



Late Pleistocene mammoths (*Mammathus Columbi*) from Mesa Redonda, Quay County, east-central NM

Gary S. Morgan, Spencer G. Lucas, and Mark E. Gordon
2001, pp. 285-292. <https://doi.org/10.56577/FFC-52.285>

in:
Geology of Llano Estacado, Lucas, Spencer G.;Ulmer-Scholle, Dana; [eds.], New Mexico Geological Society 52nd Annual Fall Field Conference Guidebook, 340 p. <https://doi.org/10.56577/FFC-52>

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LATE PLEISTOCENE MAMMOTHS (*MAMMUTHUS COLUMBI*) FROM MESA REDONDA, QUAY COUNTY, EAST-CENTRAL NEW MEXICO

GARY S. MORGAN, SPENCER G. LUCAS AND MARK E. GORDON
New Mexico Museum of Natural History, 1801 Mountain Road NW, Albuquerque, NM 87104

Abstract.—In 1929, Robert Abercrombie discovered parts of at least five mammoth skeletons near Mesa Redonda, Quay County, New Mexico. Nelson Vaughn of the Colorado Museum of Natural History (now the Denver Museum of Nature and Science) supervised the excavation of these mammoths in 1930. Many of the Mesa Redonda mammoth fossils were transferred to the New Mexico Museum of Natural History and Science in 1985 where they were used to construct a composite mounted skeleton now on display. The mammoth fossils were recovered from an alluvial fan deposit of probable late Pleistocene age. Measurements of three *Mammuthus* M3s from Mesa Redonda result in ranges of: length, 241-257 mm; width, 92-101 mm; crown height, 187-271 mm; enamel thickness, 2.3-3.0 mm; 17-19 plates; and lamellar frequency (plates/100 mm) of 6-8. The measurements and morphology of the Mesa Redonda mammoth teeth support their assignment to *Mammuthus columbi*. The presence of *M. columbi* and the associated fauna of extant terrestrial gastropods indicates a late Pleistocene (late Rancholabrean) age for the Mesa Redonda fauna. The gastropod assemblage suggests a relatively mesic, riparian habitat of grasses and woody, deciduous vegetation.

INTRODUCTION

In 1929, Robert Abercrombie discovered mammoth remains in a dry stream bed northeast of Mesa Redonda, south of Tucumcari, Quay County, northeastern New Mexico (Fig. 1). Abercrombie's find generated considerable interest because of the discovery just a few years earlier of Paleoindian artifacts associated with extinct Pleistocene *Bison* at Folsom, New Mexico. Several museums expressed an interest in the mammoths, including the Colorado Museum of Natural History (CMNH), the Museum of New Mexico, and the Frick Laboratory of the American Museum of Natural History in New York. The mammoths were subsequently excavated in 1930 by the CMNH. Gillette et al. (1985) briefly discussed the history of the Mesa Redonda mammoths. A portion of the Mesa Redonda mammoth sample was transferred to the New Mexico Museum of Natural History (NMMNH) in Albuquerque in 1985, and was eventually mounted as a composite skeleton now on display in the NMMNH. We review the history of the Mesa Redonda site and the excavation of the mammoths, describe the locality and geology, provide descriptions, measurements, and photographs of mammoth teeth, and discuss the associated molluscan fauna.

MATERIALS AND METHODS

The authors visited the Mesa Redonda mammoth site in December 2000 with Howard Abercrombie and Robert Abercrombie, Jr., the son and grandson, respectively, of the discoverer of the site, Robert Abercrombie, Sr. We made geological observations, took site photographs, collected samples for lithological analysis, and collected sediments to screenwash for microvertebrates and mollusks. The vertebrate fossils from the Mesa Redonda site are housed in the Denver Museum of Nature and Science in Denver, Colorado (formerly known as the Denver Museum of Natural History-DMNH) and the New Mexico Museum of Natural History and Science in Albuquerque (NMMNH). The mollusk samples are housed in the NMMNH. When the Mesa Redonda mammoth site was discovered and excavated in 1929 and 1930, the DMNH was called the Colorado Museum of Natu-

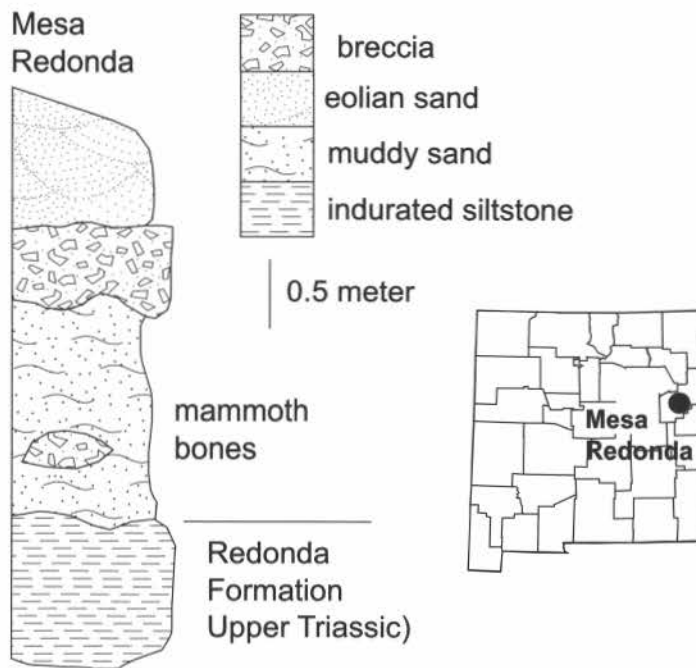


FIGURE 1. Stratigraphic section of Mesa Redonda site and map of New Mexico showing location of Mesa Redonda site (NMMNH site L-3736) in Quay County.

ral History (CMNH). To keep the account of the site in its proper historical context, the museum in Denver is referred to as the Colorado Museum of Natural History or CMNH when discussing the events surrounding the excavation of the mammoths. However, all specimens housed in Denver have the acronym DMNH. Measurements of fossils are in mm, and were taken with either digital calipers or a metric tape measure.

