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NEW EVIDENCE FOR THE AGE OF LOWER PART OF THE PALOMAS FORMATION, TRUTH OR CONSEQUENCES, NEW MEXICO

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Abstract—The Truth or Consequences fauna is from normally magnetized deposits in the lower part of the Palomas Formation that are exposed in a roadcut along I-25 just west of the city. The fauna contains nine identified mammals and four reptiles. The mammals are comparable to, but somewhat more primitive than, those known from the Rexroad 3 fauna of Kansas. The reptiles, however, are known only from more southerly faunas and probably reflect the lower latitude of Truth or Consequences. Consideration of similar faunas with known paleomagnetic constraints leads to the conclusion that the fauna was deposited during the Nunivak Normal Paleomagnetic Subchron between 4.05 and 4.20 my ago.

INTRODUCTION

Arthur H. Harris, University of Texas, El Paso, brought to our attention his discovery of fossil-horse material in a prominent roadcut on the northwestern side of I-25, 1.8 km southwest of the overpass at the north exit to Truth or consequences, New Mexico. Subsequent investigation during two field seasons has revealed more remains of large mammals as well as a relatively abundant owl-pellet accumulation of small mammals and reptiles. The microfauna has been collected from a 1.5 m thick, greenish-gray to moderately red mudstone lense in the lower third of the roadcut. Roadcuts along this portion of I-25 expose thin, discontinuous lenses of grayish and reddish mudstone within a sequence composed of medium- to coarse-grained arkosic sandstone. These sediments belong to the axial facies of the Palomas Formation of Gordon (1907), or the "extended Sierra Ladrones Formation" of Tedford (1981). Lozinsky (1986) discusses the characteristics of the Palomas Formation in the Truth or Consequences area.

Approximately 20 m of section are exposed at the Truth or Consequences locality, consisting primarily of tan to white, massive to cross-bedded, poorly consolidated sandstone and pebbly sandstone interbedded with two green to greenish-gray mudstone horizons about 6 and 14 m above road level. The fossil locality (USGS vertebrate locality M-1481) is in the lower fine-grained horizon. Samples were collected from both mudstone units to determine paleomagnetic polarity.

THE TRUTH OR CONSEQUENCES FAUNA

The fauna from USGS vertebrate locality M-1481 consists of the following taxa:

?*Terrapene ornata*—box turtle
Kinosternon flavescens—yellow mud turtle
Sceloporus undulatus—fence lizard
Masticophis flagellum?—coach-whip snake
Hypolagus vetus—large rabbit
Notolagus lepusculus—small rabbit
Geomys minor—gopher
Prosigmodon sp. aff. *Sigmodon intermedius*—primitive cotton rat
cf. *Oryzomys* sp.—primitive rice rat
Paraneotoma quadriplicatus—primitive pack rat
Stegomastodon sp.—mastodon
Dolichohippus sp.—zebrine horse
Odocoileus brachyodontus—primitive white-tailed deer

No identifiable fresh-water mollusks were found and microscopic examination of the mudstone matrix revealed no pollen, diatoms, or ostracods (Vera Markgraf, J.P. Bradbury, and R.M. Forester oral comm. 1985). Calcified fragments of bull-rush roots, *Scirpus*?, were found. Karel L. Rogers identified the reptiles and John A. White identified *Hypolagus vetus*.

Although overall abudance is quite high at locality M-1481, the taxonomic diversity of the small mammals is relatively low, a feature characteristic of owl-pellet accumulations that results from the selective food preferences of owls. The mammals present in the Truth or Consequences fauna show a marked similarity to those from the Rexroad 3 fauna of Kansas (Hibbard 1941, 1972), but in many cases have minor morphologic differences which we interpret to be primitive.

The white-tailed deer, *Odocoileus brachyodontus* Oelrich 1953, was first described from the Fox Canyon fauna of Kansas (slightly older than the Rexroad 3 fauna). It is characterized by large teeth and short, flattened antlers (from Rexroad 3) with three very rudimentary tines on each antler. While the dentition of *Odocoileus* from the Truth or Consequences fauna is both larger than modern *Odocoileus* and than measurements given by Oelrich for the teeth from the Fox Canyon fauna, the antler is small and most closely resembles that of the small, extant Central American species *O. acapulcensis*.

