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MAGNETOSTRATIGRAPHY AND PALEONTOLOGY OF WAGNER QUARRY, (LATE OLIGOCENE, EARLY ARIKAREEAN) BASAL ARIKAREE GROUP OF THE PINE RIDGE REGION, DAWES COUNTY, NEBRASKA

F. Glynn Hayes

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MAGNETOSTRATIGRAPHY AND PALEONTOLOGY OF WAGNER QUARRY, (LATE OLIGOCENE, EARLY ARIKAREEAN) BASAL ARIKAREE GROUP OF THE PINE RIDGE REGION, DAWES COUNTY, NEBRASKA

F. Glynn Hayes[1]

ABSTRACT

Mammalian fossils (the Wagner Quarry local fauna) from the basal Arikaree Group (Late Oligocene) near Chadron, Dawes County, Nebraska, are described. It is the first large mammal concentration described from the Pine Ridge Arikaree Group. Twenty-seven species of mammals are present: 1 marsupial (*Herpetotherium*), 2 insectivores (*Proscalops*, *Ocajila*), 9 rodents (*Downsimus*, *Alwoodia*, ***Cedromus savannae*** n. sp., *Nototamias*, *Agnotocastor*, *Palaeocastor*, *Proheteromys*, *Leidymys*, *Geringia*), 3 lagomorphs (*Palaeolagus* [2 sp.], *Megalagus*), 3 carnivores (*Paradaphoenus*, Canidae, *Nimravus*), 3 perissodactyls (*Miohippus*, *Diceratherium* [2 sp.]), and 6 artiodactyls (Entelodontidae, Desmatochoerinae, *Leptauchenia*, Anthracotheriidae, *Pseudolabis*, *Nanotragulus*). Faunal correlation with the Ridgeview local fauna and the radioisotopically constrained faunas of the Wildcat Ridge indicates an early Arikareean (Ar1, 30-28 Ma, Tedford et al. 2004) North American Land Mammal age for the fauna. The first paleomagnetic study of the Pine Ridge basal Arikaree Group (Wagner Quarry section) shows that polarity signals are not the same as basal Arikaree Group sediments (Gering Formation) in the Wildcat Ridge region. Correlation of the Wagner Quarry section with Chron 10n (28.25-28.9 Ma) places it older than the Gering Formation (Chron 9r, 27.95-28.25 Ma) and younger than the lowermost White River Group "Brown Siltstone" (Chron 10r-11n, 28.9-30.08 Ma) of Nebraska. These sediments could represent time not recorded in the Wildcat Ridge. *Cedromus* (Sciuridae), *Oligospermophilus* (Sciuridae), and *Alwoodia* (Aplodontidae) are newly recognized in the earliest Arikareean (Ar1) of the central Great Plains.

Key Words: Arikareean, Arikaree, Nebraska, Pine Ridge, paleomagnetics, Wagner Quarry, *Alwoodia*, *Cedromus*.

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INTRODUCTION

The lower and middle Arikaree Group in Nebraska consists of two major west-east trending paleo-valley fill sequences, one exposed in the northern Pine Ridge region and the second exposed in the North Platte Valley and Wildcat Ridge area (Fig. 1). Historically, these two deposits have been equated on the basis of lithologic and biostratigraphic similarities, although lateral continuity of the lower sediments has never been demonstrated. Specifically, the basal Arikaree fluvial deposits, exposed in the Pine Ridge region, have often been referred (see Tedford et al. 1987) to the basal Arikaree Group, Gering Formation, originally described by Darton (1899) at the Wildcat Ridge. Swinehart et al. (1985) restricted the Gering Formation to pumice-bearing beds that are not present at Pine Ridge. This has reopened the question as to where and how the Pine Ridge basal fluvial valley fill sequences fit into the history of Arikaree deposition and how their faunas fit into the biochronologic system of the North American Land Mammal ages (NALMA).

Biostratigraphic comparison has provided some support for the age correlation of these two deposits representing the early Arikareean (30-28 Ma) NALMA (Tedford et al. 1987; Tedford et al. 1996; Tedford et al. 2004). When Wood et al. (1941) proposed the NALMA system, they defined and characterized the early Arikareean using fossils recovered from the Gering Formation in the Wildcat Ridge and correlative faunas from the lower Sharps Formation of South Dakota. However, due to the lack of described faunas from the Pine Ridge lower Arikaree rocks to compare with the better known (Tedford et al. 1996), although largely informally reported (Martin 1973; Swisher 1982) faunas of the Gering Formation in the Wildcat Ridge, detailed correlation with the Pine Ridge Arikaree has not been possible.

Martin's (1973) dissertation that described the Gering faunas in the stratigraphic context of Vondra et al. (1969) was later updated by Swisher (1982) who produced a more refined biostratigraphic study. Swisher divided the sediments above the Whitney Member of the Brule Formation into Gering units A through D and referred the massive eolian sandstones above the Gering to the Monroe Creek Formation of Hatcher (1902). Later (Swinehart et al. 1985), Swisher's Gering A was removed from the Gering Formation and referred to the "Brown Siltstone" and his Gering B-D was designated the revised Gering Formation that was made up of pumice bearing channels along the Wildcat Ridge. These faunas are now well-constrained by $^{40}Ar/^{39}Ar$ radioisotopic dates (Woodburne & Swisher 1995; Tedford et al. 1996).

Interest in establishing a firmer correlation between the Pine Ridge Arikaree and Wildcat Ridge deposits, which would aid in refining the biochronology of the Arikareean NALMA, has led to the discovery of several rich fossil sites in the Pine Ridge region. A small locality (UNSM Dw-108) was studied by Martin (1973) south of Chadron that yielded *Herpetotherium, Ocajila, Domnina, Palaeolagus, Megalagus, Downsimus, Meniscomys, Agnotocastor, Proheteromys, Leidymys blacki,* and *Geringia mcgregori.* Bailey (1992, 1999, 2004) described another micro-mammal site (UNSM Dw-121) that he termed the Ridgeview local fauna (lf), which yielded 35 mammal species, the most diverse single site reported for the early Arikareean. The third locality, and the subject of this report, was found by R. Tedford and T. Galusha in 1975 near the town of Chadron, at the base of the Pine Ridge Arikaree Group. They named the site Wagner Quarry after the land owner at the time.

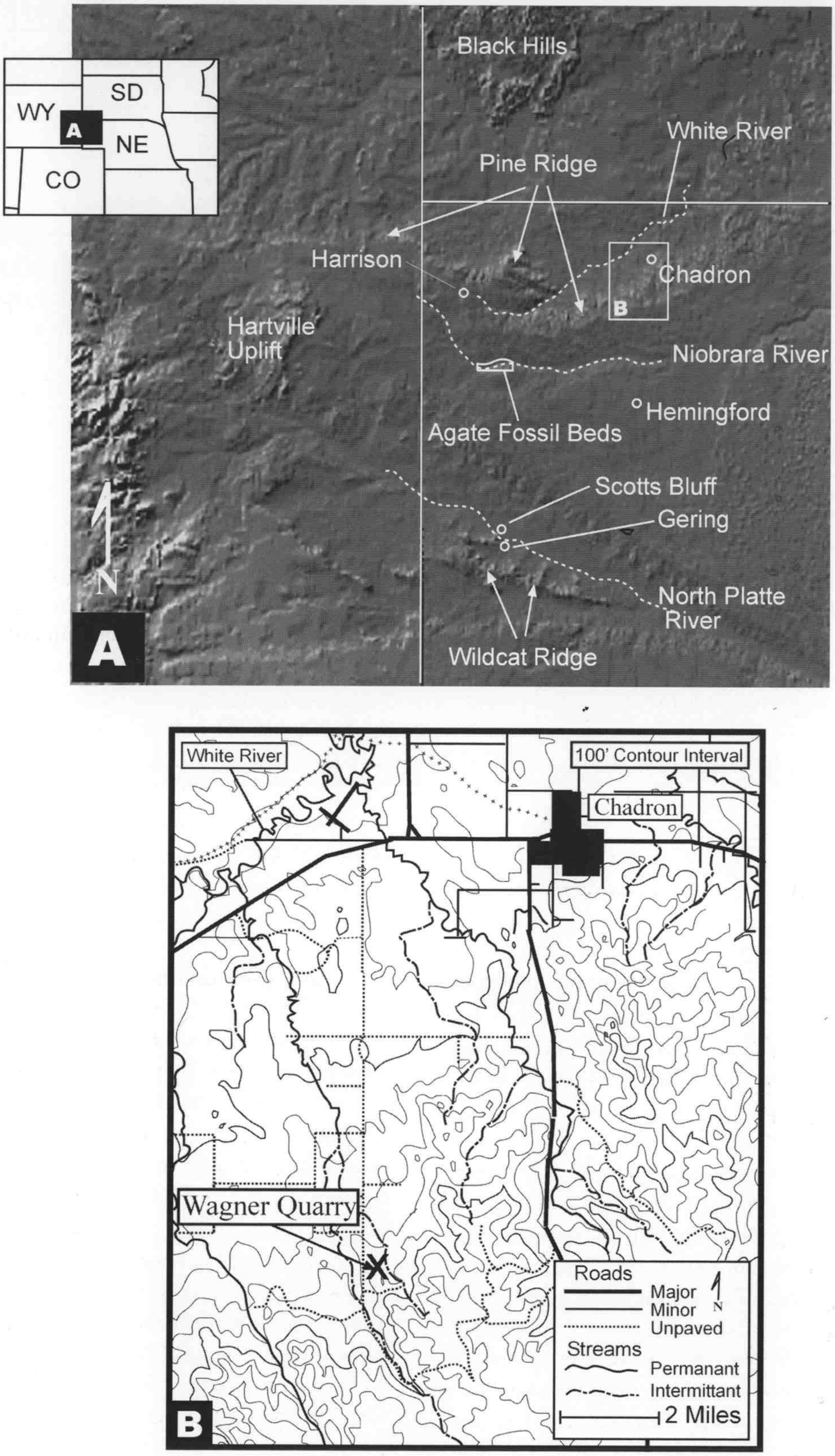

Figure 1. Location map of study area and Wagner Quarry.

Since its discovery, fossils have been collected intermittently by joint teams from the American Museum of Natural History and the University of Nebraska State Museum.

This study of the Wagner Quarry fossils, herein named the Wagner Quarry local fauna, is the first systematic description of a micromammal fossil fauna and large mammal concentration from the Pine Ridge region. Peterson (1907) described large mammals from the Pine Ridge Squaw Butte region, north of Harrison, Nebraska, but these were isolated finds. More significantly, this is also the first paleomagnetic study of basal Arikaree Group rocks at Pine Ridge. Bailey's (2004) biostratigraphic study reported only faunal lists from the localities. MacFadden & Hunt (1998) paleomagnetically sampled the upper Arikaree Group (Harrison Formation; Anderson Ranch= "Upper Harrison" Formation, [Hunt 2002]) and the middle (Monroe Creek of Hatcher 1902) to lower Arikaree interval but did not sample most of the lowest fluvial facies of the basal Arikaree at Pine Ridge. Prothero sampled paleomagnetically the White River Group of the Pine Ridge region, but did not study the Arikaree Group sediments (Tedford et al. 1996: Prothero & Whittlesey 1998).

HISTORY OF INVESTIGATION

Wagner Quarry was discovered and surface collected by R. Tedford and T. Galusha in 1975 in a brief reconnaissance of the basal Arikaree Group around Chadron, Nebraska. They returned several times over the next decade and collected horse, rhino, camel, *Nanotragulus*, and oreodont material. Tedford believed the fossils represented a lower Gering/Sharps equivalent fauna (Tedford, pers. comm., 2003).

In 1981 a joint team from the American Museum and the University of Nebraska returned to the site and collected a varied fauna, including a juvenile *Pseudolabis* skull (F:AM 141372) and an anthracothere mandible (F:AM 141369). A second channel fill higher in the section (see Fig. 5), discovered by M. Skinner in 1981 as well, also yielded material of leptauchenine oreodonts and several species of rodents (e.g., *Palaeocastor*, *Geringia*). Collection has continued until present as erosion exposes more fossils both in the quarry and in the upper channel. The skull of *Cedromus savannae* n. sp. (UNSM 48448) was discovered in 2001 by S. David Webb.

The fauna from Wagner Quarry was first mentioned in the field trip guidebook for the 45th annual SVP meeting by Tedford et al. (1985). They briefly described the quarry along with other mammal fossils collected from the basal Arikaree deposits near Chadron. Wagner Quarry was labeled on the cross section (Tedford et al.1985: 340, Fig. 2, cross section C-C'). The local faunas collected from Wagner and other localities around Chadron were listed as containing: *Heliscomys woodi, Kirkomys schlaikjeri, Sanctimus stuartae, Leidymys blacki, Geringia mcgregori, Palaeolagus philoi, Arretotherium, "Pseudocyclopidius"* (*Leptauchenia*) *major*, *Pseudolabis, Nanotragulus, Hypertragulus, Miohippus*, and *Diceratherium*. On the basis of these taxa Wagner Quarry was correlated to the early Arikareean. Hunt (2001) later described a new species of *Paradaphoenus*, *P. tooheyi*, in part based on a mandible recovered from Wagner Quarry. This species is intermediate in morphology between an Orellan species and a later medial Arikareean species.

The fauna from the quarry and the geology have never been completely described until this report. Bailey (2004) presented a faunal list (Table 1: 87) from a nearby basal Arikaree locality, the Ridgeview lf (UNSM locality Dw-121), that contains the same taxa of microfauna as in the Wagner Quarry lf. Bailey's biostratigraphic correlation of the Ridgeview lf places it slightly older than the Gering B-D faunas of the Wildcat Ridge, but younger than the Wildcat Ridge "Brown Siltstone" (= lower Sharps Formation) that has produced the earliest Arikareean taxa (Tedford et al. 1996; Tedford et al. 2004).

As part of a study on the correlation of the Arikaree Group of the Pine Ridge (Hayes 2004), the Wagner Quarry local fauna is described along with the magnetic stratigraphy of the Wagner Quarry section.

METHODS

Some of the small mammals were identified through comparison with the Ridgeview lf (Bailey 2004), which contains abundant and more complete material of many of the smaller mammal taxa found in Wagner Quarry. Otherwise, mammals were compared with reference material in the University of Nebraska State Museum collections, the Frick Collection at the American Museum of Natural History, and with taxa discussed in appropriate literature. Anatomical terminology follows that of current literature reviews of the major taxonomic groups mentioned in systematic discussions. All measurements are in millimeters unless otherwise stated. Tooth measurements were taken at the base of the crown along the principal cusp axes. Words placed in quotes are informal terms, uncertain, or represent outdated terminology retained for purposes of discussions. Referred specimens are from Wagner Quarry unless otherwise noted. Illustrations and photos of taxa omit "I" as a specimen designation because of its resemblance to the num-

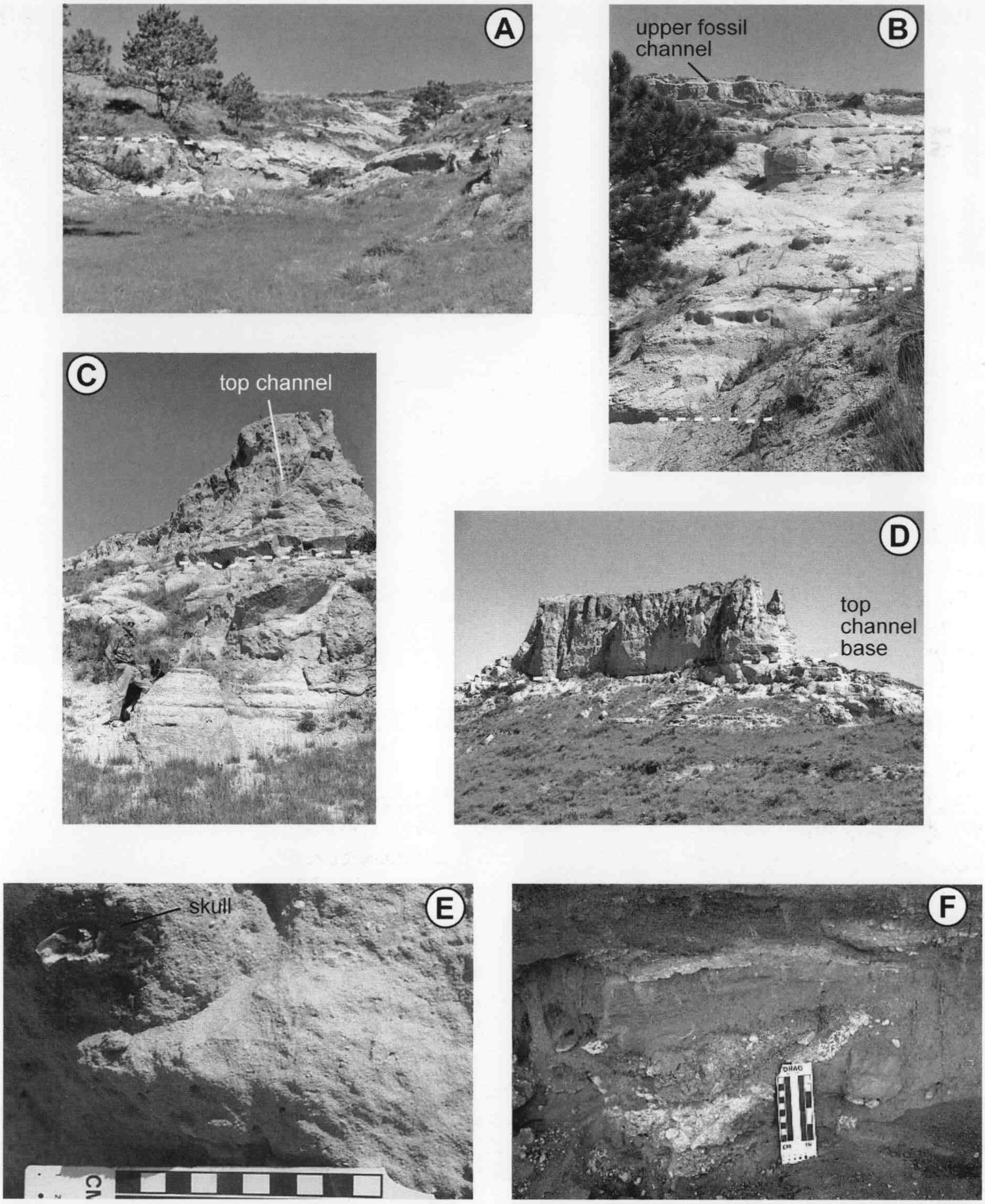

Figure 2. Photographs of outcrops and measured Wagner Quarry section. See Figure 5 for stratigraphic position. A, Wagner Quarry, view to the North, top of channel marked by dashed line; B, stacked overbank deposits above Wagner Quarry, view to north, local unconformities marked by dashed lines; C, top of Wagner Quarry section showing overbank deposits and "top channel" sands, view to north, base of channel marked by dashed line, Dave Webb for scale; D, expanded view of "top channel" butte, view to northwest; E, close view of Wagner Quarry basal Arikaree sandstone, *Cedromus* skull in coarser channel sand; F, close view of Wagner Quarry channel cross bedded sand with lithic clasts.