HISTORY OF THE SITE

Much of the history regarding the discovery and excavation of the Mesa Redonda mammoth site is preserved in the correspondence of Harold J. Cook, Honorary Curator of Paleontology at

the CMNH, who was instrumental in determining the importance of the site, and Nelson J. Vaughn, who conducted the actual excavation of the mammoths for the CMNH. The following historical account is mostly derived from their letters, now curated in the archives of the DMNH (copies in NMMNH).

The Mesa Redonda mammoth site was discovered in 1929 by Robert Abercrombie, Sr., a rancher and amateur fossil collector from Tucumcari, New Mexico. Abercrombie contacted Dr. Hewett, the director of the State Museum in Santa Fe, about the Mesa Redonda mammoth find. Hewett did not have the personnel to assist Abercrombie in the excavation and recommended that he contact Harold Cook. At that time, Cook was investigating late Pleistocene sites in eastern New Mexico in search of localities documenting the association between Paleoindians and extinct Pleistocene mammals. In the summer of 1929, Abercrombie showed the Mesa Redonda site to Cook, who expressed a strong interest in excavating the site. The earliest reference to the mammoth site was in a letter dated 24 July 1929, from Harold J. Cook to Walter C. Mead. The following is an excerpt from that letter referring to the Mesa Redonda mammoths:

"I believe we have located...perhaps the most remarkable deposit of Elephant bones yet known in this country...There are at least six mammoths present, and probably more, in one spot not forty yards across, in gravels and sand deposits of Pleistocene age...Parts of eight tusks are exposed as it is, and parts of several jaws and skulls, and many limb bones, ribs, vertebrae, etc. They seem to be scattered and disarticulated, for the most part..."

A letter dated just five days later, 29 July 1929, to Childs Frick from Charles Falkenbach, a collector for the Frick Laboratory at the American Museum of Natural History, indicated that the Frick Lab also was interested in the Mesa Redonda mammoths. Cook decided that the CMNH would excavate the Mesa Redonda mammoth site, and sent Nelson Vaughn to Tucumcari in September 1929 to make the arrangements.

The CMNH leased the parcel of land containing the Mesa Redonda mammoth site from the landowner, Charles J. Ford, for \$100 on 26 March 1930, for the specific purpose of recovering the mammoth fossils. The excavation at the Mesa Redonda mammoth site lasted from March to June 1930, and was under the direction of Nelson Vaughn. A considerable amount of information pertaining to the site is contained in an extensive correspondence between Vaughn and J. D. Figgins, then Director of the CMNH. Vaughn drew a rough map of the Mesa Redonda site (redrawn here as Fig. 3) showing a segment of the dry wash approximately 150 ft long, with the main bone deposit at the northern end of the site and a smaller concentration of bones about 75-100 ft to the south. Vaughn's letters indicate that the main bone concentration contained at least four mammoth tusks; an associated mammoth with a maxilla with one molar, pair of lower jaws, scapula, humerus, sacrum, pelvis, six vertebrae, 11 ribs, and two foot bones; and another mammoth with 14 articulated vertebrae. The southern site had a partial skull with a tusk, a pair of lower jaws, humerus, pelvis, vertebrae, and ribs. The CMNH excavations at the Mesa Redonda site ended in June 1930, and to our knowledge no one has excavated there since.

LOCALITY AND GEOLOGY

The Mesa Redonda mammoth site (NMMNH site L-3736; DMNH site 1006) is located in and along the eastern bank of a small, unnamed arroyo that flows northeast from the base of Mesa Redonda, about 23 km south of Tucumcari, Quay County, New Mexico (Figs. 1-3). The site is in the NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 26, T9N, R31E (Norton, NM, USGS 7.5' quadrangle), and the UTM coordinates are 3870956N, 625678E, (Zone 13, NAD 27). The bone-bearing stratum at the site is a 1.0- to 1.5-m thick layer of friable, light brown (5 YR 5/6) to moderate reddish-brown (10 R 4/6), very fine-grained to fine-grained, muddy sand (Figs. 1, 2). This bed rests directly on Upper Triassic bedrock of light brown (5 YR 3/4) to moderate reddish-brown (10 R 6/6) calcareous siltstone that is blocky and locally bioturbated of the Redonda Formation of the Chinle Group. Above the bone layer is a 0.3- to 0.5-m thick sedimentary breccia with imbricated clasts of Mesozoic sandstone and limestone that indicate paleoflow to the northeast. Lenses of such breccia also occur in the bone-bearing layer. Pedogenesis at the top of the bone-bearing sand locally has produced a 0.2-m thick layer of pale yellowish-brown (10 YR 6/2) sandy clay. The top of the section at the mammoth site is an unconsolidated, light brown (5 YR 5/6) eolian sand of probable Holocene age (Fig. 1).