The fossil antler from Truth or Consequences is flattened between the very small brow tine (not preserved but inferred from the changes in cross section of the beam) and the two distal tines. It is, however, less flattened than the specimen from the Rexroad 3 fauna or than those of *O. acapulcensis*, and thus appears to be somewhat more primitive.

The primitive pack rat, *Paraneotoma quadriplicatus* (Hibbard 1941) is identical to this species from the Rexroad 3 fauna except that it is smaller. Its first upper molar averages 3.0 mm in length, while that of the Rexroad form averages 3.8 mm. In comparison, in the diminutive *P. sawrockensis* Hibbard 1967 (the oldest known species of pack rat) from Radec, California (USGS vertebrate locality M-1451), the first upper molars average 2.6 mm, and the type specimen from Saw Rock Canyon, Kansas, is a first upper molar measuring 2.8 mm in length.

The pack-rat evolution is still poorly known, but it appears that forms of this simplicity (the *sawrockensis–quadriplicatus* stage) represent a single ancestral lineage in which size equates directly with evolutionary development. The pack rat from Truth or Consequences thus appears to be intermediate in age between the one from the Saw Rock Canyon fauna and the one from the Rexroad 3 fauna.

The primitive rice rat, cf. *Oryzomys* sp., is represented by only a few specimens, but the recognition of this taxon in an early Pliocene fauna from North America has significant implications for the origin of this South American group of rodents. The molars are brachyodont with transversely opposed, rather than alternating, cusps (Fig. 1). Length/width measurements for the upper teeth are M1 = 1.9/1.1 mm, M2 = 1.4/1.1 mm, and M3 = 0.8/0.8 mm. The lower teeth collected to date are extremely worn.

The molar morphology of the Truth or Consequences species compares most favorably with the modern genus *Oryzomys*. It differs from *Peromyscus* by the transversely aligned cusps, by the lack of alignment of the arms of the paracone and hypocone, and by the transverse expansion of the anterocone; from *Calomys* (*Bensonomys*) by the transverse alignment of the cusps and broader, but less strongly bilobed, anterocone; from *Copemys* by the transverse alignment of the cusps and expanded, bilobed anterocone; and from *Symmetrodontomys* by the

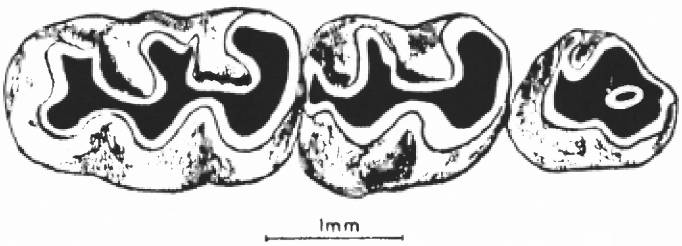

FIGURE 1—Occlusal view of cf. *Oryzomys* upper molars from the Truth or Consequences fauna. U.S. National Museum Nat. Hist. (USNM) cat. no. 264303.

more closely aligned cusps, the expanded anterocone, and the development in some individuals of accessory lophules on the first two upper molars. Within the genus *Oryzomys*, the Truth or Consequences specimens compare most closely to living species from Central and South America, but predate the oldest record of cricetid rodents in South America, suggesting a North American origin.

In all respects but one, the cotton rat from the Truth or Consequences fauna resembles *Sigmodon intermedius* Hibbard 1938. Most individuals, however, display a lingual connection of the protocone to the bilobed anterocone on the first upper molar, rather than connecting centrally as in all younger cotton rats. The lingual connection is a diagnostic feature of the ancestral genus *Prosigmodon* (Jacobs & Lindsay 1981). In addition, the last upper molar is more cuspate and less lophate than is this tooth in *S. intermedius*. *Prosigmodon* has been known only from the latest Hemphillian (very early Pliocene; about 4.9 my ago according to May & Repenning 1982) and early Pliocene (4.3–4.8 my) faunas of Chihuahua (Jacobs & Lindsay 1981).

In size and enamel pattern, the very small gopher from the Truth or Consequences fauna appears identical to *Geomys minor* Gidley from the Rexroad 3 fauna, Kansas (Hibbard 1950, 1967). The length of the lower cheek-tooth row is 5.9 mm. This compares with 5.0 mm for the species from Rexroad 3 as given by Hibbard (1967); however, available material from the Kansas locality indicates that the size range overlaps the material from Truth or Consequences.