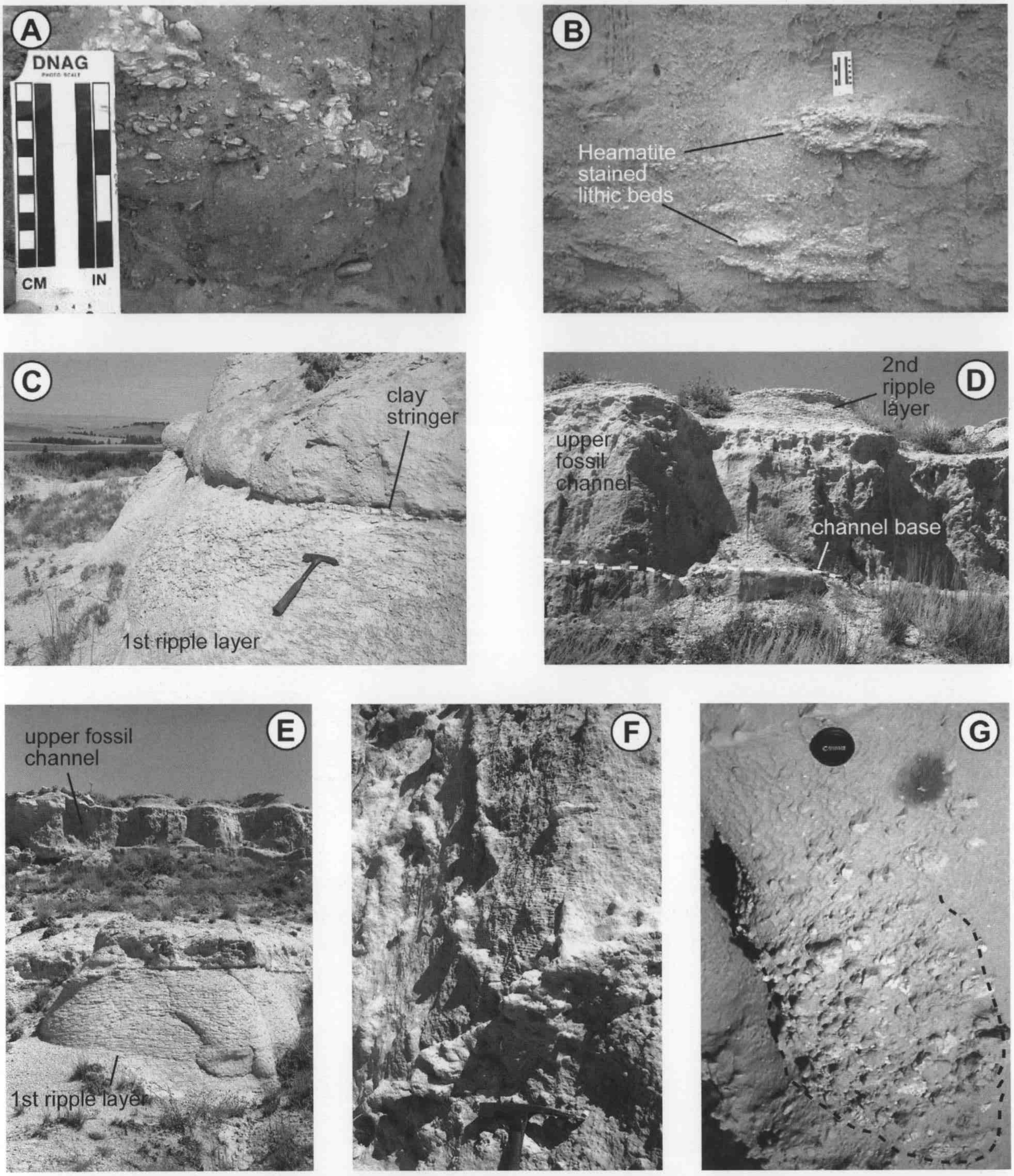

Figure 3. Photographs of outcrops and measured Wagner Quarry section. See Figure 5 for stratigraphic position. A, close view of clay and siltstone pebble clasts in Wagner Quarry channel; B, close view of hematite stained and cemented cross-beds in Wagner Quarry channel; C, close view of 1st ripple layer, above Wagner Quarry, showing local diastem marked by clay stringer; D, "upper fossil channel" and 2nd ripple layer, dashed line marks channel base; E, Wagner Quarry section showing 1st ripple layer below "upper fossil channel", sediments in between are interpreted as overbank deposits; F, close view of "upper fossil channel" showing fine scale laminae and small fossil burrows; G, close view of large fossil burrow infilled with siltstone gravels and sand in "upper fossil channel".

ber "1".

Abbreviations.— (others defined in text, tables, or figures); ap, anterior to posterior measurement, length; apt, anterior to posterior measurement of trigonid on lower molars, length; F, Fauna; Fm, Formation; L, left; lf, local fauna; M, mean; m# or M#, molar, lower case for lower molar; N, number of specimens; OR, observed range of variation; p# or P#, premolar, lower case for lower premolar; R, right; tr, transverse measurement, width; tra, transverse measurement of anterior trigonid width in lower molars; trp, transverse measurement of posterior talonid width in lower molars.

Institutional abbreviations.— AMNH, American Museum of Natural History, New York; F:AM, Frick Mammal Collection of the American Museum of Natural History, New York; LACM, Los Angeles County Museum, Los Angeles, California; SDSM, South Dakota School of Mines, Rapid City, South Dakota; UC, University of Chicago collections, Field Museum, Chicago, Illinois; UCMP, University of California Museum of Paleontology, Berkeley, California; UF, University of Florida collections, Florida Museum of Natural History, Gainesville, Florida; UNSM, University of Nebraska State Museum, Lincoln, Nebraska; YPM, Yale Peabody Museum, Yale University, New Haven, Connecticut.

GEOLOGY

The Wagner Quarry section consists of a stack of fluviatile sediments, alternating between channel fill, bar deposits, and floodplain or over-bank deposits separated by local diastems that show slight pedogenic alteration at the top of many of the beds.

The base of the measured Wagner Quarry section (Fig. 2A) does not have a contact between the fluvial Arikaree and the underlying "Brown Siltstone" (= lower Sharps) member of the Brule Formation. However, both north and south of the Wagner Quarry on Dead Horse Road, there are outcrops of Arikaree gray, cross-bedded fine-medium sands unconformably overlying light pinkish to tan siltstones of the White River Group. The southern contact outcrop exposes the Nonpareil Ash (NP) (Swinehart et al. 1985), approximately 6m topographically below Wagner Quarry, as shown in Figure 5 (Stratigraphic distance could not be determined due to ground cover). This ash in the Pine Ridge has been correlated to the NP_3 ash (Tedford et al. 1996) that is exposed at Wildcat Ridge. This ash at Wildcat Ridge was dated using $^{40}Ar/Ar^{39}$ to 30.05 +/- 0.19 Ma (Tedford et al. 1996; Swisher & Prothero 1990).

The base of the Wagner Quarry section is a channel deposit of fine gray, trough cross-bedded epiclastic sand and pebble conglomerates (Fig. 2F) with occasional

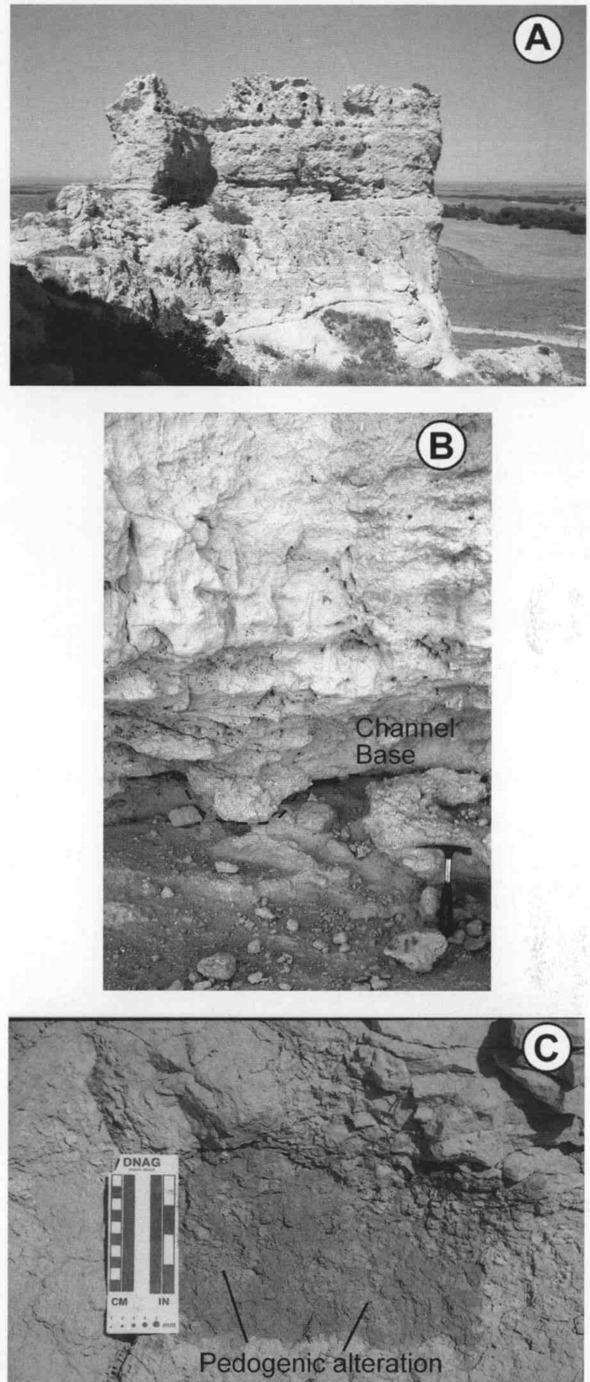

Figure 4. Photographs of outcrops and measured Wagner Quarry section. See Figure 5 for stratigraphic position. A, "top channel" sandstone butte showing eroded base of channel and large scale bedding; B, close view of "top channel" base showing local incision; C, close view of top of overbank deposits showing mottling and clay clumping interpreted to be pedogenic alteration.

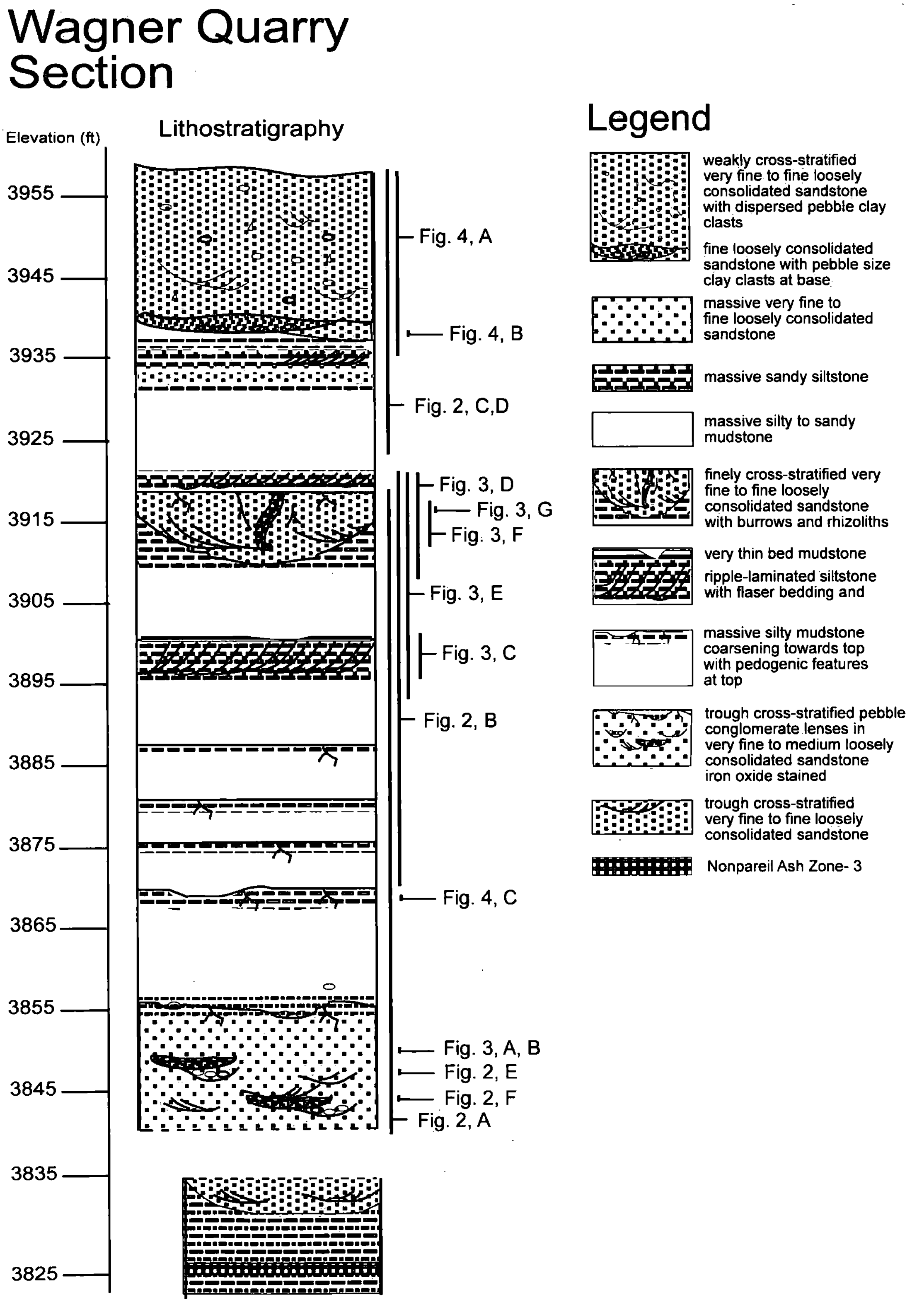

Figure 5. Lithostratigraphy of Wagner Quarry measured section and nearby outcrop of "Brown Siltstone".

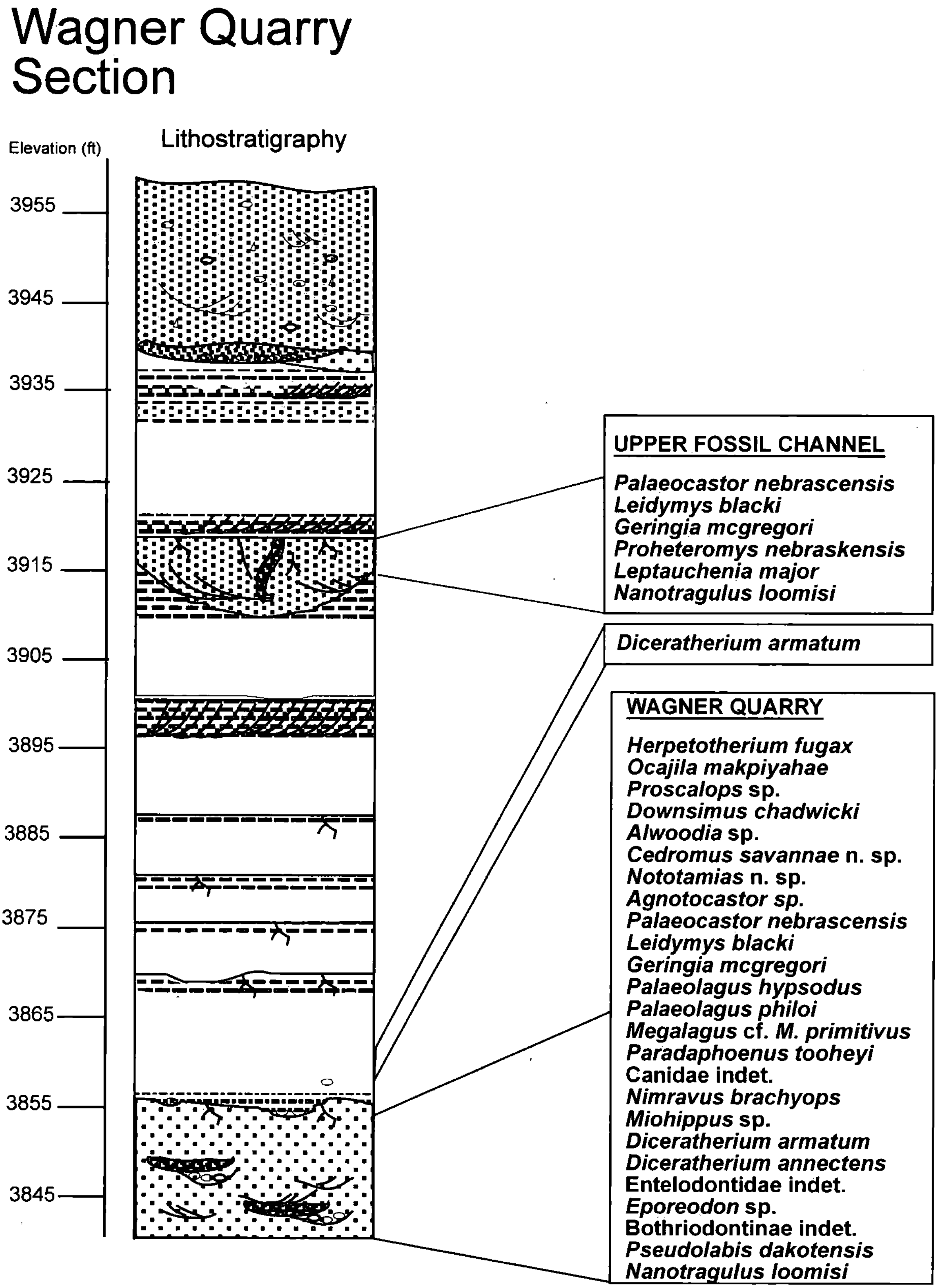

Figure 6. Stratigraphic placement within Wagner Quarry measured section of fossil mammals constituting the Wagner Quarry local fauna described in text.

hematite staining (Fig. 3B), and grey to buff trough cross-bedded clayey siltstone pebble clast conglomerates (Fig. 3A) interbedded with very fine to coarse weakly cross-bedded fine to coarse sand with scattered claystone pebbles (Fig. 2E). This channel fill fines upward where it is truncated and partially incised by a lighter pale greenish-gray massive silty mudstone that represents an over-bank deposit. A sequence of similar over-bank deposits overlie the first (Fig. 2B), many of which are marked along their upper boundaries by slight pedogenic alteration (Fig. 4C) and rhizoliths. This suggests a relatively brief period of non-deposition before deposition of a new bed by flooding. Although fragmentary fossil bones have been collected from these rocks, the only identifiable bone is a large calcaneum of *Diceratherium armatum* (Fig. 14K: F:AM 141386) collected just above the quarry.

