



## ***Late Hemphillian (Late Miocene) vertebrate fauna from the Black Mesa Quarry, Chamita Formation, Rio Arriba County, New Mexico***

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# LATE HEMPHILLIAN (LATE MIOCENE) VERTEBRATE FAUNA FROM THE BLACK MESA QUARRY, CHAMITA FORMATION, RIO ARRIBA COUNTY, NEW MEXICO

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**ABSTRACT.**—The Black Mesa Quarry contains a newly discovered vertebrate fauna of late Miocene (late Hemphillian) age from the Chamita Formation near Lyden, Rio Arriba County, northern New Mexico. This fauna is derived from the Cuarteles Member stratigraphically high in the Chamita Formation. The site is only 10-16 m below the overlying Pliocene Servilleta Basalt and is in a relatively intact landslide block on the eastern slope of Black Mesa. Eight taxa of mammals are currently known from the Black Mesa Quarry: the puma-sized cat *Pseudaelurus* cf. *P. hibbardi*, the one-toed horse *Dinohippus interpolatus*, the giant camel *Megatylopus* cf. *M. matthewi*, the llama-like camel *Hemiauchenia* cf. *H. vera*, an unidentified antilocaprid, the rabbit *Hypolagus* cf. *H. gidleyi*, a smaller unidentified rabbit, and a small unidentified murid rodent. Further work at the Black Mesa Quarry, together with additional screenwashing for microvertebrates, will certainly add to the faunal list. The Black Mesa mammals, in particular *D. interpolatus*, *M. matthewi*, and *H. gidleyi*, are similar to the well known late Hemphillian faunas from the San Juan Quarry and Rak Camel Quarries. These other quarries also occur in the Chamita Formation about 7 km to the southwest. Several <sup>40</sup>Ar/<sup>39</sup>Ar radioisotopic dates on tephra indicate that the San Juan Quarry and Rak Camel Quarries are between 6.8 and 7.0 Ma. The Black Mesa fauna is either time-equivalent to or somewhat younger than the San Juan Quarry fauna and Rak Camel Quarries fauna (5.9-6.8 Ma), but is older than latest Hemphillian (~5 Ma) faunas such as Walnut Canyon in southwestern New Mexico.

## INTRODUCTION

The Chamita Formation overlies the Tesuque Formation and is part of the Santa Fe Group in the Española basin of northern New Mexico (Fig. 1). It has produced vertebrate faunas representative of the Clarendonian and Hemphillian North American land-mammal “ages.” The Round Mountain Quarry of early Clarendonian age (late medial Miocene, ~11-12.5 Ma; Tedford et al., 2004) occurs low in the Chamita Formation on the Santa Clara Pueblo south of Española, about 25 km south of the type section of this formation (Galusha and Blick, 1971). Scattered fossils of early Hemphillian age (late Miocene, ~8-9 Ma) occur higher in the section (“Lower Chamita” sites of Tedford et al., 2004). The San Juan Quarry and Rak Camel Quarries faunas of late Hemphillian age (late Miocene, 6.8-7.0 Ma) occur in or immediately below the “Chamita upper tuffaceous zone” in the upper Chamita Formation (Galusha and Blick, 1971; MacFadden, 1977).

Daniel Koning recently discovered two teeth of the large one-toed horse *Dinohippus* in strata high in the Chamita Formation on the eastern side of Black Mesa near Lyden, Rio Arriba County, northern New Mexico. The authors and field crews from the New Mexico Museum of Natural History (NMMNH) visited this site in June and October 2004 to collect additional fossils. This site, here named the Black Mesa Quarry (NMMNH site L-5975), is located about 7 km northeast of the better known upper Hemphillian San Juan and Rak Camel Quarries (Fig. 1), which occur near the stratotype section of the Chamita Formation (Galusha and Blick, 1971; MacFadden, 1977; Tedford et al., 2004).

This is a preliminary report based on a limited sample of fossils collected during three trips to the Black Mesa Quarry. The Black Mesa vertebrate fauna presently consists of eight mammals, including a cat, a horse, two camels, a pronghorn, two rabbits, and a rodent. The fossils are well preserved and occur mostly as isolated elements. Individual teeth and postcranial elements are the

most common fossils encountered. An exception is a series of at least five articulated vertebrae of the large camelid *Megatylopus*. The large horse *Dinohippus* is the most abundant species in the Black Mesa Quarry, followed by *Megatylopus*. The three other