Geomys minor has been placed in the genus, or subgenus, *Nerterogeomys*, and it may belong there. But there is no enamel on the posterior side of the upper fourth premolar, nor is the anterior pillar of this tooth any narrower than the posterior one. These two features are like *Geomys*. Opposite conditions were listed by Gazin (1942) as two of the four characters diagnostic of the genus *Nerterogeomys;* the other two are not preserved in the Truth or Consequences specimens. Hibbard (1967) noted the great variability of some of these characters and reduced the diagnosis of *Nerterogeomys* to one of the two characters missing in the specimens from Truth or Consequences. *Geomys minor* is known throughout the Pliocene.

The small, cottontail-sized rabbit *Notolagus lepusculus* (Hibbard) is assigned to the species named from the Rexroad 3 fauna of Kansas (Hibbard 1939). The anterolingual reentrant on the third lower premolar does not have an anterolabially directed branch as in *Notolagus velox* from the Hemphillian Yepomera fauna of Chihuahua, Mexico (Wilson 1937). The rabbit from Truth or Consequences lacks any indication of the anterior reentrant seen on the third lower premolar of *Notolagus* cf. *velox* from the Benson fauna of Arizona (Downey 1968).

The large, jackrabbit-sized *Hypolagus vetus* (identified by John A. White) is rare in the collection from Truth or Consequences. It is known from the late Miocene to the middle Pliocene. According to White (oral comm. 1986), this is not one of the species found in Rexroad 3.

The remains assignable to *Dolichohippus* are few, with very worn teeth, and the mastodon find consists of a single fragmentary tooth. In both cases, the material is not adequate for specific identification or age assignment within the Pliocene.

The reptiles are extant forms, but suggest a southern and possibly hot–dry environment. According to Rogers (1976), none are known from the Rexroad 3 fauna in southwestern Kansas, but all are reported from the somewhat younger Beck Ranch fauna of central Texas at about the latitude of Las Cruces, New Mexico. Most have their modern western limits in the plains of eastern New Mexico, and all range southward into Mexico.

PALEOMAGNETISM

Eleven oriented hand samples were collected from three stratigraphically separated sites within the roadcut at Truth or Consequences. Sites TC001 and TC002 were located near the bottom and top, respectively, of the fossil-bearing mudstone, while site TC003 was located in the upper mudstone. The natural remanent magnetization (NRM) of all samples was measured on an Sc–T cryogenic magnetometer at the University of Arizona Laboratory of Paleomagnetism. Initial NRM intensities ranged from 6.6E–3 A/m to 2.5E–2 A/m; directions were well grouped for sites TC001 and TC002, but were scattered for site TC003.

Vector demagnetization diagrams were used to evaluate the directional stability and coercivity spectra of NRM during progressive demagnetization. One sample from each site was subjected to alternating-field (af) demagnetization in increasing field strengths of 2.5 to 40–80 mT. Samples from sites TC001 and TC002 exhibit linear decay of the NRM after removal of a minor secondary component in peak fields of 2.5–5.0 mT (Fig. 2). This secondary component is close to the present geomagnetic-field direction at Truth or Consequences and is interpreted as a viscous remanent magnetization (VRM). The median destructive field for samples TC001A and TC002A is approximately 15 and 10 mT, respectively, and less than 30% of the initial NRM intensity remains after exposure to a peak field of 40 mT.

Two samples from site TC003 exhibit anomalous (divergent) NRM directions with northeast declinations and moderate negative inclinations. As shown in Fig. 3, this initial direction changes rapidly during alternating-field demagnetization at peak fields of less than 15 mT, so that inclination becomes positive and declination swings to the north. This directional change is accompanied by a rapid loss of intensity, suggesting that the secondary component represents a lightning-induced isothermal remanent magnetization. Site TC003 was located topographically high in the roadcut, thus making it more susceptible to lightning strikes.