The geometry and lithotypes of the Quaternary sediments at the Mesa Redonda mammoth site clearly were part of an alluvial fan system that flowed N/NE from the mesa during part of the Pleistocene. Imbricated fan breccias thicken just east of the mammoth site and are indicative of a stream channel subject to high, although possibly periodic, current velocities. While the bone-bearing sand represents deposition of weathered Triassic bedrock, the presence of the Cretaceous oyster, *Texigrahaea pitcheri*, demonstrates that the breccias were derived at least in part from fluvial redistribution of colluvial deposits at the base of Mesa Redonda. The lenticular nature of the breccias reflects channel migration due to stream meander and/or braided channels. These processes contributed to the subsequent redeposition of finer-grained sediment over these channels (see Malanson, 1993) and thus created the fan structure. As such, the bone-bearing sand probably represents inter-channel portions of the fan and bank deposition related to lower energy discharge and/or stream meander.

There has been little study of Quaternary deposits in the Tucumcari area, including those at the Mesa Redonda mammoth site. Regional mapping (Barnes, 1977) assigns these deposits to Quaternary pediment deposits (Qpd), which are described as "silt, sand, and coarser debris derived chiefly from Triassic rocks." The Mesa Redonda mammoth site is similar to the late Pleistocene (Rancholabrean) Badlands Ranch Local Fauna described by Morgan et al. (2000), located near Barranca Creek about 20 km to the northeast. Badlands Ranch is a localized Pleistocene valley fill developed in Triassic bedrock. Geological and faunal features at Badlands Ranch also are similar to those at Mesa Redonda.

PALEONTOLOGY

The Mesa Redonda mammoths have been mentioned previously in the literature (Gillette et al., 1985; Lucas and Effinger,

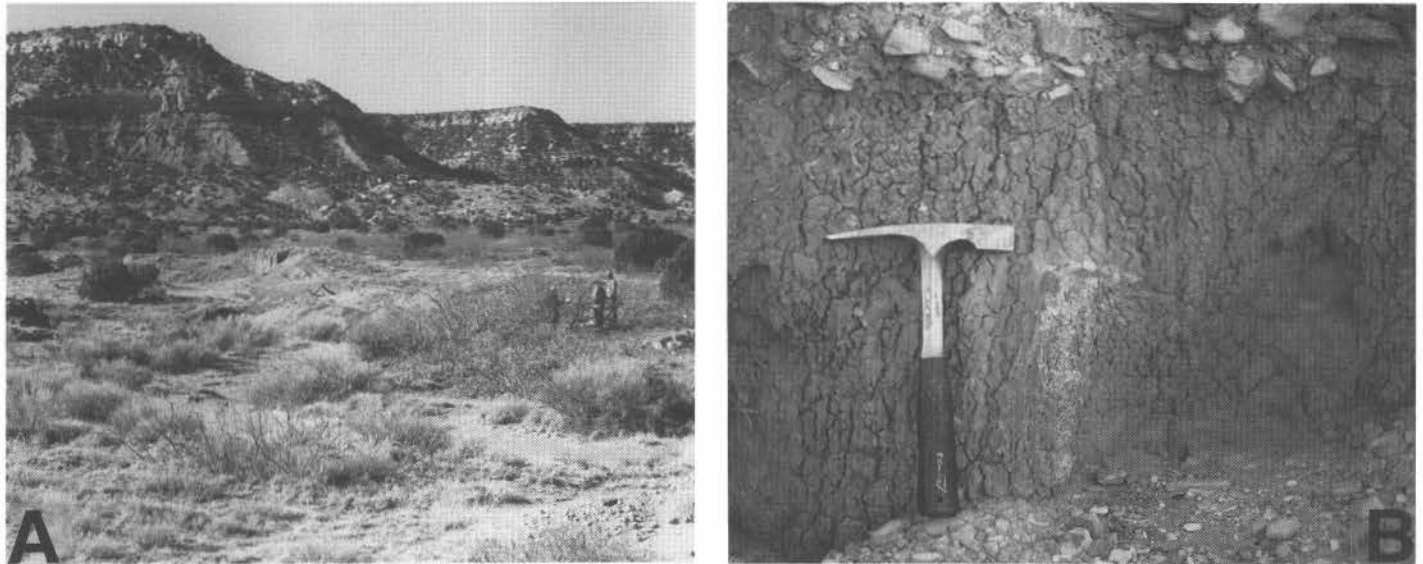


FIGURE 2. Photographs of Mesa Redonda site (NMMNH site L-3736). A. Overview of site looking toward Mesa Redonda to the southwest. People are standing on the main CMNH excavation. B. Close-up view of bone-bearing muddy sandstone. Note bone to right of hammer and alluvial fan breccia above bone-bearing stratum.

1991; Harris, 1993), but the sample was not studied in detail. Gillette et al. (1985, fig. 1.24) illustrated a complete pair of lower jaws, and Lucas and Effinger (1991, fig. 4) illustrated the mounted skeleton in the NMMNH (see Fig. 4). We provide a list of all catalogued specimens of mammoths from the Mesa Redonda site, tables of measurements (Tables 1-2), descriptions of the teeth and mandibles, illustrations of the most complete specimens (Figs. 5-6), and a brief taxonomic discussion.

