White, 1987).

Order RODENTIA
family, genus and, species undetermined

Referred Material—NMMNH P-26838, left calcaneum. NMMNH locality L-2922.

Discussion—We have not attempted to identify the rodent calcaneum from the Walnut Canyon local fauna, as the taxonomy of fossil rodents is based almost exclusively on the dentition. This specimen, along with the rabbit tooth listed above, establishes the presence of microvertebrates in the Walnut Canyon Horse Quarry, although preliminary screenwashing from NMMNH locality L-2922 has not yet yielded additional specimens of small mammals or lower vertebrates.

Order CARNIVORA
Family CANIDAE
Vulpes stenognathus Savage, 1941

Referred Material—NMMNH P-26861, left mandible with m1 and alveoli for c1–p4 and an edentulous fragment of right mandible with alveoli for p3–m1. NMMNH locality L-2926:

NMMNH P-26840, distal end of metapodial (tentative referral); NMMNH P-26841, proximal end of proximal phalanx (tentative referral). NMMNH locality L-2922.

Descriptions and Comparisons—The fox mandible from the Walnut Canyon local fauna (Figs. 5A, B) compares closely in size and morphological features of the m1 with the type description of *Vulpes stenognathus* from the Optima local fauna in Oklahoma (Savage, 1941). Measurements of the Walnut Canyon *V. stenognathus* m1 are: length, 14.8 mm; width of trigonid, 6.2 mm; width of talonid, 5.8 mm. The partial metapodial and proximal phalanx from the Walnut Canyon Horse Quarry are only tentatively referred to *V. stenognathus*, although they clearly belong to a small canid in the size range of this species.

Discussion—The fox *Vulpes stenognathus* was first described from the late Hemphillian Optima (also known as Guymon) local fauna in the panhandle of Oklahoma (Savage, 1941). Dalquest (1969, 1983) referred a fox from the late Hemphillian Coffee Ranch local fauna in the Texas Panhandle to *V. shermanensis*, a species originally described as *Leptocyon shermanensis* from the late Hemphillian Edson local fauna in Kansas (Hibbard, 1937). Harrison (1983) synonymized *L. shermanensis* with *Canis davisi* and referred the Coffee Ranch fox to *V. stenognathus*, as did Schultz (1977). MacFadden et al. (1979) listed *V. stenognathus* from the Wikieup local fauna in the Big Sandy Formation in Arizona and from the San Juan and Rak Camel Quarries in the Chamita Formation in northern New Mexico, all of which are late Hemphillian in age. Lindsay et al. (1984) added a record of this fox from the late Hemphillian Redington local fauna from the Quiburis Formation in Arizona. *V. stenognathus* also occurs in the latest Hemphillian Palmetto fauna in the upper Bone Valley Formation of central Florida (G. Morgan, personal observation). Based on the above records, *V. stenognathus* is found primarily in late Hemphillian faunas.

Family FELIDAE
genus and species indeterminate

Referred Material—NMMNH P-26839, proximal phalanx. NMMNH locality L-2922.

Discussion—A proximal phalanx of a medium-sized felid from the Walnut Canyon Horse Quarry is between a bobcat and puma in size. The Pliocene felid, *Felis proterolyncis*, is approximately the same size. *F. proterolyncis* was described from the late Hemphillian Optima local fauna in Oklahoma (Savage, 1941). Two other felids of similar size, *F. rexroadensis* and *F. lacustris*, are also known from early Pliocene faunas. *F.*

rexroadensis has been identified in both latest Hemphillian (e.g., Bone Valley, Florida) and early Blancan (e.g., Rexroad, Kansas) faunas, whereas *F. lacustris* is a Blancan species (Bjork, 1970; Kurtén and Anderson, 1980; MacFadden and Galiano, 1981). The cat toe from Walnut Canyon is probably referable to one of these three Pliocene cats, but the material at hand is not sufficient for a more precise identification.

Order PERISSODACTYLA
Family EQUIDAE
Astrohippus stockii (Lance, 1950)

Referred Material—NMMNH P-26740, anterior portion of skull with right P3–M2 and left M1–M3; NMMNH P-26741, associated left P2–P3; NMMNH P-26742, right P3; NMMNH P-26743, left P4; NMMNH P-26734, right M1 (sectioned); NMMNH P-26744, left M1; NMMNH P-26745, associated right M2–M3; NMMNH P-26733, right M2; NMMNH P-26748, associated right I1–I2 and left I1–I3; NMMNH P-26751, associated left p3–m3; NMMNH P-26752, mandible fragment with left m3; NMMNH P-26756, complete left metacarpal III; NMMNH P-26757 to P-26759, distal ends of metapodials; NMMNH P-26760 to P-26767, proximal/distal ends of lateral metapodials; NMMNH P-26768 to P-26770, proximal phalanges; NMMNH P-26771, medial phalanx of lateral digit; NMMNH P-26772 and P-26773, two partial astragali. This is only a partial list of the *Astrohippus stockii* fossils from the Walnut Canyon Horse Quarry, NMMNH locality L-2922.

Descriptions and Comparisons—The *Astrohippus* fossils from the Walnut Canyon local fauna are compared primarily to the figures and descriptions of the large sample of *A. stockii* from Yepómera, Mexico (Lance, 1950, p. 12–35, figs. 2–3, pls. 1–3; MacFadden, 1984b, p. 278–280, fig. 2). Measurements of upper cheek teeth of *A. stockii* from Walnut Canyon are provided in Table 2. The upper cheek teeth are smaller and higher crowned than *A. ansae*, slightly to moderately curved in the transverse plane, and have a thick covering of cement. See Figures 4B–D for a representative sample of *A. stockii* upper cheek teeth from Walnut Canyon. The protocones are comparatively large, elongate, have a strong anterior projection, and the posterior portion is oriented toward the lingual margin of the tooth. In most of the upper teeth in the Walnut Canyon sample, the protocones exhibit the characteristic "wooden-shoe" shape that is typical of this genus (Stirton, 1940). The fossettes are crescent-shaped with very simple enamel borders. Two of the upper teeth (NMMNH P-26734, 26745) have a single enamel plication on the posterior border of the prefossette. A pli caballin is absent on all upper teeth in the Walnut Canyon sample. A hypoconal groove is absent on most teeth in this sample, although a single lightly worn M3 (NMMNH P-26745) has a rudimentary hypoconal groove that almost certainly would have disappeared with wear.

Lower cheek teeth are considerably less common in the Walnut Canyon *Astrohippus stockii* sample than are uppers. The lower cheek teeth are straight in the transverse plane, and like the uppers have a very simple enamel pattern and a thick covering of cement (Figs. 4E, 4F). The metaconids and metastylids are relatively small, transversely flattened, and have rounded borders. The linguaflexids are U-shaped. The ectoflexids are shallow to moderate in depth and do not divide the isthmus. The protoconids and hypoconids are elongate, and their enamel walls are flattened along the lingual margin. Pli caballinids and protostylids are absent on all available lower cheek teeth. Small hypostylids are present on several specimens. All incisors in the Walnut Canyon *A. stockii* sample have cement-filled infundibula (Fig. 4A).

Most of the postcranial sample of *Astrohippus stockii* from the Walnut Canyon Horse Quarry consists of metapodials (metacarpals and metatarsals), carpals, and tarsals. There are no complete specimens of the major limb elements (humerus, radius-ulna, femur, and tibia). One complete, and two nearly complete metapodials are present in the sample (Fig. 4G). These metapodials are relatively slender and elongate. They have a well-developed keel on the distal articular surface, and the interosseous ligament scar on the posterior surface (marking the area where the lateral metapodials articulated) extends about halfway down the shaft from the proximal end. Measurements of a complete metacarpal III (NMMNH P-26756) are as follows: total length, 177; proximal breadth, 29.5; proximal depth, 22.1; midshaft breadth, 19.6; distal breadth, 26.9; distal depth, 20.2. The length of the Walnut Canyon metacarpal is within the range of variation of the large sample of third metacarpals of *A. stockii* from Yepómera (Lance, 1950, table 6).

Comparisons with the large sample of *Astrohippus stockii* from the Yepómera fauna, described and figured by Lance (1950) and MacFadden (1984b), confirms that the Walnut Canyon *Astrohippus* is very similar to the Yepomera species in essentially all dental characters. The New Mexico fossils are confidently referred to *A. stockii*.

Discussion—*Astrohippus stockii* is by far the most abundant species in the Walnut Canyon Horse Quarry. More than half of all identifiable fossils in the fauna belong to this horse. Walnut Canyon is the only fauna in New Mexico that has produced specimens of *Astrohippus stockii*. The type locality of *A. stockii* is the late Hemphillian Yepómera fauna in the state of Chihuahua, Mexico (Stock, 1950; MacFadden, 1984b), located about 400 km south of the Walnut Canyon sites. *A. stockii* also has been reported from the Matachic fauna just south of Yepómera (Lindsay, 1984) and from the Ocote local fauna in Guanajuato in central Mexico (Dalquest and Mooser, 1980; Miller and Carranza-Castañeda, 1984). *A. stockii* has been identified in several latest Hemphillian faunas in the Texas Panhandle and western Oklahoma (Johnston and Savage, 1955; MacFadden, 1984b; Tedford et al., 1987), as well as the Palmetto fauna in the upper Bone Valley Formation of central Florida (MacFadden, 1986). This horse is not known from late Hemphillian faunas in Arizona or southern California. Most faunas containing *A. stockii* are latest Hemphillian in age (Lindsay et al., 1984; Tedford et al., 1987).

Dinohippus mexicanus (Lance, 1950)

Referred Material—NMMNH P-26736, partial right P3/P4; NMMNH P-26786, associated right M1–M2; NMMNH P-26787, partial right upper cheek tooth; NMMNH P-26788, associated left p3–m3; NMMNH P-26789, right p2; NMMNH P-26790, left p2; NMMNH P-26791, left p3/p4; NMMNH P-26792, right m1/m2; NMMNH P-26794, P-26795, incisors; NMMNH P-26797, distal end of metapodial; NMMNH P-26798, proximal phalanx; NMMNH P-26799, right calcaneum. NMMNH locality L-2922.

NMMNH P-26858, left p2. NMMNH locality L-2926.

Descriptions and Comparisons—The *Dinohippus* fossils from the Walnut Canyon Horse Quarry are compared primarily to the figures and descriptions of the large sample of *D. mexicanus* from Yepómera, Mexico (Lance, 1950, p. 35–52, figs. 4–5, pls. 1–5;

MacFadden, 1984b, p. 280, fig. 3). *Dinohippus* is much less common in the Walnut Canyon Horse Quarry than is *Astrohippus*. The available sample contains no complete upper cheek teeth, although the four partial uppers record most of the important morphological details of this species (Figs. 4H, 4I). The upper teeth have a thick covering of cement and are moderately curved in the transverse plane, although all but one of the teeth are fairly heavily worn. They probably would exhibit a greater curvature in unworn to lightly worn teeth. The protocone is large, has a well-developed anterior projection, and angular borders. The postprotoconal valley is deep. The fosettes are crescent-shaped and have somewhat more complicated enamel borders than does *Astrohippus stockii*. All of the Walnut Canyon teeth that preserve the fossettes have a single enamel plication on the posterior border of the prefossette, and two have a single plication on the anterior border of the postfossette. The most complicated tooth (NMMNH P-26736) has three plications each on the posterior border of the prefossette and the anterior border of the postfossette, as well as single plications on the anterior border of the prefossette and the posterior border of the postfossette. All three of the teeth that preserve the postero-lingual border have a fairly well-developed hypoconal groove, and all of these teeth are in late wear stages.

The lower cheek teeth are much better represented in the Walnut Canyon *Dinohippus mexicanus* sample than are the upper cheek teeth, including five associated teeth from one lower jaw, three associated teeth from a second mandible, and four isolated teeth (Fig. 4J). The lower cheek teeth are straight in the transverse plane and, like the uppers, have a very thick covering of cement. The enamel pattern tends to be very simple, with few or no enamel plications. The metaconids are rounded in all of the lowers, whereas the metastylids are generally rounded, although several are more angular. The metaconids and metastylids are well separated in most of the lower teeth, except two heavily worn specimens. The linguaflexid separating the metaconid and metastylid is generally V-shaped. In several of the lower molars the ectoflexid divides the isthmus. In general, the ectoflexids are deeper in the *Dinohippus* from the Walnut Canyon sample than in *Astrohippus* from the same site. The protoconids and hypoconids have rounded lingual borders compared to the more flattened condition seen in *Astrohippus stockii*. The entoconid is very rounded and bulbous in most specimens, and in some teeth is not well-separated from the hypoconulid. Protostylids and pli caballinids are absent in all lower cheek teeth.

The *Dinohippus* sample also includes two complete incisors and several postcranial elements, including the distal end of a metapodial, a proximal phalanx (Fig. 4K), and three complete carpals/tarsals. Both of the incisors have cement-filled infundibula.

Discussion—The Walnut Canyon local fauna records the first fossils of *Dinohippus mexicanus* from New Mexico. The closest sites containing *D. mexicanus* are the late Hemphillian Redington and Camel Canyon local faunas from the Quiburis Formation in the San Pedro Valley of southeastern Arizona (Lindsay et al., 1984). The type locality of *D. mexicanus* is the latest Hemphillian Yepómera fauna in Chihuahua, northern Mexico (Lance, 1950; MacFadden, 1984b). *D. mexicanus* also occurs in the Matachic fauna in Chihuahua (Lindsay, 1984) and the Ocote local fauna in Gaunajuato, central Mexico (Dalquest and Mooser, 1980; Miller and Carranza-Castañeda, 1984), both of which are similar in age to Yepómera. Other latest Hemphillian faunas containing *D. mexicanus* include several localities in the Texas panhandle (Johnston and Savage, 1955; MacFadden, 1984) and the Palmetto fauna in the upper Bone Valley Formation of central Florida (MacFadden, 1986).

Order ARTIODACTYLA
Family TAYASSUIDAE
cf. *Catagonus brachydontus* (Dalquest and Mooser, 1980)

Referred Material—NMMNH P-26837, right p2. NMMNH locality L-2922.

Descriptions and Comparisons—*Catagonus brachydontus* was originally described as *Desmathyus brachydontus* from the late Hemphillian Ocote local fauna in Mexico (Dalquest and Mooser, 1980). Wright (1989) transferred this species to *Catagonus*, the genus of the living Chacoan peccary from Paraguay. A single tayassuid premolar from the Walnut Canyon Horse Quarry (Figs. 5C, 5D) compares favorably with *C. brachydontus*, in particular teeth referred to this species from Ocote and the late Hemphillian Palmetto fauna from Florida (Wright, 1989). The tooth from New Mexico is very similar in morphological features to the p2s from these two faunas, but is slightly smaller. Measurements of NMMNH P-26837 are: length 10.5 mm, width 7.5 mm. Comparable measurements of *C. brachydontus* p2s are: Ocote, length 11.4 (mean of 3 teeth, observed range 11.0–11.9), width 7.6 (mean of 3 teeth, observed range 7.2–7.8); Bone Valley, length 12.3, width 9.1 (measurements from Wright, 1989, table 1).

TABLE 2. Measurements of upper cheek teeth of *Astrohippus stockii* from the latest Hemphillian Walnut Canyon local fauna, Grant County, New Mexico. Abbreviations are: length (L), width (W), mean (X), observed range (O.R.), and sample size (N).