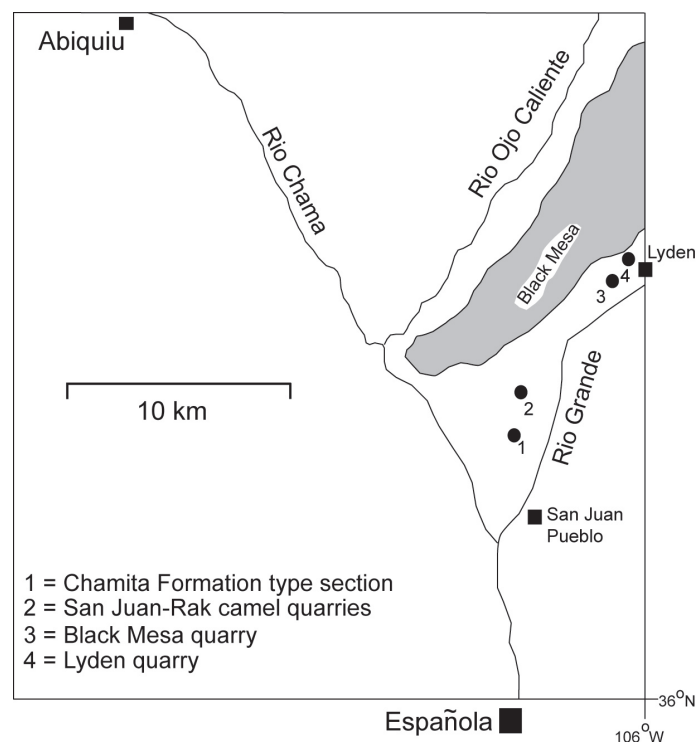


FIGURE 1. Index map showing the location of upper Hemphillian fossil sites in the Chamita Formation, including the Black Mesa Quarry, Española basin, Rio Arriba County, northern New Mexico. 1. Chamita Formation type section; 2. San Juan Quarry and Rak Camel Quarries; 3. Black Mesa Quarry; 4. Lyden Quarry.

species of large mammals in the fauna, a medium-sized felid, a small camelid, and an antilocaprid, are represented by only one or several fossils. Based on the discovery of several leporid teeth and postcranial elements on the surface of the quarry, we screen-washed a small sample (~100 kg) of sediment and have recovered additional specimens of rabbits, as well as small rodents. The Black Mesa Quarry fauna is certain to increase as we are planning further prospecting, excavating, and screenwashing, as well as prospecting in nearby exposures of the Chamita Formation.

We follow Tedford et al. (2004) in using the biochronology of the Hemphillian (late Miocene and earliest Pliocene, 4.9–9.0 Ma) North American land-mammal “age” (NALMA). Other abbreviations used are: AMNH (American Museum of Natural History) and NMMNH (New Mexico Museum of Natural History). Tooth positions are abbreviated as follows: upper teeth are designated by upper case letters followed by a number giving the tooth position (e.g., P4 is an upper fourth premolar), and lower teeth are designated by lower case letters and number for tooth position (e.g., m1 is a lower first molar).

### GEOLOGIC SETTING

The Black Mesa Quarry (NMMNH site L-5975) occurs in a landslide block of relatively intact strata along the eastern flank of Black Mesa, on the west side of the Rio Grande about 1.5 km west of Lyden, Rio Arriba County, north-central New Mexico (36°09'N, 106°02'W; Fig. 1). The site is located on private land and permission is needed for access. The fossils occur in a light gray, silty, very fine- to fine-grained, arkosic sand of the Cuarteles Member of the Chamita Formation. The quarry is probably in the uppermost portion of the Chamita Formation, about 10–16 m below the base of the Pliocene Servilleta Basalt. No distinct tephra beds were present in the near vicinity. The majority of the fossils occur within a stratigraphic interval of about 3 m in a small outcrop measuring about 25 m in width. Most of the fossils we describe are from the Black Mesa Quarry. A smaller outcrop of similar lithology at the same stratigraphic level occurs about 150 m farther east (NMMNH site L-5979). Several tooth fragments of *Dinohippus* are the only fossils recovered from this site. A complete metatarsal of *Dinohippus* and a partial distal humerus of the giant camelid *Megatylopus* were collected from a light brown, fine-grained sand at a third site (NMMNH site L-5980), located about 100 m south of the Black Mesa Quarry and at least 45 m lower in the stratigraphic section. This third site is in the Cejita Member of the Chamita Formation, which interfingers with the Cuarteles Member in this area (Koning and Aby, this volume).

MacFadden (1977) reviewed the magnetic polarity stratigraphy and biostratigraphy of the stratotype area of the Chamita Formation, located about 9–10 km southwest of the Black Mesa Quarry, and further discussed by Koning and Aby (this volume). The Chamita Formation here is 320 to 500 m thick, based on measurements by Galusha and Blick (1971) and MacFadden (1977), respectively. MacFadden based his biostratigraphy of the Chamita Formation stratotype on the faunas from several well-known fossil sites in the upper Chamita Formation, including the San Juan Quarry and Rak Camel Quarries. These quarries (the Rak Camel

Quarries consist of several sites) are located on the south side of Arroyo de los Borregos, 2.5–3.0 km north of the type section of the Chamita Formation. The San Juan Quarry and Rak Camel Quarries occur in a green silty clay at the same stratigraphic level, near the base of the Chamita upper tuffaceous zone and 190–325 m above the base of the stratotype (Galusha and Blick, 1971; MacFadden, 1977; Koning and Aby, this volume, fig. 4). Hereafter, we use the term San Juan-Rak Camel Quarries horizon for the combined fauna from these sites, following MacFadden (1977).