A second specimen cut from sample TC002C was subjected to progressive thermal demagnetization between 100 and 400°C. As illustrated

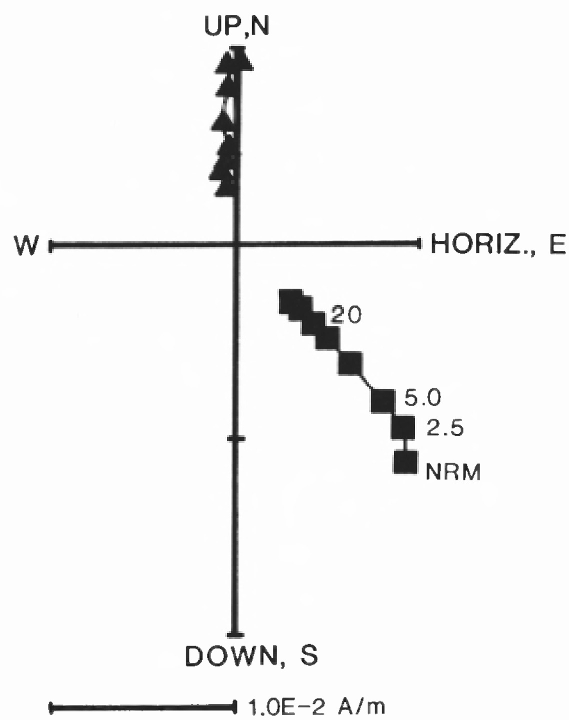

FIGURE 2—Vector demagnetization diagram illustrating progressive alternating-field (af) results for sample TC001A. Annotations next to inclination points indicate peak field strength in mT. Bar indicates scale.

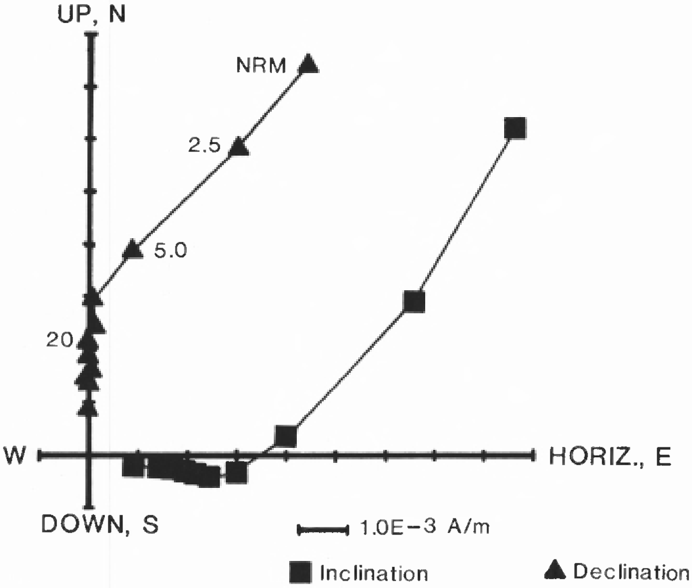

FIGURE 3—Vector demagnetization diagram illustrating progressive alternating-field (af) results for sample TC003C. Annotations next to inclination points indicate peak field strength in mT. Bar indicates scale.

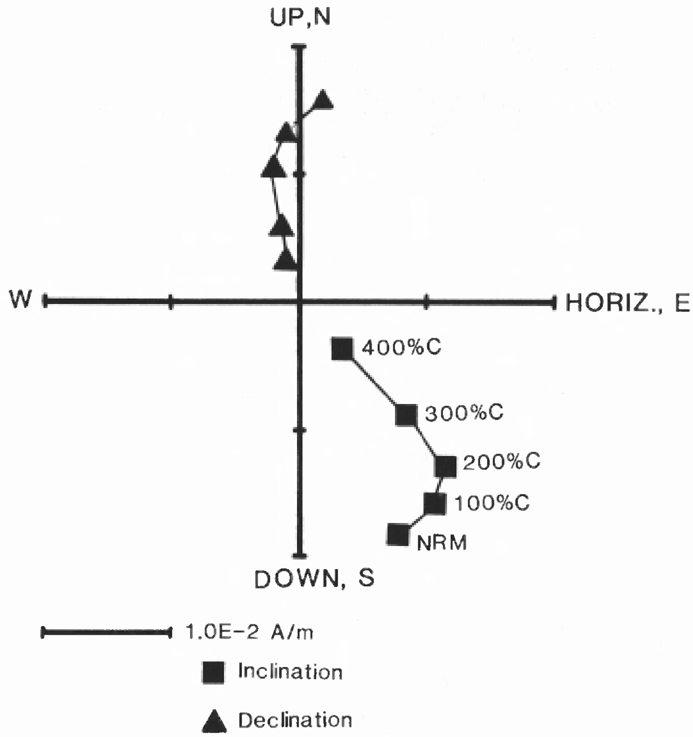

FIGURE 4—Vector demagnetization diagram illustrating progressive thermal results for sample TC002C2. Annotations next to inclination points indicate peak temperature in °C. Bar indicates scale.

in Fig. 4, the observed behavior is similar to the alternating-field-demagnetization experiments with inclination becoming slightly shallower and declination becoming slightly more westerly at low temperature steps followed by a single-component decay.