	P2		P3		P4		M1		M2		M3	
	L	W	L	W	L	W	L	W	L	W	L	W
P-26741	22.4	16.4	20.1	20.6	—	—	—	—	—	—	—	—
P-26740	—	—	18.7	20.5	18.5	20.6	17.3	20.7	17.8	20.5	20.2	18.5
P-26742	—	—	19.7	20.0	—	—	—	—	—	—	—	—
P-26743	—	—	—	—	19.1	20.7	—	—	—	—	—	—
P-26734	—	—	—	—	—	—	18.8	18.5	—	—	—	—
P-26744	—	—	—	—	—	—	17.5	19.7	—	—	—	—
P-26733	—	—	—	—	—	—	—	—	18.2	21.2	—	—
P-26745	—	—	—	—	—	—	—	—	19.2	21.1	20.4	18.8
X	22.4	16.4	19.5	20.4	18.8	20.7	17.9	19.6	18.4	20.9	20.3	18.7
O. R.	—	—	18.7–20.1	20.0–20.6	18.5–19.1	20.6–20.7	17.3–18.8	18.5–20.7	17.8–19.2	20.5–21.2	20.2–20.4	18.5–18.8
N	1	1	3	3	2	2	3	3	3	3	2	2

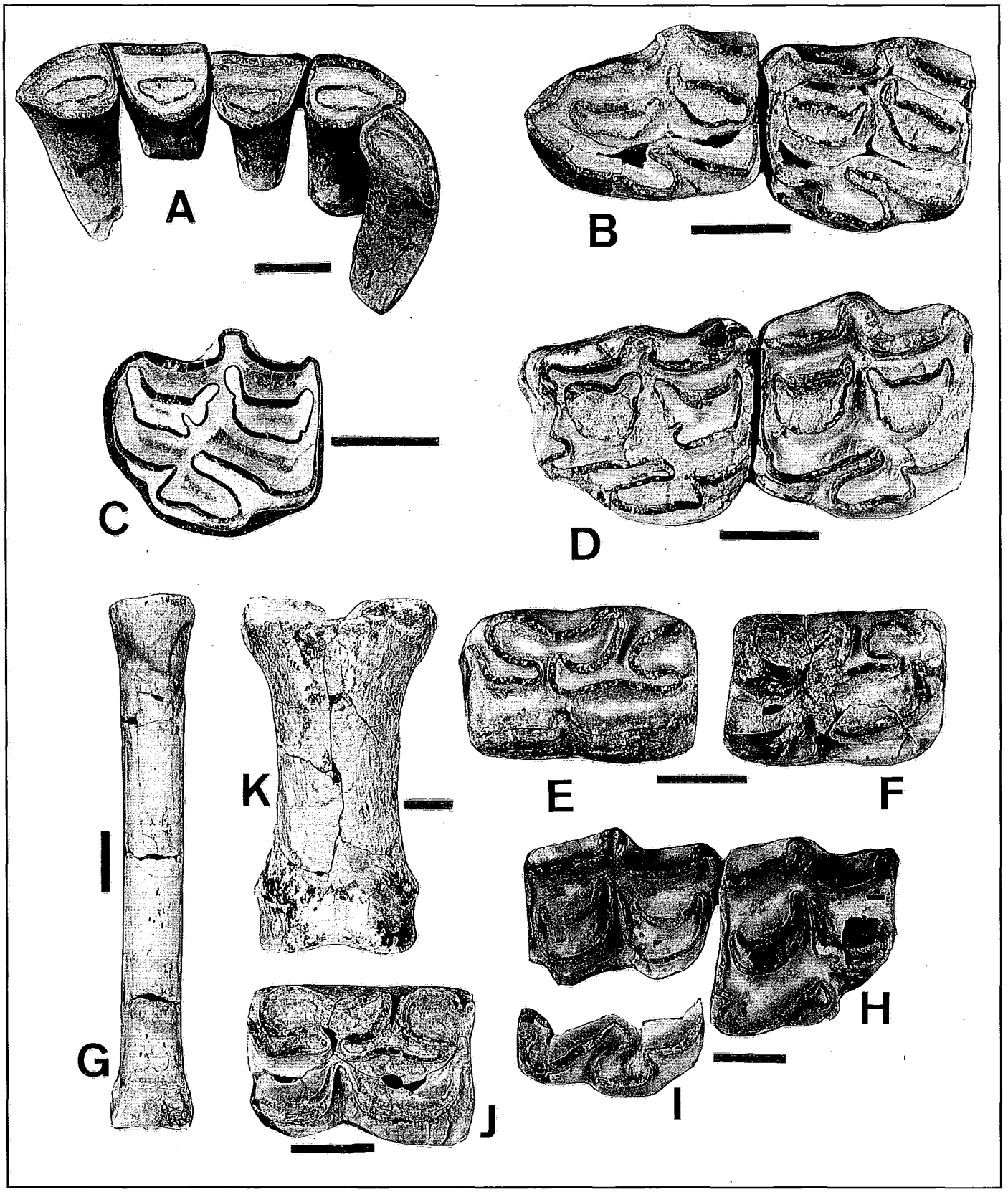


FIGURE 4. Equidae from the latest Hemphillian Walnut Canyon local fauna, Grant County, New Mexico. **A.** *Astrohippus stockii*, associated right I1–I2 and left I1–I3, NMMNH P-26748. **B.** *Astrohippus stockii*, associated left P2–P3, NMMNH P-26741. **C.** *Astrohippus stockii*, right M1 (sectioned), NMMNH P-26734. **D.** *Astrohippus stockii*, associated right M2–M3, NMMNH P-26745. **E.** *Astrohippus stockii*, left p3/p4, NMMNH P-26751. **F.** *Astrohippus stockii*, left m1/m2, NMMNH P-26751. **G.** *Astrohippus stockii*, metacarpal III, NMMNH P-26756. **H.** *Dinohippus mexicanus*, right M1–M2, NMMNH P-26786. **I.** *Dinohippus mexicanus*, lingual half of right upper cheek tooth, NMMNH P-26787. **J.** *Dinohippus mexicanus*, left p3/p4, NMMNH P-26792. **K.** *Dinohippus mexicanus*, proximal phalanx, NMMNH P-26798. All scale bars are 1 cm, except Figure 4G, which is 2 cm.

Leopoldt (1981) mentioned a tayassuid M3 from the Walnut Canyon Horse Quarry, presumably of this species, but we have not been able to locate the tooth to confirm the identification. Apparently it was curated into the USGS paleontology collection in Denver, which is currently unavailable for study.

Discussion—Dalquest and Mooser (1980) described *Desmathyus brachydontus* from the latest Hemphillian Ocote local fauna in the state of Guanajuato in central Mexico. Wright (1989) transferred this extinct species to the genus *Catagonus* and added records of *C. brachydontus* from two other latest Hemphillian faunas, the Palmetto fauna from the upper Bone Valley Formation in central Florida and the Buis Ranch local fauna in the panhandle of Oklahoma. Wright mentioned that tayassuid fossils from the latest Hemphillian Yepómera fauna in the state of Chihuauhua in northern Mexico may also belong to this species.

Family Camelidae
***Hemiauchenia* sp.**

Referred Material—NMMNH P-26802 to P-26804, lower incisors; NMMNH P-26812, associated radius-ulna, fused metacarpals III and IV, and carpals; NMMNH P-26807, right distal tibia; NMMNH P-26809-26811, partial metapodials; NMMNH P-26813-26815, proximal phalanges; NMMNH P-26816-26818, three astragali; NMMNH P-26819, left distal fibula. NMMNH locality L-2922.

Descriptions and Comparisons—There are quite a few fossils of a small camel from the Walnut Canyon Horse Quarry, most of which are postcranials. The sample does include three lower incisors and several fragmentary molars. Lack of the diagnostic lower premolars precludes identification of the small Walnut Canyon camel below the generic level. The most complete

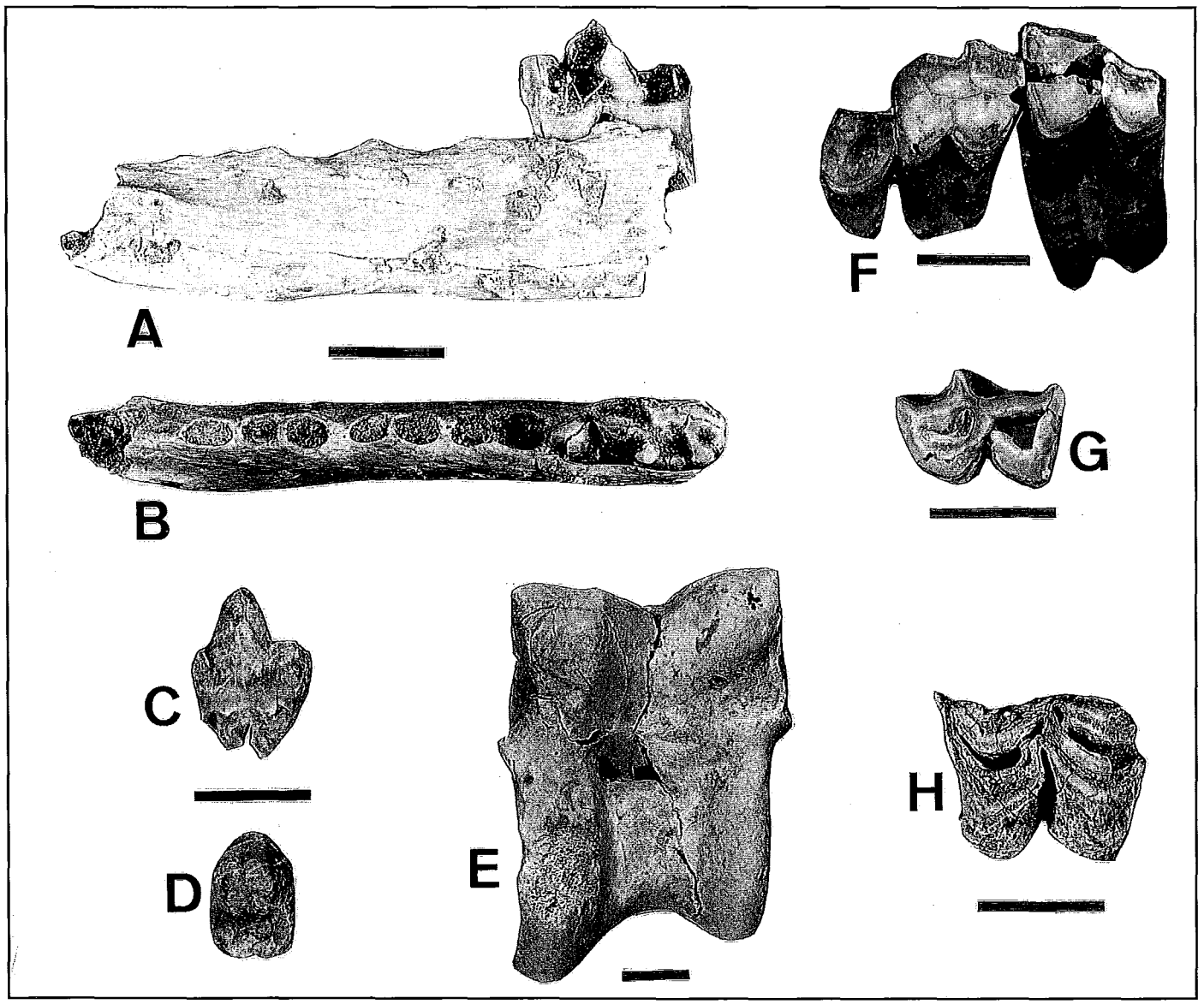


FIGURE 5. Carnivora and Artiodactyla from the latest Hemphillian Walnut Canyon local fauna, Grant County, New Mexico. **A.** *Vulpes stenognathus*, right mandible with m1, NMMNH P-26861, medial view. **B.** *Vulpes stenognathus*, right mandible with m1, NMMNH P-26861, occlusal view. **C.** cf. *Catagonus brachydontus*, right p2, NMMNH P-26837, side view. **D.** cf. *Catagonus brachydontus*, right p2, NMMNH P-26837, occlusal view. **E.** *Hemiauchenia* sp., astragalus, NMMNH P-26816. **F.** Antilocapridae, associated left P4-M2, NMMNH P-26834. **G.** Antilocapridae, right M1, NMMNH P-26835. **H.** Cervidae, partial left M3, NMMNH P-26859. All scale bars are 1 cm.

specimen in the sample consists of an associated radius–ulna, carpals, and metacarpals (NMMNH P-26812). Both the radius–ulna (length approximately 400 mm—minus the olecranon process) and metacarpals (length 360 mm) are slender and elongated, and compare most closely to specimens of the lamine genus *Hemiauchenia*, although they are not as long as the comparable elements of *H. vera* (radius–ulna, total length 506 mm; metacarpals, total length 413 mm) from the late Hemphillian Coffee Ranch local fauna in Texas (Dalquest, 1980, p. 116).

Measurements of the Walnut Canyon *Hemiauchenia* fossils are smaller, particularly in breadth of various limb elements, than comparable measurements of the medium-sized camelid *Alforjas taylori* from the late Hemphillian Edson local fauna in Kansas (Harrison, 1979) and from Coffee Ranch (originally described as *Pliauchenia hemphillensis* by Dalquest, 1980). The metacarpals from Walnut Canyon are actually somewhat longer (total length 360 mm) but narrower (proximal breadth, 43.2 mm) than those of *Alforjas* from Edson (total length, 313.4, mean of 10 specimens; proximal breadth, 53.3, mean of 21 specimens; measurements from Harrison, 1979, p. 17) and Coffee Ranch (total length, 324, 356, 2 specimens; proximal breadth, 58.0, mean of 3 specimens; measurements from Dalquest, 1980, p. 114). A distal tibia from Walnut Canyon (NMMNH P-26807) has a width of 49.5 mm, whereas the comparable measurement of a tibia of *A. taylori* from Edson is 74.8 (Harrison, 1979, p. 17). Two camelid astragali (NMMNH P-26816, 26818) from Walnut Canyon (Fig. 5E) have maximum lengths (tibial to tarsal surface) of 59.8 mm and 60.8 mm, whereas four astragali from Edson range from 63.8 to 69.3 in maximum length (Harrison, 1979, p. 17).

Discussion—Harrison (1979) noted that as many as three genera of camelids, *Alforjas*, *Hemiauchenia*, and *Megatylopus*, occur in late Hemphillian faunas from the southwestern United States. She later added a fourth late Hemphillian genus (Harrison, 1985), the giant camelid *Megacamelus*. The camelid material currently available from the Walnut Canyon Horse Quarry suggests that three genera are present. The most common is the small, slender-limbed llama *Hemiauchenia*. A small sample is referable to the medium-sized camelid *Alforjas* and a single fossil belongs to one of the giant camels, either *Megatylopus* or *Megacamelus* (see discussion below). MacFadden (1977) identified two species of *Hemiauchenia*, *H. vera* and an undescribed smaller form, from the late Hemphillian San Juan/Rak Camel quarries in northern New Mexico.

cf. *Alforjas* sp.

Referred Material—NMMNH P-26822, partial upper molar; NMMNH P-26824–26830, numerous partial molars; NMMNH P-26821, lower incisor; NMMNH P-26808, proximal half of metapodial; NMMNH P-26833, right distal fibula. NMMNH locality L-2922.

Descriptions and Comparisons—There are no complete camelid molars or premolars from the Walnut Canyon local fauna, but most of the partial teeth appear to be tentatively referable to *Alforjas* rather than to the smaller *Hemiauchenia* or to one of the giant camels. Harrison (1979), in her original description of *Alforjas taylori* from the Edson local fauna in Kansas, and Dalquest (1980) in his description of *Pliauchenia hemphillensis* (a synonym of *A. taylori*) from the Coffee Ranch local fauna in Texas, both noted that this camelid possessed fairly large, hypsodont teeth. Most of the partial teeth from Walnut Canyon are larger and higher crowned than teeth of late Hemphillian *Hemiauchenia*, but are considerably smaller than teeth of the giant camels *Megacamelus* and *Megatylopus*.

Two postcranial elements from Walnut Canyon are tentatively referred to *Alforjas*. A proximal metacarpal (NMMNH P-26808) has a much broader proximal end (proximal breadth, 62.0 mm) than does a proximal metacarpal (proximal breadth, 43.2) from Walnut Canyon referred above to *Hemiauchenia*. Measurements of the breadth of the proximal metacarpal of *Alforjas* from Edson (observed range, 47.7–64.2, sample of 21 individuals; measurements from Harrison, 1979, p. 17) and Coffee Ranch (observed range, 53.7–60.5, sample of 3 individuals; measurements from Dalquest, 1980, p. 114) are more similar in size to NMMNH P-26808 from Walnut Canyon. A large distal fibula (NMMNH P-26833) from Walnut Canyon also compares favorably in size (antero-posterior length, 37.5 mm) with the distal fibula of *Alforjas taylori* from Edson (antero-posterior length of two specimens, 37.5, 38.9), whereas a distal fibula of *Hemiauchenia* from Walnut Canyon (NMMNH P-26819) measures only 30.1 mm long.

Discussion—*Alforjas* is one of the more recently named camelid genera from the late Cenozoic of North America (Harrison, 1979). This genus is known primarily from late Hemphillian faunas, including Edson, Coffee Ranch, and Optima in Oklahoma (Harrison, 1979; Dalquest, 1980). One of the oldest records of *Alforjas* is from the early Hemphillian Wray fauna in Colorado (Harrison, 1979; Tedford et al., 1987).

giant camelid
Megacamelus or *Megatylopus*

Referred Material—NMMNH P-26832, proximal end of proximal phalanx. NMMNH locality L-2922.

Descriptions and Comparisons—A single partial proximal phalanx from the Walnut Canyon Horse Quarry belongs to one of the two late Hemphillian genera of giant camelids, *Megacamelus* or *Megatylopus*. This phalanx (NMMNH P-26832) has a proximal width of 46.7 mm, which falls within the range of variation of the proximal width (45.5–57.3) for a large sample of proximal phalanges (21 specimens) of *Megacamelus* from Keams Canyon, Arizona (measurements from Harrison, 1985, p. 17). We were unable to locate comparable measurements of the proximal phalanx for *Megatylopus* from Coffee Ranch or other late Hemphillian sites. Two proximal phalanges of *Alforjas taylori* from Edson, Kansas are considerably narrower in their proximal breadth (26.8, 30.4; measurements from Harrison, 1979, p. 17) than the large Walnut Canyon camel toe. Without further comparisons and lacking more diagnostic material, it would be unwise to attempt further identification of this camel from a single partial phalanx, beyond its referral to one of the two late Hemphillian genera of giant camels.

Discussion—The most common genus of giant camel in late Hemphillian faunas is *Megatylopus*, including the species *M. gigas* and *M. matthewi*. *Megatylopus* occurs in late Hemphillian faunas in Nebraska, Kansas, several localities in the Texas Panhandle, Oklahoma, the San Juan/Rak Camel quarries in New Mexico, and three faunas in Arizona (Harrison, 1985), as well as the Palmetto fauna in Florida (Morgan, personal observation). Harrison (1985) reported the giant camelid *Megacamelus merriami* from two late Hemphillian faunas, Keams Canyon in northeastern Arizona and Mount Eden in southern California.

Family ANTILOCAPRIDAE
genus and species indeterminate

Referred Material—NMMNH P-26834, maxillary fragment with left P4–M2; NMMNH P-26835, right M1; NMMNH P-26836, partial lower premolar. NMMNH locality L-2922.

Disscussion—Dalquest (1983) and many others have pointed out the difficulty in identifying late Cenozoic antilocaprids from isolated, or even associated, dental remains. The taxonomy of this endemic North American family is based primarily on horn cores, none of which have so far been found in the Walnut Canyon local fauna. Although probably not diagnostic, measurements of the Walnut Canyon antilocaprid teeth are provided here to give some indication of the size of this species compared to other antilocaprids from faunas of similar age elsewhere in the southwestern United States. NMMNH P-26834, associated left P4–M2 (Fig. 5F): P4, antero-posterior length, 7.5, width, 7.2; M1, antero-posterior length, 11.8, width, 9.8; M2, antero-posterior length, 14.2, width, 9.7; NMMNH P-26835, right M1 (Fig. 5G): antero-posterior length, 12.3; width, 8.5.