The over-bank sequence is interrupted by a layer of uniform flaser bedded clay to siltstone ripples representing a low mean flow velocity, probably away from the main channel during a low water stage. The "1st ripple layer" (Fig. 5) is draped by a tuffaceous silty claystone stringer (Fig. 3C). This lithology is reproduced several times in the section, occurring above the "upper fossil channel" and below the "top channel". The "upper fossil channel" grades into this depositional mode (Fig. 3D) and the ripple layer at the top of the section is laterally traceable into massive or flat bedded sandy silts.

The "upper fossil channel" consists of finely cross-stratified, very fine to fine, loosely consolidated sands, with interspersed claystone pebble clasts (Fig. 3F). Trace fossils are relatively common in this deposit as compared to the Wagner Quarry channel, which has very few. Besides small invertebrate burrows and rhizoliths, there are large burrows filled with intraformational pebbles (Fig. 3G). The more complete rodent, *Nanotragulus,* and leptauchenine material was collected from these infilled burrow deposits. Also, turtle, fragmentary oreodont, and other mammal bone fragments were collected directly from the channel deposit. The channel deposit fines upward into a second ripple layer, which lies below another massive over-bank deposit that grades upward (unlike the lower over-bank deposit) into distal fluvial silty sands and very fine sands.

The upper most part of the section is dominated by a thick sequence of weakly trough cross-stratified, otherwise massive, very fine to fine, loosely consolidated sand with dispersed intraformational clay to siltstone clasts (Figs. 2C, D; 4A). This "top channel" deposit has an intraformational pebble conglomerate with a fine to medium sand matrix at its base, which is slightly incised into the underlying deposits (Fig. 4B). Neither fossils nor invertebrate burrows or rhizoliths were found in this unit. Overall, as one ascends the section, the channel deposits become better sorted and more mature. This probably indicates a reworking of local sediments by streams with diminished flow velocity.

The channel sequences are also suggestive of a drying climatic trend for the area. Wagner Quarry has produced taxa that are typically found in wetter riparian environments (Fig. 6) such as alligators, anthracotheres, and beavers (*Agnotocastor*). That leptauchenine oreodonts are found only in the smaller "upper fossil channel" along with a partial *Palaeocastor* skull, (Fig. 6) suggests that the "upper fossil channel" likely sampled a drier environment than the channel of Wagner Quarry.

PALEOMAGNETIC RESULTS

To determine the magnetostratigraphy of the Wagner Quarry section, 11 sites were selected at 3-4.5m (10-15') stratigraphic intervals. At each site, three separately

Table 1. Paleomagnetic results for individual sites at the Wagner Quarry measured section

Site	Dec	Inc	K	VGP	Class	Polarity	Elevation	A95
W1	355.9	70.9	438.6	76.9	I	N	3850	5.9
W2	342.3	62.5	126.8	77	I	N	3863	11
W3	19.3	73.5	378	69.4	I	N	3870	6.3
W3A	96.4	52.7	21.9	17.6	I	N	3880	27
W4	27.9	70.9	20.6	67.9	I	N	3890	27.9
W5	351.1	61.2	203.2	83.4	I	N	3905	8.7
W6	179.8	-44.4	3.4	-73.6	I	R	3915	81
W7	128.6	-18.6	25.3	-34.5	I	R	3925	25.1
W8	353.4	64.9	74.2	83.6	I	N	3935	14.4
W9			Not used				3945	
W10	314.3	23.6	17.6	40.3	I	N	3955	30.3

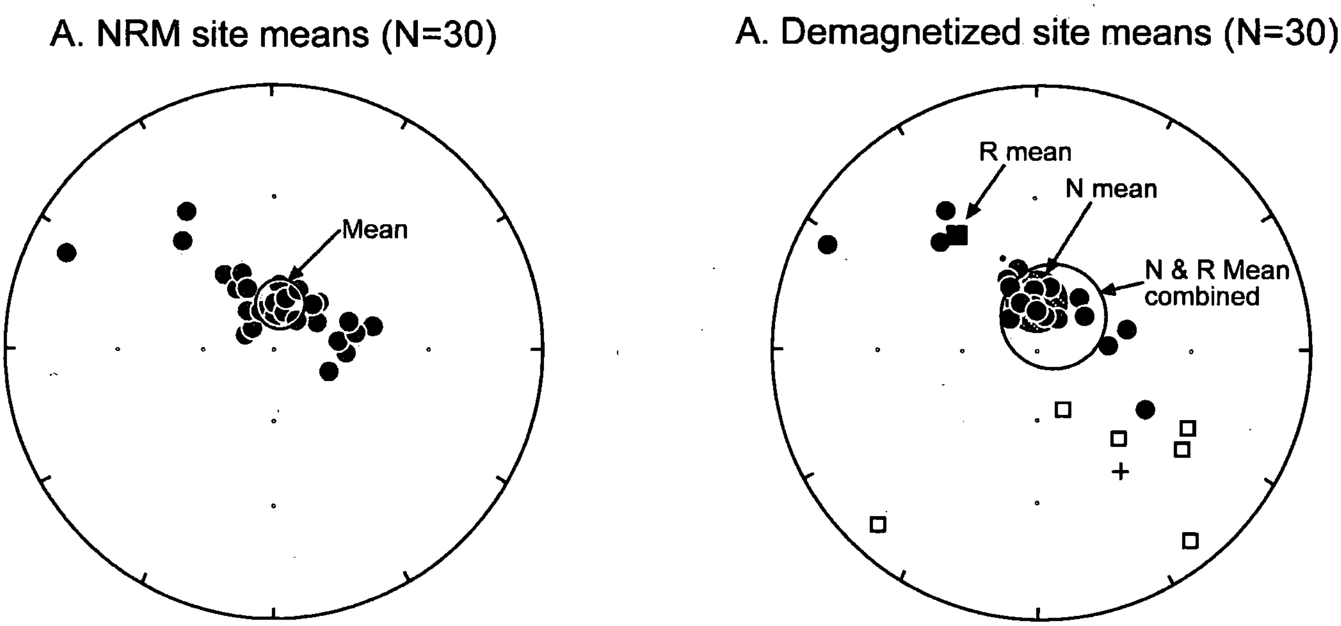

Figure 7. Equal-angle stereographic projections of all used site mean data for the natural remanent magnetization (NRM) and site sample data after thermal demagnetization. The circles are the 95% confidence cone for the mean. Black circles represent positive inclination, open squares are negative inclination.

oriented samples were collected. Sample orientation was measured using a Brunton geologic compass. Samples were recovered from the outcrop by the use of hand tools and then drilled into 2cm cores using a non-magnetic bit in the laboratory. The direction of magnetization was measured in a 3-axis 2G Enterprises cryogenic magnetometer at the University of Michigan.

Thirty samples were measured (Fig. 7) for Natural Remanent Magnetization (NRM) - Mean Dec: 7.6, Inc: 70.2, N: 30, R: 27.13, k: 10.1, a95: 8.7- and then thermally demagnetized in 8 to 10 steps. Previous studies (Prothero & Whittlesey 1998, Tedford et al. 1996, MacFadden & Hunt 1998) identified magnetite as the Detrital Remanent Magnetization (DRM) carrier, and have shown that thermal demagnetization provides the clearest paleomagnetic data in samples of Arikaree sediments. Alternating field demagnetization is not successful in removing iron hydroxide overprints (Butler 1992).

Polarity directions were determined by principal component analysis (Kirschvink 1980) and visual inspection of orthogonal demagnetization diagrams analyzed by the Super-IAPD99 software (by Torsvik, T. H., Brinden, J. C., & M. A. Smethurst— available at the following website- www.ngu.no/geophysics). Virtual Geomagnetic Poles (VGP) were calculated using the same program (Table 1). Figure 8 shows representative sample demagnetization plots (Zijderveld diagrams) and intensity decay graphs. Fisher statistics (Fisher 1953) were used to calculate site mean directions and confidence limits. Samples usually show a two-component magnetization. The first, a secondary NRM component, is removed between 180-220°C and probably represents a present-day magnetic overprint carried by goethite. Directions interpreted to represent the depositional remanent magnetization, carried by magnetite, are revealed between 200-550°C. Remanence levels drop below 10% of total intensity (Fig. 8) after 580-600°C, above the Curie point of magnetite.

A reversals test is not supported, due to the small number of specimens and the incomplete removal of normally oriented components (Fig. 7). However, all the sites used in the Wagner Quarry section showed three samples with concordant directions. A Class I site shows concordant directions for all three single site samples (*sensu* Opdyke et al.1977). A Class II site, of which there were none in this study, has two concordant samples.

Several sites exhibited very high k values (see Table 1). The only site not used, W-9, was taken from the "top channel" sediments. It was not used because the samples could not be hardened enough to either cut with the coring drill or hand cut into cubes.

Of the 10 criteria to rate overall quality of magnetic studies proposed by Opdyke (1990) and Opdyke & Channel (1996), this study satisfies 6. They suggest that valid modern magnetostratigraphic studies should meet 5 or more of their criteria. As mentioned above the antipodal test is not supported, a radioisotopic age is

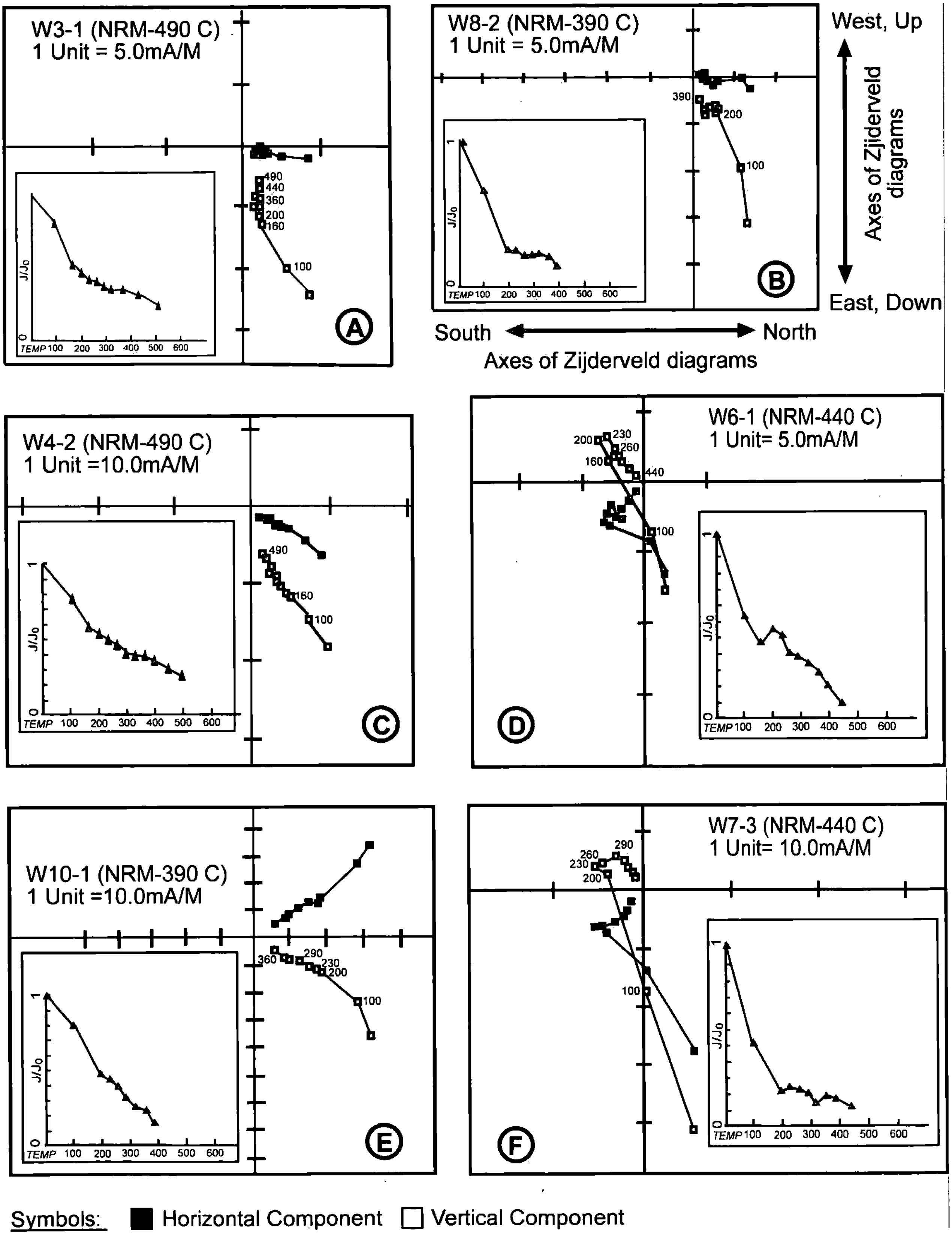

Figure 8. Representative Zijderveld thermal demagnetization diagrams and decay of Natural Remanent magnetization (NRM) intensity of the Wagner Quarry section. Numbers denote temperature steps in degrees Celsius.

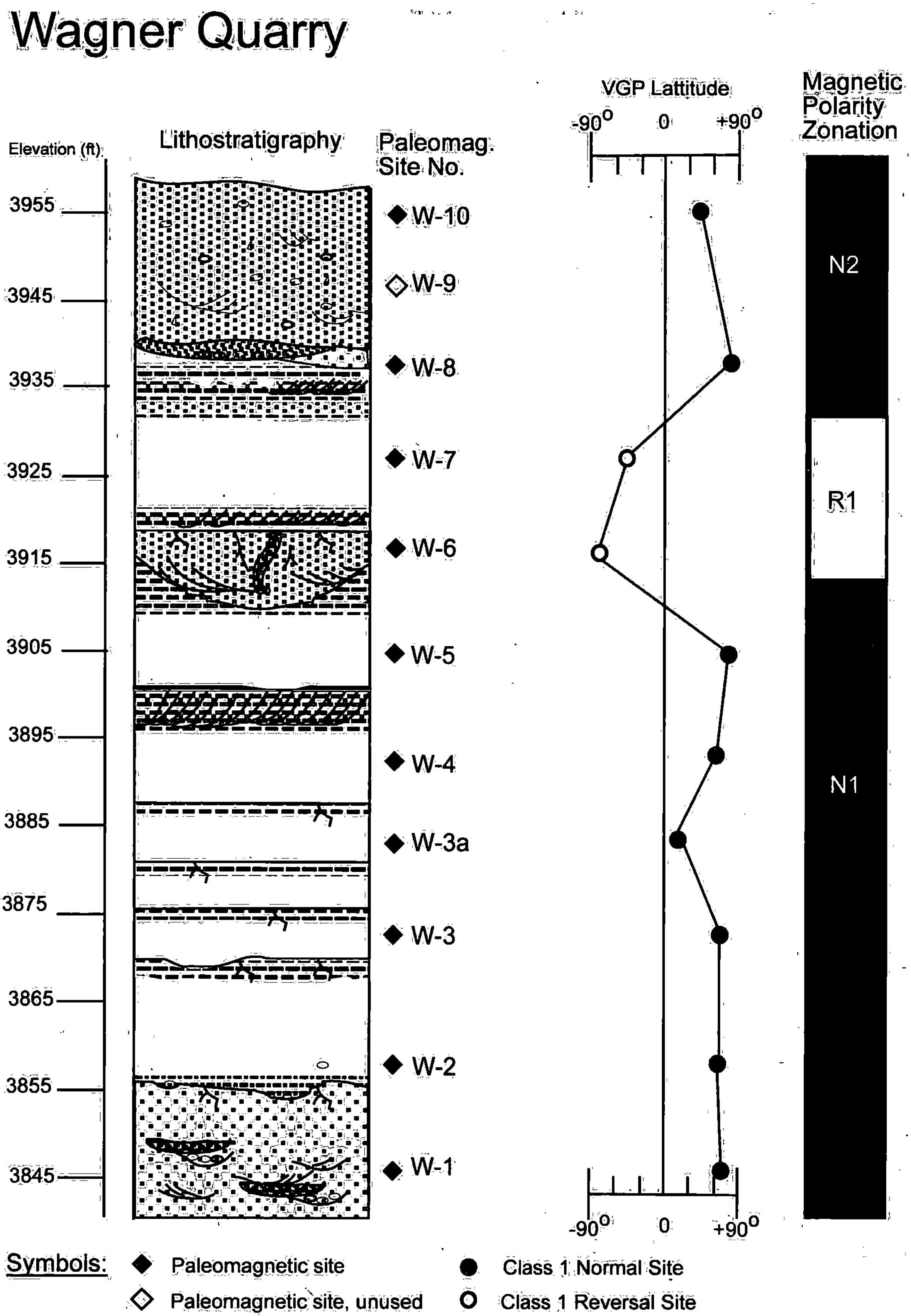

Figure 9 . Lithostratigraphy and corresponding Virtual Geomagnetic Poles for the Wagner Quarry section. (see Fig. 5 for lithology legend).

Table 2. Wagner Quarry local fauna mammalian faunal list.