In addition to mammoths, Vaughn's letters state that he collected ground sloth teeth, horse teeth, and an indeterminate carnivore tooth from Mesa Redonda. However, in our inventory of the Mesa Redonda collection at the DMNH, the only non-mammoth specimen we located consisted of two associated incisors of the horse *Equus* (DMNH 15950). We screenwashed a small sample of the fine-grained sand containing the mammoth fossils. The only microvertebrate fossil we recovered was an edentulous

maxilla of a small indeterminate species of rodent (NMMNH 34000). This sediment sample also yielded six species of terrestrial gastropods, all presently extant (see Table 3).

Class Mammalia
Order Proboscidea
Family Elephantidae

***Mammuthus columbi* (Falconer, 1857)**

Referred specimens

DMNH 1639a (DMNH 1639 includes mandibles from two individuals; we have given these specimens the suffixes, a and b, so they can be distinguished in Table 1 and Figs. 5-6), right dentary with m3 (Figs. 6C, D); DMNH 1639b, associated dentaries with complete left m3 and partial right m3 (Figs. 5B-E); DMNH 15136, partial left M3; NMMNH 33255, palate with right and

TABLE 1. Measurements (in mm) of teeth of *Mammuthus columbi* from Mesa Redonda (NMMNH site L-3736), Quay County, New Mexico.

specimen number	tooth	length	maximum width	crown height	plate number	lamellar frequency ¹	enamel thickness ²
DMNH 15136	LM3	--	101	187	--	6	-- ³
NMMNH 33255	LM3	257	92	271	19	8	2.7 (2.5-3.0)
NMMNH 33256	LM3	241	101	265	17	8	2.6 (2.3-3.0)
DMNH 1639a	Rm3	--	80	-- ⁴	19	8	2.4 (2.1-2.6)
DMNH 1639b	Lm3	220	73	160	18	8	2.4 (2.2-2.7)
NMMNH 33257	Lm2	215	83	-- ⁴	14	6	2.8 (2.6-3.1)
NMMNH 33257	Rm3	--	--	-- ⁴	14 ⁵	9 ⁶	-- ³

¹Lamellar frequency is the number of plates/100 mm of tooth length.

²Enamel thickness measurements are the means of five measurements taken on each individual tooth (observed range in parentheses).

³Tooth not fully erupted, enamel thickness measurements could not be taken.

⁴Tooth in dentary, crown height could not be measured.

⁵Tooth not fully erupted, an undetermined number of plates were unerupted and could not be counted.

⁶Tooth not fully erupted; lamellar frequency is probably too high.

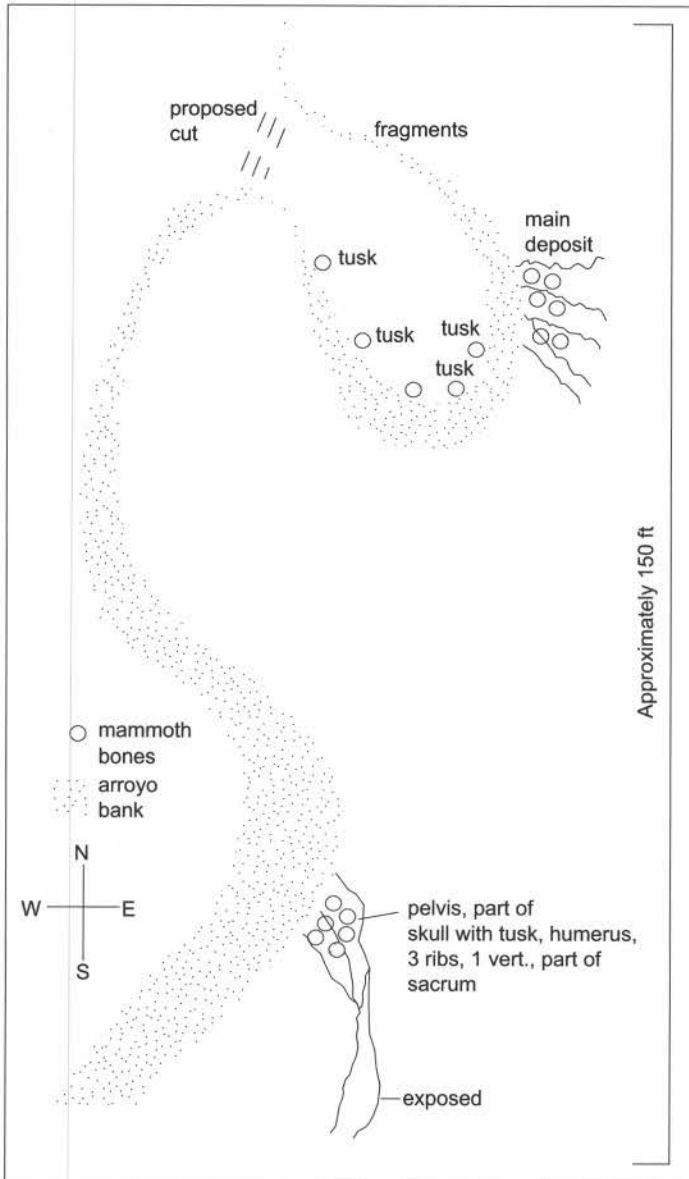


FIGURE 3. Map of Mesa Redonda site (NMMNH site L-3736). The primary bone concentration (main deposit on map) is at the northern end of the site, with a secondary concentration about 100 feet farther south. This map is redrawn from the original site map hand-drawn by Nelson Vaughn in 1930 and housed in the archives of the Denver Museum of Nature and Science.