Lindsay et al. (1984) listed seven late Hemphillian genera of antilocaprids: *Hexameryx, Hexobelomeryx, Ilingoceros, Osbornoceros, Plioceros, Sphenophalos,* and *Texoceros*. None of these antilocaprid genera are known from the subsequent Blancan NALMA. *Texoceros* is the most widespread of these genera in southwestern late Hemphillian faunas, where it is known from Coffee Ranch, Texas and Camel Canyon, Redington, and Wikieup in Arizona (Dalquest, 1983; Lindsay et al., 1984). MacFadden (1977) reported *Osbornoceros osborni* and *Ilingoceros alexandrae* from the late Hemphillian San Juan/Rak Camel quarries in northern New Mexico.

Family CERVIDAE
genus and species indeterminate

Referred Material—NMMNH P-26859, partial left M3; NMMNH P-26860, left distal fibula. NMMNH locality L-2926.

Discussion—A partial M3 (Fig. 5H) and a distal fibula from NMMNH locality L-2926, the same site that produced the mandible of *Vulpes stenognathus*, are here referred to the family Cervidae. The two fossils from Walnut Canyon compare closely with the extant cervid genus *Odocoileus*; however, most cervid taxonomy is based on antlers, and thus these two specimens are not sufficient for identification to genus or species.

The occurrence of deer in the Walnut Canyon local fauna is particularly significant because it was long thought that the first appearance of true cervids (not to be confused with the family Palaeomerycidae, including the Hemphillian genus *Pediomeryx*, which some paleontologists refer to as deer-like) in North America did not occur until the Blancan. Lindsay et al. (1984, p. 473) stated that *Bretzia pseudalces* from the early Blancan White Bluffs local fauna in Washington was probably the earliest known cervid in North America. However, odocoileine deer are now known to be fairly common in the latest Hemphillian Palmetto Fauna from the upper Bone Valley Formation in central Florida (Tedford et al., 1987; Morgan, personal observation). The Bone Valley deer represents a new genus and species that is being described by S. D. Webb. The presence of cervids at Walnut Canyon lends support to the idea that this fauna is very late Hemphillian (earliest Pliocene) in age.

Age of the Walnut Canyon local fauna

The presence in the Walnut Canyon local fauna of the horses *Astrohippus stockii* and *Dinohippus mexicanus*, the fox *Vulpes stenognathus*, the tayassuid cf. *Catagonus brachydontus*, the camelid *Alforjas*, and a true cervid are indicative of a late Hemphillian age. The late Hemphillian covers the time interval between 6.0 and 4.5 Ma (Tedford et al., 1987), thus spanning the Miocene–Pliocene boundary, which is placed at 5.2 Ma (Berggren et al., 1995). Unless radioisotopic dates or more precise biochronological information is present, it is often not possible to determine if a late Hemphillian site is latest Miocene or earliest Pliocene in age. Most of the better known late Hemphillian sites, such as Coffee Ranch, Edson, Optima, and the San Juan/Rak Camel quarries, fall in the early phase of the late Hemphillian and are latest Miocene in age (7.0–5.5 Ma). Two well known faunas from the late phase of the late Hemphillian, the Yepómera fauna from northern Mexico and the Palmetto or Upper Bone Valley fauna from Florida, are earliest Pliocene in age (5.2–4.5 Ma).

The best known Hemphillian sites from New Mexico, the San Juan and Rak Camel quarries, are from the Española Basin in Rio Arriba County, northwest of Santa Fe (MacFadden, 1977). The San Juan Quarry and the several sites that comprise the Rak Camel Quarry are located just a few hundred meters from one another in an east-west trending ridge crest just south of the Arroyo de los Borregos. The fossils in these quarries are derived from the same stratigraphic level in the Chamita Formation, the upper tuffaceous zone, and are thus considered to be contemporaneous. From a biochronological perspective, the most important mammalian taxa in the San Juan and Rak Camel quarries are the wolverine *Plesiogulo marshalli*, the fox *Vulpes stenognathus*, the horses *Astrohippus ansae* and *Dinohippus interpolatus*, and the giant camel *Megatylopus matthewi*. *Plesiogulo*, an Old World immigrant, first appears in North America in the late Hemphillian and goes extinct by the beginning of the Blancan, and is thus an excellent biochronologic indicator for late Hemphillian faunas (Harrison, 1981; Tedford et al., 1987). *V. stenognathus, A. ansae, D. interpolatus,* and *M. matthewi* also are restricted to late Hemphillian faunas (Tedford et al., 1987). Furthermore, the two horses appear to be limited to faunas from the early phase of the late Hemphillian. Two tephra layers from the upper tuffaceous zone that bracket the two fossil quarries yield $^{40}Ar/^{39}Ar$ dates of 6.93 and 6.78 Ma (McIntosh and Quade, 1995). These ages are somewhat older that those proposed by McFadden (1977) and Tedford (1981) for the San Juan/Rak Camel quarries. Early Hemphillian (9–7 Ma) faunas from the lower part of the Chamita Formation in the Española Basin (MacFadden, 1977; Tedford, 1981) and from the Gabaldon Badlands in the Popotosa Formation in the southern part of the Albuquerque Basin (Lozinsky and Tedford, 1991) show very little similarity to the Walnut Canyon local fauna.

The Coffee Ranch local fauna in the Texas Panhandle is probably the best known late Hemphillian fauna (Dalquest, 1969, 1983; Tedford et al., 1987). Coffee Ranch shares *Plesiogulo marshalli, Vulpes stenognathus, Astrohippus ansae, Dinohippus interpolatus,* and *Megatylopus matthewi* with the San Juan and Rak Camel quarries, suggesting that these faunas are similar in age. Three different radioisotopic dates have been obtained from an airfall tuff that immediately overlies the Coffee Ranch Quarry, ranging from 6.8–4.9 Ma (Tedford et al., 1987). Using a combination of mammalian biochronology and radioisotopic dates, Coffee Ranch and the San Juan and Rak Camel quarries

appear to be very close in age, dating to the early phase of the late Hemphillian (latest Miocene, 7.0–5.5 Ma) (MacFadden, 1977; Tedford, 1981; Lindsay et al., 1984; Tedford et al., 1987).

The San Juan and Rak Camel quarries and Coffee Ranch possess the equid species *Astrohippus ansae* and *Dinohippus interpolatus*, whereas the more advanced species *A. stockii* and *D. mexicanus* are found in the Walnut Canyon local fauna. *A. stockii* and *D. mexicanus* originally were described from the latest Hemphillian Yepómera fauna in Chihuahua, northern Mexico (Lance, 1950; MacFadden, 1984b). These same two horses are present in the Ocote local fauna in Guanajuato, central Mexico (MacFadden, 1984b; Miller and Carranza-Castañeda, 1984), although the Ocote horses originally were named as separate species, *A. albidens* and *D. ocotensis* (Dalquest and Mooser, 1980). The Walnut Canyon horses are considered to be the most advanced species within their respective genera. *D. mexicanus* is thought to be close to the ancestry of the modern horse genus *Equus*, which first appears in the subsequent Blancan NALMA (MacFadden, 1984b). *A. stockii* and *D. mexicanus* are indicative of latest Hemphillian faunas (latest Miocene to earliest Pliocene, 5.5–4.5 Ma). Several other latest Hemphillian faunas also record the association of *A. stockii* and *D. mexicanus*, including the Christian Ranch local fauna from the Texas Panhandle (Johnston and Savage, 1955; Schultz, 1977) and the Palmetto fauna in the upper Bone Valley Formation of central Florida (MacFadden, 1986).

The presence of the genera *Astrohippus* and *Dinohippus*, both of which go extinct at the end of the Hemphillian, clearly establishes that the Walnut Canyon local fauna is older than 4.5 Ma, which is the lower boundary of the Blancan NALMA (Lindsay et al., 1984). Biochronological comparisons of their respective equid faunas indicate that Walnut Canyon is younger than Coffee Ranch and the Rak and San Juan Camel quarries. The minimum age of the latter faunas is about 5.5 Ma based on mammalian biochronology, magnetostratigraphy, and radiometric dates on volcanic ashes overlying the fossil sites (MacFadden, 1977; Lindsay et al., 1984; Tedford et al., 1987). The Walnut Canyon local fauna appears to be closest in age to the Yepómera fauna from northern Chihuahua, located about 400 km south of the New Mexico site. Lindsay et al. (1984) placed the age of the Yepómera fauna at about 4.5 Ma (earliest Pliocene) based on both mammalian biochronology and magnetostratigraphy. Yepómera is one of the latest Hemphillian faunas known, along with the Palmetto fauna from Florida (Tedford et al., 1987; Morgan, 1994). Another indication of a latest Hemphillian age for Walnut Canyon is the presence of true cervids. The first appearance of cervids in North America as immigrants from the Old World was long thought to signify the beginning of the Blancan (e.g., Lindsay et al., 1984); however, several latest Hemphillian faunas are now known to possess odocoileine deer, in particular the Palmetto fauna (Tedford et al., 1987). The presence of cervids at Walnut Canyon supports the idea that this fauna is very late Hemphillian (earliest Pliocene) in age. The available evidence suggests that the Walnut Canyon local fauna is latest Hemphillian (5.5–4.5 Ma) and is probably earliest Pliocene in age (5.2–4.5 Ma), although a latest Miocene age is technically possible (5.5–5.2 Ma).

BUCKHORN LOCAL FAUNA

Badlands northwest of Buckhorn in northern Grant County, southwestern New Mexico, have yielded a fairly diverse vertebrate fauna of Pliocene age (early or middle Blancan), here designated the Buckhorn local fauna. The Buckhorn sites are located about 30 km northwest of the Walnut Canyon Horse Quarry (Fig. 1). The fossils occur at four different stratigraphic levels within an approximately 50-m-thick interval in our Formations C and D in the upper part of the Gila Group (Figs. 2D, 3A, Appendix). Greenish mudstones (units 2 and 3) near the base of the exposed section of Formation C have produced a few fossils of camels and birds. An unconsolidated fine, grayish sand somewhat higher in Formation C (unit 11) contains numerous microvertebrates, including rodents, birds, snakes, fish, and frogs. Reddish mudstones near the top of Formation C (unit 15) have produced fossils of camels and a gomphotheriid proboscidean. From much higher in the local section in Formation D, a light gray clayey sand (unit 25) has produced a partial skeleton and several partial limb bones of a flamingo, as well as bones of several smaller birds and frogs. Two major localities and 12 smaller sites comprise the Buckhorn local fauna, which consists of at least 27 species of vertebrates, including: 1 fish, 1 frog, 1 salamander, at least 2 snakes, at least 6 birds, and 16 mammals (Table 3).

Vertebrate fossils were first found in the vicinity of Buckhorn in 1953 by G. B. Pearce, who was collecting for Childs Frick. Steadman (1980), Leopoldt (1981), Tedford (1981), and Becker (1987) have mentioned fossils collected by Pearce from the vicinity of Buckhorn. Steadman (1980) identified the fossil turkey cf. *Meleagris* sp. Tedford (1981) reported the horses, *Nannippus* and *Equus* cf. *E. simplicidens*, the camels *Camelops* and *Hemiauchenia* cf. *H. blancoensis*, and the peccary *Platygonus*, as well as carnivores, rabbits, rodents, and mastodonts. He noted that the joint occurrence of *Nannippus* and *Equus* cf. *E. simplicidens* indicated a middle Blancan age. Leopoldt (1981) provided a list of the fossil vertebrates from Pearce's Buckhorn site, based on identifications by Richard Tedford and Earl Manning. In addition to the taxa published by Tedford (1981), Leopoldt listed an ursid, *Felis* sp., *Taxidea* cf. *T. taxus*, *Hypolagus* sp., *Spermophilus* sp., and an unidentified ruminant (cervid or antilocaprid). In a review of North American Neogene avian localities, Becker (1987) listed the presence of Anatidae and cf. *Meleagris* sp. from the Frick Buckhorn site.

On the basis of reports by Tedford (1981) and Leopoldt (1981) of Blancan fossils from badlands near Buckhorn, Paul Sealey visited the Buckhorn area in May and June of 1993 to look for additional sites. He found several associated postcranial elements, as well as numerous tooth and tusk fragments, of a gomphotheriid proboscidean (cf. *Stegomastodon* sp.) on land owned by Hugh McKeen of Alma, New Mexico. Members of the McKeen family had earlier collected several vertebrae from this same gomphothere. Sealey discovered eight additional fossil sites in this same vicinity, ranging from localities with a single specimen to a layer that produces abundant microvertebrate fossils. Gary Morgan subsequently became interested in the Buckhorn Blancan fauna and visited most of the sites with Sealey in July 1994. Over the past three years, we have continued to explore the Buckhorn area for additional fossil sites.

The Buckhorn local fauna now includes 14 individual sites, some of which are discussed in more detail below. Pearce's original site "5 miles northwest of Buckhorn" has not been pinpointed on a map. Eleven of the sites are clustered in a small area 3–4 km northwest of Buckhorn in the SW¼ of sec. 20 and the NW¼ of sec. 29, T14S, R18W, and two small sites are located about 5 km farther north in the SW¼ of sec. 6, T14S, R18W.

TABLE 3. Fossil vertebrates from the Blancan Buckhorn local fauna, Grant County, New Mexico.

Class Osteichthyes
- family, genus, and species undetermined

Class Amphibia
- Order Anura
  - Family Ranidae
    - *Rana* sp.
- Order Urodela
  - Family Ambystomatidae
    - *Ambystoma* sp.

Class Reptilia
- Order Squamata
  - Suborder Serpentes
    - Family Colubridae
      - genus and species undetermined (more than one species present)

Class Aves
- Order Anseriformes
  - Family Anatidae
    - genus and species undetermined (two species present)
- Order Galliformes
  - Family Phasianidae
    - cf. *Meleagris* sp.
- Order Charadriiformes
  - Family Phoenicopteridae
    - *Phoenicopterus* sp.
- Order Gruiformes
  - Family Rallidae
    - genus and species undetermined
- Order Passeriformes
  - family, genus, and species undetermined

Class Mammalia
- Order Lagomorpha
  - Family Leporidae
    - genus and species indeterminate
- Order Rodentia
  - Family Sciuridae
    - *Spermophilus* cf. *S. bensoni*
  - Family Muridae
    - Subfamily Sigmodontinae
      - *Baiomys* sp.
      - *Repomys* cf. *R. panacaensis*
    - Subfamily Arvicolinae
      - *Mimomys* cf. *M. poaphagus*
- Order Carnivora
  - Family Felidae
    - Subfamily Felinae
      - genus and species indeterminate
    - Subfamily Machairodontinae
      - genus and species indeterminate
  - Family Mustelidae
    - *Taxidea* sp.
  - Family Ursidae
    - genus and species indeterminate
- Order Perissodactyla
  - Family Equidae
    - *Equus* (*Dolichohippus*) *simplicidens*
    - *Nannippus* sp.
- Order Artiodactyla
  - Family Tayassuidae
    - cf. *Platygonus* sp.
  - Family Camelidae
    - *Hemiauchenia* cf. *H. blancoensis*
    - cf. *Camelops* sp.
  - Suborder Ruminantia
    - family, genus, and species indeterminate (either a cervid or antilocaprid)
- Order Proboscidea
  - Family Gomphotheriidae
    - cf. *Stegomastodon* sp.

Buckhorn Localities

In 1953, G. B. Pearce collected fossils for Childs Frick from a locality "5 miles northwest of Buckhorn." Over the past several years, Sealey and Morgan have made several attempts to relocate Pearce's site, but without success. Leopoldt (1981, p. 129) also noted that "All efforts to locate this site accurately were unsuccessful." We have explored virtually all of the Gila Group exposures in the area between about 2 and 6 miles (3–10 km) northwest of Buckhorn. Although we have discovered 13 additional Blancan localities in this area, we are fairly certain than none of these are the same as Pearce's original site because he collected many teeth and postcranial elements of the horse *Equus*, whereas the most common larger ungulate in our sites is the camel *Hemiauchenia*. We do not have detailed locality or stratigraphic data for Pearce's site; however, based on the species of mammals present and the preservation of the fossils, we are confident that this site is similar in age and general location to the remainder of the Buckhorn local fauna. It is not known if the fossils from Pearce's Buckhorn site were collected from one small concentration or from a series of outcrops over a wider area. All specimens from Pearce's collection are housed in the Frick Collection at the American Museum of Natural History (listed below with F:AM numbers).

A second locality included in the Buckhorn local fauna is derived from an unconsolidated fine grayish sand (unit 11, Formation C) near the middle of the Buckhorn measured section (NMMNH locality L-2912) in the upper Gila Group. The site occurs about 3 km northwest of Buckhorn on a ridge north of Duck Creek in the NE¼ NE¼ SW¼ NW¼ sec. 29, T14S, R18W, UTM zone 12, 3660007N, 712199E, on the Buckhorn USGS 7.5 minute quadrangle (1965). This site has yielded only a few specimens of larger mammals, but has a significant sample of microvertebrates, including rodents, birds, snakes, salamanders, fish, and abundant frogs. This is one of the richest concentrations of vertebrate fossils in the Buckhorn local fauna.

A layer of unconsolidated greenish-gray clayey sand about 20–25 m higher in the local stratigraphic section than the microfossil layer (unit 25, Formation D), and just above a prominent 1-m-thick buff-colored sand, has produced one partial skeleton and numerous other isolated bones of birds. This site (NMMNH locality L-2921) occurs along a fairly steep exposure on the east side of the tallest hill in the immediate vicinity (exact elevation given on map as 5118 feet) about 0.5 km north of the microfossil site. L-2921 is in the NE¼ NW¼ NW¼ Section 29, T14S, R18W; UTM zone 12, 3660300N, 712000E, on the Buckhorn USGS 7.5 minute quadrangle (1965).

Additional localities—This list does not include all of the individual sites that comprise the Buckhorn local fauna, only those that contain significant specimens or sites that have taxa not present in other Buckhorn sites. All sites are located on the Buckhorn USGS 7.5 minute quadrangle, 1965 edition. Data for the Buckhorn sites are stored in the locality files at the New Mexico Museum of Natural History.

NMMNH L-2914: NE¼ SW¼ NE¼ NW¼ sec. 29, T14S, R18W; UTM zone 12, 3660240N, 712310E. Possibly associated camelid (*Hemiauchenia*) phalanges, carpals, and tarsals (NMMNH P-26619–26630).