Mammalia			
	Marsupialia		
			Herpetotherium fugax
	Insectivora		
			Ocajila makpiyahe
			Proscalops sp.
	Rodentia		
		Aplodontidae	
			Downsimus chadwicki
			Alwoodia cf. *A. magna*
		Sciuridae	
			Cedromus savannae n. sp.
			Nototamias sp.
		Castoridae	
			Agnotocastor sp.
			Palaeocastor sp.
		Heteromyidae	
			Proheteromys cf. *P. nebraskensis*
		Cricetidae	
			Leidymys blacki
			Geringia mcgregori
	Lagomorpha		
		Leporidae	
			Palaeolagus hypsodus
			Palaeolagus philoi
			Megalagus cf. *M. primitivus*
	Carnivora		
		Amphicyonidae	
			*Paradaphoenus tooheyi**
		Canidae	
			Canidae indet.
		Nimravidae	
			Nimravus brachyops
	Perissodactyla		
		Equidae	
			Miohippus sp.
		Rhinocerotidae	
			Diceratherium annectens
			Diceratherium armatum
	Artiodactyla		
		Entelodontidae	
			Entelodontidae indet.
		Merycoidodontidae	
			Desmatochoerinae indet.
			Leptauchenia major
		Anthracotheriidae	
			Bothriodontinae indet.
		Camelidae	
			Pseudolabis dakotensis
		Hypertragulidae	
			Nanotragulus loomisi

* described by Hunt, 2001

not available in the section (although the NPZ is present close to the section, as mentioned in the geology section), a field stability test is not possible, and directions were only partially determined by principal component analysis. The criteria fulfilled by this study include: 1) stratigraphic age known to the level of Cenozoic stage, 2) sampling localities placed in a measured stratigraphic section, 3) complete thermal or AF demagnetization performed and vector analysis carried out using orthogonal plots, 4) data published completely, 5) magnetic mineralogy determined, and 6) associated paleontology presented adequately.

The results show that even though the Wagner section is relatively short, there are three magnetozones present (Fig. 9). From the base of the Wagner Quarry section up to the beds below the "upper fossil channel", 6 sites are of normal polarity. A short reversal, among the otherwise normally polarized samples, is characterized by two Class I sites, although mean confidence levels were relatively dispersed for the sites (Fig. 7; Table 1). This probably indicates incomplete removal of a normal overprint, though the individual samples all showed clear reverse polarity. Above the reversal, there is a normal interval also characterized by two Class I sites.

WAGNER QUARRY LOCAL FAUNA

In addition to the mammal fauna, the non-mammalian material includes sparse fish and snake vertebrae, an alligator premaxilla (UNSM 123224), turtle elements (UNSM 123234 nuchal plate, UNSM 123236, humerus), and sparse avian material (e.g.: UNSM 123449-123453). The mammalian fauna is diverse considering that many taxa are represented by only a single specimen. The fauna is also relatively unique in that it contains both micro- and mega fauna. Most sites in the Pine Ridge or Wildcat Ridge are restricted, through taphonomic filters, to either small mammals or isolated occurrences of larger mammals. Twenty-seven mammalian species are present, including a marsupial, 2 insectivores, 9 rodents, 3 lagomorphs, 3 carnivores, 3 perissodactyls, and 6 artiodactyls (Table 2).

SYSTEMATIC PALEONTOLOGY

Class MAMMALIA Linnaeus 1758
Order DIDELPHIMORPHIA (Gill 1872)
Family DIDELPHIDAE Gray 1821
Genus *HERPETOTHERIUM* Cope 1873
HERPETOTHERIUM FUGAX Cope 1873
Table 3

Type.—AMNH 5254, R M1-M4 (Cope 1884).
Type Locality.—Cedar Creek Beds, White River

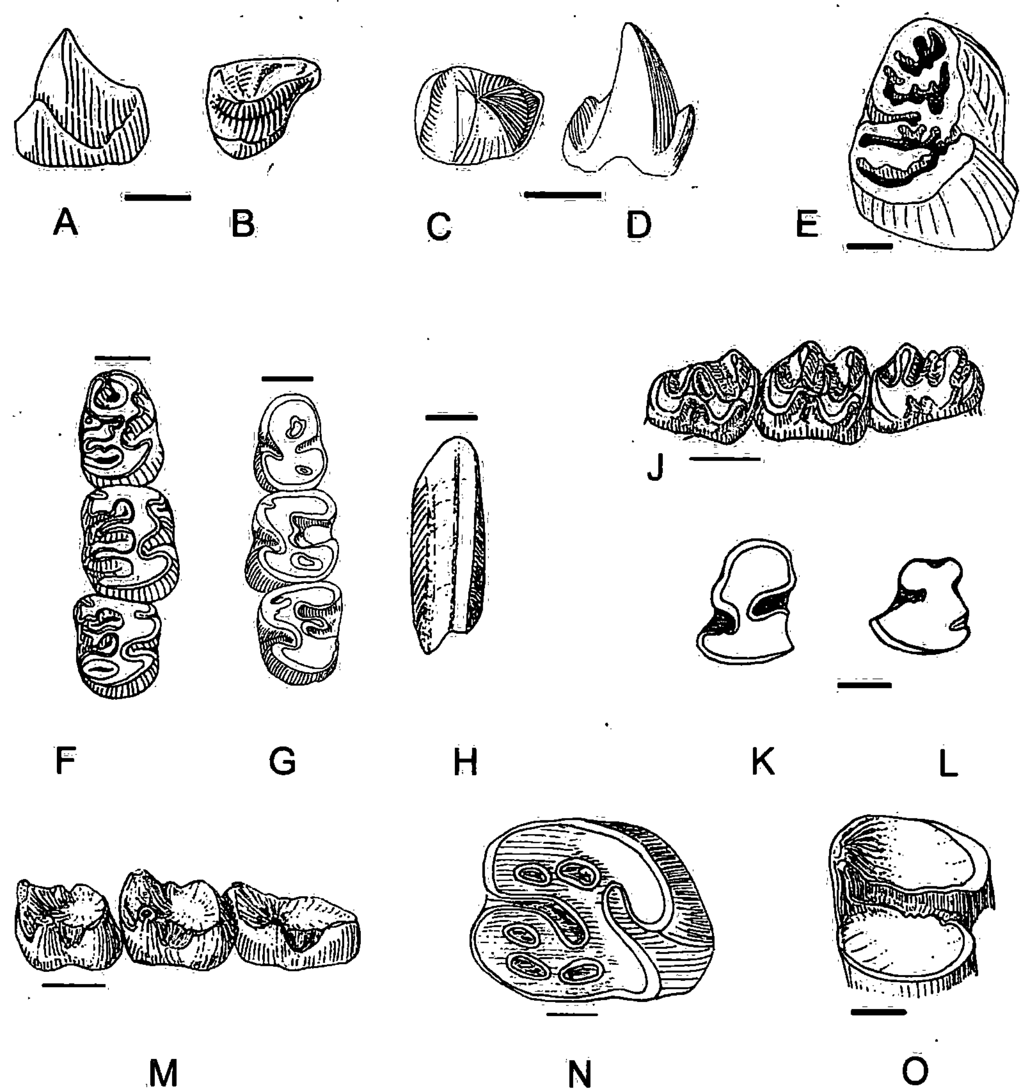

Figure 10. Wagner Quarry local fauna: insectivores, rodents, and lagomorphs. A-B: UNSM 123291, *Proscalops* cf. *P. miocaenus*, L P4, A, lingual view; B, occlusal view. C-D: UNSM 123288, *Ocajila makpiyahe*, R p4, C, occlusal view; D, labial view. E, UNSM 123295, *Agnotocastor* sp., Lp4, unworn, occlusal view. F, UNSM 123286, *Geringia mcgregori*, R m1-m3, occlusal view, upper fossil channel. G, UNSM 123283, *Geringia mcgregori*, L m1-m3, worn, occlusal view. H, UNSM 123286, *Geringia mcgregori*, L i1, anterior view, upper fossil channel. J, UNSM 123287, *Leidymys blacki*, R m1-m3, oblique occlusal view. K, F:AM 141247, *Palaeolagus hypsodus*, L p3, occlusal view. L, UNSM 48452, *Palaeolagus philoi*, L p3, occlusal view. M, UNSM 123293, *Nototamias* sp., L m1-3, oblique occlusal view. N, UNSM 123284, *Palaeocastor nebrascensis*, R M1 or 2, occlusal view. O, UNSM 123294, *Megalagus* cf. *M. primitivus*, R lower cheektooth, occlusal view. Scale bars = 1mm.

Table 3. Dental measurements for *Herpetotherium fugax*, rodents and *Palaeolagus hypsodus* (other small mammal taxa in text or separate table). Specimens are from Wagner Quarry lf unless otherwise stated. (Compiled from author's measurements; MacDonald, 1970; Rensberger, 1983; Wood, 1937.)

H. fugax													
		UNSM 123290				UNSM 123289							
		M3	ap	1.90		m1/m2	ap	1.80					
			tr	2.15			tra	0.99					
							trp	1.16					
					FM 141248								
		m3	ap	1.98		m4	ap	1.15					
			tr	1.17			tr	1.11					
Downsimus							UNSM 123285						
chadwicki		p4	ap	2.17	m1	ap	2.13	m2	ap	2.14	m3	ap	2.35
			tr	1.66		tr	1.62		tr	1.77		tr	1.74
		LACM 17031 (type) Sharps Fm							LACM 1959 Sharps Fm				
		m1	ap	1.83	m2	ap	1.90		m3	ap	2.41		
			tr	1.57		tr	1.70			tr	1.65		
Alwoodia sp.			UNSM 123400 Wagner Quarry		UNSM 81500 Monroe Creek			UNSM 24088 McCann Can. *A. harkseni*			UCMP 76941 John Day *A. magnus* (type)		
	P4	ap	3.43		4.12			3.17			3.6		
		tr	3.84		4.18			3.26			3.75		
Nototamias sp.						UNSM123293							
	m1	ap	1.42		m2	ap	1.76		m3	ap	2.01		
		tr	1.34			tr	1.52			tr	1.56		
		trp	1.39			trp	1.63			trp	1.52		
Palaeocastor sp.						F:AM 141246							
	P4	ap	3.11		M1	ap	2.69		M2	ap	2.70		
		tr	4.87			tr	4.90-4.96			tr	4.43-4.76		
			F:AM 141246			F:AM 141245		UNSM 123284					
		M3	ap	2.65		p4	ap	4.99		M1 or 2	ap	3.38	
			tr	3.27			tr	4.28			tr	4.16	
Proheteromys						UNSM 123281							
cf. *P.*			ap	p4	1.17	-			-	m3	1.37		
nebraskensis			tra		0.99						1.48		
			trp		1.11						0.97		
						MCZ 5051 (holotype) Brule Fm							
			ap	p4	1.02	m1	1.24	m2	1.20	m3	1.08		
			tra		1.02		1.38		1.41		1.11		
			trp		1.11		1.42		1.27		0.98		

Table 3. Continued

Leidymys					UNSM 123287						
blacki	m1	ap	1.67	m2	ap	1.55	m3	ap	1.53		
		tra	0.97		tra	1.26		tra	1.26		
		trp	1.18		trp	1.31		trp	1.08		
					FM 141248						
	M1	ap	2.02	M2	ap	1.63	M3	ap	0.95		
		tr	1.36		tr	1.42		tr	1.18		
Geringia					UNSM 123283						
mcgregori	m1	ap	1.67	m2	ap	1.55	m3	ap	1.53		
		tra	0.97		tra	1.26		tra	1.26		
		trp	1.18		trp	1.31		trp	1.08		
					UNSM 123286						
	m1	ap	1.81	m2	ap	1.75	m3	ap	1.83		
		tra	1.21		tra	1.63		tra	1.59		
		trp	1.44		trp	1.69		trp	1.42		
	incisor	ap	1.37		tr	1.24					
Palaeolagus					F:AM 141247						
hypsodus	ap	p3	2.15	p4	2.69	m1	2.69	m2	2.67	m3	1.55
	tr		1.67		2.44		2.46		1.45		1.45

Formation, Logan County Colorado.

Referred Specimens.—UNSM 123289, lower molar; UNSM 123290, R M3; F:AM 141249, L m3-4.

Discussion.—Korth (1994b) reviewed North American Tertiary marsupials and placed all Arikareean *Herpetotherium* in *H. youngi*, diagnosing the species on the basis that upper molars possess a single central stylar cusp. However, new material from the Ridgeview lf (=UNSM Dw-121) (Bailey 2004) and from Florida (Hayes 2005) shows that early Arikareean *Herpetotherium* possesses a variable central stylar cusp morphology similar to *H. fugax*, an older species known from Chadronian-Orellan NALMA deposits. Therefore, Hayes (2005) extended the range of *H. fugax* into the early Arikareean to encompass the Ridgeview lf and Florida specimens. The small amount of material from Wagner is the same size and morphology (possesses multiple stylar cusps) as the Ridgeview lf *Herpetotherium* and is referred to *H. fugax*.

Order INSECTIVORA Illiger 1811
Family PROSCALOPIDAE Reed 1961
Genus *PROSCALOPS* Matthew 1909
PROSCALOPS sp.
Figure 10A-B

Referred Specimen.—UNSM 123291, L P4.

Discussion.—This tooth closely matches those in the large sample of *Proscalops* material from the Ridgeview lf that Bailey (2004) identified as *P.* cf. *P. miocaenus*. Measurements: ap = 2.17, tr = 1.96.

Family ERINACEIDAE Fisher von Waldheim 1817
Genus *OCAJILA* Macdonald 1963
OCAJILA MAKPIYAHE Macdonald 1963
Figure 10C-D

Type.—SDSM 56105, L ramus with m2-m3.

Type Locality.—SDSM V5360, Sharps Formation, early Arikareean.

Referred Specimen.—UNSM 123288, R p4.

Discussion.—Referral of this tooth is based on comparison with more complete dentitions from the Ridgeview lf, which were identified through comparison to a cast of the type. There is currently only one species assigned to the genus *Ocajila*, *O. makpiyahe.* A single m1 (UNSM 24166) described by Korth (1992) from the McCann Canyon lf is larger than any known for *O. makpiyahe* and may be a younger second species. Measurements: ap = 1.51, tr = 1.04

Order RODENTIA Bowdich 1821

Family APLODONTIDAE Trouessart 1897
Genus *DOWNSIMUS* Macdonald 1970
DOWNSIMUS CHADWICKI Macdonald 1970
Figure 13C; Table 3

Type.—LACM 17031, partial R mandible, with m1-3.

Type Locality.—LACM 1959, Sharps Formation, early Arikareean.

Referred Specimen.—UNSM 123285, L ramus with p4-m3.

Description.—See Macdonald (1970:28-29) for description of type m1-m3 and Storer (2002: 110-112) for description of upper and lower deciduous premolars, adult premolars, and molars. Measurements: p4, ap = 1.96, tra = 1.38, trp = 1.70; m1, ap = 2.04, tra = 1.52, trp = 1.72; m2, ap = 1.86, tra = 1.58, trp = 1.68; m3, ap = 2.33, tra = 1.70, trp = 1.62.

Discussion.—UNSM 123285 is inseparable in morphology from an observed cast of the type of *Downsimus chadwicki* from the upper Sharps Formation (Macdonald 1970), which Tedford et al. (2004) correlate with the Gering Formation. It falls within the measurements given for a large sample of *Downsimus* reported from the "Monroe Creek" equivalent (*sensu* L.J. MacDonald 1972) Kealey Springs lf (Storer 2002), except for having a more elongate p4. This taxon is also found in the Ridgeview lf (Bailey 2004) and the Gering faunas (Martin 1973; Swisher 1982). It has not been reported from older faunas such as the lower Sharps fauna or its equivalents, e.g. "Brown Siltstone" or "Gering A" of Swisher (1982).

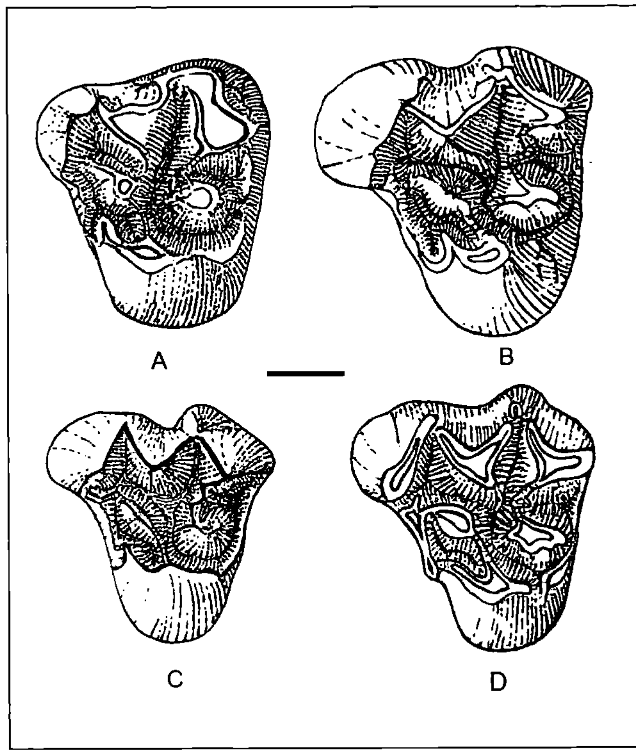

Figure 11. *Alwoodia* upper P4s, occlusal views. A. UNSM 123400, *Alwoodia* cf *A. magna*, L P4, Wagner Quarry; B, UNSM 81500, *Alwoodia* sp., R P4(reversed), Mo-107, Reddington Gap, "Monroe Creek" anthills; C, UNSM 24088, *Alwoodia harkseni*, McCann Canyon lf; D, UCMP 76941, *Alwoodia magna*, holotype, R P4 (reversed), Picture Gorge 22 (V-66116) John Day Fm.

Subfamily ALLOMYINAE Marsh 1877
Genus *ALWOODIA* Rensberger 1983
ALWOODIA cf. *A. MAGNA*
Figures 11A; 13F; Table 3

Type.—UCMP 76941, R maxillary, P3-M3.

Type Locality.—Picture Gorge 22 (V-66116), early Arikareean, 5m above Picture Gorge Ignimbrite (^{40}Ar/^{39}Ar- 28.7 +/- 0.08 Ma, Tedford et al. 2004).

Referred Specimen.—UNSM 123400, L P4.

Description.—Anterocone is large, but smaller than *A. magna* or specimens from Gering Formation, situated on anterior portion of anterior labial margin, separated from smaller parastyle on labial margin. Mesostyle is lengthened into loph that blocks deep central fossette. Paracone and metacone is subequal in size with deep labially concave face on paracone. Metacone face is less concave. Protoconule is smaller than metaconule. Protoconule is connected by weak lophs to paracone and protocone with small lophule extending towards anterocone. Protocone curves anterolabially to form anterolingual fossette. Metaconule is large and separated from metacone by shallow posterior labial fossette and separated from protocone and small cingular hypocone by posterior lingual fossette continuous with central fossette. Measurements: ap = 3.41, tr = 3.89.

Discussion.—This tooth is referred to the Allomyinae based on Rensberger's (1983) diagnosis: upper cheek teeth brachyodont; ectoloph with a deep labially concave face on the paracone, less concave on the metacone; a mesostyle closes the labial end of the central transverse valley; principal cusps developed into high crests; hypocone forms part of the posterior cingulum; a small double metaconule present in molars behind the lingual metaconule, and in P4 it forms a small cusp or ridge labial to the metaconule.