TABLE 2. Measurements (in mm) of a complete pair of right and left dentaries of *Mammuthus columbi* (NMMNH 33257) from Mesa Redonda (NMMNH site L-3736), Quay County, New Mexico.

Total length of mandible from tip of spout to posterior edge of ascending ramus	728
Height from ascending ramus to tip of coronoid process	372
Height of horizontal ramus below m2	215
Maximum width across horizontal rami	635
Length of mandibular spout	80
Width of mandibular spout	37

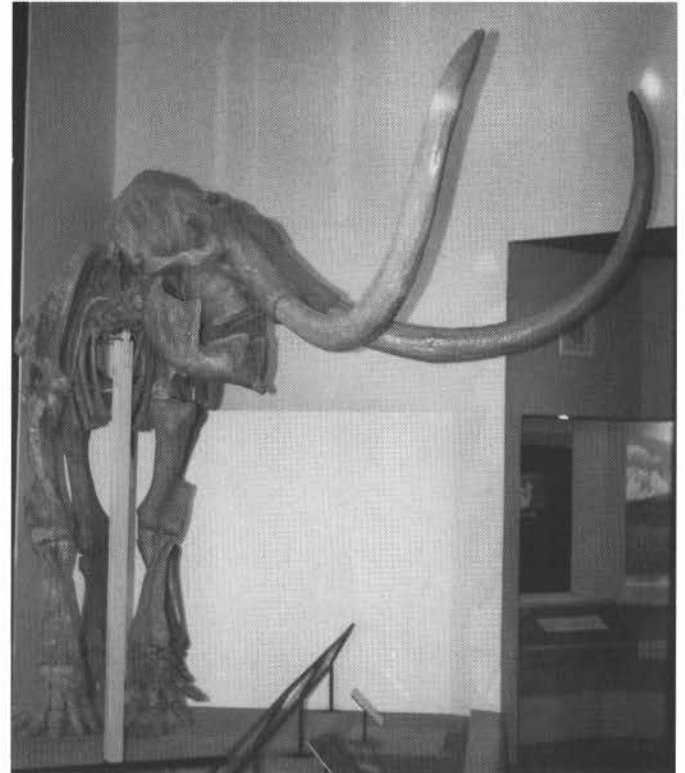


FIGURE 4. Composite mounted skeleton of *Mammuthus columbi* (NMMNH 27234) from the Mesa Redonda site (NMMNH site L-3736), Quay County, New Mexico. This skeleton is on display in the New Mexico Museum of Natural History in Albuquerque.

left M3 (Fig. 5A); NMMNH 33256, maxillary fragment with left M3 (Fig. 5F); NMMNH 33257 (original number DMNH 1639), right and left dentaries with m2s and partially erupted m3s (Figs. 6A, B); NMMNH 33258, reconstructed scapula; NMMNH 33259, 33260, two partial innominates; NMMNH 33261, thoracic vertebra; NMMNH 33262, shaft of femur; DMNH 15317, carpal. There are two additional mammoth mandibles from the Mesa Redonda site in the DMNH collection that we did not examine: DMNH

TABLE 3. Terrestrial gastropods recovered from alluvium at Mesa Redonda (NMMNH site L-3736), Quay County, New Mexico.

PHYLUM MOLLUSCA

Class Gastropoda

Subclass Pulmonata

Order Stylommatophora

Family Pupillidae

Gastrocopta cristata (Pilsbry and Vanatta, 1900)

Pupilla blandi Morse, 1865

Family Succineidae

Catinella vermata (Say, 1829)