NMMNH L-2915: NW¼ NW¼ NE¼ NW¼ sec. 29, T14S, R18W; UTM zone 12, 3660450N, 712260E. Ursid (?) navicular (NMMNH P-26634).

NMMNH L-2916: SW¼ SE¼ SW¼ SW¼ sec. 20, T14S, R18W;

UTM zone 12, 3660527N, 712083E. Associated elements of the proboscidean cf. *Stegomastodon* (NMMNH P-26635).

NMMNH L-2917: NE¼ SE¼ SW¼ SW¼ sec. 20, T14S, R18W; UTM zone 12, 3660640N, 712130E. Camelid (*Hemiauchenia*) proximal end of radio-ulna (NMMNH P-26636).

NMMNH L-2920: SE¼ NE¼ SW¼ SW¼ sec. 20, T14S, R18W; UTM zone 12, 3660780N, 712150E. Possibly associated postcranial elements of the camelid *Hemiauchenia* (NMMNH P-26639-26652).

NMMNH L-3328: NW¼ NW¼ sec. 7, T14S, R18W; UTM zone 12, 3665000N, 710000E. Machairodontine felid distal tibia (NMMNH P-26659); camelid (*Hemiauchenia*) distal radius-ulna (NMMNH P-26660); *Equus* juvenile maxilla with fragmented teeth (NMMNH P-26661).

NMMNH L-3467: SE¼ SW¼ NW¼ NW¼ sec. 29, T14S, R18W; UTM zone 12, 3660205N, 711998E. Astragalus and cuboid (NMMNH P-26683, 26684) of a small species of camelid (*Hemiauchenia*) and several bird bones (NMMNH P-26679-26681). These fossils were collected from the lowest stratigraphic level in the Buckhorn section that has produced Blancan fossils (unit 3, Formation C).

SYSTEMATIC PALEONTOLOGY

Class OSTEICHTHYES

Referred Material—uncatalogued cranial elements and vertebrae. NMMNH locality L-2912.

Discussion—Miscellaneous cranial elements and vertebrae of very small fish are common in the Buckhorn microvertebrate quarry (L-2912). We did not attempt to identify the fish fossils to a lower taxonomic level. Continued sorting of the fine matrix from this site will undoubtedly add to the fish sample. The only other record of fish from the Blancan of New Mexico was a report of the catfish *Ictalurus* from the Mesilla basin in Doña Ana County (Vanderhill, 1986).

Class AMPHIBIA
Order ANURA
Family RANIDAE
Rana sp.

Referred Material—NMMNH P-26685, 3 maxillary fragments; NMMNH P-26686, 6 frontals; NMMNH P-26687, 5 parietals; NMMNH P-26688, 5 exoccipitals; NMMNH P-26689-2669015 dentaries; NMMNH P-26691, 2 atlas vertebrae; NMMNH P-26692, 8 sacral vertebrae; NMMNH P-26693, 10 scapulae; NMMNH P-26694-26695, 30 ilia; NMMNH P-26696-26697, 8 pubises; NMMNH P-26698-26699, 12 urostyles; NMMNH P-26700-26701, 23 humeri; NMMNH P-26702-26703, 12 radio-ulnae; NMMNH P-26704, 6 femora; NMMNH P-26705-26706, 34 tibio-fibulae. The catalogued sample of 179 fossils (minimum of 15 individuals) represents just a small fraction of the total anuran sample from NMMNH locality L-2912, the Buckhorn microvertebrate site. There are many hundreds of additional uncatalogued frog fossils representing all parts of the skeleton.

NMMNH P-26662, tibio-fibula; NMMNH P-26663, ilium. NMMNH locality L-2921.

Discussion—Frogs are by far the most abundant vertebrates in the fossil sample from the Buckhorn microvertebrate quarry. Frogs outnumber all other vertebrate groups in this locality by at least an order of magnitude. The identifiable elements, in particular certain cranial elements and the ilium, indicate that only one species is present. This site has a large sample of well-preserved ilia (Fig. 6A), generally considered the most diagnostic element for frog identification. The Buckhorn frog ilia possess an expanded dorsal crest that is diagnostic of the aquatic genus *Rana*, the group that includes the living bullfrog and leopard frog (Holman, 1959). The abundance of ranid frogs in this locality clearly indicates an aquatic depositional environment, probably a pond or lake. Two frog bones were identified from NMMNH locality L-2921, located about 20-25 m above locality L-2912 in the local stratigraphic section. The lithology of the sediments in L-2921 and the presence of wading birds, in particular flamingoes, both indicate that this second site represents a lacustrine depositional environment. This is the first Blancan record of frogs from New Mexico. Harris (1993) reported the genus *Rana* from eight late Pleistocene (Rancholabrean) faunas in New Mexico.

Order URODELA
Family AMBYSTOMATIDAE
Ambystoma sp.

Referred Material—NMMNH P-26707, 2 vertebrae. NMMNH locality L-2912.

Discussion—These two amphicoelous vertebrae (Fig. 6B) are referred to the salamander genus *Ambystoma* on the basis of their relatively large size compared to most other southwestern salamanders (antero-posterior length 6.2 mm, breadth across prezygapophyses 5.3 mm, breadth across postzygapophyses, 5.6 mm), and on features of the neural arch and zygapophyses (see Tihen, 1958; Holman, 1977; Rogers, 1982). These two vertebrae compare closely to the description and the illustration of a vertebra of *A. tigrinum*, the tiger salamander, from the Irvingtonian Cumberland Cave in Maryland (Holman, 1977, p.162, fig. 2A). However, an identification of the Buckhorn *Ambystoma* to the species level will require additional fossil material and more detailed comparisons. This is the first record of a salamander from the Blancan of New Mexico. Harris (1993) reported *Ambystoma tigrinum* from ten late Pleistocene (Rancholabrean) faunas in New Mexico.

Class REPTILIA
Order SQUAMATA
Suborder SERPENTES
Family COLUBRIDAE

Referred Material—NMMNH P-26708, 5 vertebrae; NMMNH P-26886, 5 vertebrae; NMMNH P-26887, 1 vertebra. NMMNH locality L-2912.

Discussion—Eleven snake vertebrae have been recovered from the Buckhorn microvertebrate quarry, all of which are from small to medium-sized snakes. According to figures, descriptions, and a key to snake vertebral characters in Holman (1979), these vertebrae can all be identified as colubrids. They are distinguished from boids by the fact that the vertebrae are longer than wide and from viperids by the lack of thick, elongated hypapophyses. Some of the Buckhorn snake vertebrae, in particular the five specimens catalogued as NMMNH P-26708, posses short, thin hypapophyses, indicating they belong to the colubrid subfamily Natricinae (Fig. 6C). Differences in size and morphological features suggest that several species of colubrids are present in the Buckhorn sample. A larger sample of better preserved vertebrae will be necessary to adequately document

the snake fauna from this site.

Colubrid snakes have been reported from two other New Mexico Blancan faunas. Repenning and May (1986) listed *Masticophis flagellum*?, the coachwhip snake, from the early Blancan Truth or Consequences local fauna from the Palomas Formation in Sierra County. Lucas et al. (1995) identified *Rhinocheilus lecontei*, the long-nosed snake, from a Blancan site in the Camp Rice Formation near Hatch in Doña Ana County.

Class AVES
Order ANSERIFORMES
Family ANATIDAE

Referred Material—F:AM 10435, proximal and distal ulnae; F:AM 10436, shaft of humerus, proximal ulna, radius, four vertebrae. Frick Buckhorn site.

NMMNH P-26679, humeral end of left coracoid. NMMNH locality L-3467.

NMMNH P-26712, right scapula; NMMNH P-26890, humeral end of left coracoid. NMMNH locality L-2912.

Discussion—We did not have the opportunity to examine the Frick Buckhorn anatid specimens (F:AM 10435, 10436). The identifications were taken from specimen labels in the fossil bird collection at the AMNH (M. A. Root, observation). Becker (1987) listed Anatidae from the Frick Buckhorn site, almost certainly based on these same specimens.

The small sample of anatids from the NMMNH Buckhorn collection includes at least two different taxa, both represented by the same element. A partial coracoid (NMMNH P-26679) of a large goose-like form (Subfamily Anserinae) has been identified from locality L-3467, the lowest site in the Buckhorn Blancan section, whereas a coracoid (NMMNH P-26890) representing a smaller duck (Subfamily Anatinae) has been identified in the Buckhorn microvertebrate quarry (locality L-2912).

Order GALLIFORMES
Family PHASIANIDAE
cf. *Meleagris* sp.

Referred Material—F:AM 10434, tibiotarsus. Frick Buckhorn site.

Discussion—In a review of fossil turkeys, Steadman (1980, p. 141, 168, table 4) tentatively referred a tibiotarsus from the Frick Buckhorn site to the living genus *Meleagris*. This is the first published reference to a vertebrate fossil from the Buckhorn site. Steadman (1980) considered this locality to be Hemphillian in age; however, Becker (1987), who also listed cf. *Meleagris* from Buckhorn, correctly assigned this fauna to the Blancan, following Tedford (1981). Fossil turkeys of the living genus *Meleagris* are widespread in Blancan sites from western North America (Steadman, 1980; Becker, 1987).

Order GRUIFORMES
Family RALLIDAE

Referred Material—NMMNH P-26709, right distal tarsometatarsus; NMMNH P-26888, humeral end of right coracoid. NMMNH locality L-2912.

NMMNH P-26667, left proximal carpometacarpus; NMMNH P-26668, left proximal femur. NMMNH locality L-2921.

Discussion—Four specimens of rails are identified from the Buckhorn local fauna, from two different localities. Two rallid bones occur in the microvertebrate quarry (L-2912), and two bones occur about 20–25 m higher in the stratigraphic section in locality L-2921. Both of these sites are dominated by aquatic vertebrates. These specimens compare reasonably well with medium-sized members of the genus *Rallus*, but a species-level identification must await better fossil material and more detailed morphological comparisons with both living and fossil rails. The Rallidae is one of the most common avian groups identified from Blancan avifaunas in western North America (Becker, 1987), although rails have not previously been reported from the Blancan of New Mexico.

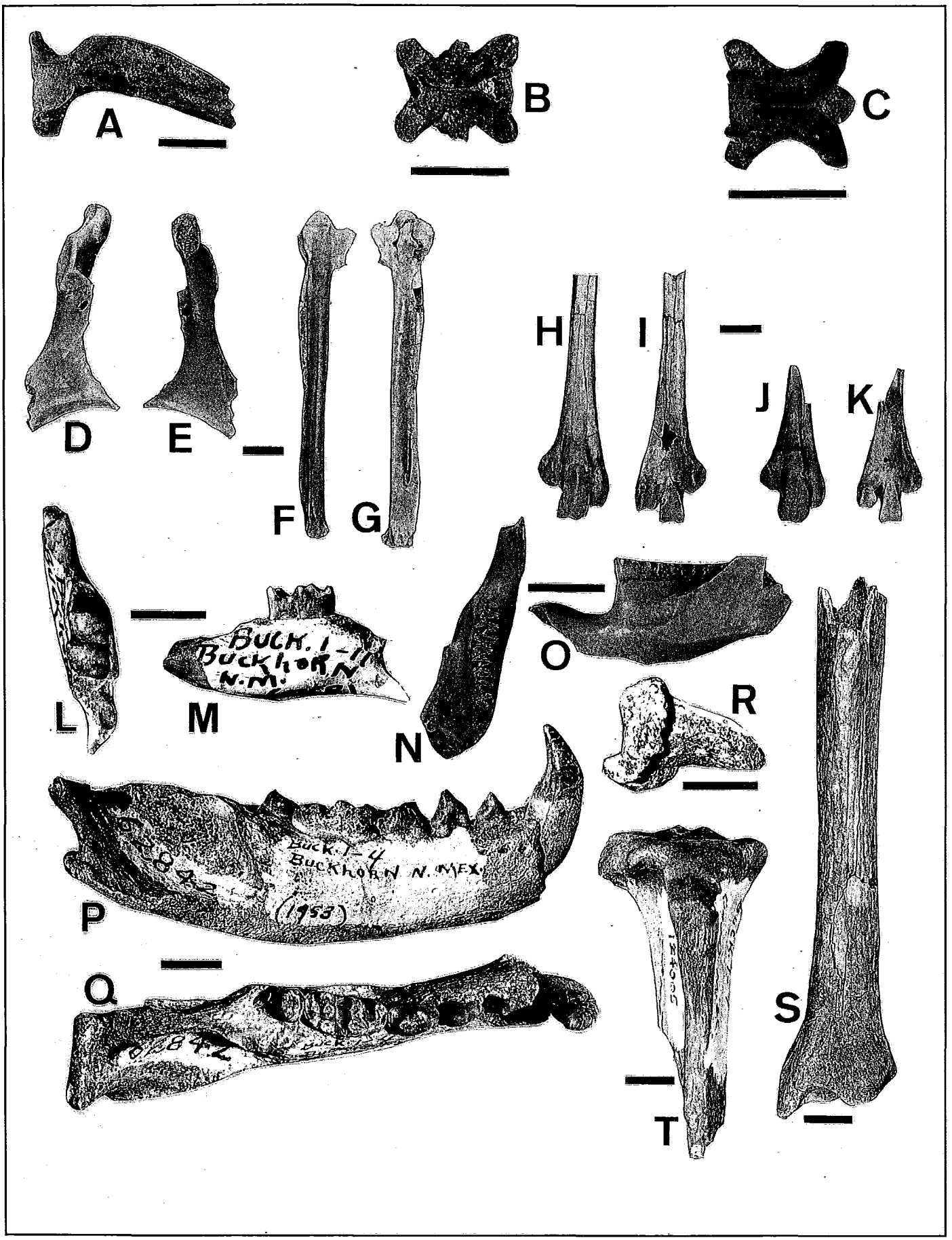
Order CHARADRIIFORMES
Family PHOENICOPTERIDAE
Phoenicopterus sp.

Referred Material—NMMNH P-26664, associated coracoid, scapula, distal ulna, distal radius, and carpometacarpus; NMMNH P-26665–26666, left distal tarsometatarsus. NMMNH locality L-2921.

Discussion—The bones in this sample, particularly the coracoid, carpometacarpus, and two distal tarsometatarsi (Figs. 6D–K), compare very closely in morphology to the same elements in the living West Indian flamingo, *Phoenicopterus ruber*. The comparable elements tend to be somewhat smaller in the Buckhorn flamingo, but the fossils are clearly referable to the genus *Phoenicopterus*. Measurements of the most complete elements of the Buckhorn *Phoenicopterus* are as follows: NMMNH P-26664, complete coracoid, total length 56.8; NMMNH P-26664, complete carpometacarpus, total length 82.1, proximal width 15.6, distal width 7.9; NMMNH P-26665, distal tarsometatarsus, distal width 17.6; NMMNH P-26666, distal tarsometatarsus, distal width 16.1.

Two extinct species of *Phoenicopterus* are known from North American Pliocene sites. Brodkorb (1953, 1955) described *P. floridanus* from the latest Hemphillian Palmetto fauna in Florida,

FIGURE 6. Fossil vertebrates from the Blancan Buckhorn local fauna, Grant County, New Mexico. **A.** *Rana* sp., right ilium, NMMNH P-26695. **B.** *Ambystoma* sp., vertebra, NMMNH P-26707, dorsal view. **C.** Colubridae, vertebra, NMMNH P-26708, dorsal view. **D.** *Phoenicopterus* sp., left coracoid, NMMNH P-26664, dorsal view. **E.** *Phoenicopterus* sp., left coracoid, NMMNH P-26664, internal view. **F.** *Phoenicopterus* sp., right carpometacarpus, NMMNH P-26664, external view. **G.** *Phoenicopterus* sp., right carpometacarpus, NMMNH P-26664, internal view. **H.** *Phoenicopterus* sp., left distal tarsometatarsus, NMMNH P-26665, anterior view. **I.** *Phoenicopterus* sp., left distal tarsometatarsus, NMMNH P-26665, posterior view. **J.** *Phoenicopterus* sp., left distal tarsometatarsus, NMMNH P-26666, anterior view. **K.** *Phoenicopterus* sp., left distal tarsometatarsus, NMMNH P-26666, posterior view. **L.** *Spermophilus* cf. *S. bensoni*, right mandible with m1–m2, F:AM 124006, occlusal view. **M.** *Spermophilus* cf. *S. bensoni*, right mandible with m1–m2, F:AM 124006, medial view. **N.** *Mimomys* (*Ogmodontomys*) cf. *M. poaphagus*, left mandible with m1–m3, NMMNH P-26720, occlusal view. **O.** *Mimomys* (*Ogmodontomys*) cf. *M. poaphagus*, left mandible with m1–m3, NMMNH P-26720, lateral view. **P.** *Taxidea* sp., right mandible with c1, p2–m2, F:AM 62842, lateral view. **Q.** *Taxidea* sp., right mandible with c1, p2–m2, F:AM 62842, occlusal view. **R.** Ursidae, ungual phalanx, F:AM 124008. **S.** Felidae (Machairodontinae), left distal tibia, NMMNH P-26659. **T.** Felidae (Felinae), right proximal tibia, F:AM 124005. Scale bars are 5 mm for A–C, L–O; 1 cm for D–K, P–R, T; 2 cm for S.


A
B
C
D
E
F
G
H
I
J
K
L
M
BUCK. I-11
BUCKHORN
N.M.
N
O
R
P
BUCK. I-4
BUCKHORN N. MEX.
(1953)
Q
S
T

and Miller (1944) described *P. stocki* from the latest Hemphillian Yepómera fauna from Chihuahua in northern Mexico. *P. floridanus* is more robust than the living *P. ruber*, whereas *P. stocki* is smaller than *P. ruber* (Emslie, 1992). Like *P. stocki*, the Buckhorn flamingo fossils are smaller than living *P. ruber*. The Yepómera and Buckhorn flamingo fossils are not directly comparable, as *P. stocki* was described from a proximal and distal tibiotarsus, elements not present in the Buckhorn sample. Emslie (1992) reported *Phoenicopterus* sp. from the late Blancan Macasphalt local fauna in Florida and Becker (1987) listed unstudied fossils of Phoenicopteridae, presumably *Phoenicopterus*, from three late Blancan sites in southeastern Arizona—Duncan, Matthews Wash, and 111 Ranch.