The Allomyinae contains three genera, *Parallomys*, *Allomys*, and *Alwoodia*. UNSM 123400 differs from

Parallomys in lacking a comparatively wide U-shaped central valley with a low protoloph and metaloph, in having small accessory cusps in the anterior and posterior valleys, in lacking flat occlusal wear, and in having the labial faces of the paracone and metacone that slope less lingually than *Parallomys*. *Allomys* has a more vertical labial face on the ectoloph similar to the Wagner Quarry tooth, but the crests of the ectoloph, protoloph, and metaloph in *Allomys* are weaker and develop more complex prominent accessory crests. Korth (1989) described a new genus, *Campestrallomys*, from the Whitneyan and Orellan of the Great Plains that has many allomyine characters, except it lacks the double metaconule on the upper cheekteeth. *Campestrallomys* is considerably smaller than the Wagner tooth and the P4 has a more complete ectoloph.

Two species are currently included in the genus *Alwoodia*, *A. magna*, described by Rensberger (1983) from the John Day region and *A. harkseni*, recognized by Korth (1992) from the Great Plains McCann Canyon lf. Tedford et al. (2004) use the first appearance of *A. magna* in the John Day as a characterizing taxon for the early early Arikareean (Ar1). The occurrence of *Alwoodia* in the John Day, as reported by Rensberger (1983), is chronologically well-constrained by its occurrence between the Picture Gorge Ignimbrite (28.7 +/- 0.07 Ma) and the Deep Creek Tuff (27.89 +/- 0.57 Ma) (dates from Tedford et al. 2004). The chronological range of *Alwoodia harkseni* is more poorly constrained. The McCann Canyon lf has been considered either early late Arikareean (Ar3) (Korth 1992) or late early Arikareean (Ar2) (Tedford et al. 2004). *Alwoodia harkseni* is also morphologically different, in the development of the ectoloph, smaller size, and more trenchant ridge-like cusps (Fig. 11C), than the earlier Arikareean samples discussed below. Storer (2002) referred a fragmentary P4 to ?*Alwoodia* from the Kealey Springs lf of the Saskatchewan Cypress Hills Formation, which he correlated to the late early Arikareean (Ar2). Storer (2002) considered planar occlusal wear a diagnostic character of *Alwoodia* in comparison to other Allomyines. The P4s illustrated in Figure 8 show four states of wear, from the almost unworn state of *A. harkseni* (Fig. 11C) to the heavily worn state of the Wagner tooth. (Fig. 11A).

The Wagner Quarry tooth has comparatively robust cusps and a metaconule/metaloph and protoloph with the short accessory ridges and crests on the valley lophules that are diagnostic of *Alwoodia* (Rensberger 1983). It is within the size range of *A. magna* but has a smaller anterocone in relation to *A. magna* (Fig. 11), and the doubled metaconule is not as well- developed. Instead, there is a simple low ridge that connects the metaconule to the metacone. Unlike *A. magna*, the mesostyle is broad and lophate with more wear. UNSM 123400 may represent a new species of *Alwoodia* based on these differences but more material is needed to make a conclusive determination.

Additional specimens of *Alwoodia* (Fig. 11B) from the Wildcat Ridge Monroe Creek Formation are recognized here for the first time. These samples contain both upper and lower molars. A single upper molar from the Nipple Butte Quarry, found at the base of the "Brown Siltstone" at Wildcat Ridge (Swisher 1982), is provisionally referred to *Alwoodia*. It is highly worn but possesses the diagnostic characters of the Allomyinae (Rensberger 1983; and see *Alwoodia* cf *A. magna* below) and is a large tooth relative to other allomyine species (Measurements: ap = 2.82, tr = 3.90), *Alwoodia* is the largest genus of the allomyines. If the identification is correct, then it represents the stratigraphically lowest occurrence of this taxon. The "Brown Siltstone" has been radioisotopically and magnetically dated to have been deposited between slightly younger than 29 Ma to slightly older than 30 Ma (Tedford et al. 1996). Two teeth collected from Swisher's (1982) "Gering C" (= upper Gering Formation) are here referred to *Alwoodia* based on size and morphology. Two ant hill collections (UNSM localities Mo- 107 MCAH; Mo-163) found in the stratigraphically higher Monroe Creek Formation, or undifferentiated Arikaree (dated by Olsen's third ash 27.79 +/- 0.08 Ma from Tedford et al. 1996), also produced a significant amount of material that can be referred to *Alwoodia*. Specimens in this sample are slightly larger in size (Table 2) than *A. magna* and slightly more derived, with a more developed ectoloph and additional lophules in the fossette valleys. Formal description of the above material is deferred to a later report.

The material of *Alwoodia* discussed above provides a well-calibrated early Arikareean sequence for this rodent in both the Great Plains and the John Day region, from the earliest definitive appearance in Wagner Quarry to the latest Monroe Creek sample. In the P4, there appears to be a gradual expansion of the anterocone, increasing complexity of the inter-valley lophules, development of the "double metaconule", and small increase in size (Fig. 11). This lineage is probably separate from the lineage that leads to *A. harkseni*, which is smaller, and exhibits a less complex P4 with less robust cusps.

Additional *Alwoodia* sp. Referred Specimens.— UNSM locality Mo-104, Nipple Butte Quarry, (Swisher 1982, Gering A = Brown Siltstone = Sharps Formation): UNSM 81513, R M 1 or 2. UNSM locality Mo-107 Anthill

#2 (Swisher 1982, Gering C): UNSM 81210, L dP4; UNSM 81213, L m1. UNSM locality Mo-107, Monroe Creek Ant Hill (Swisher 1982, Monroe Creek Formation): UNSM 81278, R M2; UNSM 81282, L dP4; UNSM 81283; R M2; UNSM 81284, L p4; UNSM 81285, R M1; UNSM 81286, L M2; UNSM 81287, L M1; UNSM 81500, R P4; UNSM 81501, R M1 or 2; UNSM 81502, R M1 or 2; UNSM 81503, L m1; UNSM 81504, R m1; UNSM 81514, R m3; UNSM 81515, RM3; UNSM 81516, R m1; UNSM 81517, LM1 or 2; UNSM 81518, R P4. UNSM locality Mo-163, Monroe Creek/Harrison Formation undifferentiated: UNSM 81505, R M1 or 2; UNSM 81506, L M3; UNSM 81507, R M1; UNSM 81508, L M1; UNSM 81509, R M1 or 2; UNSM 81510, L M1 or 2; UNSM 81512, L M1 or 2.

Family SCIURIDAE Gray 1821
Subfamily CEDROMURINAE Korth & Emry 1991
Genus *CEDROMUS* Wilson 1949
CEDROMUS SAVANNAE n. sp.
Figure 12A-F; Table 4

Holotype.—UNSM 48448, partial skull with RP4-M3 and LP4-M3, M2 missing.

Etymology.—Named for Savanna S. R. Hayes. An inspiration for this report.

Diagnosis.—Zygomasseteric structure more developed and robust than *C. wilsoni* and *C. wardi*; masseteric ridge margin extending anteriorly over the infraorbital foramen and dorsally higher than in *C. wilsoni* or *C. wardi*; infraorbital foramen larger than *C. wilsoni*; upper cheekteeth more quadrate than in *C. wardi* or *C. wilsoni*; *C. savannae* has more lophate, less cuspate, metaloph on upper molars; P4 more quadrate in outline than in *C. wilsoni*, which is more quadrate than in *C. wardi*; P4 parastyle reduced and anterior valley wider and more U-shaped than other species; mesostyle at base of metacone in *C. savannae* on P4 and at base of paracone on molars; *C. wilsoni* with mesostyle at base of paracone on all cheekteeth; *C. wardi* with mesostyle equidistant from paracone and metacone on upper P4-M3.

Description.—Skull (Fig. 12C-E): Palate is ventrally concave. Anterior limit of masseter is relatively thick ridge that extends anteriorly over infraorbital foramen. Infraorbital foramen is oval shaped, 2.4mm dorsoventrally. Sphenopalatine foramen occurs dorsal to M2 at maxilla, frontal, and palatine suture. Incisive foramen is 40% of length of diastema. Rostrum is short anteroposteriorly and deep dorsoventrally.

Upper Dentition (Fig. 12A-B): Incisor is relatively small, with slight interwoven striations on curved anterior face of tooth. P3 is represented by alveoli only, single rooted. P4 is quadrate, protoloph only slightly developed, metaloph weakly connects large metaconule to metacone. Posterior cingulum begins at cusp of metacone and extends to lingual cingulum. Small mesostyle is set next to metacone on labial margin. Expanded parastyle partially surrounds distinct large paracone. M1-M2 are similar and quadrate in shape. Strong anterior cingulum merges with expanded parastyle on buccal anterior corner. Anterior cingulum joins protocone which extends posteriorly to distinct hypocone. A small lingual cleft separates hypocone from protocone. Hypocone merges into posterior cingulum which curves anteriorly and connects with metacone. Paracone and metacone conical cusps distinct, but not separated from protoloph and metaloph. Metaloph is slightly expanded at indistinct metaconule and almost incomplete, very weakly linked to protocone. Protoloph is complete but weakly unites with protocone. Mesostyle is present on labial margin joined at base to paracone forming incomplete ectoloph. M3 is similar to M1-M2, except a metacone, metaloph, and hypocone are not present. Instead, the posterior is expanded posteriorly into shallow, highly rugose basin. Small mesostyle is present and weakly separated from base of paracone.

Discussion.—*Cedromus* at various times has been referred to the Ischyromyidae (Wilson 1949), Sciuridae (Galbreath 1953), and Aplodontidae (Black 1963; Wood 1980). Based on complete cranial material from the Orellan of Wyoming, Korth & Emry (1991) reviewed the genus and demonstrated that *Cedromus* has derived dental and cranial features that are more similar to sciurids than aplodontids. *Cedromus* as a genus is defined by its unique zygomasseteric structure in comparison to other sciurids (the Wagner Quarry skull shows this feature in an even more developed state than in older species). Korth & Emry therefore erected a new subfamily, the Cedromurinae to recognize this distinction. He also included the previously described *Oligospermophilus* (Korth, 1987) in this subfamily.

Korth & Emry (1991) recognized three species of *Cedromus*: the Orellan *C. wardi*, the late Orellan or Whitneyan *C. wilsoni*, and a possible unnamed species from the medial Orellan (*Cedromus* sp.) that has four roots on the lower m1-m2 unlike the other species. (Note: the ramus Korth & Emry referred to *C.* sp. is incorrectly labeled as UNSM 80133; the correct number is UNSM 81033). *Cedromus wilsoni*, described by Korth & Emry (1991) from material recovered from Converse County, Wyoming, is the smallest species and may represent an intermontane variant of the species known from the Great Plains; *C. wardi*, *C.* sp, and the skull from Wagner are similar in upper dental measurements

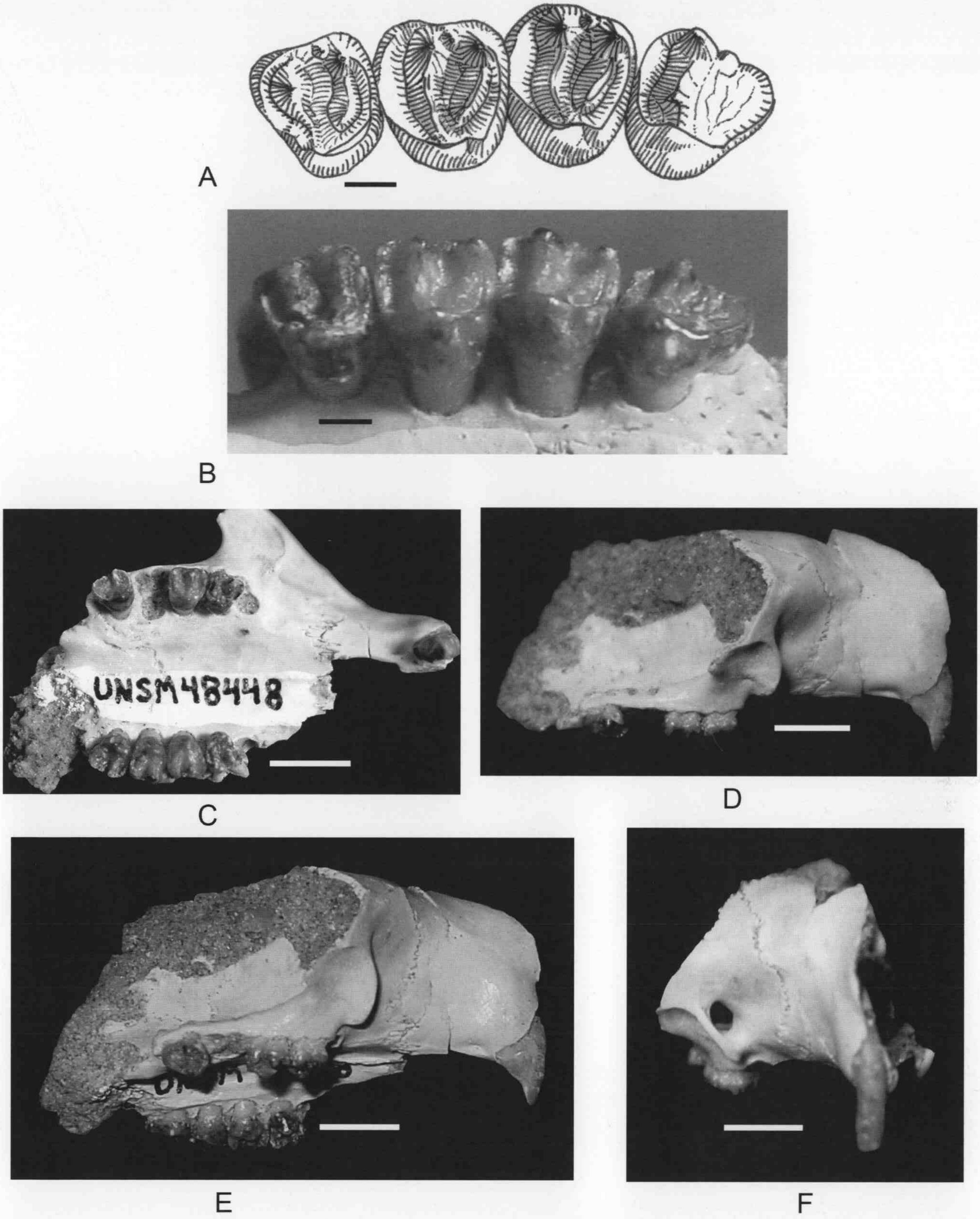

Figure 12. A-F, UNSM 48448, *Cedromus savannae* n. sp. partial skull with LP4-M3, RI1, RP4-M1, RM3; Wagner Quarry. A, LP4-M3, occlusal view; B, LP4-M3, oblique occlusal view; C, skull, ventral view; D, skull, lateral view; E, skull, oblique lateral view; F, skull, anterior view. A-B, scale bars = 1mm; C-F, scale bars = 5mm.

Table 4. Dental measurements for *Cedromus savannae* n. sp. and comparative measurements of other *Cedromus* species. The first two molars are difficult to tell apart so measurements are duplicated for Gering sample. Table is arranged from youngest to oldest occurence. (Compiled from author's measurements; Korth, 1991.)

		C. sp. Gering Fm	*C. savannae* n. sp. Wagner	*C.* sp. "Brown Siltstone"	*C. wilsoni* late Orellan-early	*C.* sp. medial Orellan Whitneyan	*C. wardi* early Orellan
P3	ap				1.20-1.26		1.2
	tr				1.27-1.22		1.2
P4	ap		2.31-2.34		2.36		2.6-2.7
	tr		2.75-2.78		2.76		3.0
M1	ap	2.50-2.62	2.36-2.41		2.17-2.31		2.4-2.7
	tr	2.73-3.10	2.85-2.87		2.90-3.00		2.9-3.2
		or					
M2	ap	2.50-2.62	2.54	2.65-2.89	2.17-2.30		2.4
	tr	2.73-3.10	3.05	3.30-3.50	2.90-2.98		3.1
M3	ap		2.70-2.73	2.96	2.57-2.58		3.0
	tr		2.89-2.94	3.08	2.56-2.61		3.0
p4	ap	2.55		3.00-3.08	2.12		2.61
	tra	2.02		2.06-2.22	1.77		1.92
	trp	2.30		2.28-2.52	2.28		2.66
m1	ap	2.70		2.67-3.07	2.15-2.20		2.47
	tra	2.70		2.36-2.58	1.89-1.97		2.43
	trp	2.74		2.60-2.80	2.37-2.55		2.70
		or					
m2	ap	2.70		3.11-3.36	2.28-2.32	2.65	2.71
	tra	2.70		2.86-2.95	2.25-2.57		2.72
	trp	2.74		2.72-3.28	2.57-2.75		2.79
m3	ap			3.18-3.47	2.86	3.07	3.37
	tra			2.88-3.04	2.31-2.44	2.56	2.75
	trp			2.68-2.85	1.97-2.12	2.34	2.64
Dp4	ap			2.40			
	tra			1.36			
	trp			1.86			
i1	ap			3.13			3.04
	tr			1.84			1.98
I1	ap		2.81				
	tr		1.68				

(Table 3). Lower teeth of *Cedromus* from the "Brown Siltstone," discussed below, are somewhat larger than the other species.

Martin's (1973) dissertation referred the relatively large rugose-toothed sciurid from the Wildcat Ridge "Gering A= Brown Siltstone" to a new species of *Protospermophilus*; however this material has never been formally described. Comparison of this material, along with "sciurid" teeth from the younger Gering Formation, with the more diagnostic skull from Wagner Quarry and other identified *Cedromus* material in the University of Nebraska State Museum collections indicates that these teeth can be included in *Cedromus*. The lower cheekteeth have a reduced metalophulid II and hypolophulid, which expands and flattens the talonid basin, and the teeth are more quadrate in occlusal outline with a flatter, broader surface in comparison to *C. wilsoni* (Korth & Emry 1991). The lower m1 and m2 also show the presence of four roots, unlike *C. wardi* (e.g. UNSM 81086, L ramus with m3), but similar to *Cedromus* sp. material (UNSM 81033 Lm2-m3) from the Whitney Member of the Brule. The Wildcat Ridge *Cedromus* specimens may represent *C. savannae*, but there is not sufficient material to make a definitive assignment at this time.