After analyzing the progressive-demagnetization experiments, all samples were demagnetized in a peak alternating field of 20 mT and site mean directions were calculated using the statistics of Fisher (1953) (Tab. 1).

TABLE 1—Site mean paleomagnetic data. Directions (DEC = declination, INC = inclination) are given before (NRM) and after (20 mT) alternating-field (af) demagnetization. Alpha 95 (= half angle cone of 95% confidence) and K (= Fisher precision parameter) are given for demagnetized results.

	NRM		20 mT			
SITE	DEC	INC	DEC	INC	ALPHA 95	K
TC001	2.5	45.6	351.5	40.2	13.0	90.8
TC002	1.5	51.9	356.7	51.7	12.6	97.5
TC003	23.0	-17.1	347.9	24.2	28.9	19.3

A single magnetic separtate was obtained from the mudstone bed containing sites TC001 and TC002. A strong-field thermomagnetic experiment (Fig. 5) revealed a Currie temperature of 580°, suggesting that magnetite is the dominant ferromagnetic phase present. The slight irreversible "hump" on the heating curve probably reflects the presence of a small amount of maghemite as a low-temperature oxidation product of magnetite.

After demagnetization at 20 mT, sample directions are reasonably well grouped with northerly declinations and positive inclinations. The characteristic remanent direction is believed to be a primary depositional magnetization carried by magnetite and recording normal geomagnetic polarity during deposition of the fossiliferous Truth or Consequences roadcut sediments.

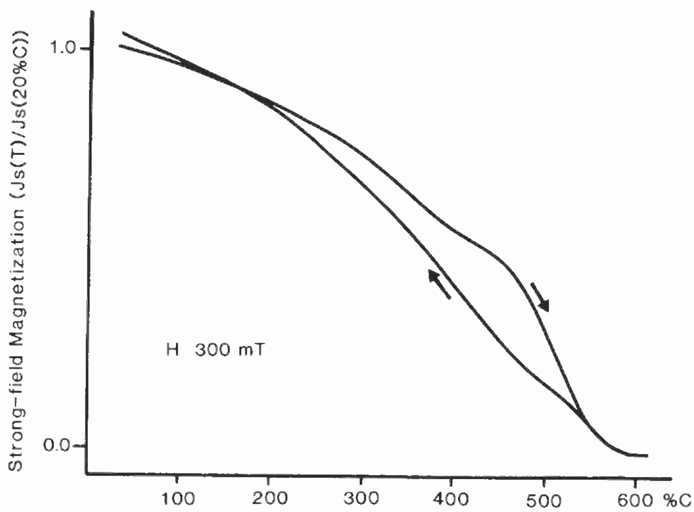

FIGURE 5—Strong-field thermomagnetic behavior for magnetic separate from TC001–TC002 mudstone bed. Arrows indicate heating and cooling curves. Sample was measured in an argon atmosphere with a heating rate of 15°C/minute.

AGE OF FAUNA

The Truth or Consequences fauna has a strong similariity to the Blancan II (4.2 to 3.7 my ago: Repenning 1986) Rexroad fauna of Kansas (Fig. 6). Only the large rabbit species, the reptiles, and the rice rat are not represented by similar forms in the Rexroad fauna. The reptiles and the rice rat suggest a somewhat more southerly environment than that of the Rexroad fauna and may represent the lower latitude of Truth or Consequences. The cotton rat, pack rat, and white-tailed deer suggest a slightly more primitive fauna, and an older age, than the Rexroad 3 fauna. The pack rat also suggests that the Truth or Consequences fauna is not as old as the Saw Rock Canyon fauna of Kansas. The Saw Rock Canyon fauna is between 4.5 and 4.8 my old on the basis of similar faunas that have been dated in Washington (White Bluffs) and California (Upper Alturas) (Repenning 1986).