Order PASSERIFORMES

Referred Material—NMMNH P-26710, right proximal humerus; NMMNH P-26711, right proximal ulna. NMMNH locality L-2912.

Discussion—Two tiny bird bones from the Buckhorn microvertebrate quarry represent small passerines. Postcranial elements of passerines are difficult to identify, even to the family level. Further study of these specimens is certainly warranted, especially considering that more material of passerines will probably be recovered through further screenwashing. The Buckhorn fossils represent the first record of passerines from the Blancan of New Mexico. Steadman and McKitrick (1982) reported the fringillid cf. *Passerina* from the latest Hemphillian Yepómera fauna from Chihuahua in northern Mexico. Numerous elements of an emberizid or fringillid were reported from the early Blancan Verde local fauna in central Arizona (Czaplewski, 1990), and two taxa of passerines, the emberizid *Junco* sp. and an unidentified fringillid, are known from the middle Blancan Benson fauna in southeastern Arizona (Wetmore, 1924; Becker, 1987).

Class MAMMALIA
Order LAGOMORPHA
Family LEPORIDAE
Genus and species indeterminate

Referred Material—F:AM uncataloged (field number, Buck 1-5), femur, distal tibia, two calcanea, and three metapodials. Frick Buckhorn site.

Discussion—The leporid specimens from the Buckhorn local fauna consist of several possibly associated postcranial elements, but there is no cranial or dental material. As noted above under the discussion of the Walnut Canyon rabbit, the taxonomy of North American fossil leporids is based almost exclusively on teeth, specifically the p3 (White, 1987). The lack of a p3 in the Buckhorn sample precludes identification below the family level. Tedford (1981) mentioned the presence of rabbits in the Frick Buckhorn site, and Leopoldt (1981) listed *Hypolagus*? from the same site, although as noted above the material is not sufficient for a generic identification. Other Blancan leporids reported from New Mexico include *Hypolagus vetus* and *Notolagus lepusculus* from the early Blancan Truth or Consequences local fauna from the Palomas Formation in Sierra County (Repenning and May, 1986), *Hypolagus* cf. *H gidleyi* from the Blancan Tijeras Arroyo site from the Sierra Ladrones Formation in Bernalillo County (Lucas et al., 1993), and *Aluralagus virginiae* from a Blancan/Irvingtonian transition fauna in the Mesilla basin in Doña Ana County (Vanderhill, 1986).

Order RODENTIA
Family SCIURIDAE
Spermophilus cf. *S. bensoni* Gidley, 1922

Referred Material—F:AM 124006, right mandible with m1–m2. Frick Buckhorn site.

Discussion—A mandible with well-preserved m1–m2 is the only sciurid specimen so far identified from the Buckhorn local fauna (Figs. 6L, 6M). Comparisons of this specimen with Blancan ground squirrels from several sites in southeastern Arizona indicate that the Buckhorn mandible is similar to *Spermophilus bensoni*, originally described from the middle Blancan Benson fauna (Gidley, 1922; Gazin, 1942) and later tentatively reported (*Spermophilus* cf. *S. bensoni*) from the late Blancan San Simon Power Line and 111 Ranch faunas (Tomida, 1987). Measurements of the Buckhorn *Spermophilus* teeth are as follows (measurements of *Spermophilus* cf. *S. bensoni* from the Blancan of Arizona in parentheses, from Tomida, 1987, table 11): m1 length 2.1 (2.1), m1 width 2.6 (2.6); m2 length 2.2 (2.2), m2 width 2.8 (3.0). In additional to the close similarity in size, the Buckhorn teeth agree in morphology with the figures and descriptions of *Spermophilus* cf. *S. bensoni* (Tomida, 1987, p. 49): overall size is fairly large; the m1 and m2 are slightly compressed anteroposteriorly and thus are wider than long; the m2 is somewhat larger than the m1; the cusps are relatively high; the metaconid and protoconid are separated by a distinct notch in the metalophid on m1; the protoconid and hypoconid are rather close but are separated by a deep valley; and the entoconid is indistinct.

The *Spermophilus* mandible from the Buckhorn local fauna is only tentatively referred to *S. bensoni* pending further comparisons with other fossil ground squirrels. More than ten Blancan species of *Spermophilus* have been described from western North America (Kurtén and Anderson, 1980). This is the second report of a Blancan sciurid from New Mexico. The giant marmot *Paenemarmota* was identified from a Blancan site near Los Lunas in Valencia County, north-central New Mexico (Tedford, 1981).

Family MURIDAE
Subfamily SIGMODONTINAE
Baiomys sp.

Referred Material—NMMNH P-26896, left maxilla with M1–M2; NMMNH P-26723, left mandible with i1, m1–m3; NMMNH P-26897, left mandible with i1, m1. NMMNH locality L-2912.

Discussion—A tiny sigmodontine rodent is represented in the Buckhorn local fauna by two mandibles with heavily worn teeth and a maxillary fragment with two lightly worn teeth. NMMNH P-26723 is a nearly intact mandible possessing the incisor and m1–m3. The only missing portions of the dentary are the tip of the coronoid process and the mandibular angle. The second mandible (NMMNH P-26897) has an incisor and m1, but the region posterior to the first molar is missing. The cheek teeth in both of these mandibles are so heavily worn that their dental pattern is nearly obliterated, but enough enamel is preserved to provide accurate measurements (see Table 4).

The extremely small size of the dentaries and teeth rule out most typical Blancan sigmodontines, with the exception of *Baiomys* and *Reithrodontomys*. The mandibles are similar to *Baiomys* and differ from *Reithrodontomys* in their somewhat smaller size, dorsoventrally narrower lower incisor, less concave

TABLE 4. Measurements (in mm) of upper and lower molars of *Baiomys* sp. from the Blancan Buckhorn local fauna, Grant County, New Mexico. Abbreviations are: occlusal length (L) and occlusal width (W).

	M1		M2		m1		m2		m3	
	L	W	L	W	L	W	L	W	L	W
NMMNH P-26896	1.31	0.77	0.90	0.72	—	—	—	—	—	—
NMMNH P-26723	—	—	—	—	1.13	0.77	0.86	0.77	0.68	0.63
NMMNH P-26897	—	—	—	—	1.08	0.68	—	—	—	—

diastema, slightly more anterior position of the mental foramen, shallower dentary ventral to the toothrow, and smaller m3.

The maxillary fragment with M1–M2 (NMMNH P-26896) also agrees with *Baiomys* in most characters, including very small size and bifurcation of the anterocone on M1. The heavily worn teeth in the mandibles and small sample size preclude a referral of the Buckhorn *Baiomys* to species at the present time. Further screenwashing of the Buckhorn microvertebrate site will almost cetainly add more material of this diminutive mouse. The Buckhorn fossils represent the first record of *Baiomys* from the Blancan of New Mexico.

Repomys cf. *R. panacaensis* May, 1981

Referred Material—NMMNH P-26898, left M2. NMMNH locality L-2912.

Discussion—The extinct hypsodont sigmodontine genus *Repomys* is represented in the Buckhorn local fauna by a single well-preserved upper molar. Four described species of *Repomys*, *R. gustelyi*, *R. maxumi*, *R. panacaensis*, and *R. arizonensis*, occur in late Hemphillian through late Blancan faunas in the southwestern United States. The species of *Repomys* are similar to one another in dental morphology and are distinguished primarily on the basis of size (May, 1981; Tomida, 1987). The M1 and M2 in *Repomys* are difficult to differentiate, and are separated primarily by the smaller size and less complex anterocone of M2. Using these criteria, the Buckhorn tooth is an M2. The Buckhorn *Repomys* M2 can be distinguished from the late Hemphillian species *R. gusteyli* and the early Blancan *R. maxumi* by its considerably smaller size and from the late Blancan *R. arizonensis* by its slightly smaller size and presence of three roots. The anterior and lingual roots are fused on the M2 in *R. arizonensis*. *R. panacaensis* and the Buckhorn *Repomys* are similar in size. Measurements of the Buckhorn *Repomys* M2 are (measurements in parentheses are for M2s of *R. panacaensis* from the Panaca fauna, Nevada, from May 1981, table 1; followed by *R.* cf. *R. panacaensis* from the Clarkdale fauna, Arizona, from Czaplewski, 1987, p. 145): M2 length 1.65 (1.72, 1.74); M2 width 1.33 (1.14, 1.30). The Buckhorn tooth is tentatively referred to *R. panacaensis* pending the recovery of additional fossil specimens.

This is the first record of the genus *Repomys* from New Mexico. The only other Blancan locality from the state that has been extensively screenwashed for microvertebrates, the early Blancan Truth or Consequences local fauna from Sierra County, contains the primitive packrat *Neotoma quadriplicata*, but not *Repomys*. Four species of *Repomys* have been described from late Hemphillian and Blancan faunas in the southwestern United States (May, 1981; Tomida, 1987): *R. gustelyi* from the late Hemphillian Warren local fauna in the Mojave Desert of California; *R. maxumi* from the early Blancan Maxum local fauna in Contra Costa County, California; *R. panacaensis* from the early or middle Blancan Panaca fauna in southeastern Nevada (also tentatively referred from the middle Blancan Clarkdale local fauna in central Arizona; Czaplewski, 1987); and *R. arizonensis* from the late Blancan 111 Ranch fauna in southeastern Arizona. There is some disagreement on the age of the Panaca fauna. In his description of *R. panacaensis*, May (1981) assigned this fauna to the middle Blancan, and Repenning placed Panaca in his Blancan III (=middle Blancan) microtine age. Mou (1997), however, considered Panaca to be early Blancan, primarily based on the evolutionary stage of the arvicoline rodent *Mimomys panacaensis*.

Subfamily ARVICOLINAE

Mimomys cf. *M.* (*Ogmodontomys*) *poaphagus* (Hibbard, 1941)

Referred Material—NMMNH P-26721, left mandible with i1, m1–m3; NMMNH P-26720, left mandible with m1–m3; NMMNH P-26722, left mandible with m2; NMMNH P-26891, right m1; NMMNH P-26892, right m2; NMMNH P-26893, left m2; NMMNH P-26894, partial right M1. All *Mimomys* fossils are from NMMNH locality L-2912, the Buckhorn microvertebrate quarry.

Descriptions and Comparisons—Fossil species of arvicoline rodents are identified primarily on the morphology of the m1 and to a lesser extent the M3. The Buckhorn arvicoline sample includes three complete m1s, one of which is heavily worn, but as yet no M3s. The Buckhorn m1s have a posterior loop, three alternating triangles, and a relatively simple anteroconid complex lacking an enamel pit and with only minor crenulations in the enamel on the labial surface (dental terminology is standard for arvicoline rodents, see Martin, 1995, fig.1). Furthermore, all of the teeth are rooted, show very limited development of dentine tracts, and lack cement in the reentrant angles, suggesting that the Buckhorn arvicoline is a primitive member of the genus *Mimomys*. A mandible with m1–m3 of the Buckhorn *Mimomys* is shown in Figures 6N and 6O.

We follow Repenning's (1987) taxonomic arrangement in which he includes *Cosomys*, *Ogmodontomys*, and *Ophiomys* as subgenera of *Mimomys*. The oldest North American representatives of this genus are *Mimomys* (*Cosomys*) *sawrockensis*, originally described from the Saw Rock Canyon local fauna, Kansas and *M.* (*Ophiomys*) *mcknighti*, described from the White Bluffs local fauna, Washington, both of which are early Blancan in age (Blancan I of Repenning, 1987). These two species occur together in the early Blancan Upper Alturas local fauna, California (Repenning, 1987). *M. sawrockensis* and *M. mcknighti*, as well as *Mimomys panacaensis*, recently described from the early or middle Blancan Panaca fauna in Nevada (Mou, 1997), are smaller than the Buckhorn *Mimomys* (Zakrzewski, 1967; Gustafson, 1978; Mou, 1997), although *M. sawrockensis* is only slightly smaller. Measurements of the *Mimomys* teeth from the Buckhorn local fauna are presented in Table 5. All known species

of *Mimomys* (*Ophiomys*) are smaller than the Buckhorn species, which is most similar to the subgenera *Cosomys* and *Ogmodontomys*. The species *M.* (*Ogmodontomys*) *poaphagus* and *M.* (*Cosomys*) *primus* from the early to middle Blancan compare most closely to the Buckhorn *Mimomys* in size and dental characters. Compared to the Buckhorn species, the anteroconid or anterior loop in *M. primus* generally has more complex enamel crenulations on the labial edge, an isolated enamel islet in early wear stages, and a prism fold on the labial edge of the primary wing. The three Buckhorn arvicoline m1s all lack an enamel islet and a prism fold. A heavily worn m1 shows no enamel crenulations, a moderately worn m1 has minor crenulations, and the labial edge of the anteroconid is broken on a lightly worn m1.

Mimomys (*Ogmodontomys*) is characterized by its large size, reduction of an enamel islet on m1, grooved upper incisor, and presence of three roots on M3 (Zakrzewski, 1967). The first two of these characters apply to the Buckhorn *Mimomys*, whereas the latter two characters can not be evaluated because the sample does not presently include an upper incisor or M3. Based on size, absence of an enamel islet on the anteroconid, and the degree of dentine tract development, the Buckhorn arvicoline most closely resembles *M.* (*Ogmodontomys*) *poaphagus*. The occlusal length of m1–m3 in the two Buckhorn mandibles (7.5, 7.8) compares closely to a mandible of *M.* (*O.*) *poaphagus* (occlusal length of m1–m3, 7.8) from Sand Draw, Nebraska (Hibbard, 1972) and is slightly larger than five mandibles referred to *M.* (*O.*) *poaphagus* from Fox Canyon, Kansas (occlusal length of m1–m3, mean 7.2, range 7.0–7.5). The dental patterns of the Buckhorn m1s are similar to illustrations of *M.* (*O.*) *poaphagus* m1s from Sand Draw (Hibbard, 1972, fig. 39) and Fox Canyon (Hibbard, 1950, figs. 15, 17). The Buckhorn *Mimomys* also compares closely in size and dental characters to teeth referred to *M.* (*O.*) *poaphagus* from the Verde local fauna in Arizona (Czaplewski, 1990). However, definite referral to this species will require a larger sample, which should be forthcoming with further screenwashing of the Buckhorn microvertebrate site.

Discussion—*Mimomys* is the most common rodent in the Buckhorn local fauna, represented by three mandibles and four isolated teeth from a minimum of four individuals. Likewise, *Mimomys* is one of the most common genera of arvicoline rodents in North American Blancan faunas. The evolutionary history of arvicoline or microtine rodents provides perhaps the most useful tool for biostratigraphic subdivision of the Blancan NALMA in North America (e.g., Repenning, 1987). One of the only drawbacks to using arvicoline teeth is the variability encountered in their enamel patterns, thus requiring fairly large sample sizes of teeth to permit assessment of individual variation. The size of the Buckhorn m1s and their enamel pattern are reasonably well established from the small sample available, but there is not quite enough material to provide a positive species identification.

The presence of well-developed roots, weakly developed dentine tracts, and lack of cement are primitive features of the Buckhorn arvicoline m1s, which together with their relatively large size and lack of an enamel islet and a simple enamel pattern on the anterconid, suggest referral to *Mimomys* (*Ogmodontomys*), with the early to middle Blancan species *M.* (*O.*) *poaphagus* the most similar. According to Repenning (1987), the boundary between his Blancan I and II microtine ages is based on the first appearance of large *Mimomys* (i.e., *Mimomys* subgenus *Ogmodontomys*) at the beginning of Blancan II time. By Blancan IV time, *Mimomys* (*Ogmodontomys*) had developed higher dentine tracts (Repenning, 1987) than are present in the Buckhorn arvicoline, thus restricting the age of the Buckhorn local fauna to either Blancan II or Blancan III (late early or early middle Blancan, about 4.0–3.0 Ma). *M.* (*O.*) *poaphagus* occurs in several early and middle Blancan faunas in western North America, including the Verde local fauna in Arizona, Beck Ranch local fauna in Texas, the Sand Draw local fauna in Nebraska, and the Rexroad (type locality) and Fox Canyon local faunas in Kansas (Hibbard, 1941, 1950, 1972; Dalquest, 1978; Repenning, 1987; Czaplewski, 1990). The Buckhorn local fauna represents the first record of a Blancan arvicoline from New Mexico. The only other Blancan fauna from the state that has been screenwashed for small mammals, the early Blancan (Blancan II) Truth or Consequences local fauna, lacks arvicolines (Repenning and May, 1986; Repenning, 1987).

Order CARNIVORA
Family FELIDAE
Subfamily FELINAE
genus and species indeterminate

Referred Material—F:AM 124005, proximal end of right tibia. Frick Buckhorn site.

NMMNH P-26728, proximal phalanx. NMMNH locality L-2912.