Martin (1973) described another, much smaller sciurid from the Wildcat Ridge region that he assigned to *Miospermophilus*. This material is referable to the Cedromurinae because it has the specialized masseteric structure developed on the ramus (UNSM 14993, L ramus with p4-m1). It has the same dental morphology described for *Oligospermophilus douglassi* (see Korth 1981, 1987) except that it is smaller, the hypolophid is reduced or absent, and the mesostyle is minute (UNSM 11522, R P4). This sample represents a new species of *Oligospermophilus* that extends the range of the genus into the earliest Arikareean.

Storer (2002) and L. J. Macdonald (1972) both described a large sciurid from the late early Arikareean (Ar2) that has dental characters similar to both *Cedromus* and *Protospermophilus* (Black 1963). Detailed study of this material, and the earliest Arikareean *Cedromus*, may show that either *Protospermophilus* replaces *Cedromus* or that the *Cedromus* lineage continues into the late early Arikareean (Ar2).

Observation of all the *Cedromus* material from stratigrapically oldest to youngest provides evidence for a lineage in North America beginning in the early Orellan and ending in the early Arikareean (Ar1 or Ar2). There is a trend in the cheek teeth to become more quadrate through reduction of transverse width in the upper molars and expansion of the transverse width in lower molars. Except for *C. wilsoni,* which enlarges the hypolophulid (Korth & Emry 1991), there is also a trend in reduction of lophules in the lower molars.

Minjin (2004) described a new genus of sciurid, *Kherem hsandgoliensis*, from the early Arikareean equivalent (31.5- 28 Ma Shandgolian) Hsanda Gol Formation. This sciurid is distinguished from *Cedromus* by having an incomplete metalophid (metalophulid II), a reduced hypolophid, and slightly smaller size than *C. wilsoni.* This description would match the "Brown Siltstone" and Gering *Cedromus* in morphology. I have not proposed formal synonymy here but recommend further investigation into the similarity of these taxa.

Additional *Cedromus* sp. Referred Specimens.—Mo-119 (Swisher 1982, Gering A= "The Brown Siltstone"): UNSM 14993, L p4-m1; UNSM 14958, R M1 or 2; UNSM 14960, R m2; UNSM 14959, R m2; UNSM 11621, L M2; UNSM 11631, L m3; UNSM 11623, L M2; UNSM 11650, R dp4; UNSM 11628, R mandible fragment w/incisor; UNSM 11651, R M3; UNSM 11626, L p4; UNSM 11640, L m1; UNSM 11553, R m1. Mo-108 (Reddington Gap): UNSM 11728, L m1. Mo-107 Anthill #1 (Swisher 1982, Gering B): UNSM 81219, R M1 or 2; UNSM 81218, R m1 or 2. Mo-107 Anthill #2 (Swisher 1982, Gering C): UNSM 81214, R M1 or 2; UNSM 81216 R p4.

Genus *NOTOTAMIAS* Pratt & Morgan 1989
NOTOTAMIAS sp.
Figures 10M; 13B; Table 3

Referred Specimen.—UNSM 123293, L ramus fragment with m1-3.

Discussion.—Identification of this ramus is based on comparison to the more complete and diagnostic material of this new species in the Ridgeview lf. These specimens, together with the Wagner Quarry mandible, show the diagnostic criteria for *Nototamias* as defined by Pratt & Morgan (1989) and reviewed by Korth (1992:100) for *N. quadratus* from the McCann Canyon lf. These include: absence of the mesoconid, reduction of trigonid or anterolabial groove, presence of metastylid, and two-rooted lower molars. I defer formal description of this new species to those researchers describing the Ridgeview lf.

Family CASTORIDAE Gray 1821
Subfamily AGNOTOCASTORINAE Korth & Emry 1997
Genus *AGNOTOCASTOR* Stirton 1935
AGNOTOCASTOR sp.
Figure 10E

Referred Specimen.—UNSM 123295, R p4.

Discussion.—Because cranial features rather than dental features define the various genera and species of fossil Castoridae (Korth 1994a), no specific determination is attempted here from only a single tooth. However, the relatively low crown height and the complexity of the fossettids in this tooth easily separate it from *Palaeocastor* and assign it to *Agnotocastor*. *Agnotocastor* first appears in the Chadronian and last occurrs in the Great Plains at ~ 27.5 Ma (Xu 1996), but persists longer in the Gulf Coast (Hayes, 2000). Measurements: ap = 3.74, tra = 2.26, trp = 2.80

Subfamily PALAEOCASTORINAE Martin 1987
Genus *PALAEOCASTOR* Leidy 1869
PALAEOCASTOR sp.
Figure 10N; Table 3

Referred Specimens.—UNSM 123284, R M1 or 2; UNSM 123294, cheektooth; F:AM 141243, R M3; F:AM 141244, lower incisor; F:AM 141245, R p4; F:AM 141246, partial maxilla with L P4-M3 and R M1-M2.

Discussion.—The lower incisor has a flattened anterior surface and the cheektooth fossette pattern is simple, both characters diagnostic of the Palaeocastorinae. In size the maxilla more closely resembles that of *P. nebrascensis* than that of the other earliest Arikareean *Palaeocastor* species, *P. pennisulatus*, recognized by Xu (1996). The actual number and diagnosis of palaeocastorine genera is still somewhat controversial (Korth, 1994a: 147, lists four species of *Palaeocastor*) and like *Agnotocastor* differences in species are primarily based on cranial characters. Therefore, with such meager material from Wagner Quarry, no species assignment is attempted here.

Family HETEROMYIDAE Gray 1868
Genus *PROHETEROMYS* Wood 1932
PROHETEROMYS cf. *P. NEBRASKENSIS* Wood 1937
Figure 13A; Table 3

Type.—MCZ 5051, L ramus with p4-m3.

Type Locality.—Upper Brule Formation, *Protoceras* beds, below "top ash," Jail House Rock, Morrill County, Nebraska, late Whitneyan.

Referred Specimen.—UNSM 123281, R ramus with incisor, p4, m3.

Discussion.—This mandible has a simple four-cusped p4 with no anteroconid or cingula. The Wagner Quarry ramus is larger than another common early Arikareean *Proheteromys*, *P. fedti* (Bailey 2004). It is similar in size and morphology to the "type" of *P. bumpi* and *P. nebraskensis*, although *P. bumpi* has a more complex p4. The dental morphology matches the description of *P. nebraskensis* by Wood (1937), although the m3 is more elongate and wider (Table 3). Korth and Bailey (pers. comm., 2004) are in the process of revising this genus and species based on the substantial material of "*Proheteromys*" *nebraskensis* found in the Ridgeview lf (over 1000 specimens).

Family CRICETIDAE Rochebrune 1883
Subfamily EUCRICETODONTINAE Mein & Fruedenthal 1971
Genus *LEIDYMYS* Wood 1936
LEIDYMYS BLACKI Macdonald 1963
Figure 10; Table 3

Eumys blacki Macdonald 1963

Type.—SDSM 5574, R ramus with m1-3.

Type Locality.—SDSM V5410, Sharps Formation, early Arikareean.

Referred Specimens.—UNSM 123287, R ramus with m1-m3; F:AM 141248, R maxilla with M1-3.

Range.— South Dakota, Wyoming, Nebraska, early early Arikareean (Ar1).

Discussion.— For a complete description, see Martin (1980), and for species comparisons, see Williams & Storer (1998). Comparison with the extensive material described by Martin (1980) from the Gering Formation confirms the identity of this ramus. The absence of non-planar wear and low crown height separates this taxon from other cricetids such as *Geringia* below. Martin (1980:20) diagnosed the taxon as having "cuspidate and terraced" molars.

Genus *GERINGIA* Martin 1980
GERINGIA MCGREGORI Macdonald 1970
Figures 10F-H; 13D-E; Table 3

Paciculus mcgregori Macdonald 1970

Type.—LACM 9271, partial cranium with I1, M1-M3.

Type Locality.—LACM 1959, Sharps Formation, early Arikareean.

Referred Specimens.—UNSM 123283, L ramus with m1-3; UNSM 123286, R ramus with i1, m1-3, from "upper fossil channel."

Discussion.—For a detailed description, see Martin (1980: 25-30). The two specimens found at Wagner Quarry and the "upper fossil channel" do not differ from the material referred to *Geringia mcgregori* by Martin (1980) from the "Gering" of the Wildcat Ridge; nor do they differ from the substantial *Geringia* material in the

Ridgeview lf. *Geringia* is the most abundant rodent in the Gering Formation (Martin 1980) and is very common in the Ridgeview lf (Bailey 2004). Martin discussed *Geringia* as having a variable size and morphology which the two rami (Fig. 10F-G; Table 3) from Wagner Quarry demonstrate. The preserved incisor (UNSM 123286; Fig. 10H) has the single ventral ridge typical (Martin 1980:25; 40; Fig. 26) of the genus.

Williams & Storer (1998) described a sample of *Geringia* from the Kealey Springs lf that they referred to *G. gloveri*, a species named by Macdonald (1970:51-52) from the "Monroe Creek" Formation of South Dakota. The Kealey Springs sample is intermediate in size between *G. gloveri* and *G. mcgregori*. Both Martin (1980) and Williams & Storer (1998) brought into question the validity of *G. gloveri*, because the two species only differ slightly in size; but neither formally synonymized the two. There appears to be a morphocline in size from the first record of *G. mcgregori* at the beginning of the Arikareean (Ar1) to the last appearance of the genus, *G. gloveri*, at the beginning of the early late Arikareean (Ar2).

Order LAGOMORPHA Gidley 1912
Family LEPORIDAE Gray 1821
Genus *PALAEOLAGUS* Leidy 1856
PALAEOLAGUS HYPSODUS Schlaikjer 1935
Figure 10K; Table 3

Type.—MCZ 2889, R maxillary with P3-M2.

Type Locality.—NW 1/4, Section 21, Township 20 North, Range 62 West, Goshen County, Wyoming, 46m (150') above Brule contact; early Arikareean.

Referred Specimen.—F:AM 141247, L ramus with p3-m3.

Discussion.—The ramus and dentition are similar in size to both *P. philoi* and *P. hypsodus*, both known from early Arikareean localities (e.g. MacDonald 1963, 1970). According to Dawson (1958), *P. philoi* develops a single reentrant on p3 with wear and the m3 maintains a double column "hourglass" shape through extended wear. The Wagner specimen has an "hourglass" p3 with both a lingual and labial, cement-filled reentrant unlike *P. philoi* and the m3 has merged into a single column with a labial reentrant (Fig. 10K). Both of these characters are consistent with *P. hypsodus* (Dawson 1958).

PALAEOLAGUS PHILOI Dawson 1958
Figure 10L

Type.—SDSM 53389, R maxilla with P2-M2.

Type Locality.—SE 1/4, Section 31, Township 40 North, Range 43 West, Lower Rosebud beds; early Arikareean.

Referred Specimen.—UNSM 48452, L p3.

Description.—The p3 is slightly worn with two transverse lophs. The anteroloph is divided into 2 cusps by a shallow, cement-filled anterior groove, which extends minimally down the anterior face. The posteroloph, or talonid, is divided from the anteroloph by a distinct labial, cement-filled reentrant that would enlarge and extend more lingually across the tooth with wear. On the labial side there is a shallow reentrant that would be quickly lost with wear. Dimensions: ap = 1.82 (at cusp), 2.02 (at base), tr = 2.06.

Discussion.—Dawson (1958: 30, Fig. 13) described an unworn p3 of *Palaeolagus philoi* that, with slight wear, would produce the morphology seen in UNSM 48452. With continued wear this tooth would show a single buccal reentrant unlike the p3 described above for *P. hypsodus*. *Megalagus* cf. *primitivus*, also described by Dawson (1958:17) from the early Arikareean, has a p3 with similar morphology to the Wagner tooth but is considerably larger in transverse size (e.g.: ap = 2.0-2.1, tr = 2.6-2.8). In size UNSM 48452 is closest in size to *P. philoi* (e. g.: ap = 1.9-2.5, tr = 1.9-2.2) described by Dawson (1958).

Genus *MEGALAGUS* Walker 1931
MEGALAGUS cf. *M. PRIMITIVUS*
Figure 10O

Referred Specimens.—UNSM 123294, lower molar.

Description.—There is a lingual enamel connection between the trigonid and talonid. The anterior enamel margin of the talonid is thin and weakly crenulated. Dimensions: ap = 2.80, tra = 2.92, trp = 2.65.

Discussion.—This tooth is referred to *Megalagus* based on its larger size in

comparison to *Palaeolagus hypsodus* and *P. philoi*. Also, typical of *Megalagus* is the lingual connection between the trigonid and talonid, as well as the weak crenulations in the anterior margin of the talonid (Hayes 2000). This tooth matches the size range for *Megalagus primitivus* given in Dawson's (1958) description of the species, but this single specimen precludes a definite referral.

Order CARNIVORA Bowdich 1821
Division ARCTOIDEA Flower 1869
Family AMPHICYONIDAE Trouessart 1885
Genus *PARADAPHOENUS* Wortmann & Matthew 1899

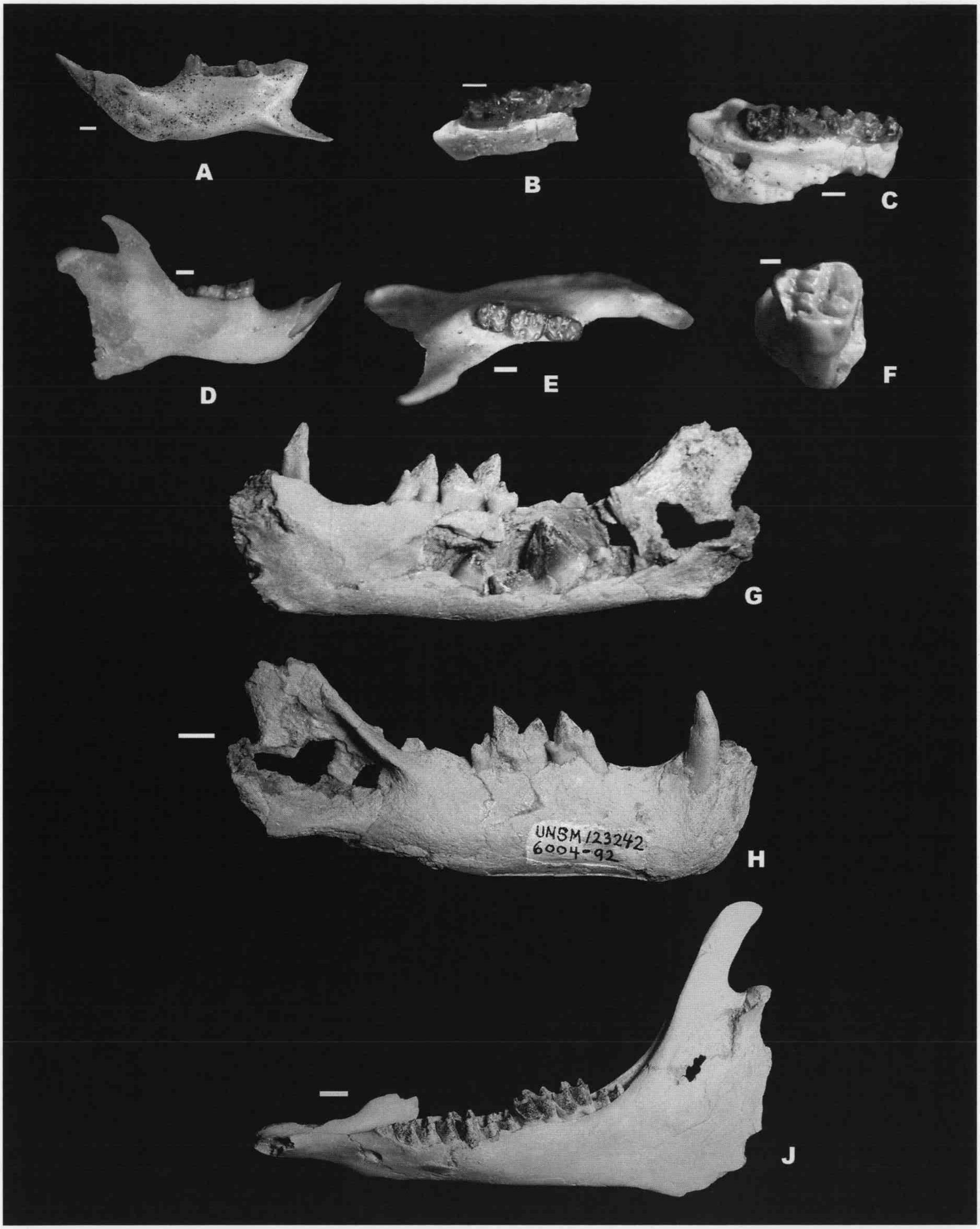

Figure 13. Wagner Quarry local fauna: rodents, *Nimravus*, and *Miohippus*. A, UNSM 123281, *Proheteromys* cf. *P. nebrascensis*, R ramus with i1, p4, m3, lingual view. B, UNSM 123293, *Nototamias* sp., L m1-3, oblique occlusal view. C, UNSM 123285, *Downsimus chadwicki*, L ramus with p4-m3, occlusal view. D, UNSM 123286, *Geringia mcgregori*, R m1-m3, lateral view, upper fossil channel.; E, UNSM 123286, *Geringia mcgregori*, R m1-m3, occlusal view, upper fossil channel. F, UNSM 123400, *Alwoodia* cf *A. magna*, L P4, occlusal view. G-H, UNSM 123242, *Nimravus brachyops*, L juvenile ramus with dc, dp3-dp4; G, medial view; H, lingual view, showing unerupted p4-m1; J, UNSM 123241, *Miohippus* sp., L juvenile mandible and symphysis with p2-m3, m1-m2 erupted, lateral view. A-F, scale bars = 1mm; G-J, scale bars = 10mm.

PARADAPHOENUS TOOHEYI Hunt 2001

Referred Specimen.—UNSM (field #) 6002-92, L mandible w/ p3-m2.

Description and Discussion.—Hunt (2001) described a new species of *Paradaphoenus* and designated the mandible (UNSM [field #] 6002-92) referred above from Wagner Quarry as the holotype. Additional material from White River sediments in Nebraska (UNSM 26130) and a maxilla (LACM 21649) from the Sharps Formation of South Dakota was also referred to this species. He demonstrated that *P. tooheyi* from the Whitneyan to earliest Arikareean was an intermediate form between the Orellan *P. minimus* and the late early to medial Arikareean *P. cuspigerus*.

Family CANIDAE Gray 1821
CANIDAE indet.

