

MIOCENE MAMMALIAN FAUNAS AND BIOSTRATIGRAPHY OF THE ZIA FORMATION, NORTHERN ALBUQUERQUE BASIN, SANDOVAL COUNTY, NEW MEXICO

GARY S. MORGAN and SPENCER G. LUCAS

New Mexico Museum of Natural History, 1801 Mountain Road, NW, Albuquerque, NM 87104

Tedford (1981) reviewed the fossil mammal faunas from late Cenozoic basins in New Mexico, including the Albuquerque basin in the north-central part of the state. Early and middle Miocene mammal faunas are known from the northern third of the Albuquerque basin in Sandoval County, representing the Arikareean, Hemingfordian, Barstovian, and Clarendonian land-mammal "ages" (Galusha, 1966; Gawne, 1975, 1976; Tedford, 1981; Tedford and Barghoorn, 1997, 1999; Morgan and Williamson, 2000). The Miocene vertebrate faunas from the northern Albuquerque basin are derived from the Zia Formation (Fig. 1). Galusha (1966) named the Zia "Sand" Formation with two members, the lower Piedra Parada Member and the upper Chamisa Mesa Member. The Cañada Pilares Member of Gawne (1981) is similar in age to the Chamisa Mesa Member, but is lithologically distinct. Connell et al. (1999) named the Cerro Conejo Member as the uppermost unit of the Zia Formation. Vertebrate fossils occur in all four members of the Zia Formation in the northern Albuquerque basin (Fig. 1).

Arikareean age to the Standing Rock LF based on the association of the carnivores *Daphoenodon*, *Cephalogale*, and *Promartes* cf. *P. lepidus*, and the stenomyline camel *Stenomylus* cf. *S. gracilis*. Standing Rock Quarry is the type locality of the rodents *Proheteromys cejanus* and *Ziamys tedfordi*, named by Gawne (1975), and has also produced a nearly complete skeleton of the primitive rabbit *Archaeolagus* (Gawne, 1976). The Standing Rock LF is slightly younger than the well known late Arikareean Agate Springs Quarry from the Harrison Formation in western Nebraska.

The Blick Quarry and the stratigraphically equivalent *Cynarctoides* Quarry are in the middle of the Chamisa Mesa Member of the Zia Formation, located along Arroyo Pueblo east of Jemez Pueblo on the Jemez Reservation (Galusha, 1966). Gawne (1975) named the Blick LF for the combined fossil mammal assemblage from these two quarries. Tedford (1981) and Gawne (1975, 1976) assigned an early Hemingfordian age to the Blick LF based on the presence of the dog *Tomarctus optatus* (placed in the genus *Protomarctus* by Wang et al., 1999), the dog *Cynarctoides acridens*, the rodent *Pleurolicus* cf. *P. sulcifrons*, and the pika (ochotonid) *Oreolagus* cf. *O. nebrascensis*. The Blick Quarry is the type locality of the endemic stenomyline camel *Blickomylus galushai* (Frick and Taylor, 1968). The Blick LF is early Hemingfordian in age, and is similar to the Thomas Farm LF from Florida, the Martin Canyon LF from Colorado, and the faunas from the Runningwater Formation in Nebraska (Gawne, 1975).

The Jeep Quarry is located in the same general vicinity as the Blick Quarry in the Arroyo Pueblo drainage, but is higher stratigraphically, in the upper part of the Chamisa Mesa Member. Gawne (1975) named the Jeep LF for the mammalian assemblage from the Jeep Quarry and several nearby localities. Tedford (1981) assigned an early Hemingfordian age to the Jeep LF based on the presence of the bear dog *Amphicyon*, the mustelid *Promartes*, the camel *Protolabis*, and the mylagaulid rodent *Mesogaulus*. Other mammals from the Jeep LF (Gawne, 1975) include the bear dog *Ysengrinia*, the canids *Desmocyon thompsoni* and *Metatomarctus canavus*, the pronghorn antilocaprid *Merycodus*, and the camels *Michenia* and *Blickomylus galushai*. The Jeep Quarry is the type locality of the canid *Cynarctoides gawnae* (Wang et al., 1999). The Jeep LF is early Hemingfordian in age, slightly younger than the Blick LF, and intermediate in age between medial