Without fossil data it would be difficult to correlate the Black Mesa Quarry strata with the Chamita Formation stratotype. The Black Mesa Quarry is about 6200 ft (1890 m) in elevation, whereas an old Frick Laboratory fossil quarry (NMMNH site L-5978) we recently rediscovered (either the San Juan Quarry or one of the Rak Camel Quarries) near the Chamita Formation stratotype is at 5830 ft (1777 m) in elevation. This places the Black Mesa Quarry approximately 370 ft (113 m) topographically higher than the San Juan-Rak Camel Quarries horizon of MacFadden (1977). The Black Mesa Quarry is only 10–16 m below the Pliocene Servilleta Basalt. The Servilleta Basalt lies over the Chamita Formation across an angular unconformity and is interpreted to be 2.8–3.7 Ma based on two radioisotopic dates:  $2.78 \pm 0.44$  Ma (K/Ar age, Manley, 1976a, 1976b) and  $3.65 \pm 0.09$  Ma ( $^{40}\text{Ar}/^{39}\text{Ar}$  age, Laughlin et al., unpublished report for Los Alamos National Laboratory, 1993). In their Chamita Formation type section, Galusha and Blick (1971) placed the San Juan Quarry and Rak Camel Quarries 125–130 m below the contact with the overlying unit, a terrace gravel. According to MacFadden (1977), these quarries lie 170 m below the Chamita Formation upper contact. However, differential preservation of the Chamita Formation due to latest Miocene-early Pliocene tectonism (Manley, 1976a, 1979; Koning et al., 2004a) does not allow use of the Servilleta Basalt as a stratigraphic datum for underlying strata. A previous north-south cross-section suggests the Black Mesa Quarry may lie 30–50 m above the Chamita upper tuffaceous zone (cross-section D-D' in Koning et al., 2004b), but any attempt to physically correlate strata between the Black Mesa Quarry and the Chamita Formation stratotype is made difficult by the prevalent mass-wasting along the eastern slopes of Black Mesa.

### SYSTEMATIC PALEONTOLOGY

#### CLASS MAMMALIA

#### ORDER CARNIVORA

#### FAMILY FELIDAE

#### *Pseudaelurus* cf. *P. hibbardi*

**Referred Specimen**—NMMNH 45109, partial right dentary with the canine and p3 (Figs. 2J, 2K).

**Description**—The anterior portion of a right dentary with the canine and p3 of a puma-sized felid was collected from the Black Mesa Quarry. The canine is fairly robust and elliptical in cross-section. The diastema separating the canine and the p3 is short. The two-rooted p3 is narrow and elongate with a tall, triangular primary cusp, a well-developed rounded secondary cusp posterior to the main cusp, and a smaller cusp on the cingulum at the posterior edge of the tooth. There is a large mental foramen ven-