Referred Specimen.—UNSM 48450, ramus with m1 talonid, m2, and m3 alveolus

Discussion.— In size, this jaw compares with early Arikareean *Archaeocyon* and *Otarocyon* (Wang et al. 1999), but a generic determination is not possible due to the poor condition of this specimen.

Suborder FELIFORMIA Kretzoi 1945
Family NIMRAVIDAE Cope 1880
Genus *NIMRAVUS* Cope 1879a
NIMRAVUS BRACHYOPS (Cope) 1878
Figure 13G-J; Table 5

Machairodus brachyops Cope 1878
Hoplophoneus brachyops Cope 1879a

Lectotype.—AMNH 6935, partial R ramus.

Range.—Whitneyan to late early Arikareean (Ar2) of Great Plains and Pacific coast.

Referred Specimens.—UNSM 123242, juvenile R jaw dc, dp3-4, unerupted p4-m1.

Description.—Symphyseal region is anteroposteriorly angled and almost flat from symphysis to canine (Fig. 13G, H). Small mental foramen is located below dp3. Masseteric fossa is deep and extends anteriorly to position approximately ventral to m1. Alveolus is for single-rooted dp2. The dp3 is elongate and transversely compressed with central ridge from trenchant anterior cusp along principal cusp to cuspate (relatively broad) posterior cusp. The dp4 has small metaconid present at lingual base of protoconid. Ridge joins metaconid to trenchant, posterolabialy directed hypoconid. Paraconid and protoconid transversely compressed with protoconid taller than paraconid and widely separated by deep carnassial notch. Weak serrations present on anterior ridge of protocone. The p4 and m1 is unerupted. Principal cusp is only visible part of p4. Weak serrations occur along posterior and anterior ridges of cusp. Principal cusp of p4 is similar in size to paraconid of m1. The m1 has a slit-like deep carnassial notch. Protoconid and paraconid are similar size, transversely compressed with weakly serrated edges. Protoconid is taller than paraconid. Small alveolus is located directly behind the m1 that could have held unerupted m2. Measurements for specimen not included in Table 4 include: depth of horizontal ramus at alveolar margin of dp4 = 20.16; length of masseteric fossa = 30.50; length of diastema = 9.24.

Discussion.—Martin's (1998) review of the nimravids recognizes three genera in the early Arikareean, *Nimravus*, *Pogonodon*, and *Eusmilus*. This differs from Bryant's (1996) earlier work that also included *Hoplophoneus dakotensis*. Although Martin referred this taxon to *Eusmilus*, generic referral of this taxon is controversial (see Bryant 1996: 465). *Eusmilus* is now known to be a very small nimravid (Hunt, pers. comm., 2004), and too small to correspond to the Wagner Quarry mandible. The m1 of *Eusmilus* has also lost the talonid. In size the Wagner Quarry mandible is closest to *Nimravus* and *Pogonodon*. *H. dakotensis* is considerably larger.

Referral of this juvenile dentary to *Nimravus*, and its only species, *N. brachyops* (Toohey 1959), is based on several factors. Adult *Nimravus* is, in part, distinguishable from *Pogonodon* because *Pogonodon* has a ventral symphyseal flange that does not appear to be developing in the Wagner Quarry mandible. *Nimravus* has a continuous ventral mandibular border that is ventrally concave, which matches the Wagner Quarry specimen. *Pogonodon* has a ventrally convex mandible margin. Finally, the extension of the masseteric fossa is a useful diagnostic characteristic. The masseteric fossa extends anteriorly to below the m1 in *Nimravus*; eruption of the m1 in the Wagner specimen would be above the fossa. *Pogonodon* has a masseteric fossa that extends only to behind the posterior margin of the m1 unlike UNSM 123242.

Order PERRISSODACTYLA Owen 1894
Family EQUIDAE Gray 1821
Genus *MIOHIPPUS* Marsh 1874
MIOHIPPUS sp.
Figure 13K; Table 5

Type Species.—*Miohippus annectens* Marsh 1874.

Table 5. Dental measurements for *Nimravus brachyops*, *Miohippus* sp., *Leptauchenia major, Pseudolabis dakotensis, Nanotragulus loomisi*. Specimens are from Wagner Quarry lf unless otherwise stated. a= approximate measurements.

Nimravus brachyops	UNSM 123242								
	ap	dc	5.74	dp3	9.25	dp4	15.22	m1	a23.80
	tra		4.47		2.81		4.31		-
	trp				3.47		3.80		-
	AMNH 6930 (holotype) John Day, OR					ap		m1	24.32
	AMNH 6936 John Day, OR					ap		m1	22.33
	UNSM 2509-59, MO-103, Morrill, Co., NE					ap		m1	24.99
Miohippus sp.	UNSM 123241								
		p2	p3	p4	m1	m2	m3		
	ap	15.33	15.30	13.70a	14.91	13.98	17.07a		
	tra	8.60	9.80	10.08a	10.40	10.40	-		
	trp	8.80	11.25	-	10.33	9.60	-		
Leptauchenia major	F:AM141385								
		P2	P3	P4	M1	M2	M3		
	ap	5.42	5.42	5.62	9.25	12.48	14.05		
	tr	4.41	4.41	8.42	10.64	12.38	12.90		
	F:AM141384					UNSM 123280			
		m1	m2	m3		dp4	m1		
	ap	10.47	12.84	14.90a		12.16	11.30		
	tra	6.74	8.41	7.31a		4.16	5.99		
	trp	7.63	9.09	-		5.85	6.83		
Pseudolabis dakotensis	F:AM141372								
	ap	dP3	10.48	dP4	13.71	M1	14.25	M2	16.54
	tr		4.14		8.14		10.85		13.40
	F:AM 41814 Muddy Creek, Lusk, WY								
		P2	P3	P4	M1	M2			
	ap	10.17	12.75	13.64	15.26	16.97			
	tr	3.74	7.27	10.15	12.61	13.60			
Nanotragulus loomisi	F:AM 141242								
		P2	P3	M1	M2	M3			
	ap	1.83	3.79	4.09	5.76	7.07			
	tr	1.41	2.87	5.47	5.88	5.93			
	UNSM 48449								
	ap	p4	4.70	m1	5.30	m2	5.72		
	tra		2.40		3.05		3.71		
	trp				3.52		4.16		

Type Locality.—John Day Formation, Oregon.

Referred Specimens.—UNSM 123238, magnum; UNSM 123241, juvenile L mandible with R p2-m3, m1-2 erupted; UNSM 123401, R metatarsal III; UNSM 123402, R proximal phalanx.

Description.—Only the alveolus of p1 is preserved. The p2-m3 have weak labial cingula discontinuous around labial margin. Cingula is developed only on anterior, hypoflexid valley, and posterior surfaces. No lingual cingula is present. Posterior cingulum merges with small hypoconulid. Metaconid and metastylid distinctly twinned, high, equal in height to entoconid and other principal cusps. Lophids is low in comparison to cusps. Metalophid is confluent with metastylid only after wear. The m3 has large heel and metalophid separated from the metastylid.

Discussion.—Prothero & Shubin (1989) diagnosed *Miohippus* on the basis of an articular surface developed between the cuboid and third metatarsal. UNSM 123401, a right third metatarsal, has the cuboid facet and would be of appropriate size to correspond to the mandible. A proximal phalanx that may be associated with the metatarsal (UNSM 123402) is also of appropriate size to be referred to *Miohippus* rather than *Mesohippus* (O'Sullivan 2003; Fig. 7).

When Prothero & Shubin (1989) reviewed the Oligocene horses, they listed five species of *Miohippus* in the early Arikareean. The majority of these species are diagnosed on morphology of the skull, upper dentition, or size. Comparison of the Wagner Quarry mandible and postcranials with their measurements (Table 10.3, p 151 and Table 10.4, p. 158-159) indicates that the Wagner horse is closest in size to the type of *M. intermedius* (AMNH 1196, from the late Whitneyan Poleslide member of the Brule Formation, *Protoceras* channels) and type of *M. annectens* (YPM 12230, from the early Arikareean John Day Formation, Turtle Cove member between Picture Gorge Ignimbrite and Deep Creek Tuff). *Miohippus equinanus* and *M. obliquidens* are 20-25% smaller, *M. gidleyi* is 20% larger. *Miohippus annectens* is 10% larger than the Wagner *Miohippus*. Referral to *M. intermedius* is not conclusive however, because the Wagner *Miohippus* has a more elongate and cuspate p2, and the metalophid is more confluent with the metastylid.

In the most recent summary of the Equidae, MacFadden (1998) included 7 named species of *Miohippus* and stated that a complete revision is still needed.

Family RHINOCEROTIDAE Owen 1845
Subfamily DICERATHERIINAE Dollo 1885

Genus *DICERATHERIUM* Marsh 1875

Comment.—Throughout the Whitneyan and most of the Arikareean in the Great Plains, *Diceratherium* is the single rhinocerotid present (Prothero et al. 1989) until the immigrant, *Menoceras*, appears in the late Arikareean. *Subhyracodon* is on average smaller, with less molarized premolars, than *Diceratherium* and, while found in the Chadronian through Orellan of the Great Plains, is known only from the west coast regions in the early Arikareean (Prothero 1998). At times there have been at least 6 proposed species of *Diceratherium* from the John Day region in Oregon and the Great Plains.

Albright (1999) briefly reviewed *Diceratherium* and the distinctions between species. He synonymized *D. cuspidatum* with *D. annectens* and questioned the validity of *D. gregorii*, a taxon Peterson (1920) erected for material from the Great Plains and was later supported by Green (1958) and Macdonald (1963, 1970). Prothero's (1998) summary of the Rhinocerotidae did not recognize *D. gregorii* as a separate species.

Prothero (1998) stated that two parallel lineages of *Diceratherium* exist throughout the late Whitneyan and Arikareean of the Great Plains: a large species, *D. armatum* and a smaller species, *D. annectens*. A third relatively large species, *D. niobrarense* occurs in the later Arikareean and early Hemingfordian. Albright (1999) proposed 3 valid *Diceratherium* species, *D. annectens, D. armatum*, and *D. niobrarense*. Prothero also referred a Whitneyan species, *Subhyracodon tridactylum*, to *Diceratherium*.

The two early Arikareean species of *Diceratherium* differ chiefly in size; the smaller species is *D. annectens* and the larger species, *D. armatum*. Within each species considerable sexual dimorphism has been observed. The large Arikareean sample from 77 Hill Quarry near Lusk, Wyoming preserves male and females of both *D. annectens* and *D. armatum* (Prothero et al. 1989) and this sample has provided comparative material for this study as well as others (Albright 1999).

DICERATHERIUM ANNECTENS (Marsh) 1873
Figure 14A-B, E, J; Table 6

Rhinoceras annectens Marsh 1873
Diceratherium nanum Marsh 1875
Diceratherium cuspidatum Troxell 1921

Type.—YPM 10001, L upper premolars with associated incisor.

Type Locality.—"lower to middle John Day" Formation, Oregon (Peterson 1920).

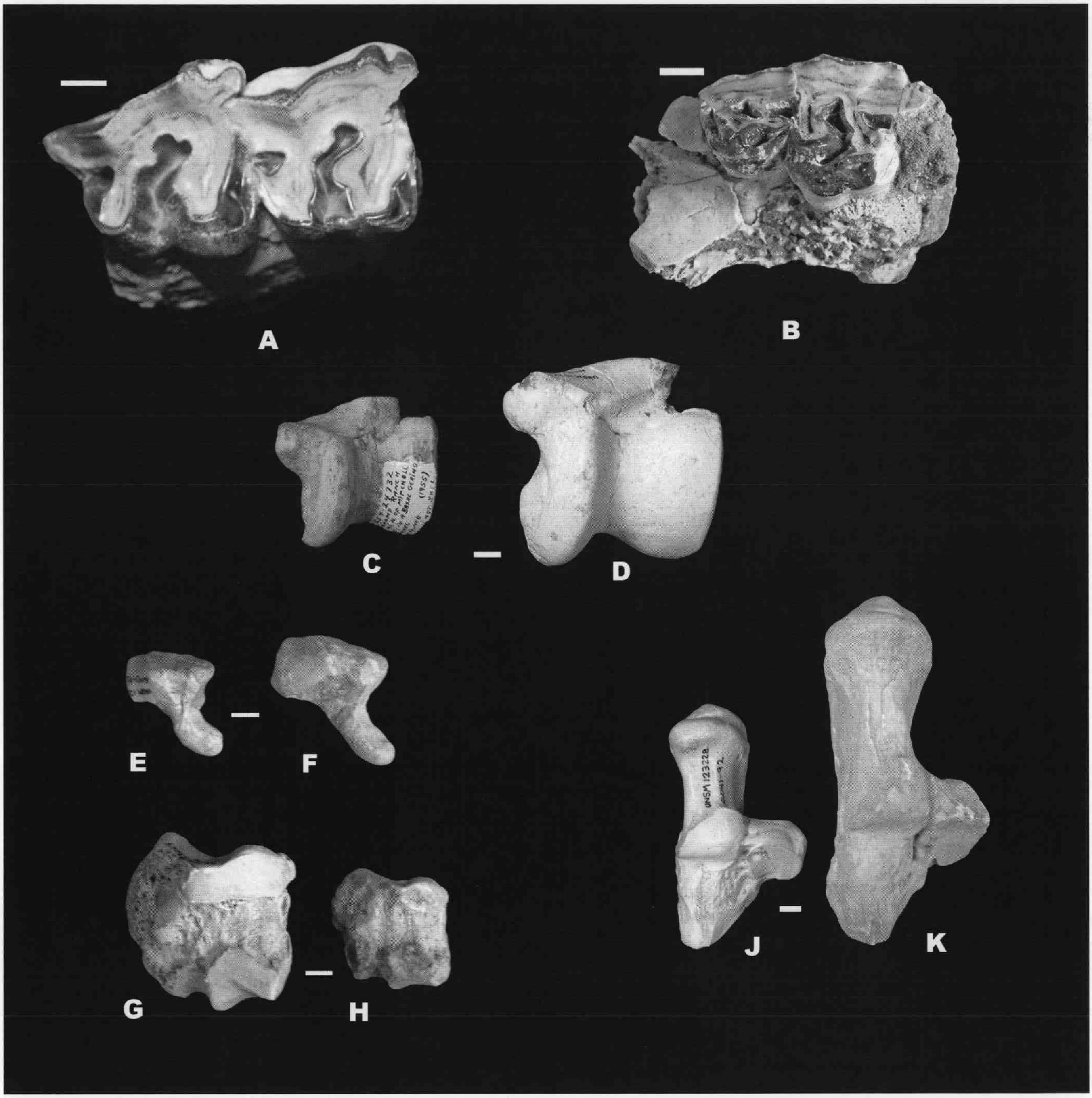

Figure 14. A-K, *Diceratherium*. A, F:AM 141374, *D. annectens*, R M1-M2, occlusal view, Wagner Quarry. B, UNSM 123233, *D. annectens*, L maxilla with P1-3, oblique occlusal view, Wagner Quarry. C-D, astragalus comparison. C, AMNH 112185, *D. annectens*, Schomp Ranch, basal ?Gering Fm, Sioux Co., NE; D, UNSM 123230, *D. armatum*, Wagner Quarry. E-F, unciform comparison. E, UNSM 123231, *D. annectens*, Wagner Quarry; F, AMNH 112185, "*D. annectens*", Schomp Ranch, basal ?Gering Fm, Sioux Co., NE. G-H, scaphoid comparison. G, UNSM 123229, *D. armatum*, Wagner Quarry; H, AMNH 112185, *D. annectens*, Schomp Ranch, basal ?Gering Fm, Sioux Co., NE. J-K, calcaneum comparison. J, UNSM 123228, *D. annectens*, Wagner Quarry. K, F:AM 141386, *D. armatum*, 1m above Wagner Quarry. Scale bars = 10mm.

Referred Specimens.—F:AM 141375, R p1-p3; F:AM 141374, R M1-M2; UNSM 123228, calcaneum; UNSM 123233, L maxilla w/P1-3; UNSM 123231, unciform; UNSM 123230, R astragalus; trochlear tr = 68.37, nav-cuboid tr = 71.50.

Discussion.—There are two size groupings of rhino material in the Wagner Quarry lf. Comparison of the Wagner material within the sample and with complete material from the 77 Hill Quarry mentioned above illustrates this. Comparison of the two calcanea (Fig. 14J-K) demonstrates the size difference between the two species and the similar morphology of the two taxa. This smaller sized rhino material is referred to *D. annectens*. The partial maxilla (Fig. 14B) and the unciform (Fig. 14E) are slightly smaller in measurements, but not significantly, when compared with *D. annectens* (Table 6; Fig. 14F). *Diceratherium* is known to be sexually dimorphic and the size difference in these two specimens may reflect the morphology of a smaller female.

DICERATHERIUM ARMATUM Marsh 1875
Figure 14D, G-K; Table 6

Diceratherium lobatum Troxell 1921

Type.—YPM 10003, complete skull with postcranials.

Type Locality.—"lower John Day" Formation, Oregon (Peterson 1920).

Referred Specimens.—F:AM 141386, calcaneum, 1m above Wagner Quarry; UNSM 123229, scaphoid; UNSM 123432, vertebrae; UNSM 123433, distal femur; UNSM 123420, thoracic vertebrae; UNSM 123421, L metatarsal IV: ap = 15.7cm, 22.79cm distal end width; UNSM 123426, juvenile partial occipital condyle: 52mm width; UNSM 123416, navicular; UNSM 123417, ungual phalanx: tr = 31.8, ap = 39.08 ; UNSM 123418; juvenile proximal phalanx; UNSM 123434, L juvenile ulna; UNSM 123422, partial lower molar.

Discussion.—The larger rhino postcranial material is referred to the larger *Diceratherium* species. Figure 14G and 14H is a comparison between a Wagner scaphoid and a *D. annectens* scaphoid from the early Arikareean, Schomp Ranch locality of Sioux County, Nebraska. Figure 14C and D also show the size difference, but show a similar morphology of small Gering Formation *D. annectens* and large Wagner astragali. The large *Diceratherium* calcaneum (Fig. 14K) is the only identifiable fossil found outside of Wagner Quarry and the "upper fossil channel" (Fig. 6)

Order ARTIODACTYLA Owen 1848
Family ENTELODONTIDAE Lydekker 1883

Table 6. Upper dental measurements for various *Diceratherium* species. (Compiled from author's measurements; Albright 1999.)