Discussion—Two specimens of a small cat are identified from two different Buckhorn localities. A proximal tibia (F:AM 124005) from the Frick Buckhorn site (Fig. 6T) is similar in size

TABLE 5. Measurements (in mm) of lower molars of *Mimomys* cf. *M. poaphagus* from the Blancan Buckhorn local fauna, Grant County, New Mexico. Abbreviations are: occlusal length (L), greatest occlusal width (W), mean (X), observed range (O.R.), and sample size (N).

	m1		m2		m3		m1–m3
	L	W	L	W	L	W	L
NMMNH P-26720	3.3	1.7	2.2	1.6	2.1	1.5	7.8
NMMNH P-26721	3.0	1.5	2.0	1.4	1.9	1.3	7.5
NMMNH P-26891	3.1	1.6	—	—	—	—	—
NMMNH P-26722	—	—	2.1	1.5	—	—	—
NMMNH P-26892	—	—	2.1	1.5	—	—	—
NMMNH P-26893	—	—	2.2	1.6	—	—	—
X	3.1	1.6	2.1	1.5	2.0	1.4	7.7
O. R.	3.0–3.3	1.5–1.7	2.0–2.2	1.4–1.6	1.9–2.1	1.3–1.5	7.5–7.8
N	3	3	5	5	2	2	2

and morphology to the tibia of the living bobcat, *Lynx rufus*. Three species of small to medium-sized cats are known from Blancan faunas in western North America, *L. rufus*, and two extinct species, *Felis lacustris* and *F. rexroadensis*. Both of these extinct cats have been described as intermediate in size between a bobcat and the puma, *Puma concolor*, with *F. rexroadensis* the smaller of the two species (Bjork, 1970; Dalquest, 1975; MacFadden and Galiano, 1981). Measurements of the Buckhorn tibia are (measurements of a proximal tibia of *Felis lacustris* from the Blancan Hagerman local fauna, Idaho, in parentheses from Bjork, 1970, table 15): proximal width 34.8 (37.6), proximal depth 34.5 (37.8).

A well preserved proximal phalanx (NMMNH P-26728) from the Buckhorn microvertebrate site is also similar in size and morphology to that of *Lynx rufus*. Czaplewski (1987, fig. 12B) described and figured a comparable cat phalanx from the middle Blancan Clarkdale local fauna from the Verde Formation in central Arizona. Measurements of the Buckhorn proximal phalanx are (measurements of the felid proximal phalanx from Clarkdale in parentheses, from Czaplewski, 1987, p. 146): total length 23.6 (20.2), proximal width 7.7 (6.6), and distal width 6.2 (5.8).

The two Buckhorn felid fossils are inadequate for a generic or specific identification. Based on the older taxonomic literature on felids, the Buckhorn fossils would be placed in the genus *Felis*; however, small to medium-sized cats are now divided among a number of genera (e.g., *Felis*, *Leopardus*, *Lynx*, *Puma*, etc.) that can only be distinguished by cranial or dental material (Salles, 1992). The Buckhorn fossils are closest in size to *Felis rexroadensis*, a species reported from both latest Hemphillian (e.g., Bone Valley, Florida) and early Blancan (e.g., Rexroad, Kansas) faunas (MacFadden and Galiano, 1981). The somewhat larger cat, *Felis* cf. *F. lacustris*, is known from the middle Blancan Duncan fauna in southeastern Arizona (Tedford, 1981; Tomida, 1987).

Subfamily MACHAIRODONTINAE
genus and species indeterminate

Referred Material—NMMNH P-26659, distal end of left tibia. NMMNH locality L-3328.

Discussion—A large distal tibia from the Buckhorn local fauna (Fig. 6S) compares most closely with tibiae belonging to members of the felid subfamily Machairodontinae, the sabercats. The Buckhorn fossil consists of approximately the distal three quarters of the tibia, including much of the cnemial crest. Although the proximal end is missing, the location and development of the cnemial crest clearly indicate that the complete tibia would have been rather short and very robust, which is typical of the tibia in most sabercats. The preserved portion of the Buckhorn tibia measures about 220 mm in length; other measurements are: distal width 48.8, distal depth 31.1, midshaft width 22.7, midshaft depth 22.5.

At least four genera of sabercats are known from North American Blancan faunas, including *Dinofelis*, *Ischyrosmilus*, *Megantereon*, and *Smilodon* (Kurtén and Anderson, 1980). *Megantereon hesperus* occurs in the latest Hemphillian Palmetto fauna in Florida, as well as several Blancan faunas, including Broadwater in Nebraska, Hagerman in Idaho, and Rexroad in Kansas (Berta and Galiano, 1983). According to Berta and Galiano (1983), *M. hesperus* is about the size of the puma, *Puma concolor*, and is thus smaller than the Buckhorn sabercat. Although the earliest appearance of *Smilodon* in western North America appears to be in the early Irvingtonian (Lindsay et al., 1984; Lundelius et al., 1987), the species *S. gracilis* is well documented from several late Blancan faunas in peninsular Florida (Berta, 1987; Morgan and Hulbert, 1995). Berta (1987, 1995) provided descriptions, figures, and measurements of the postcrania of the gracile sabercat, *S. gracilis*, including several tibiae from the late Blancan and Irvingtonian of Florida. The tibia of *S. gracilis* is smaller, particularly the distal width, than comparable measurements of the Buckhorn tibia.

The other two genera of Blancan sabercats, *Dinofelis* and *Ischyrosmilus*, both include large species that are closer in size to the Buckhorn cat. Four species of *Ischyrosmilus* have been described from the early through the late Blancan of western North America. Kurtén and Anderson (1980) characterized *Ischyrosmilus* as having long and slender limb bones, whereas the Buckhorn tibia seems to be comparatively short and robust. *Dinofelis paleoonca* from the late Blancan Blanco and Cita Canyon local faunas in Texas is about the size of the jaguar, *Panthera onca*, (Kurtén and Anderson, 1980), which suggests that this species may be somewhat smaller than the Buckhorn cat. The single partial tibia from the Buckhorn local fauna is probably not identifiable beyond the subfamily Machairodontinae; however, it indicates the presence of a large sabercat in the fauna, probably either *Ischyrosmilus* or *Dinofelis*. This specimen and the two fossils of a small cat described above represent the only records of fossil felids from the Blancan of New Mexico.

Family MUSTELIDAE
Taxidea sp.

Referred Material—F:AM 62842, right mandible with c1, p2–m2. Frick Buckhorn site.

Discussion—A well preserved badger mandible with a nearly complete dentition, lacking only the incisors and the coronoid process, was collected from the Frick Buckhorn site (Figs. 6P, 6Q). This mandible was compared to recent mandibles of the badger, *Taxidea taxus*, and to descriptions and measurements of various fossil badger mandibles (Drescher, 1939; Hall, 1944; Bjork, 1970; Wagner, 1976). The p2 and p3 are fairly small, single-cusped teeth. The p4 is larger than the anterior premolars and has a well-developed accessory cusp posterior and labial to the protoconid. The trigonid of m1 is noticeably longer than the talonid, and the paraconid, protoconid, and metaconid are all well developed. The talonid is composed of an entoconid, hypoconulid, and centrally-placed hypoconid, all about equal in size, and one accessory cusp along the posterior margin. The small m2 is round with a shallow central basin.

The Buckhorn badger mandible is similar in size and dental characters, particularly the morphology of the m1, to *Taxidea taxus* and the extinct species *T. mexicana* from the latest Hemphillian Yepómera fauna from northern Mexico (Wagner, 1976). The New Mexico fossil is considerably larger and the talonid of m1 is comparatively shorter than in *Pliotaxidea* from various Hemphillian sites in western North America (Hall, 1944; Wagner, 1976). Dental measurements of the Buckhorn *Taxidea* are as follows: c1 length 7.9, c1 width 6.0; p2 length 5.1, p2 width 2.7; p3 length 6.4, p3 width 3.7; p4 length 8.3, p4 width 5.1; m1 length 13.4, m1 width 6.8; m2 length 5.2, m2 width 5.7.

Badger fossils are known from numerous Blancan faunas in western North America, including early to middle Blancan records from Hagerman in Idaho, Broadwater and Sand Draw in Nebraska, and Rexroad in Kansas, and late Blancan records from

Cita Canyon and Red Light in Texas (Kurtén and Anderson, 1980). With the exception of the Rexroad badger, which Hibbard (1941) referred to the living species, *Taxidea taxus*, most other Blancan badgers have been identified only as *Taxidea* sp. Before the Buckhorn *Taxidea* mandible can be identified to the species level, more detailed comparisons need to be made with other Blancan badgers, as well as with the late Hemphillian *T. mexicana*.

Family URSIDAE
genus and species indeterminate

Referred Material—F:AM 124008, ungual phalanx. Frick Buckhorn site.

Discussion—An ungual phalanx from the Frick Buckhorn site (Fig. 6R) is diagnostically ursid, but is not identifiable below the family level. The comparatively small size of the Buckhorn bear claw would indicate that this fossil is more likely to be *Tremarctos* or a small species of *Ursus*, than the larger *Arctodus*. Bears are not common in North American Blancan faunas. Bjork (1970) described the small species, *Ursus abstrusus*, from the middle Blancan Hagerman local fauna in Idaho. This species has also been identified from the early Blancan White Bluffs local fauna in Washington and the late Blancan Cita Canyon local fauna in Texas (Kurtén and Anderson, 1980). *Tremarctos* is found primarily in Rancholabrean faunas, but Blancan fossils are known from Hagerman and Grand View in Idaho (Kurtén and Anderson, 1980). Most records of *Arctodus* are Irvingtonian and Rancholabrean, but Emslie (1995) reported fossils of *A. pristinus* from two late Blancan faunas in Florida.

Order PERISSODACTYLA
Family EQUIDAE
Equus (*Dolichohippus*) *simplicidens* (Cope, 1893)

Referred Material—F:AM 124010, right P3, M1–M2 and left P3–M2; numerous uncataloged postcranial elements (field numbers: Buck 1-1, 1-3, 1-7), including distal radius, astragalus, and proximal and medial phalanges. Frick Buckhorn site.

Discussion—Seven associated upper cheek teeth (F:AM 124010) from the Frick Buckhorn site are referred to the common large Blancan horse, *Equus simplicidens* (Fig. 7A). These teeth are characterized by their large size (Table 6), moderate curvature, simple enamel pattern (most of the teeth have one or at most two enamel plications in each of the fossettes), "wooden shoe-shaped" protocone lacking a lingual identation and with small anterior and larger posterior projections, deep postprotoconal valley, small pli caballin, and well-developed hypoconal groove. Two other species of *Equus* have been reported from Blancan faunas in New Mexico, *E. scotti* and *E. cumminsii* (Tedford, 1981). The Buckhorn teeth have a simpler enamel pattern and show no lingual indentation of the protocone compared to cheek teeth of *E. scotti* and are larger than teeth of *E. cumminsii*. The postcranial elements are referred to *E. simplicidens* primarily on the basis of their large size. A proximal phalanx is shown in Figure 7B. Some of these bones could possibly belong to the large species, *E. scotti*. However, *E. scotti* is found principally in Irvingtonian faunas and a few late Blancan faunas such as Red Light in western Texas (Akersten, 1972).

Equus simplicidens is widely distributed in western North America throughout the Blancan, although it may not occur in very early Blancan faunas (Kurtén and Anderson, 1980). This horse is an excellent indicator of Blancan faunas, but owing to its long stratigraphic range is not particularly useful for placing the Buckhorn local fauna within the Blancan. *E. simplicidens* has been reported from five other Blancan faunas in New Mexico: Arroyo de la Parida in Socorro County (Tedford, 1981; Lucas and Morgan, 1996); Cuchillo Negro Creek (Lucas and Oakes, 1986), Elephant Butte Reservoir, and Las Palomas Creek (Tedford, 1981) in Sierra County; and the Duncan basin near Virden along the Arizona border in Hidalgo County (Tedford, 1981).

TABLE 6. Measurements of upper cheek teeth of *Equus simplicidens* from the Blancan Buckhorn local fauna, Grant County, New Mexico. Abbreviations are: length (L), width (W).

	P3		P4		M1		M2	
	L	W	L	W	L	W	L	W
F:AM 124010	29.7	28.5	28.7	29.8	25.7	28.6	25.0	28.2

Equus sp.

Referred Material—NMMNH P-26631, proximal end of lateral metapodial. NMMNH locality L-2914.

NMMNH P-26661, partial maxilla with several shattered deciduous premolars. NMMNH locality L-3328.

Discussion—Only two equid specimens have been recovered from the various NMMNH Blancan localities in the vicinity of Buckhorn, including upper tooth fragments belonging to a juvenile individual and a lateral metapodial. These specimens are too incomplete for a species-level identification. They are referred to *Equus* because of their large size compared to *Nannippus*, the only other genus of equid present in the southwestern United States at this time.

Nannippus sp.

Referred Material—F:AM 124009, juvenile left mandible with dp3–dp4; F:AM uncataloged, proximal and medial phalanx (field numbers: Buck 1-1 and 1-7). Frick Buckhorn site.

Descriptions and Comparisons—A mandible containing two deciduous premolars is considerably smaller than any species of Blancan *Equus*, and also differs from that genus in dental characters (Fig. 7C). This mandible and several small, slender phalanges (Figs. 7D, 7E) are referred to the three-toed horse *Nannippus*. Tedford (1981) previously reported *Nannippus* from the Frick Buckhorn site based on these same specimens. Two species of *Nannippus* occur in the Blancan. *N. beckensis* is known only from the early to middle Blancan Beck Ranch local fauna in Texas (Dalquest and Donovan, 1973), whereas the widespread *N. peninsulatus* (generally called *N. phlegon* in the literature, but synonymized with *N. peninsulatus* by MacFadden, 1984a) has been reported from early through late Blancan faunas in Florida, Kansas, Nebraska, Texas, and Arizona (MacFadden and Waldrop, 1980). Both Dalquest and Donovan (1973) and MacFadden and Waldrop (1980) provided descriptions, figures, and measurements of lower deciduous premolars of Blancan *Nannippus*. Measurements of the Buckhorn *Nannippus* teeth are presented in Table 7, along with measurements of deciduous lower premolars of *N. peninsulatus* and *N. beckensis*. The Buckhorn dp3 is somewhat smaller than a sample of four dp3s of *N. beckensis* from Beck Ranch and slightly larger than dp3s of *N. peninsulatus* from Santa Fe River, Florida and Mount Blanco, Texas. The Buckhorn dp4 is within the size range sample of four dp3s of *N. beckensis* from Beck Ranch, is smaller than a dp4 of *N.*

peninsulatus from Mount Blanco, and larger than a dp4 of *N. peninsulatus* from Santa Fe River. The Buckhorn *Nannippus* appears to be intermediate in size between the larger *N. beckensis* and the somewhat smaller *N. peninsulatus*. Another character that separates these two species, the more hypsodont cheek teeth of *N. peninsulatus*, cannot be determined from deciduous teeth. We are not able to identify the Buckhorn *Nannippus* to species on the basis of the fossil material currently available.

Discussion—In addition to the fossils of *Nannippus* from Buckhorn described here, there are three other Blancan records of *Nannippus* from New Mexico. Tedford (1981) reported *Nannippus* from Las Palomas Creek in Sierra County in the south-central part of the state and from the Duncan basin near Virden in Hidalgo County along the Arizona border. Tomida (1987) included the Virden *Nannippus* (he identified this species as *N. phlegon*) and several other mammals in his Pearson Mesa fauna, which he considered to be middle Blancan in age and within the Gauss magnetic chron. Both Tedford (1981) and Tomida (1987) suggested that the occurrence of *Nannippus* was indicative of pre-late Blancan faunas (i.e., older than 2.5 Ma) in the southwestern United States. Vanderhill (1986) identified *N. peninsulatus* from his Blancan Faunule A in the Mesilla basin in Doña Ana County in southernmost New Mexico. Vanderhill considered Faunule A to be about 2.5 Ma in age based on the association with the Neotropical immigrant glyptodont, *Glyptotherium*, and on the occurrence of the fossils in normally magnetized sediments in the late Gauss magnetic chron. Blancan faunas of similar age to Faunule A in the Mesilla basin are the Hudspeth and Red Light local faunas in southwestern Texas (Strain, 1966; Akersten, 1972) and the 111 Ranch fauna in southeastern Arizona (Galusha et al., 1984; Tomida, 1987).

Order ARTIODACTYLA
Family TAYASSUIDAE
cf. *Platygonus* sp.

Referred Material—F:AM uncataloged (field number, Buck 1-7), proximal end of left radius-ulna. Frick Buckhorn site.

Discussion—The presence of a peccary in the Buckhorn local fauna is based on a single partial radius-ulna from the Frick Buckhorn site. This specimen was previously reported from Buckhorn as *Platygonus* by Tedford (1981) and *Platygonus vetus* by Leopoldt (1981). No tayassuid fossils have been identified from the various NMMNH Buckhorn sites. The Buckhorn radius-ulna is diagnostically tayassuid, but it is questionable whether or not this fragmentary limb can be identifed to genus. It is tentatively referred to *Platygonus* pending recovery of more diagnostic fossils from this fauna.

Most Blancan records of peccaries are of *Platygonus*, including the small species *P. pearcei* from Hagerman and Grand View in Idaho and White Bluffs in Washington and the larger *P. bicalcaratus* from Blanco (type locality), Rexroad, and numerous other sites ranging from early Blancan to early Irvingtonian (Kurtén and Anderson, 1980). A species of the smaller, more slender-limbed genus *Mylohyus*, *M. floridanus*, occurs in late Blancan faunas in Florida (Kurtén and Anderson, 1980), although it is unlikely that the Buckhorn peccary is referable to the Florida species. Peccaries are known from only one other Blancan fauna in New Mexico, the middle Blancan Las Palomas Creek local fauna from the Palomas Formation in Sierra County (Tedford, 1981).

Family CAMELIDAE
Hemiauchenia cf. *H. blancoensis* (Meade, 1945)

Referred Material—F:AM 47939, distal end of humerus, radius-ulna, miscellaneous foot bones; F:AM 124007, left astragalus. Frick Buckhorn site.

NMMNH P-26730, right astragalus; P-26731, patella. NMMNH locality L-2912.

NMMNH P-26619, tooth fragment; P-26620, left scaphoid; P-26621-26622, 2 left magnums; P-26623, right unciform; P-26624, left unciform; P-26625, left cuboid; P-26626, left navicular; P-26627, 3 calcaneum fragments; P-26628, proximal phalanx; P-26629-26630, 2 medial phalanges (many of the bones included in NMMNH P-26619-26630 may be from one individual). NMMNH locality L-2914.

NMMNH P-26636, proximal end of left radius-ulna. NMMNH locality L-2917.