The Rexroad 3 fauna was deposited during an interval of normal geomagnetic polarity (Lindsay et al. 1975) and is older than the dispersal of muskrats from the Old World to North America (Repenning 1980, 1986); the Hagerman fauna of Idaho contains early muskrats and overlies the Cochiti Subchron (Neville et al. 1979). Thus, the normal polarity

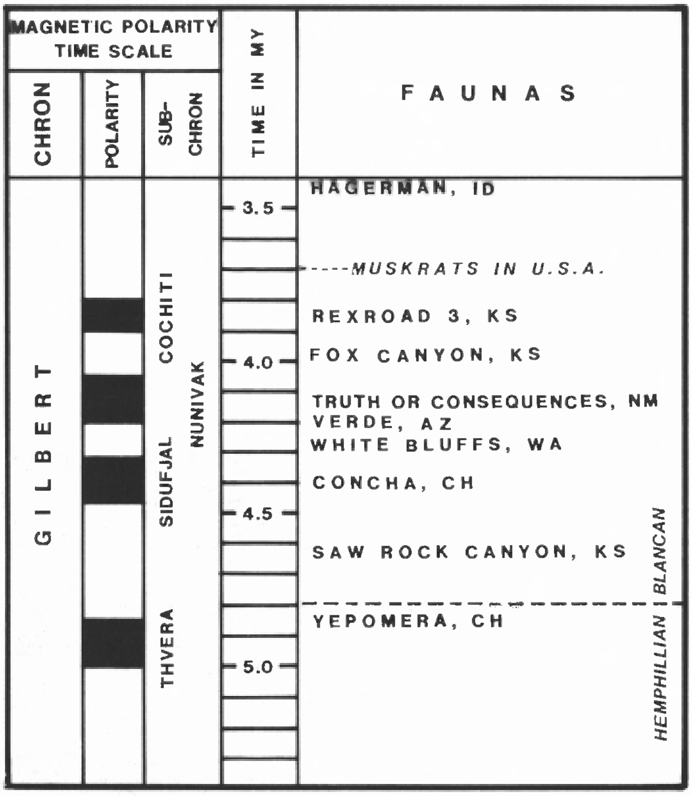

FIGURE 6—Correlation of discussed faunas to the paleomagnetic stratigraphy and the Truth or Consequences fauna.

of the Rexroad 3 fauna must represent the Cochiti Subchron or an older normal event.

The White Bluffs fauna of Washington (Gustafson 1978) contains a pack rat that is smaller than that from Rexroad 3 and comparable in size to the Truth or Consequences form; the fauna is in sediments that overlie the Sidufjal (Repenning 1986) or Nunivak Subchron (Gustafson 1985). Thus, the Rexroad 3 fauna seems to be correlative to either the Cochiti or Nunivak Subchrons of the Gilbert Chron.

The Verde fauna of Arizona (Lindsay et al. 1984) contains a pack rat comparable (or identical) to the Truth or Consequences form, as well as other rodents clearly more primitive than those from the Rexroad 3 fauna and very similar to those of the Truth or Consequences fauna. The Verde fauna has been recovered from sediments in the base of a normal polarity magnetozone that has been correlated with the Nunivak Subchron (Bressler & Butler 1978). Thus, it seems unlikely that the Rexroad 3 fauna is as old as Nunivak time.

Based upon the above correlations (Fig. 6), we believe that the normal-polarity magnetozone existing during the deposition of the Rexroad 3 fauna is best correlated with the Cochiti Subchron. The normal polarity magnetozone existing during the deposition of the Truth or Consequences fauna is best correlated with the Nunivak Subchron because of the somewhat more primitive character of the fauna and its similarities to the other faunas deposited at about the time of the next older normal subchron.

Following the age assignments of Mankinen & Dalrymple (1979), the age of the Truth or Consequences fauna from the lower part of the Palomas Formation is thus interpreted to be between 4.05 and 4.20 my. In the terms of the microtine biochronology of the United States (Repenning 1986), it is very early Blancan II.

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Anne H. Walton collected with us the Truth or Consequences fauna and also helped to prepare the specimens. Arthur H. Harris kindly provided us with directions to the locality, as well as to several other localities. With his usual complete cooperation, Richard H. Tedford provided available locality information for the earlier collections in the area by the Childs Frick parties. Mr. John Jaramillo, New Mexico Highway Department, granted us permit to collect at the roadcut along I-25.

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