Succinea concordialis Gould, 1848

Succinea grosvenori Lea, 1864

Succinea vaginacantorta Lee, 1951

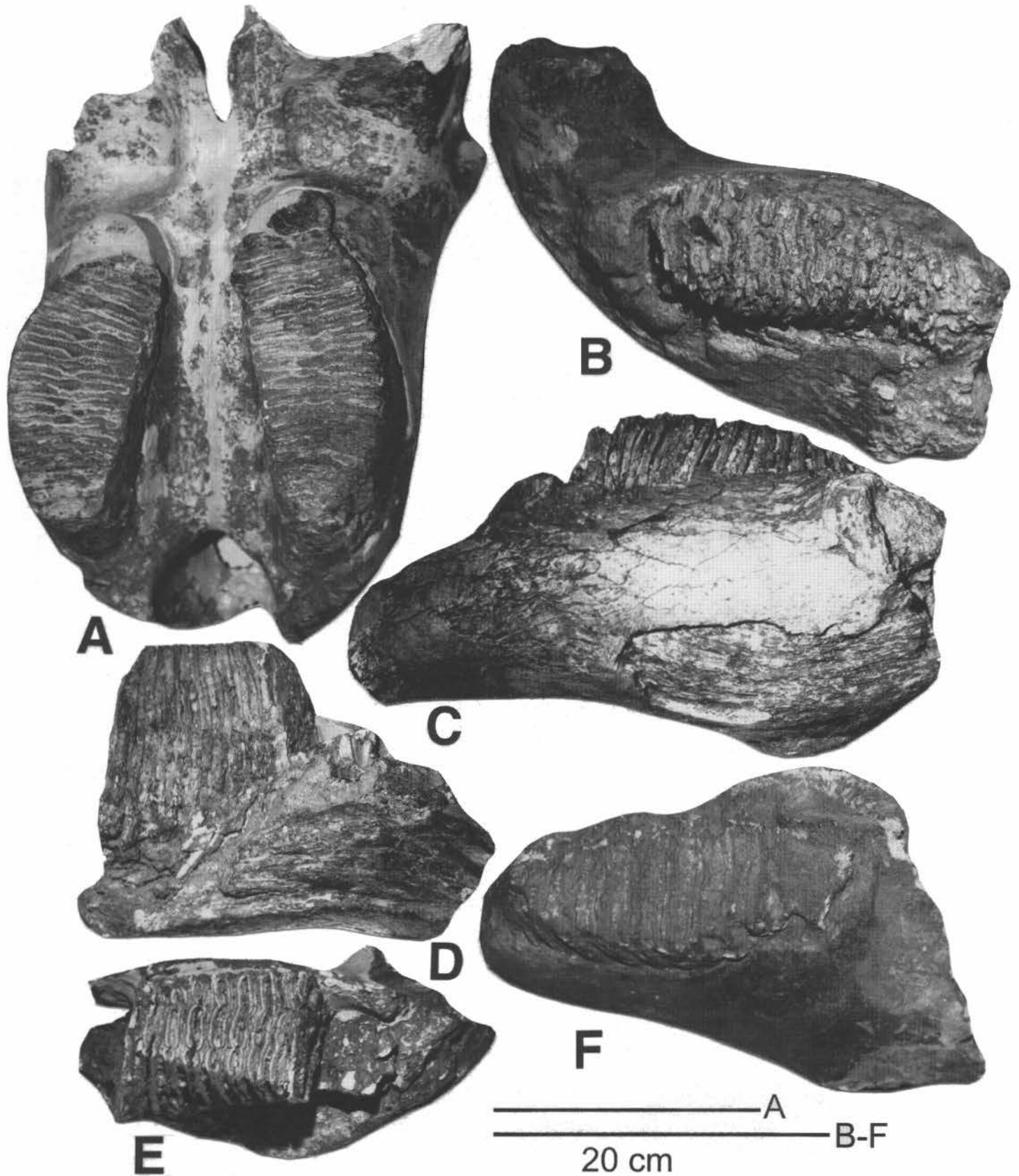


FIGURE 5. Maxillae and dentaries of *Mammuthus columbi* from the Mesa Redonda site (NMMNH site L-3736), Quay County, New Mexico. A. Occlusal view, palate with left and right M3, NMMNH 33255; B. occlusal view and C. lateral view, left dentary with m3, DMNH 1639b; D. lateral view and E. occlusal view, right dentary with partial m3, DMNH 1639b; F. occlusal view, maxillary fragment with LM3, NMMNH 33256. Scale bars are 20 cm.