NMMNH P-26639, thoracic vertebra; P-26640, lumbar vertebra; P-26641, head of humerus; P-26642, distal end of left humerus; P-26644, head of femur; P-26646, left unciform; P-26647, left calcaneum; P-26648-26649, 2 proximal phalanges; P-26650, medial phalanx; P-26651, distal phalanx (NMMNH P-26639-26651 may be associated elements from one individual). NMMNH locality L-2920.

NMMNH P-26653, lower molar. NMMNH locality L-3327.

NMMNH P-26660, distal end of left radius-ulna. NMMNH locality L-3328.

TABLE 7. Measurements of lower deciduous premolars of *Nannippus* from four Blancan sites: *Nannippus* sp. from the Buckhorn local fauna, New Mexico; *N. beckensis* from the Beck Ranch local fauna, Texas (measurements from Dalquest and Donovan, 1973, p. 42); and *N. peninsulatus* from Santa Fe River, Florida and Mount Blanco, Texas (measurements from MacFadden and Waldrop, 1980, table 3). Abbreviations are: length (L), width (W); mean (X), observed range (O.R.), and sample size (N).

	dp3		dp4	
	L	W	L	W
Nannippus sp.				
Buckhorn, NM				
F:AM 124009	22.2	9.3	25.8	8.7
Nannippus beckensis				
Beck Ranch, TX				
X	23.9	8.2	26.0	7.5
O.R.	23.1-25.1	6.8-8.9	25.2-26.8	6.0-8.1
N	4	4	4	4
Nannippus peninsulatus				
Santa Fe River, FL				
X	20.9	8.6	24.2	8.1
O.R.	20.7-21.1	8.5-8.7	—	—
N	2	2	1	1
Mt. Blanco, TX				
AMNH 104710	21.7	16.8	26.7	10.3

NMMNH P-26683, left astragalus; P-26684, right cuboid. NMMNH locality L-3467.

Discussion—Camelids are the most common large mammals in the Buckhorn local fauna, in particular from the various NMMNH localities. Identification of the Buckhorn camels is hindered by the lack of cranial material and mandibles. The camel sample does include several isolated teeth, but consists primarily of vertebrae, ends of limb bones, phalanges, carpals, and tarsals (Figs. 7F–J). A radius–ulna from the Frick Buckhorn site is the only nearly complete limb bone in the fauna (Fig. 7K). Measurements of the more complete camelid postcranial elements are provided in Table 8. These measurements indicate that the majority of the Buckhorn fossils are from medium-sized camels of the genus *Hemiauchenia*. Most other genera of Blancan camelids are of large or very large size, including *Camelops* and several genera of giant camels, such as *Blancocamelus*, *Gigantocamelus*, and *Titanotylopus*. A few bones from Buckhorn are identified below as *Camelops*, but comparisons with postcranial meaurements of *Camelops* (Webb, 1965, tables 9–11) indicate that most of the Buckhorn camel fossils are too small to be referred to this much larger camel.

There is a rather wide range of sizes represented in the *Hemiauchenia* sample from the Buckhorn local fauna, although *H. blancoensis* is supposedly the only species of this genus present in the Blancan (Kurtén and Anderson, 1980). *H. blancoensis* occurs in numerous faunas ranging from early Blancan to early Irvingtonian in age. We tentatively refer most of the Buckhorn camelid fossils to *H. blancoensis*, with the caution that a smaller species of *Hemiauchenia* may be present in the sample. More diagnostic cranial and mandibular material is needed to confidently identify these *Hemiauchenia* fossils to species. Camelids occur in most New Mexico Blancan sites (Tedford, 1981), but *Hemiauchenia* has been identified from only three of these faunas, including Buckhorn (Leopoldt, 1981; Tedford, 1981; this paper); Cuchillo Negro Creek (Lucas and Oakes, 1986); and Faunule A from the Mesilla basin (Vanderhill, 1986).

cf. *Camelops* sp.

Referred Material—F:AM 47943, partial left radius–ulna (including proximal end with unattached olecranon process and distal end), distal metapodials, calcaneum, and astragalus. Frick Buckhorn site.

Discussion—Several large camelid postcranial elements are tentatively identified as *Camelops*. They are larger than fossils referred above to *Hemiauchenia*, but are smaller than comparable elements of giant Blancan camels such as *Gigantocamelus* and *Blancocamelus*. A distal radius–ulna (measurements in Table 8) overlaps in size with specimens of late Pleistocene *Camelops* from Rancho la Brea (Webb, 1965, table 9). Compared to a distal radius–ulna of *Hemiauchenia* from Buckhorn (NMMNH P-26660), the Buckhorn *Camelops* (F:AM 47943) radius–ulna is considerably more robust with a much deeper distal articular surface in the antero-posterior dimension, in particular the distal end of the fused ulna that articulates with the cuneiform. The calcaneum and astragalus were identified as *Camelops* on F:AM specimen labels, but we did not have the opportunity to examine or measure these two elements. Leopoldt (1981) and Tedford (1981) previously reported *Camelops* from Buckhorn. This genus also occurs in a late Blancan fauna in the Mesilla basin in southernmost New Mexico (Tedford, 1981; Vanderhill, 1986).

Suborder Ruminantia
unidentified ruminant (cervid or antilocaprid)

Referred Material—F:AM uncataloged, proximal phalanx. Frick Buckhorn site.

Discussion—A cervid or antilocaprid is represented in the Buckhorn local fauna by a single proximal phalanx from the Frick Buckhorn site. The specimen is not adequate for a more precise identification. Ruminants are poorly represented in New Mexico Blancan faunas. The only previous records are the cervid *Odocoileus brachyodontus* from the early Blancan Truth or Consequences local fauna in Sierra County (Repenning and May, 1986) and the antilocaprid *Capromeryx* from the late Blancan Arroyo de la Parida local fauna in Socorro County (Tedford, 1981).

Order Proboscidea
Family Gomphotheriidae
cf. *Stegomastodon* sp.

Referred Material—NMMNH P-26635, associated elements from a single individual, including numerous fragments of tusks and cheek teeth, four thoracic vertebrae, one lumbar vertebra, tibia, distal two-thirds of fibula, two metapodials, astragalus, three carpals/tarsals, and four phalanges. NMMNH locality L-2916.

Discussion—A number of associated cranial and postcranial remains from one individual are tentatively referred to the gomphotheriid proboscidean *Stegomastodon*. This specimen includes numerous tooth and tusk fragments, but no complete teeth. Several of the tooth fragments are large enough to demonstrate that the teeth had complicated enamel lophs/lophids, as well as large numbers of accessory conules between the lophs/lophids and near the base of the crown. Cementum is clearly present on several of the tooth fragments. The complicated enamel, large number of accessory conules, and presence of cementum supports a tentative referral of this specimen to *Stegomastodon*. These tooth fragments appear to have more complicated enamel than the other three genera of proboscideans known from the Blancan of New Mexico, the mammutid *Mammut* and the gomphotheriids *Cuvieronius* and *Rhynchotherium*. The postcranial elements are not particularly diagnostic in identifying this specimen, but several comments and measurements are provided here. The tibia is nearly complete, with minor damage to the proximal and distal ends; its total length is 665 mm. Both the proximal and distal epiphyses of the tibia are unfused, indicating this was a juvenile individual. Overall, the tibia is short and very robust (Fig. 7L). The distal fibula (Fig. 7M) and all of the vertebrae (Fig. 7N) also have unfused epiphyses. A complete astragalus measures 155 mm in transverse breadth and 164 mm in anteroposterior length.

Stegomastodon is the most common proboscidean in Blancan faunas from New Mexico. Blancan records of *Stegomastodon* from the state include the early Blancan Truth or Consequences local fauna (Repenning and May, 1986) and the middle Blancan Cuchillo Negro Creek local fauna (Lucas and Oakes, 1986), both from the Palomas Formation in Sierra County, the middle Blancan Pearson Mesa fauna from the Duncan basin near Virden in Hidalgo County (Tomida, 1987), and the late Blancan Arroyo de la Parida local fauna from the Sierra Ladrones Formation near Socorro in Socorro County (Tedford, 1981; Lucas and Morgan, 1996). *Stegomastodon* occurs throughout the Blancan and survives into the early Irvingtonian (Kurten and Anderson, 1980). Three

other proboscideans are known from Blancan faunas in New Mexico, each of which has been reported from a single site. The primitive mastodont *Mammut raki* was described from a middle Blancan fauna located on the western side of Elephant Butte Reservoir in Sierra County (Frick, 1933; Lucas and Morgan, in press). *Rhynchotherium falconeri* has been identified in the late Blancan Arroyo de la Parida local fauna (Lucas and Morgan, 1996), and *Cuvieronius* sp. occurs in a Blancan/Irvingtonian transition fauna in the Mesilla basin in Doña Ana County (Vanderhill, 1986).

Age of the Buckhorn Local Fauna

Several genera and species of mammals in the Buckhorn local fauna are typical of the Blancan NALMA, and some of these species allow a more precise placement of this fauna within the Blancan. A brief discussion of the subdivisions and boundaries of the Blancan is presented here.

Tedford (1981) used a three-part subdivision of the Blancan: early Blancan (4.5–3.7 Ma); middle Blancan (3.7–2.5 Ma); late Blancan (2.5–2.0 Ma). Repenning (1987) divided the Blancan into five parts (Blancan I–V) based on his microtine (=arvicoline) rodent ages: Blancan I (4.8–4.2 Ma); Blancan II (4.2–3.7 Ma); Blancan III (3.7–3.2 Ma); Blancan IV (3.2–2.6 Ma); Blancan V (2.6–1.9 Ma). Repenning's Blancan I and II are roughly equivalent to Tedford's early Blancan, Blancan III and IV are equivalent to the middle Blancan, and Blancan V and late Blancan cover about the same time interval. There are minor discrepancies between Tedford (1981) and Repenning (1987) for the ages of the boundaries between the Hemphillian and Blancan and the Blancan and Irvingtonian. We follow Tedford (1981) and Lindsay et al. (1984) in placing the Hemphillian/Blancan boundary at 4.5 Ma. Several authors (e.g., Lundelius et al., 1987) have remarked that between about 2.2 and 1.8 Ma there was a gradual transition from Blancan to Irvingtonian faunas. We have arbitrarily chosen the midpoint of this time range (2.0 Ma) for the Blancan–Irvingtonian boundary (see more complete discussion in Morgan and Hulbert, 1995).

Repenning's (1987) microtine (=arvicoline) ages are quite useful biostratigraphically, provided a fauna contains arvicoline rodents. However, only two New Mexico Blancan faunas, Buckhorn and Truth or Consequences, have significant samples of microvertebrates, and only Buckhorn contains arvicolines. Despite extensive screenwashing, the Truth or Consequences local fauna has not produced any arvicolines, although the small mammal fauna recovered does permit fairly precise correlation (Repenning and May, 1986). Other Blancan faunas from New Mexico consist of large mammals that are not easily correlated with Repenning's microtine ages. Whenever possible we do indicate placement of New Mexico Blancan faunas in Repenning's system.

Taxa from the Buckhorn local fauna that are indicative of the Blancan include the large one-toed horse *Equus* (*Dolichohippus*) *simplicidens*, the small three-toed horse *Nannippus* sp. (either *N. beckensis* or *N. peninsulatus*), the sigmodontine rodent *Repomys* cf. *R. panacaensis*, and the arvicoline rodent *Mimomys* cf. *M. poaphagus*. Horses of the living genus *Equus* do not appear until the Blancan, whereas the extinct genus *Dinohippus*, the reputed "ancestor" of *Equus*, is typical of late Hemphillian faunas such as Walnut Canyon. The species *Equus* (*Dolichohippus*) *simplicidens* is apparently absent from very early Blancan faunas (Kurtén and Anderson, 1980), but is otherwise found throughout the remainder of the Blancan. The Buckhorn *Nannippus* probably is referable to either *N. beckensis* or *N. peninsulatus*, most likely the latter, but the material currently available is not sufficient for a species-level identification. *N. beckensis* is known from a single early to middle Blancan fauna, whereas *N. peninsulatus* occurs in numerous faunas spanning most of the Blancan. *Nannippus* apparently disappeared from the southwestern United States about 2.5 Ma (Tedford, 1981; Galusha et al. 1984). The rodent genus *Repomys* first appears in the late Hemphillian and goes extinct in the late Blancan. The species *R. panacaensis*, tentatively

TABLE 8. Measurements of camelid postcranials (*Hemiauchenia* and *Camelops*) from the Blancan Buckhorn local fauna, Grant County, New Mexico.

element taxon, and catalog number	total length	proximal width	proximal depth	distal width	distal depth
humerus					
Hemiauchenia cf. *H. blancoensis*					
F:AM 47939	—	—	—	60.9	—
NMMNH 26642	—	—	—	66.5	67.3
radius–ulna					
cf. *Camelops* sp.					
F:AM 47943	—	—	—	91.5	58.4
Hemiauchenia cf. *H. blancoensis*					
F:AM 47939	489[1]	—	—	54.5	—
NMMNH 26636	—	66.7[2]	—	—	—
NMMNH 26660	—	—	—	86.5	53.2
calcaneum					
Hemiauchenia cf. *H. blancoensis*					
NMMNH 26647	130.0	—	—	—	—
astragalus					
Hemiauchenia cf. *H. blancoensis*					
NMMNH 26683	51.9[3]	36.1[4]	—	—	—
NMMNH 26730	55.7	39.2	—	—	—
F:AM 124007	53.8	39.0	—	—	—
proximal phalanx					
Hemiauchenia cf. *H. blancoensis*					
NMMNH 26628	93.4	24.4	27.4	20.3	19.1
NMMNH 26649	98.2	28.3	28.8	23.8	21.3
NMMNH 26648	115.4	31.3	32.3	28.1	25.3

[1] This measurement is not actually the total length of the radius–ulna, but the length from the proximal articular surface to the distal end. The olecranon process is damaged, preventing a total length measurement—the length of this bone as preserved is 520 mm.

[2] The proximal width of the radius–ulna is the width across the proximal articular surface.

[3] The total length of the astragalus is the maximum antero-posterior length along the lateral edge.

[4] The proximal width of the astragalus is actually the maximum width.

identifed from Buckhorn, is known from only two other faunas, the early to middle Blancan (Blancan II or III) Panaca fauna in Nevada (May, 1981) and the middle Blancan (Blancan III or IV) Clarkdale local fauna in Arizona (Czaplewski, 1987). The Buckhorn arvicoline is a large species of *Mimomys* (subgenus *Ogmodontomys*), and is very similar to *M.* (*O.*) *poaphagus*, particularly samples of that species from Blancan II and Blancan III faunas, such as Rexroad (type locality) and Fox Cayon in Kansas, Sand Draw in Nebraska, and Verde in Arizona. One of the criteria for the boundary between the Blancan I and II microtine ages is the first appearance of large *Mimomys* (*Ogmodontomys*) at the base of Blancan II time (Repenning, 1987). By Blancan IV time, *Mimomys* (*Ogmodontomys*) had developed higher dentine tracts (Repenning, 1987) than are present in the Buckhorn arvicoline. The presence of a large *Mimomys* (*Ogmodontomys*) with poorly developed dentine tracts restricts the age of the Buckhorn local fauna to either Blancan II or Blancan III.

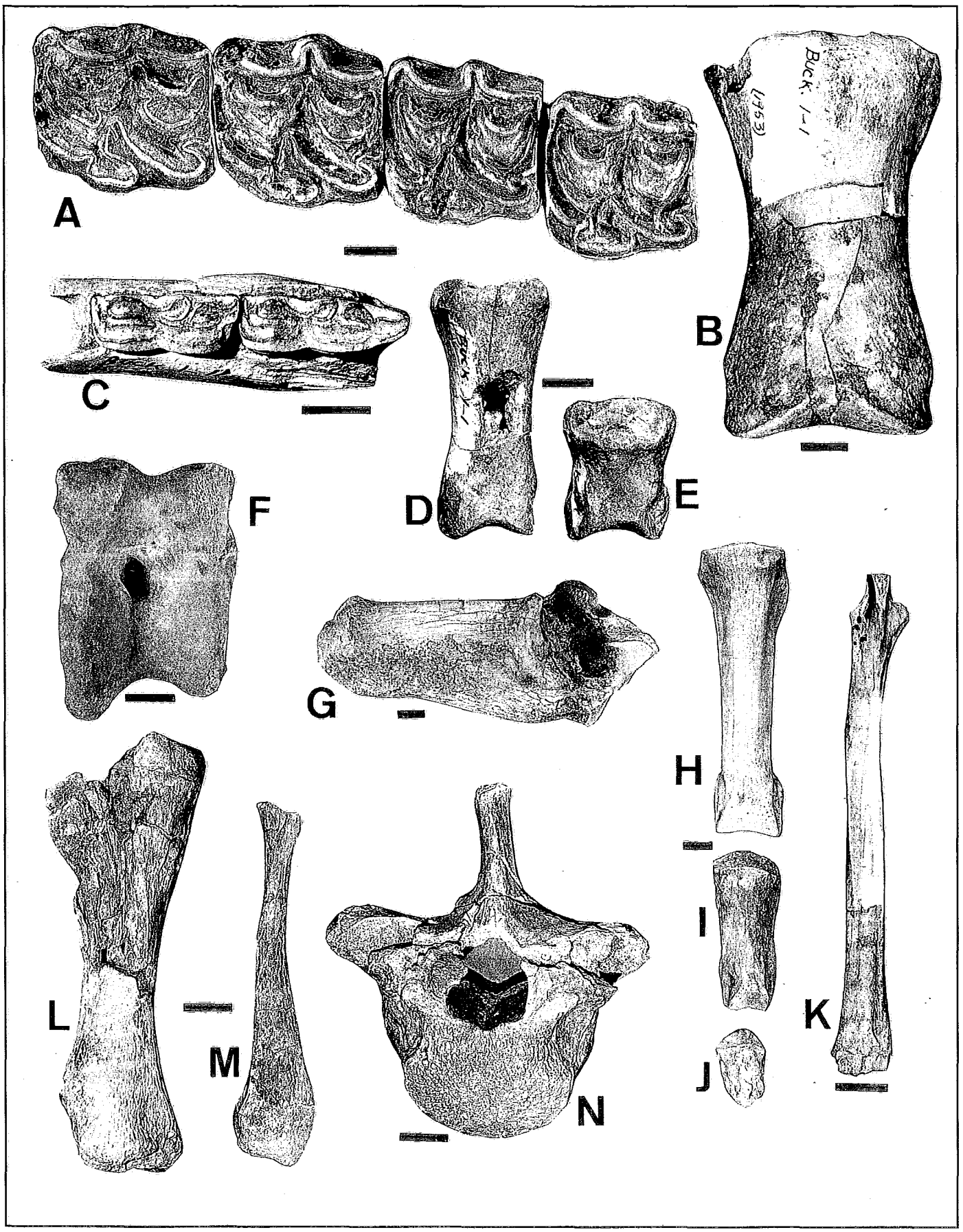
Tedford (1981) assigned a middle Blancan age to the Buckhorn local fauna based on the association of the small three-toed horse *Nannippus* and the larger horse *Equus* cf. (*Dolichohippus*) *simplicidens*. The great majority of Blancan records of *Nannippus* in the southwestern United States predate the Gauss–Matuyama magnetic reversal at 2.47 Ma, and are thus either early or middle Blancan in age (Tedford, 1981; Galusha et al., 1984). However, there are several late Blancan records of *N. peninsulatus*, including the type locality of this horse, the Blanco local fauna in Texas, and all Florida faunas in which this horse occurs (MacFadden and Waldrop, 1980; Morgan and Hulbert, 1995). The total absence of Neotropical immigrant mammals (glyptodonts, mylodont ground sloths, capybaras, porcupines, etc.) from Buckhorn strongly suggests that this fauna predates the Great American Faunal Interchange which began between 2.8 and 2.5 Ma (Galusha et al., 1984; Lindsay et al., 1984). Although the absence of species should be used with caution, the Buckhorn local fauna consists of numerous fossils from 14 different sites, lessening the likelihood that localized taphonomic and paleoecological differences or collecting biases are responsible for this absence of Neotropical immigrants.