Ma	Epoch	NALMA	LITHOSTRATIGRAPHY	MAMMAL FAUNAS			
10 15 20	MIOCENE	Middle	Santa Fe Group Zia Formation	Arroyo Ojito Fm			
				Cerro Conejo Member	Clarendonian sites Alamo Ranch sites Benavidez Ranch LF Zia Prospect Rincon Quarry		
		Early		Hemingfordian	Chamisa Mesa Member	Kiva Quarry Jeep LF Blick LF	
				Arikareean	Piedra Parada Member	Standing Rock LF	
					Claren.		
					Barstovian		
					early		
					late		
					early		
					late		
		early					
		late					

Figure 1. Lithostratigraphic and bistratigraphic correlation of the Zia Formation in the northern Albuquerque basin.

The Standing Rock Quarry is in the Piedra Parada Member of the Zia Formation, located in Arroyo Piedra Parada, south of San Ysidro on the Zia Reservation (Galusha, 1966). It has produced the oldest fossil mammal assemblage from the Zia Formation, the rich late Arikareean assemblage named the Standing Rock Local Fauna (LF) by Gawne (1975). Tedford (1981) assigned a late

Hemingfordian faunas from the Runningwater Formation and the late Hemingfordian Sheep Creek Fauna, both from Nebraska (Gawne, 1975; Tedford, 1981).

The Kiva Quarry is in the Chamisa Mesa or Piedra Parada members of the Zia Formation in the Jemez River area near Arroyo Ojito and Arroyo Piedra Parada (Cañada de Zia and Cañada Piedra Parada, respectively, of Galusha, 1966; Tedford, 1981). The presence of the borophagine dogs *Paracynarctus kelloggi* and *Microtomarctus conferta* and a primitive species of the horse genus *Protohippus* indicates a late Hemingfordian age for the Kiva Quarry (Tedford, 1981; Wang et al., 1999). The Kiva Quarry fauna is similar to mammalian faunas from the Nambé Member of the Tesuque Formation in the Española basin in northern New Mexico.

In Arroyo Ojito, and farther south along the Ceja del Rio Puerco, especially on the Alamo Ranch and Benavidez Ranch, faunas of late Barstovian age occur in the Cerro Conejo Member (usage of Connell et al., 1999) of the Zia Formation (Tedford 1981; Tedford and Barghoorn, 1999; Morgan and Williamson, 2000). The Benavidez Ranch LF is in the Cerro Conejo Member west of Rio Rancho in southern Sandoval County. The Benavidez Ranch mammalian fauna includes the rhinoceros *Peraceras*, the camels *Michenia*, *Procamelus*, and *Protolabis*, the pronghorn antilocaprid *Ramoceros*, and the proboscidean *Gomphotherium productum* (Morgan and Williamson, 2000). The Benavidez Ranch LF also has a diverse footprint fauna, including tracks made by a small wading bird, small and medium-sized camels, a rhinoceros, a horse, a large felid, a large borophagine canid, and a proboscidean (Williamson and Morgan, 2001). The most age-diagnostic taxon in the Benavidez Ranch LF is *Gomphotherium*, which first appears in southwestern faunas in the early middle Miocene at about 14.5 Ma, defining the beginning of the late Barstovian (Tedford et al., 1987; Tedford and Barghoorn, 1997, 1999). The remainder of the Benavidez Ranch LF is consistent with a late Barstovian age.

At Arroyo Ojito, the Rincon quarry of Galusha (1966) is in the lower 50 m of the Cerro Conejo type section, and the Zia prospect is near the middle of the Cerro Conejo section at Arroyo Ojito (S.D. Connell, 2000, oral commun.). The Rincon Quarry fauna includes the borophagine canids *Aelurodon ferox* and *Paratomarctus temerarius* and primitive species of the horse genera *Neohipparion* and *Pliohippus* (Tedford, 1981; Wang et al., 1999). The Rincon Quarry assemblage is similar to the late Barstovian fauna from the Santa Cruz sites in the Pojoaque Member of the Tesuque Formation in the Española basin (Tedford, 1981).