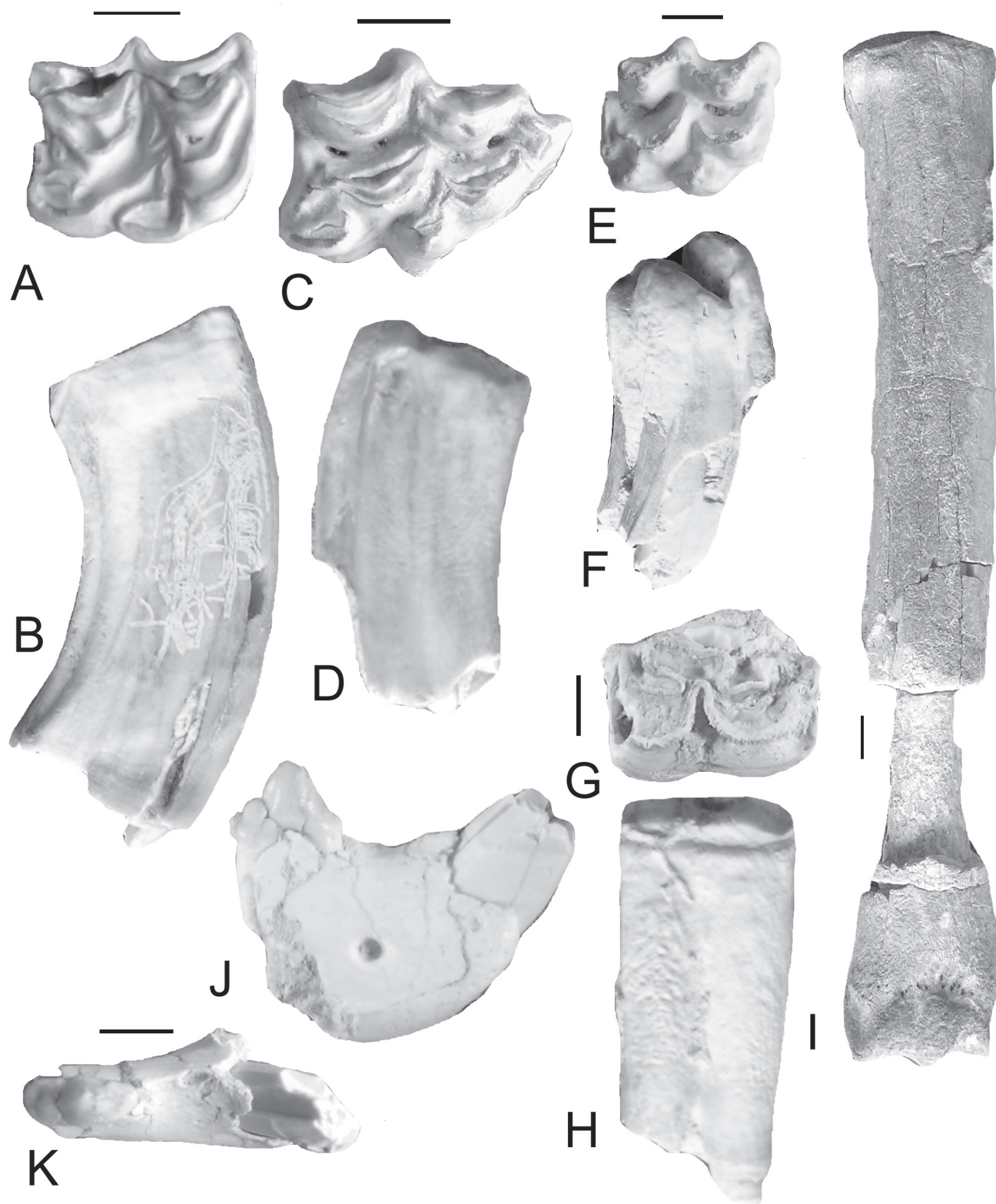


FIGURE 2. Mammalian fossils from the late Miocene (late Hemphillian) Black Mesa Quarry, Chamita Formation, Rio Arriba County, northwestern New Mexico. **A–I.** *Dinohippus interpolatus*. **A.** occlusal view, **B.** anterior view, right M1; NMMNH 45096; **C.** occlusal view, **D.** posterior view; right P2, NMMNH 45118; **E.** occlusal view. **F.** anterior view, right P4, NMMNH 45095; **G.** occlusal view, **H.** lateral view; left m1/m2, NMMNH 45097; **I.** metatarsal 3, anterior view, NMMNH 45128; **J.** lateral view, **K.** occlusal view, *Pseudaelurus* cf. *P. hibbardi*, partial right dentary with canine and p3, NMMNH 45109.

tral to the anterior edge of p3, about halfway between the ventral edge of the horizontal ramus and the alveolar margin. Measurements (in mm) of NMMNH 45109 are: anteroposterior length of canine, 14.2; width of canine, 9.9; anteroposterior length of p3, 14.0; width of p3, 6.5; length of diastema between canine and p3, 14.7; depth of horizontal ramus at mandibular symphysis, 25.2.

**Remarks**—The felid mandible from the Black Mesa Quarry is similar in size to the lower jaw of the mountain lion *Puma concolor*. There are three described species of felids in this size range from late Hemphillian faunas: *Adelphailurus kansensis* from the Edson local fauna in Kansas (Hibbard, 1934; Harrison, 1983), *Pseudaelurus hibbardi* from the Coffee Ranch local fauna in the Texas Panhandle (Dalquest, 1969), and *Megantereon hesperus* from the Palmetto fauna in Florida (Berta and Galiano, 1983). *Megantereon hesperus* is a medium-sized sabercat that differs from the Black Mesa felid in having a reduced p3, longer diastema, and much deeper mandibular symphysis with a moderately developed flange (Berta and Galiano, 1983). The type of *Adelphailurus kansensis* is represented only by the anterior portion of a skull and upper dentition, and thus cannot be directly compared to the Black Mesa mandible. Harrison (1983) mentioned undescribed specimens of *Adelphailurus* from two other late Hemphillian faunas, Optima (=Guymon), Oklahoma and Wikieup, Arizona. The type jaw of *Pseudaelurus hibbardi* is more robust than the Black Mesa felid jaw, particularly the lower canine (Dalquest, 1969); however, the p3 of *P. hibbardi* is shorter (11.1 mm compared to 14.0 mm), narrower (5.5 mm vs. 6.5 mm), and lacks a posterior accessory cusp. The felid mandible from the Black Mesa Quarry is tentatively referred to *P. hibbardi* based on similarity in size and overall morphology; however, its smaller canine, larger p3 with a strong posterior accessory cusp, and more gracile ramus suggest further comparisons are needed. Furthermore, ontogenetic and sexual variation are difficult to assess because of the small sample sizes typical of fossil cats.

ORDER PERISSODACTYLA  
FAMILY EQUIDAE  
*Dinohippus interpolatus*

**Referred Specimens**—NMMNH 45118, right P2 (Figs. 2C, 2D); NMMNH 45095, right P4 (Figs. 2E, 2F); NMMNH 45096, right M1 (Figs. 2A, 2B); NMMNH 45127, two upper cheek tooth fragments; NMMNH 45097, left m1/m2 (Figs. 2G, 2H); NMMNH 45098, partial lower cheek tooth; NMMNH 45099, partial incisor; NMMNH 45119, incisor; NMMNH 45128, metatarsal 3 (Fig. 2I) and associated lateral metatarsals 2 and 4.

**Description**—The most common species in the Black Mesa Quarry is the large one-toed (equine) horse *Dinohippus interpolatus*. This advanced horse is represented by four complete teeth, several partial teeth, and a complete metatarsal 3. Measurements of the four complete teeth are presented in Table 1. Measurements and dental nomenclature of horse teeth follow MacFadden (1984a). The Black Mesa *Dinohippus* teeth include (Fig. 2, Table 1): an unerupted and unworn right upper P4 (NMMNH 45095) and possibly associated lightly worn right upper M1 (NMMNH 45096), an unerupted and unworn right upper P2 (NMMNH 45118), and a

left lower m1 or m2 (NMMNH 45097). The most diagnostic teeth are the M1 and lower m1/m2. The P2 and P4 are both unworn, and thus their occlusal patterns are not fully developed.

The M1 is large, very high crowned, and fairly strongly curved when viewed anteriorly (Figs. 2A, 2B). This tooth has a well developed protocone with a rounded anterior margin and a narrower, pointed, triangular-shaped posterior margin. The connection between the protocone and protoloph is somewhat constricted. The hypoconal groove is well developed, extending to the base of the crown. The fossettes are crescent-shaped and fairly simple, with one large and one small plication on the posterior border of the prefossette and two small plications on the anterior border of the postfossette. A pli caballin is absent. Cement is present and moderately thick, especially on the lingual margin.