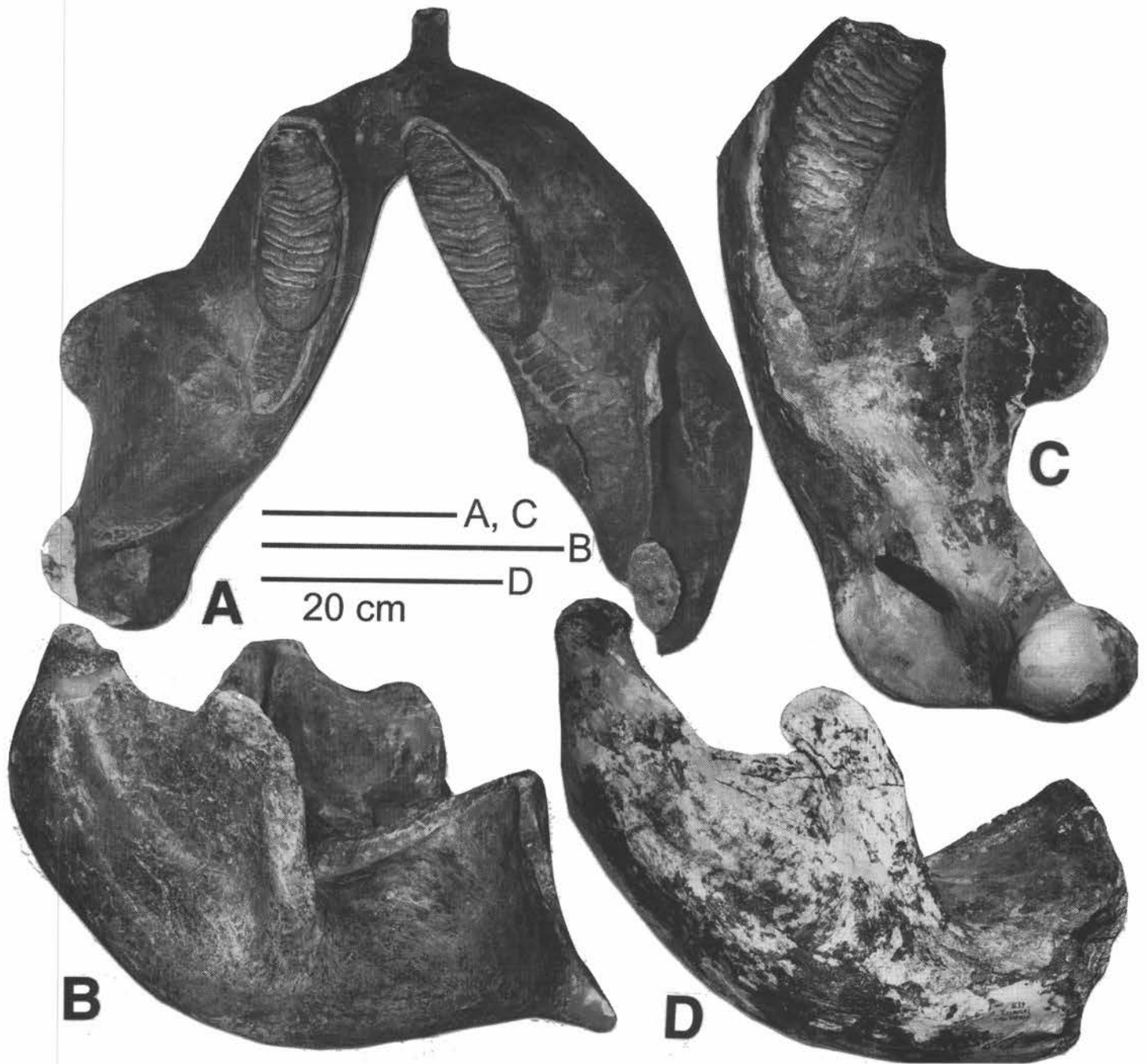


FIGURE 6. Dentaries of *Mammuthus columbi* from the Mesa Redonda site (NMMNH site L-3736), Quay County, New Mexico. A. occlusal view and B. right lateral view of right and left dentaries with m2 and unerupted m3, NMMNH 33257; C. occlusal view and D. lateral view of right dentary with m3, DMNH 1639a. Scale bars are 20 cm.

1485, partial dentary (on exhibit in the DMNH, apparently used in the reconstruction of another mammoth from Milo, Kansas); DMNH 1638, right and left dentaries (on exhibit in the DMNH).

NMMNH 27234 is a composite mounted skeleton on display in the New Mexico Museum of Natural History and Science (Fig. 4). An examination of this skeleton, as well as an inventory of the mammoth fossils from Mesa Redonda received from the DMNH, reveals that this mount is composed of about 30% fossil material. Actual mammoth fossils from Mesa Redonda in the

NMMNH mounted skeleton include: right humerus, radius, and ulna; right and left scapulae (reconstructed); right and left innomines (reconstructed); six cervical vertebrae; 15 thoracic vertebrae (found as an articulated series), and two lumbar vertebrae. The remainder of the skeleton consists of casts.

Descriptions and comparisons

Four or five species of mammoths (*Mammuthus*) are known from North American Pleistocene faunas (Maglio, 1973; Kurtén

and Anderson, 1980; Madden, 1981; Graham, 1986; Agenbroad, 1994). Three species of mammoths occur in New Mexico (Lucas and Effinger, 1991): *M. meridionalis*, *M. imperator*, and *M. columbi*. *M. meridionalis* (referred to *M. hayi* by Webb and Dudley, 1995) is a primitive species from the early Pleistocene (early Irvingtonian) that differs from the Mesa Redonda teeth in having fewer plates with much thicker enamel. *M. imperator* from the Irvingtonian and early Rancholabrean also has fewer plates and thicker enamel than the Mesa Redonda *Mammuthus* teeth. *M. columbi* is found primarily in late Rancholabrean sites and is distinguished from *M. imperator* by its relatively short, broad molars, larger number of plates, and thinner enamel. Morphological characters and measurements of the Mesa Redonda mammoth teeth compare most closely with *M. columbi*. Three M3s from Mesa Redonda (Table 1) range from: 241-257 mm in length, 92-101 mm in width, and 187-271 mm in crown height. These teeth have from 17-19 plates, a lamellar frequency (number of plates/100 mm) of 6-8, and enamel thicknesses of 2.3-3.0 mm (mean 2.7 mm). The size, plate number, lamellar frequency, and enamel thickness of the Mesa Redonda mammoth teeth compare well with the morphometric data on the large sample of *M. columbi* from Hot Springs, South Dakota (Dutrow, 1980; Agenbroad, 1994).

Remarks

Correspondence and various historical accounts suggest that as many as six individual mammoths, including eight tusks, were found at the Mesa Redonda site. Our complete inventory of the Mesa Redonda mammoth samples housed in the DMNH and NMMNH reveals a smaller number of specimens (see above), and not a single tusk or even tusk fragment. We calculated a minimum number of five individuals of *Mammuthus columbi* from Mesa Redonda based on lower jaws (DMNH 1485, 1638, 1639a, b and NMMNH 33257). With the exception of a single carpal (DMNH 15317), the current DMNH sample consists only of jaws and isolated teeth, because the postcranial sample was transferred to the NMMNH in 1985 and subsequently incorporated into a composite mounted skeleton (NMMNH 27234; Fig. 4).

DISCUSSION

Mammuthus columbi is the most common mammoth in New Mexico, where it is known from more than 20 sites (Lucas and Effinger, 1991). All mammoth records from late Pleistocene (late Rancholabrean) sites in New Mexico and elsewhere in the southwestern United States appear to be *M. columbi* (Madden, 1981). The presence of *M. columbi* suggests that the Mesa Redonda site is late Pleistocene (late Rancholabrean), although there are no radiocarbon dates or other age-diagnostic mammals (e.g., *Bison*) to confirm this age.