The Alamo Ranch site is another late Barstovian (Tedford, 1981, Tedford and Barghoorn, 1999).

locality that is part of the Cerro Conejo Member. Faunas from the Cerro Conejo Member along the northern Ceja del Rio Puerco, from Cañada Navajo south to Cañada Pilares and Cañada Moquino, most of which are located on the Alamo Ranch, are similar to the Rincon Quarry assemblage. (Tedford, 1981) The Alamo Ranch sites are characterized by the beaver *Eucastor*, the camels *Aepycamelus*, *Michenia*, *Protolabis*, and *Procamelus*, the antilocaprid *Ramoceros*, and *Gomphotherium productum* (Tedford, 1981; Tedford and Barghoorn, 1999). The mammalian assemblages from the Cerro Conejo Member on the Alamo Ranch are typical of the late Barstovian (middle Miocene, 12-14 Ma; Tedford and Barghoorn, 1999). A late Barstovian age for the vertebrate faunas is supported by a K-Ar date of 13.64 Ma on a fallout ash in the Cerro Conejo Member (Tedford and Barghoorn, 1999).

Scattered, generally poorly documented Clarendonian mammal fossils are found in the upper part of the Cerro Conejo Member on the Zia Reservation between the San Ysidro and Zia faults of Connell et al. (1999), which are equivalent to the Jemez and Rincon faults, respectively, of Galusha (1966) and Tedford (1981). Another poorly documented Clarendonian locality includes the carnivore *Epicyon* and is near US-550 on the Santa Ana Reservation (R.H. Tedford, 1999, oral commun.), where several volcanic ashes are interbedded in the uppermost part of the Cerro Conejo Member. One of these ashes correlates to one of the Trapper Creek tephra in Idaho, which is dated at ~ 10.8 Ma (Personius et al., 2000). The age of this ash is consistent with the occurrence of the Clarendonian horses *Pliohippus* cf. *P. pernix*, *Cormohipparion* cf. *C. occidentale*, and a derived species of *Neohipparion* (Galusha, 1966; Tedford, 1981). Eastward, across the Zia fault, and in the Arroyo Arenoso drainage north of the Jemez River, rocks that are probably correlative with the Cerro Conejo Member have produced similar Clarendonian fossils (Tedford, 1981). Deposits that may be correlative with the Cerro Conejo Member are interbedded with the Chamisa Mesa basalt (Connell et al., 1999), which has a K-Ar date of about 10.4 Ma (Bailey and Smith, 1978). These two dates are consistent with a Clarendonian age for the youngest faunas from the Cerro Conejo Member.

The mammalian faunal succession from the Zia Formation in the northern Albuquerque basin begins in the late Arikareean and ends in the Clarendonian (between about 19-21 and 11 Ma), overlapping in age with much of the better known faunal sequence from the Española basin in northern New Mexico (Tedford, 1981). Late Arikareean faunas from the Aiquiu Formation are similar in age to the Standing Rock LF in the Albuquerque basin. Early Hemingfordian sites comparable in age to the Blick and Jeep LFs appear to be absent from the Española

basin. Sites from the Nambé Member of the Tesuque Formation are similar to the late Hemingfordian Kiva Quarry in the Albuquerque basin. There appears to be a hiatus in the northern Albuquerque basin sequence, equivalent to the early Barstovian, and corresponding to faunas from the Skull Ridge Member of the Tesuque Formation in the Española basin (Tedford, 1981; Tedford and Barghoorn, 1999). This hiatus is documented by magnetostratigraphy (Tedford and Barghoorn, 1999). Late Barstovian faunas from the Rincon Quarry, Alamo Ranch, and Benavidez Ranch in the northern Albuquerque basin are comparable in age to faunal assemblages in the Española basin from the Pojoaque Member of the Tesuque Formation, in particular the Santa Cruz sites (Tedford, 1981, fig. 2). The youngest faunas from the Zia Formation are Clarendonian in age, and are similar to several faunas in the Española basin, such as the Round Mountain Quarry in the Chamita Formation (Tedford, 1981).

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