The m1/m2 is high crowned and straight (Figs. 2G, H). The metaconid and metastylid are both rounded, although the metastylid is much smaller. The linguaflexid is broadly V-shaped. The ectoflexid is well developed, extending slightly beyond the base of the isthmus. The protoconid and hypoconid are somewhat rounded. There is a thick covering of cement on both the lingual and labial margins. A protostylid and pli caballinid are absent.

A complete metatarsal 3 of *Dinohippus* (Fig. 2I) was collected from site L-5980, at least 45 m lower in the Chamita Formation than the Black Mesa Quarry (Fig. 1). This metatarsal appears to represent the same species of horse found in the Black Mesa Quarry. Measurements (in mm) of this metatarsal (NMMNH 45128) are: total length, 241; proximal width, 40.8; proximal depth, 34.2; midshaft width, 28.2; distal width, 37.6; distal depth, 28.7. The length of this metatarsal is very similar to the mean of 37 metatarsals (mean = 240.9) of *D. mexicanus* from the latest Hemphillian Yepómera fauna in Chihuahua, northern Mexico (Lance, 1950; MacFadden, 1984b).

**Remarks**—The M1, m1/m2, and metatarsal 3 of *Dinohippus* from the Black Mesa Quarry are similar in size and morphological characters to comparable elements of both *D. interpolatus* and *D. mexicanus*. Measurements of the best-preserved tooth of the Black Mesa *Dinohippus*, an M1 (NMMNH 45096), are within the

TABLE 1. Measurements (in mm) of teeth of *Dinohippus interpolatus* from the late Hemphillian Black Mesa Quarry, Chamita Formation, Rio Arriba County, New Mexico. Measurements follow descriptions and illustrations in MacFadden (1984a).

Tooth position and specimen number	anteroposterior length	transverse width	crown height <sup>1</sup>
Right P2 (NMMNH 45118)	35.7	26.6	55.2 <sup>2</sup>
Right P4 (NMMNH 45095)	31.8	28.2	66.7 <sup>2</sup>
Right M1 (NMMNH 45096)	25.5	27.7	79.7
Left m1/m2 (NMMNH 45097)	25.3	17.1	61.2

<sup>1</sup>Mesostyle crown height for upper teeth; metaconid crown height for lower tooth.  
<sup>2</sup>Tooth slightly damaged at base, crown height measurement is a minimum.

range of variation of a sample of 12 M1s of both *D. interpolatus* and *D. mexicanus* (MacFadden and Carranza-Castañeda, 2002, table 1). Based on the descriptions and illustrations in MacFadden (1984b) and MacFadden and Carranza-Castañeda (2002), the most important difference between the upper cheek teeth of *D. interpolatus* and *D. mexicanus* is the curvature—strongly curved in *D. interpolatus* and slightly to moderately curved in *D. mexicanus*. The strong curvature of the Black Mesa M1 (see Fig. 2B) is most similar to the upper molars of *D. interpolatus*. *D. mexicanus* appears to be transitional or ancestral to *Equus*, which has weakly curved upper cheek teeth (MacFadden and Carranza-Castañeda, 2002). The only sample of *D. mexicanus* from New Mexico is from the Walnut Canyon local fauna in the Gila Group in Grant County, southwestern New Mexico (Morgan et al., 1997). A comparison between the M1 from Black Mesa Quarry and three upper cheek teeth of *D. mexicanus* from Walnut Canyon (NMMNH 26786, 26787) shows that the Black Mesa tooth is more strongly curved, while the Walnut Canyon teeth are only slightly curved. Koning et al. (2004a, b) listed *D. mexicanus* from the Black Mesa Quarry based on a preliminary misidentification of these teeth by GSM. However, a more thorough analysis of the Black Mesa Quarry horse teeth, detailed here, confirms their identification as *D. interpolatus*.

*Dinohippus interpolatus* is characteristic of southwestern late Hemphillian faunas (Hh3, ~5.9–7.0 Ma), including Coffee Ranch, Edson in Kansas, Optima (=Guymon) in Oklahoma, and Redington and Camel Canyon in Arizona (MacFadden and Carranza-Castañeda, 2002), as well as the San Juan Quarry and Rak Camel Quarries in the Chamita Formation (MacFadden, 1977). *D. mexicanus* is typical of latest Hemphillian faunas (Hh4, ~4.9–5.9 Ma), including the type locality Yepómera in Chihuahua, northern Mexico and Rancho el Ocote in Guanajuato, central Mexico, as well as Walnut Canyon in southwestern New Mexico (Lance, 1950; Morgan et al., 1997; MacFadden and Carranza-Castañeda, 2002). *D. mexicanus* is the youngest and most morphologically-advanced species of one-toed horse in the Hemphillian, prior to the first appearance of *Equus* in the early Pliocene (early Blancan NALMA). *D. mexicanus* supposedly went extinct at the end of the Hemphillian (Tedford et al., 2004); however, recent studies indicate this species survived into the early Blancan in central Mexico (MacFadden and Carranza-Castañeda, 2002).