Besides Mesa Redonda, the only other large sample of *Mammuthus columbi* from New Mexico is from the Blackwater Draw/Clovis site in Roosevelt County, where Paleoindians of the Clovis culture apparently killed and butchered mammoths. Limited morphometric data have been published on the *Mammuthus* sample from Blackwater Draw. Examination and measurements of a small sample of mammoth teeth in the Blackwater Draw Museum

and the Blackwater Draw Site (see Morgan et al., this volume) substantiate the identification of the Blackwater Draw mammoths as *M. columbi*. The mammoth teeth from Mesa Redonda and Blackwater Draw are very similar in size and other morphological characters (see comparative measurements in Morgan et al., this volume), confirming the presence of *M. columbi* in both sites. Radiocarbon dates from Blackwater Draw (between 13,000 and 11,000 yr B.P.) establish a latest Pleistocene age for *M. columbi* from this site (Haynes, 1995).

The presence of a gastropod fauna composed of six currently extant taxa further supports a late Pleistocene (late Rancholabrean) age for the Mesa Redonda site. All species recovered from the alluvial deposits were terrestrial taxa. This lack of an aquatic fauna suggests that the stream flows through the alluvial fan may have been periodic; however, subsurface flow apparently was sufficient to support riparian vegetation. Ecological preferences for these gastropod species (see Pilsbry, 1948; Metcalf and Smartt, 1997) indicate a riparian community with muddy stream banks, grasses, and deciduous trees or shrubs.

ACKNOWLEDGMENTS

We thank Howard Abercrombie and Robert Abercrombie, Jr. for allowing access to the Mesa Redonda mammoth site, and for providing information regarding the discovery of the mammoths by their father/grandfather, Robert Abercrombie, Sr. Paul Sealey helped us in the field. The Denver Museum of Nature and Science archives provided copies to the NMMNH of all relevant letters and other documents relating to the Mesa Redonda mammoth site. Suzanne Cowan assisted us in examining these documents. We thank Logan D. Ivy and Russell W. Graham for allowing access to the Mesa Redonda mammoth specimens housed in the DMNH vertebrate paleontology collection. Russell W. Graham and Michael O'Neill provided helpful comments on a earlier draft of the manuscript.

REFERENCES

- Agenbroad, L. D., 1994, Taxonomy of North American *Mammuthus* and biometrics of the Hot Springs mammoths; in Agenbroad, L. D. and Mead, J. I., eds., The Hot Springs mammoth site: The Mammoth Site of South Dakota, Hot Springs, South Dakota, p. 158-207.
- Barnes, V. E., 1977, Geologic atlas of Texas, Clovis sheet: Bureau of Economic Geology, The University of Texas at Austin, scale 1:250,000.
- Dutrow, B. L., 1980, Metric analysis of a late Pleistocene mammoth assemblage, Hot Springs, South Dakota: MS Thesis, Dallas, Texas, Southern Methodist University, 165 p.
- Gillette, D. D., Gillette, J. L., and Murphy, J., 1985, The Tucumcari mammoths excavated by the Denver Museum of Natural History in 1930: New Mexico Geological Society, Guidebook 36, p. 14-17.
- Graham, R. W., 1986, Taxonomy of North American mammoths; in Frison, G. C. and Todd, L. C., eds., The Colby Mammoth Site-Taphonomy and archaeology of a Clovis kill in northern Wyoming: Albuquerque, University of New Mexico Press, p. 165-229.
- Harris, A. H., 1993, Quaternary vertebrates of New Mexico; in Lucas, S. G. and Zidek, J., eds., Vertebrate paleontology in New Mexico: New Mexico Museum of Natural History and Science Bulletin 2, p. 179-197.
- Haynes, C. V., 1995, Geochronology of paleoenvironmental change, Clovis type site, Blackwater Draw, New Mexico: Geoarchaeology, v. 10, p. 317-388.
- Kurtén, B., and Anderson, E., 1980, The Pleistocene mammals of North America: New York, Columbia University Press, 442 p.

- Lucas, S. G. and Effinger, J. E., 1991, *Mammuthus* from Lincoln County and a review of the mammoths from the Pleistocene of New Mexico: New Mexico Geological Society, Guidebook 42, p. 277-282.
- Madden, C. T., 1981, Mammoths of North America: PhD Dissertation, University of Colorado, Boulder, 271 p.
- Maglio, V. J., 1973, Origin and evolution of the Elephantidae: Transactions of the American Philosophical Society, v. 63, part 3, p. 1-149.
- Malanson, G. P., 1993, Riparian landscapes: Cambridge, Cambridge University Press, 296 p.
- Metcalf, A. L., and Smartt, R. A., 1997, Land snails of New Mexico: a systematic review; *in* Metcalf, A. L., and Smartt, R. A., eds., Land snails of New Mexico: New Mexico Museum of Natural History and Science Bulletin 10, 69 p.
- Morgan, G. S., Lucas, S. G., Sealey, P. L., McDonald, H. G., and Gordon, M. E., 2000, Pleistocene (Rancholabrean) vertebrate and invertebrate fossils from Badlands Ranch, Quay County, New Mexico; *in* Lucas, S. G., ed., New Mexico's Fossil Record 2: New Mexico Museum of Natural History and Science Bulletin 16, p. 241-251.
- Pilsbry, H. A., 1948, Land Mollusca of North America (north of Mexico), volume II, part 2: The Academy of Natural Sciences of Philadelphia Monographs 3, p. 521-1113.
- Webb, S. D. and Dudley, J. P. 1995, Proboscidea from Leisey Shell Pits, Hillsborough County, Florida; *in* R. C. Hulbert, Jr., G. S. Morgan, and S. D. Webb, eds., Paleontology and geology of the Leisey Shell Pits, early Pleistocene of Florida: Bulletin of the Florida Museum of Natural History, v. 37, part II, p. 645-660.