A brief summary of the biochronological data for the Buckhorn local fauna is as follows. The presence of *Nannippus* and a primitive species of *Mimomys* (*Ogmodontomys*), as well as the absence of Neotropical immigrants, all suggest an age older than late Blancan or Blancan V (older than 2.5 Ma). The presence of *Equus simplicidens* seemingly rules out very early Blancan (Blancan I) faunas, as does the occurrence of a large member of the arvicoline subgenus *Ogmodontomys*. The evolutionary stage of the *Mimomys* (*Ogmodontomys*) species from Buckhorn (*M.* cf. *M. poaphagus*) is most consistent with a fauna younger than Blancan I and older than Blancan IV. The weight of the evidence indicates that the Buckhorn local fauna is either late early Blancan or early middle Blancan in age (Blancan II or Blancan III, about 4.0–3.0 Ma). Approximately correlative faunas in the southwestern United States are (ages mostly from Repenning, 1987; but also see Dalquest, 1978; Lucas and Oakes, 1986; Repenning and May, 1986; Czaplewski, 1987; 1990; Mou; 1997): Cuchillo Negro Creek (Blancan III or IV) and Truth or Consequences (Blancan II), New Mexico; Rexroad and Fox Canyon, Kansas (both Blancan II); Verde, Arizona (Blancan II); Panaca, Nevada (Blancan II or III); Clarkdale, Arizona (Blancan III); and possibly Beck Ranch, Texas (Blancan III).

The oldest Blancan fauna known from New Mexico is the early Blancan (Blancan II, 4.0–4.3 Ma) Truth or Consequences local fauna from the Palomas Formation in Sierra County (Repenning and May, 1986; Repenning, 1987). Truth or Consequences is the only other Blancan site in New Mexico, besides Buckhorn, that has been screenwashed for microvertebrates. The age of the Truth or Consequences site was determined from rodents and lagomorphs, as well as magnetostratigraphy (Repenning and May, 1986). However, Mack et al. (1993) questioned the magnetostratigraphy of Repenning and May (1986), and suggested that the Palomas Formation in this region may be as young as 3.4 Ma. Although the Truth or Consequences and Buckhorn local faunas appear to be similar in age (the former is Blancan II, the latter is either Blancan II or III), they have very few species in common. These faunal differences are more likely related to taphonomic, paleoecologic, or biogeographic factors, rather than to a marked difference in their ages. The Truth or Consequences local fauna was collected from a thin layer at a single locality and is composed primarily of small mammals. The Buckhorn local fauna was collected from 14 sites over a much larger area. Small mammals occur in three of the Buckhorn sites, while the other 11 sites have only large mammals. Even among small mammals the two faunas show little similarity. The two biochronologically diagnostic genera of rodents from Buckhorn, *Repomys* and *Mimomys*, are absent from Truth or Consequences, whereas the latter fauna lacks arvicolines, but has other age-diagnostic small mammals, including the rabbit *Notolagus lepusculus*, the pocket gopher *Geomys minor*, and the primitive packrat *Neotoma quadriplicata* (see Repenning and May, 1986). The similarity in age between these two faunas is not based on direct comparisons because they have so few species in common, but rather through comparisons with other well-dated Blancan faunas elsewhere in the southwestern United States.

Several other Blancan faunas have been reported from the Rio Grande Valley in central and southern New Mexico, although only a few of these faunas have been thoroughly studied. Three Blancan faunas from the Palomas Formation in Sierra County, Elephant Butte Reservoir (Tedford, 1981), Cuchillo Negro Creek (Lucas and Oakes, 1986), and Las Palomas Creek (Tedford, 1981), all appear to be middle Blancan in age (3.7–2.5 Ma, Blancan III or IV of Repenning, 1987). Late Blancan faunas are known from the Mesilla basin in Doña Ana County in the southernmost part of the state (Tedford, 1981; Vanderhill, 1986). Both Faunule A and

FIGURE 7. Fossil vertebrates from the Blancan Buckhorn local fauna, Grant County, New Mexico. **A.** *Equus* (*Dolichohippus*) *simplicidens*, associated left P3–M2, F:AM 124010. **B.** *Equus* (*Dolichohippus*) *simplicidens*, proximal phalanx, F:AM uncataloged. **C.** *Nannippus* sp., left mandible with dp3–dp4, F:AM 124010. **D.** *Nannippus* sp., proximal phalanx, F:AM uncataloged. **E.** *Nannippus* sp., medial phalanx, F:AM uncataloged. **F.** *Hemiauchenia* cf. *H. blancoensis*, left astragalus, NMMNH P-26683. **G.** *Hemiauchenia* cf. *H. blancoensis*, left calcaneum, NMMNH P-26647. **H.** *Hemiauchenia* cf. *H. blancoensis*, proximal phalanx, NMMNH P-26649. **I.** *Hemiauchenia* cf. *H. blancoensis*, medial phalanx, NMMNH P-26650. **J.** *Hemiauchenia* cf. *H. blancoensis*, ungual phalanx, NMMNH P-26651. **K.** *Hemiauchenia* cf. *H. blancoensis*, nearly complete radius–ulna, F:AM 47939. **L.** cf. *Stegomastodon* sp., tibia, NMMNH P-26635. **M.** cf. *Stegomastodon* sp., distal fibula, NMMNH P-26635. **N.** cf. *Stegomastodon* sp., thoracic vertebra, NMMNH P-26635. Scale bars are 1 cm for A–J; 5 cm for K; 40 cm for N; 80 cm for L–M.


A
B
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Faunule B from the Mesilla basin (Vanderhill, 1986) contain theNeotropical immigrant glyptodont, *Glyptotherium*. Faunule A contains *Nannippus peninsulatus* and occurs in normally magnetized sediments of the upper Gauss polarity epoch suggesting an age slightly older than 2.5 Ma, whereas the younger Faunule B lacks *Nannippus* and may represent the Blancan/Irvingtonian transition (Vanderhill, 1986). The Arroyo de la Parida local fauna from the Sierra Ladrones Formation, located farther north in the Rio Grande Valley near Socorro, is probably late Blancan. The association of the horses *Equus simplicidens*, *E.* cf. *E. cumminsii*, and *E.* cf. *E. scotti* in Arroyo de la Parida is typical of late Blancan southwestern faunas, but there are no Neotropical immigrants in this fauna to confirm a late Blancan age (Tedford, 1981; Lucas and Morgan, 1996). A Blancan fauna from the Sierra Ladrones Formation in Tijeras Arroyo near Albuquerque in Bernalillo County cannot be placed more precisely within the Blancan (Lucas et al., 1993).

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APPENDIX

MANGAS BASIN STRATIGRAPHIC SECTIONS

Duck Creek

Section measured in the NW¼ sec. 29, T14S R18W, section begins at UTM zone 12, 712072E, 3660058N. Top of section is pediment gravels at UTM zone 12, 712326E, 3659930N. Strata are flat-lying.

unit	lithology	thickness (m)
Formation D:		
28	Sandstone; pinkish gray (5YR8/1); like unit 27, but more poorly sorted, more indurated; tabular; bioturbated.	1.0
27	Sandstone; grayish orange pink (5YR7/2); fine-grained, subangular, well-sorted slightly clayey litharenite; blocky; bioturbated, with some interbeds of diatomaceous shale like unit 26; calcareous.	1.9

26 Sandy shale; same color and lithology as unit 24. 5.6
25 Sandstone; grayish orange pink (5YR7/2) with some light gray (N7); very fine- to medium-grained, subrounded, litharenite; calcareous to very calcareous; variably indurated, with more well-indurated portions light gray (N7) and more calcareous; ledge 2.6 m above base produces fossil birds. 4.2
24 Sandy shale; light brown (5YR6/4); diatomite; laminated to ripple laminated. 2.0
23 Tuff; very pale orange (10YR8/4) and pale yellowish brown (10YR6/2); well-indurated, not calcareous;forms a bench. 0.1–0.2
22 Interbedded muddy sandstone and sandy mudstone; grayish orange pink (5YR7/2); very fine- to fine-grained, subrounded, poorly sorted, clayey lithic wacke; very calcareous; tabular; interbeds typically 0.2–0.3 m thick. 2.1
21 Sandstone and mudstone; 1-m-scale interbeds of unit 19 and 20 colors and lithologies; forms a slope;many white calcrete nodules. 8.9
20 Sandy limestone; brownish gray (5YR6/1); very well-indurated; very calcareous; forms a ledge. 0.6
19 Mudstone; pale grayish red (10R5/2); calcareous; forms a slope. 1.3

Formation C:

18 Mudstone; pale grayish red (10R5/2); not calcareous. 0.8
17 Sandstone; same color and lithology as unit 15. 0.6
16 Mudstone; same color and lithology as unit 12. 1.5
15 Muddy sandstone and sandy mudstone; grayish orange pink (5YR7/2); very fine- to coarse-grained, poorly sorted, subrounded lithic wacke; calcareous; horizon produces Blancan fossils. 0.2
14 Mudstone; same color and lithology as unit 12. 0.7
13 Sandstone; same color and lithology as unit 11. 0.2
12 Sandy mudstone and sandy shale; yellowish gray (5Y8/1); slightly calcareous; blocky. 0.5
11 Sandstone; pale yellowish brown (10YR6/2); fine- to very coarse-grained, poorly sorted, subrounded lithic wacke; some gravel trough crossbeds; scour base; slightly calcareous; this horizon produces microtines and other Blancan fossils. 0.6
10 Diatomite; pinkish gray (5YR8/1); calcareous. 1.8
9 Sandstone; yellowish gray (5Y8/1); fine-grained, subrounded, moderately sorted litharenite; clayey; very calcareous; trough crossbedded; scour base; forms a ledge. 0.2
8 Mudstone/tuff; light brownish gray (5YR6/1); slightly calcareous. 0.8
7 Sandy mudstone; pale yellowish brown (10YR6/2); not calcareous. 0.4
6 Tuff; light greenish gray (5GY8/1) with blobs of light bluish gray (5B7/1) opal; not calcareous. 0.4
5 Welded tuff; light greenish gray (5GY8/1); not calcareous. 0.2
4 Mudstone; light olive gray (5Y6/1); calcareous; contains two lenses of sandstone 0.4 and 0.8 m thick 1.1 and 3.2 m above base; sandstone is light greenish gray (5GY8/1); very fine- to very coarse-grained, subangular, poorly sorted, lithic wacke; very immature; very calcareous. 5.5
3 Muddy sandstone; sandy mudstone; grayish orange pink (5YR7/2); sandstone is fine- to medium-grained, subangular, poorly sorted wacke; very calcareous; some laminar to low-angle planar crossbeds; forms abench/cliff; some scattered bone. 2.3
2 Mudstone; yellowish gray (5Y8/1); very calcareous; produces camel bones at site L-3467 2.5
1 Mudstone; grayish orange pink (5YR7/2); very calcareous; popcorn texture; slightly variegated with green bands. 7.8

North Fork of Walnut Canyon

Section measured begins at UTM zone 12, 731048E, 3645880N and ends at zone 12, 730829E, 3645267N.

unit	lithology	thickness (m)

Formation B:

upper member:

26 Sedimentary breccia; grayish orange pink (5YR7/2); matrix is very fine- to coarse-grained, angular to subangular, poorly sorted lithic wacke; clasts up to 5 mm diameter; subangular; conglomerate clasts are primarily quartz, biotite and volcanic debris; cyclical; not calcareous. 19–19.5
25 Sedimentary breccia; grayish orange pink (5YR7/2); clasts are andesitic; up to 60 mm diameter; matrix supported; not calcareous; graded beds; forms a prominent bench. 12.1
24 Sedimentary breccia; grayish orange pink (5YR7/2); matrix is very fine- to coarse-grained, angular to subangular, poorly sorted lithic wacke; clasts up to 5 mm diameter; subangular; conglomerate clasts are primarily quartz, biotite and volcanic debris; cyclical; not calcareous. 4.1

Offset from top of unit 23 at UTM zone 12: 731474E, 3646421N ESE to 731275E, 3645821N

23 Sedimentary breccia, same color and lithology as unit 12. 2.7

middle member:

22 Tuff; same color and lithology as unit 17. 0.4
21 Calcrete; same color and lithology as unit 19; more indurated. 0.2
20 Siltstone; same color and lithology as unit 18; abundant rhizoliths. 1.9
19 Calcrete; grayish orange pink (10R8/2); very clayey; stage II calcrete; slightly calcareous; forms a ledge. 0.4
18 Siltstone; grayish orange pink (10YR8/2); micaceous; massive to faintly trough crossbedded; not calcareous. 2.8
17 Devitrified welded tuff; light brownish gray (5YR6/1); not calcareous. 0.2
16 Sandstone and tuff; sandstone is same color and lithology as units 10, 14; trough crossbedded; and tuff is same color and lithology as unit 17, above. 3.1
15 Muddy siltstone; grayish orange pink (10R8/2); not calcareous. 0.4
14 Conglomeratic sandstone; same color and lithology as unit 12; not tuffaceous. 4.3
13 Conglomeratic sandstone; grayish orange pink (10R8/2); fine- to coarse-grained, angular, very poorly sorted litharenite matrix; clasts up to 10 mm diameter; volcaniclastic debris; not calcareous; trough crossbedded. 0.3
12 Clayey and conglomeratic sandstones; base is conglomeratic sandstone that is grayish orange pink (10R8/2); fine- to coarse-grained, angular, very poorly sorted litharenite matrix; clasts up to 10 mm diameter; volcaniclastic debris; not calcareous; trough crossbedded; clayey sandstone is grayish orange pink (5YR8/1); very fine- to coarse-grained, angular, very poorly sorted lithic wacke; not calcareous; contains abundant tuffaceous debris and silica-rich rhizoliths. 4.2
11 Sandy tuff; intermediate between pinkish gray (5YR8/1) and light brownish gray (5YR6/1); not calcareous; similar to unit 7. 0.3
10 Conglomeratic sandstone; moderate orange pink (5YR8/4); matrix is very fine- to coarse-grained, subrounded, moderately poorly sorted volcanic lithic wacke; volcaniclastic debris common; scour base; trough crossbedded; not calcareous. 1.0
9 Conglomeratic sandstone; grayish orange pink (5YR7/2); matrix is very fine- to coarse-grained, subrounded, moderately poorly sorted volcanic lithic wacke; slightly finer-grained than overlying unit; sedimentary breccia crops out 0.3 m above base; trough crossbedded. 0.8
8 Diatomaceous mudstone/muddy diatomite; very pale orange (10YR8/2); not calcareous; horse and camel quarry level; blocky. 1.1

Offset north across wash on top of unit 7 to horse quarry at UTM zone 12, 730193E, 3647120N

7 Devitrified, welded tuff; pale yellowish brown (10YR6/2); forms a persistent bench. 0.4

lower member:

6 Sandstone; very pale orange (10YR8/2); very fine-grained, subrounded, well-sorted litharenite; and grayish orange pink (5YR7/2); coarser grained, rhizolith sandstone identical to unit 5, below; neither sandstone is calcareous; abundant silicified rootlets. 1.4

5 Sandstone and sedimentary breccia; moderate orange pink (10YR8/4); very fine- to coarse-grained, pebbly, subangular, poorly sorted litharenite; well-indurated; not calcareous. 0.8

4 Sandstone; grayish orange pink (5YR7/2); very fine- to fine-grained, subangular- to subrounded, poorly sorted litharenite; not calcareous; massive. 1.7

3 Slightly sandy mudstone; grayish orange pink (5YR7/2); tuffaceous; calcareous. 0.3

2 Sandstone; same color and lithology as unit 1 with interbeds of pinkish gray (5YR8/1); very coarse-grained, subangular to angular, moderately poorly sorted, tuffaceous, litharenite; three cycles of graded beds 2.6, 2.2, and 3.0 m thick from bottom to top. 7.8

1 Sandstone and sedimentary breccia; light brown (5YR6/4); very fine- to coarse-grained, pebbly, subangular, poorly sorted litharenite; well-indurated; not calcareous; top is clayey; base is a scour; beds are graded. 1.0+