## ORDER ARTIODACTYLA

### FAMILY CAMELIDAE

#### *Hemiauchenia* cf. *H. vera*

**Referred specimens**—NMMNH 45101, right pisiform; NMMNH 45102, right lunar.

**Remarks**—Two possibly associated carpal elements, a pisiform and a lunar, represent a small camelid. These two carpals compare well in morphology with the same elements of *Hemiauchenia blancoensis* from Blancan sites in New Mexico but are considerably smaller. A small species of *Hemiauchenia* with elongated metapodials, *H. vera*, occurs in several other late Hemphillian faunas. MacFadden (1977) identified *H. vera* from the Chamita Formation, about 10 m below the top of the section, in

approximately the same stratigraphic position as the Black Mesa Quarry. MacFadden (1977) mentioned another smaller species of *Hemiauchenia* from the San Juan Quarry and Rak Camel Quarries. We tentatively refer the small *Hemiauchenia* from the Black Mesa Quarry to *H. vera*, pending the recovery of more diagnostic fossils and further comparisons with *H. vera* and the small *Hemiauchenia* from other Chamita Formation sites.

#### *Megatylopus* cf. *M. matthewi*

**Referred specimens**—NMMNH 45105, dentary fragment with two partial teeth; NMMNH 45106, three associated fragments of an upper molar; NMMNH 45129, partial distal humerus. Five articulated vertebrae were examined and partially excavated but are still in the field at the Black Mesa Quarry.

**Remarks**—A large species of camelid from the Black Mesa Quarry is represented by a jaw fragment with two partial teeth, a partial upper molar, and a partial distal humerus. These specimens are from a large camelid and compare most closely to the typical late Hemphillian genus *Megatylopus*. The most complete specimens yet discovered at the Black Mesa Quarry, five and possibly more articulated vertebrae, also belong to a large camelid, and are probably referable to *Megatylopus*. These vertebrae still remain in the field as of this writing, but will be excavated and removed during the 2005 field season. MacFadden (1977) identified *Megatylopus matthewi* from the San Juan Quarry and Rak Camel Quarries, and we tentatively refer the Black Mesa *Megatylopus* fossils to this species. Webb (1965) described *M. matthewi* from the late Hemphillian Coffee Ranch local fauna in Texas, a principal correlative of the San Juan Quarry and Rak Camel Quarries faunas (MacFadden, 1977). Harrison (1985) reported *Megatylopus* from several late Hemphillian sites in Arizona, including Camel Canyon, Redington, and Wikieup.

## FAMILY ANTILOCAPRIDAE

### Genus and species indeterminate

**Referred Specimens**—NMMNH 45103, partial lower cheek tooth; NMMNH 45104, distal metapodial fragment; NMMNH 45116, humeral head; NMMNH 45117, entocuneiform.

**Remarks**—Several fragmentary specimens from the Black Mesa Quarry belong to a medium-sized antilocaprid but cannot be identified to the genus or species level because the taxonomy of the family Antilocapridae is based on horn cores. MacFadden (1977) identified two antilocaprids, *Ilingoceras alexandrae* and *Osbornoceras osborni*, from the San Juan and Rak Camel Quarries.

## ORDER LAGOMORPHA

### FAMILY LEPORIDAE

#### *Hypolagus* cf. *H. gidleyi*

**Referred Specimen**—NMMNH 45110, left upper cheek tooth.

**Description**—A large rabbit is tentatively referred to the archaeolagine leporid *Hypolagus* based on a large upper cheek



tooth. This tooth is essentially identical in morphology and size to an upper cheek tooth identified as *Hypolagus* from the late Hemphillian San Juan-Rak Camel Quarries horizon. In the teeth from both sites, the hypostria extends only halfway across the breadth of the tooth, the thick enamel on the anterior margin of the hypostria is highly crenulated, and the thin enamel on the posterior margin of the hypostria is weakly crenulated. The transverse breadth of the two teeth is very similar (Black Mesa Quarry, 5.9 mm; San Juan-Rak Camel Quarries, 5.8 mm).

**Remarks**—Although upper teeth of leporids are generally considered non-diagnostic (White, 1987), the leporid sample from the San Juan-Rak Camel Quarries horizon, including several diagnostic p3s, appears to belong to a single species of large *Hypolagus*. MacFadden (1977) referred the Chamita leporid to *Hypolagus vetus*, but White (1987) later reidentified it as the larger species, *H. gidleyi*. White (1987) also identified *H. gidleyi* from the late Hemphillian Coffee Ranch fauna and several early Pliocene (early Blancan) faunas. Much of the leporid material listed below under “genus and species indeterminate” probably belongs to *Hypolagus* as well, although rabbit postcranials are not diagnostic except as an indicator of size.

#### Genus and species indeterminate

**Referred Specimens**—NMMNH 45121, partial upper cheek tooth; NMMNH 45120, M3; NMMNH 45111, upper incisor fragment; NMMNH 45112, proximal femur (juvenile); NMMNH 45113, 45122, 45123, phalanges; NMMNH 45124, ungual phalanx (claw).

**Remarks**—The lagomorph specimens listed here are not diagnostic below the family level. However, the partial upper cheek tooth (NMMNH 45121) is significant because it is much smaller than the upper cheek tooth referred above to *Hypolagus*, and also differs in having highly crenulated enamel on both the anterior and posterior margins of the hypostria. This smaller tooth almost certainly represents a second species of leporid in the Black Mesa Quarry fauna.

### ORDER RODENTIA

#### FAMILY MURIDAE

#### Genus and species indeterminate

**Referred Specimen**—NMMNH 45125, left dentary with incisor and alveoli for m1-m2.

**Remarks**—A tiny murid rodent mandible was recovered by screenwashing sediment from the Black Mesa Quarry. The partial jaw is well preserved but bears only the lower incisor and lacks the diagnostic m1. This mandible cannot be identified below the family level; however, we are confident that further screenwashing of the Black Mesa Quarry will eventually produce diagnostic teeth of murid rodents. We also intend to screenwash sediments from the upper Hemphillian San Juan-Rak Camel Quarries horizon lower in the Chamita Formation. The late Hemphillian is a very interesting time interval for the evolution of North American murid rodents. Some of the earliest members of the South American group of murid rodents (“sigmodontines” or “phyllostines”)

have been described from late Hemphillian White Cone (Baskin, 1978, 1979) and Redington (Jacobs, 1977) faunas in Arizona. These faunas are similar in age to the Black Mesa Quarry and the San Juan Quarry and Rak Camel Quarries.

### DISCUSSION

In the following discussion, we make preliminary biostratigraphic comparisons of the mammalian fauna from the Black Mesa Quarry with several other late Hemphillian faunas from the upper Chamita Formation, in particular the well known San Juan Quarry and Rak Camel Quarries. MacFadden (1977) reviewed the biostratigraphy and magnetostratigraphy of the Chamita Formation stratotype. McIntosh and Quade (1995) obtained several radioisotopic dates from the Chamita upper tuffaceous zone, the base of which is near the stratigraphic level of the San Juan Quarry and Rak Camel Quarries. The well-studied geochronology of the San Juan-Rak Camel Quarries horizon is very helpful for biostratigraphic comparisons with the Black Mesa Quarry, as well as correlation with other late Hemphillian faunas in Texas and Arizona.

MacFadden (1977) listed 14 species of mammals from the San Juan-Rak Camel Quarries horizon in the upper Chamita Formation. More than half of these mammals are age diagnostic and are typical of late Hemphillian faunas (Hh3, 5.9-7.0 Ma; Tedford et al., 2004), including: the wolverine *Plesiogulo* sp.; the badger *Pliotaxidea garberi*, the dog *Eucyon davisi*, the rabbit *Hypolagus vetus*, the beaver *Dipoides williamsi*, the horses *Astrohippus ansae* and *Dinohippus interpolatus*, the large camelid *Megatylopus matthewi*, and the pronghorn antilocaprids *Osbornoceros osborni* and *Ilingoceras alexandrae*. Harrison (1981) has since referred the wolverine to *Plesiogulo marshalli* and White (1987) reidentified the rabbit as *Hypolagus gidleyi*.

We recently rediscovered one of the old Frick Laboratory quarries (NMMNH site L-5978) in the Chamita Formation on the south side of Arroyo de los Borregos. We are not certain if this is the San Juan Quarry or one of the Rak Camel Quarries. It was obvious that a large amount of sediment had been excavated from this site and there was a considerable amount of bone present on the surface. We also found another site at about this same stratigraphic level about 500 m farther west on the south side of Arroyo de los Borregos, and immediately below the lowest bed of the Chamita upper tuffaceous zone (NMMNH site L-5976). Fossils collected from these two sites include at least five species of mammals typical of the San Juan-Rak Camel Quarries horizon of MacFadden (1977): *Astrohippus ansae*, *Dinohippus interpolatus*, *Megatylopus matthewi*, *Hypolagus gidleyi*, and *Dipoides williamsi*.

McIntosh and Quade (1995) obtained several  $^{40}\text{Ar}/^{39}\text{Ar}$  ages on tephra within the Chamita upper tuffaceous zone, with an age of  $6.93 \pm 0.05$  Ma near the base and an age of  $6.78 \pm 0.03$  Ma near the top. These  $^{40}\text{Ar}/^{39}\text{Ar}$  dates constrain the absolute age of the San Juan-Rak Camel Quarries horizon, which lies at or immediately below the base of the Chamita upper tuffaceous zone, to between 6.8 and 7.0 Ma. Izett and Obradovich (2001) obtained a  $^{40}\text{Ar}/^{39}\text{Ar}$  date of  $6.9 \pm 0.03$  Ma on the upper tuffaceous zone of



the Chamita Formation at the stratigraphic level of the San Juan and Rak Camel Quarries. Tedford et al. (2004) gave an age of ~7.0 Ma for the San Juan and Rak Camel Quarries based on the radioisotopic dates discussed above, and assigned these faunas to the early part of the late Hemphillian (early Hh3). An  $^{40}\text{Ar}/^{39}\text{Ar}$  date of 6.8 Ma on a volcanic ash just above the Coffee Ranch Quarry in the Texas Panhandle (Izett and Obradovich, 2001) is similar in age to the tephra dates bracketing the San Juan-Rak Camel Quarries horizon. Tedford et al. (2004) noted the similarity of the mammalian fauna from the San Juan-Rak Camel Quarries horizon to the late Hemphillian fauna from Coffee Ranch. Other correlative late Hemphillian faunas include Edson in Kansas, Optima (=Guymon) in Oklahoma, and White Cone and Redington in Arizona (Lindsay et al., 1984).

The limited mammalian fauna currently known from the Black Mesa Quarry has several species in common (including provisionally referred taxa) with the late Hemphillian fauna from the San Juan-Rak Camel Quarries horizon, including *Dinohippus interpolatus*, *Megatylopus matthewi*, and *Hypolagus gidleyi*. Although sample sizes from the Black Mesa Quarry are currently small, *Dinohippus interpolatus* is the most common species in the fauna, and *Astrohippus* is absent. In the San Juan Quarry and Rak Camel Quarries, the most common horse is *Astrohippus ansae*, and *D. interpolatus* is rare.

The biostratigraphy of the Black Mesa mammals is not yet well enough known to establish if this fauna is the same age as the San Juan-Rak Camel Quarries strata, or if certain of the taxa indicate a somewhat younger age. The late Hemphillian (Hh3) is slightly more than a million years in duration, between 5.9 Ma and 7.0 Ma. Radioisotopic dates from the San Juan-Rak Camel Quarries horizon (McIntosh and Quade, 1995) and Coffee Ranch (Izett and Obradovich, 2001) suggest these faunas are early late Hemphillian in age (6.8–7.0 Ma), whereas the Black Mesa Quarry could be as young as ~6 Ma and still possess a similar late Hemphillian fauna. The presence of *Dinohippus interpolatus* suggests that the Black Mesa fauna is not latest Hemphillian in age (i.e., no younger than 5.9 Ma).

The only latest Hemphillian (Hh4; ~4.9–5.9 Ma) fauna known from New Mexico is the Walnut Canyon local fauna from the Gila Group in southwestern New Mexico (Morgan et al., 1997). The Walnut Canyon and Black Mesa faunas do not appear to have any taxa in common. The horses *Dinohippus mexicanus* and *Astrohippus stockii* are present in Walnut Canyon, whereas *D. interpolatus* occurs at Black Mesa and *Astrohippus* is absent. Further study of the felid mandible and the discovery of additional diagnostic rodents and other mammals should help clarify the biostratigraphic age of the Black Mesa Quarry strata.

Galusha and Blick (1971) and MacFadden (1977) briefly mentioned the Lyden Quarry of the Frick Laboratory, in the upper Chamita Formation near Lyden. The Lyden Quarry is indicated on a map of Española area fossil sites hand drawn by John C. Blick in 1936 (Galusha and Blick, 1971, fig. 7). It is located near the head of a short, steep canyon northwest of Lyden on the Blick map, which appears to be the next major wash north of the Black Mesa Quarry. The Black Mesa Quarry and Lyden Quarry are almost certainly different sites, probably located within 1–2 km

of one another. The relative stratigraphic levels of these two sites are unclear. It is difficult to correlate strata along the eastern slope of Black Mesa because this slope generally consists of numerous landslide complexes. Galusha and Blick (1971) did not indicate the stratigraphic position of the Lyden Quarry on their section of the Chamita Formation. They cited a personal communication from Morris Skinner that there are "...horses in the collections from Lyden Quarry...that he [Skinner] regards as late Hemphillian forms" (Galusha and Blick, 1971, p. 107). MacFadden (1977, p. 796) noted that "The [mammalian] assemblage from this horizon [Lyden Quarry] is generally similar to the fauna from the statotype [San Juan-Rak Camel Quarries horizon]." Galusha and Blick stated that latest Hemphillian faunas are not known from the Chamita Formation. Wang et al. (1999) identified the borophagine canid *Borophagus secundus* from the Lyden Quarry. Most sites where *Borophagus secundus* (including *Osteoborus cyonoides*) occurs are late Hemphillian in age, including Coffee Ranch, Optima, and Edson. Study of the mammalian fauna from the Lyden Quarry in the F:AM collection, and comparisons with faunas from the Black Mesa Quarry and the San Juan Quarry and Rak Camel Quarries, should permit a more precise assessment of the comparative biostratigraphic age of these faunas.

## CONCLUSION

Eight species of mammals were collected from the upper Chamita Formation in the newly discovered Black Mesa Quarry, located on private land 1.5 km west of Lyden in Rio Arriba County. Age-diagnostic mammals from the Black Mesa Quarry include *Pseudaelurus* cf. *P. hibbardi*, *Dinohippus interpolatus*, *Megatylopus* cf. *M. matthewi*, *Hemiauchenia* cf. *H. vera*, and *Hypolagus* cf. *H. gidleyi*. These species are typical of late Hemphillian faunas (Hh3, 5.9–7.0 Ma). *D. interpolatus* is indicative of late Hemphillian faunas, whereas the more advanced species *D. mexicanus* is restricted to latest Hemphillian faunas (Hh4, 4.9–5.9 Ma). The Black Mesa Quarry shares at least three species, *D. interpolatus*, *M. matthewi*, and *H. gidleyi*, with the late Hemphillian San Juan and Rak Camel Quarries, which are derived from the Chamita Formation stratotype near the base of the Chamita upper tuffaceous zone. Several  $^{40}\text{Ar}/^{39}\text{Ar}$  dates from the upper tuffaceous zone of the Chamita Formation constrain the age of the San Juan and Rak Camel Quarries strata to between 6.8 and 7.0 Ma. The Black Mesa Quarry may be located slightly higher in the Chamita Formation than the San Juan and Rak Camel Quarries, but the precise stratigraphic separation between these faunas is not known. The presence of *D. interpolatus* in the Black Mesa Quarry and the possible stratigraphic occurrence of this site above the San Juan-Rak Camel Quarries horizon argues for a late Hemphillian age (5.9–6.8 Ma). This provides an important minimum age limit for the Chamita Formation in this part of the Española basin.

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