		Wagner UNSM 123233	*Diceratherium annectens* YPM 10001 (type)	*D. annectens* AMNH 7324	*D. armatum* YPM 10003 (type)	"*D. gregorii*" AMNH 12933 Sharps Fm SD
P1	ap	-	20.4	19.0	29.0	21.0
	tr	14.5	17.2	17.0	25.5	20.0
P2	ap	19.0	23.2	24.0	32.0	26.0
	tr	24.2	34.3	28.0	39.5	32.0
P3	ap	22.35	27.5	28.0	37.0	31.0
	tr	29.24	34.3	35.0	46.0	44.0
		Wagner F:AM 141374				
M1	ap	37.1	-	35.0	48.0	38.0
	tr	39.4	-	41.0	53.0	45.0
M2	ap	41.4	-	40.0	54.0	45.0
	tr	40.6	-	41.0	55.0	47.0

ENTELODONTIDAE indet.

Referred Specimens.—UNSM 123457, ungual phalanx; UNSM 123458, thoracic vertebrae; UNSM 123455, R scapula; UNSM 123456, L scapula; UNSM 123439, L ectocuneiform.

Discussion.—There are only postcranial remains known from this taxon in Wagner Quarry. *Dinohyus* ranges from the early Arikareean until the early Hemingfordian (Effinger 1998). Martin (1973) referred a mandible missing the incisors, canines, and part of the symphysis (UNSM 1083) to *Dinohyus minimus*? from four feet above the Brule Formation- "?Gering" contact, Goshen County, Wyoming. The only other entelodont reported in the early Arikareean, *Archaeotherium trippensis* (Skinner et al. 1968), is from the early to medial Turtle Butte fauna (Tedford et al. 1987), but it is known only from cranial material. The two recovered scapulae, ungual phalanx, and vertebrae, are indistinguishable in size and morphology from *Dinohyus* material collected from the Agate waterhole bone bed in the Nebraska State Museum. However, since there are no known postcranial remains of *A. trippensis* to compare with, and *A. trippensis* is similar in cranial size to *Dinohyus* and much larger than other species of *Archaeotherium* (Skinner et al. 1968), referral to this taxon cannot be ruled out.

Family MERYCOIDODONTIDAE Thorpe 1923
Subfamily DESMATOCHOERINAE Schultz & Falkenbach 1954
DESMATOCHOERINAE indet.
Figure 15K

Referred Specimens.—UNSM 123240, juvenile L ulna; UNSM 123235, metapodial MIV; UNSM 123445, R M1.

Discussion.—Identification of this material was based on comparison to oreodont material housed in the UNSM collections. Further comparison was conducted at the AMNH. Both the ulna (Fig. 12K) and metapodial agree in size and morphology to a desmatochoerine partial skeleton, F:AM 44936, *Desmatochoerus hatcheri*, from the lower Arikaree Group at Muddy Creek, Niobrara County, Wyoming. This specimen was referred to *D. hatcheri niobrarensis* by Schultz & Falkenbach (1954: 191). Desmatochoerines are typical of lower Arikaree rocks and thus the early to medial Arikareean (Hunt, pers. comm., 2004).

Genus *LEPTAUCHENIA* Leidy 1856
LEPTAUCHENIA MAJOR Leidy 1856
Figure 15H-J; Table 5

Type.—AMNH 8115, skull and mandibles with associated postcranials.

Type.—Deep River Beds, Smith Creek Montana.

Range.—Orellan through late early Arikareean (Ar2) of the Great Plains, Wyoming, and Montana.

Referred Specimens.—UNSM 123279, L maxilla fragment w/P1-P2; F:AM 141385 L maxilla w/P2-M3, alveolus for P1; UNSM 123239, L M2; UNSM 123280, R Dp4-m1.

Discussion.—CoBabe (1996) reviewed the leptauchenine oreodonts and reduced the total species to 3: *L. decora*, *L. major*, and *Sespia nitida*. Lander (1998) listed 4 *Leptauchenia* species, each with several subspecies, and *Sespia*. CoBabe's (1996) taxonomy is followed here for the sake of simplicity. *Sespia* is separable from *Leptauchenia* by its extremely hypsodont molars and smaller size. There are two species of *Leptauchenia*; *L. decora* is generally smaller than *L. major*, although there is some overlap in size. The major difference between the two species is that *L. decora* has lost its M3. AMNH 472-4294 possesses the M3 and is larger in average tooth measurements than *L. decora*; therefore, I have referred the leptauchenine material to *L. major*. Leptauchenines are limited in their occurrence in the central Great Plains to rocks of the lower Arikaree Group.

Family ANTHRACOTHERIIDAE Gill 1872
Subfamily BOTHRIODONTINAE Scott 1940
BOTHRIODONTINAE indet.
Figures 15A-B, F; 16C; Table 7

Referred Specimens.—UNSM 123222, R calcaneum; UNSM 123225, radius; UNSM 123226, ulna; F:AM 141369, R and L mandibles with p2-m3, alveoli for i1-p1; UNSM 123407, juvenile tibia; UNSM 123419, partial innominate juvenile.

Description.—Mandible and dentition. Symphysis is elongate, posterior margin below the p2. Anterior dentition missing, p2-m3 present on both sides. Large mental foramen is below diastema between p2 and p3. Masseteric fossa extends to just below crown of m3 on ascending ramus. Angular process has rounded ventral margin that extends posteriorly and below ramus. Enamel on all teeth is rough and cingula rugose. Alveoli show that incisors increased in size from i1 to i3. Canine was oval in shape, transversely compressed. The p2 and p3 have high central cusps, weakly concave on lingual face and strongly convex on labial face. Anterior cingulum is not present on p1, although a weak anterior cingulum

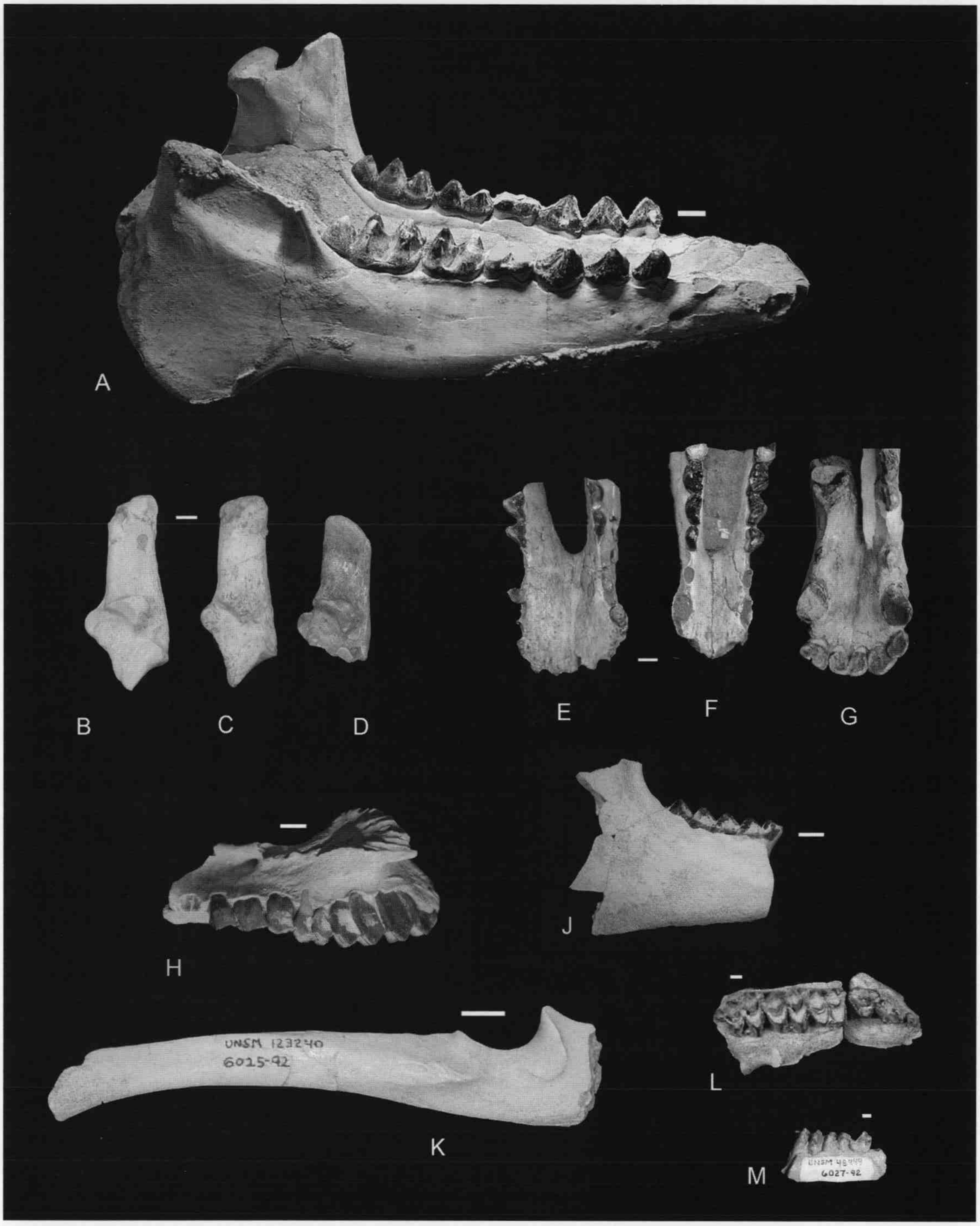

Figure 15. A-G: Anthracotheres. A, F:AM 141369, Bothriodontinae indet., mandible, Wagner Quarry, lateral view. B-D, Anthracothere right calcaneum comparison. B, UNSM 123222, Wagner Quarry; C, AM 13005, *Arretotherium leptodus* (holotype), "lower Rosebud beds", Shannon Co., SD ; D, F:AM 132053, *Arretotherium fricki*, Potter Quarry, Runningwater Fm, Dawes Co., NE. E-G: Anthracothere symphysis comparison, occlusal view. E, AM 13005, *Arretotherium leptodus* (holotype), old female; F, F:AM 141369, Bothriodontinae indet., Wagner Quarry, young female; G, F:AM 132054, "*Arretotherium*", Gering Fm, Goshen Co., WY, old male. H-J: *Leptauchenia major*, upper fossil channel- Wagner Quarry section. H, F:AM 141385, L maxilla, labial view; J, F:AM 141384, R ramus with M2-M3, labial view. K, UNSM 123240, Desmatochoerinae indet., L ulna. L-M: *Nanotragulus loomisi*. L, F:AM 141241, R maxilla, occlusal view; M, UNSM 48449, L m1-2, labial view. A-K, scale bars = 10mm; L-M, scale bars = 1mm.

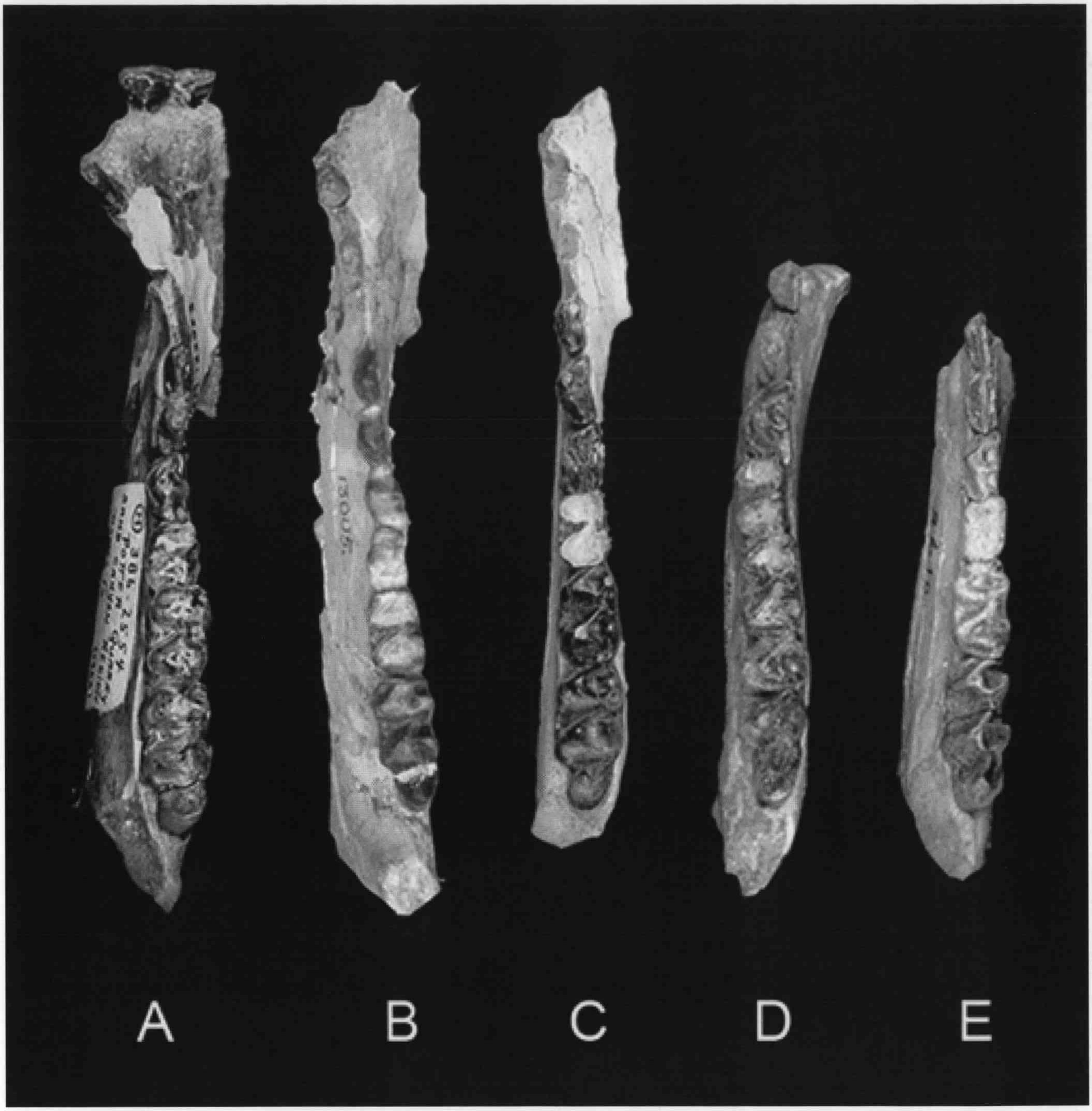

Figure 16. Anthracothere mandible comparison, occlusal views. A, F:AM 132055, *Arretotherium fricki*, Running Water Fm, Potter Quarry, Sand Canyon, Dawes, County, NE; B, AM 13005, *Arretotherium leptodus* (holotype), “Monroe Creek” Fm, Porcupine Butte, Pine Ridge, SD; C, F:AM 141369, Bothriodontinae indet., Wagner Quarry; D, F:AM 132054, “*Elomeryx*”, Gering Fm, East of Tremain, Goshen County, WY. E, F:AM 132055, “*Arretotherium*”, “Monroe Creek” Fm, Slim Buttes, Shannon County, SD.

Table 7. Comparative lower dental measurements of selected North American anthracotheres with Wagner anthracothere. (Compiled from author's measurements; Albright, 1999; Macdonald, 1954.) a=approximate measurements.

		Wagner F:AM 141369 female	Gering Fm F:AM 132054 male	"Monroe Creek" F:AM 32055	*Arretotherium*? *leptodus* AMNH 13005 (type)	*A. fricki* F:AM 132053
c	ap	12.9-13.5a	20.26			
	tr	8.7a	13.37			
p1	ap	9.8a	9.1-9.7			
	tr	6.3-6.5a	4.7-5.0			
p2	ap	14.4-14.6	13.9-14.3	-	17.3	13.2
	tr	6.37-6.8	6.3-6.6	7.9	8.4	7.1
p3	ap	16.7-17.1	16.95-17.04	18.4	21.32	12.9
	tr	8.7-8.8	7.9-8.4	8.6	9.3	7.8
p4	ap	18.3-18.5	19.15-19.27	20.3	18.6	16.7
	tr	10.4-10.8	10.2-10.4	11.5	12.95	10.4
m1	ap	18.42-18.62	17.0-17.1	19.6	21.54	16.9
	tr	12.53-12.57	10.8-12.3	12.3	13.2	12.7
m2	ap	22.8-23.2	25.4-26.7	25.2	28.55	21.3
	tr	15.6-15.9	14.4-14.8	14.4	18	-
m3	ap	35.8-37.1	38.8-39.1	38.4	42.6	37.2
	tr	16.6-17.2	16.0-16.8	16.9	20.32	18.02
diastema						
c-p1		9.54	11.4-12.5			
p1-p2		7.45	21.2-22.5			
p2-m3		125.29	127.26	130.35		
p4-m3		95.32-97.42	100.3-102.7	103.54	111.29	92.1

forms on p3 and thicker on p4. The m2 and m3 have strong anterior cingula. The m1 is too worn to distinguish anterior cingulum. On p2 lingual cingulum begins near crest of central cusp and descends towards base. It thickens slightly, midway to form progressively deeper valley between it and cutting edge of central cusp in p3 and p4. Lingual cingulum develops small accessory cusp that enlarges and separates from central cusp and higher lingual cingulum in p3 and p4. Small flexure in cutting anterior edge of central cusp in p2 also progressively enlarges and forms more distinct accessory cusp in p3 and p4. Lingual cingulum joins with posterior cingulum at base. Posterior cingulum curves around base, joins with central cusp ridge, which progressively enlarges in p3 and p4, and then curves slightly anteriorly before merging into labial face of the central cusp. Posterior cingulum forms small basin separate from lingual valley. The p3 and p4 have increasingly larger talonid heels with deeper and more expanded basins and valleys.

Lower molars have four high pointed crests with deep central valley blocked by labial cingulum and blocked lingually by crista that emerges from base of metaconid and extends upward to hypoconid. This is mirrored by crista that extends upward from anterior cingulum and connects with protoconid. Entoconid and metaconid is pyramidal in shape with flat faces but transversely compressed. Protoconid and hypoconid is conical in shape except for a slightly concave lingual surface. The m3 is similar to other molars except that it has a prominent hypoconulid with an enclosed elongate fossette that extends high on cusp.

Discussion.—Kron & Manning (1998) reported three genera in the Arikareean: *Elomeryx*, *Arretotherium*, and *Kukusepasutanka*. *Kukusepasutanka* is clearly separable from the Wagner anthracothere based on its much larger size and unusual morphology (see Macdonald 1956). Separation of *Elomeryx* from *Arretotherium* based on morphological characters of the lower dentition and mandible is more difficult. There may be transitional forms in the early Arikareean because *Arretotherium* is thought to be derived from *Elomeryx* (Macdonald 1956; Macdonald & Martin 1987). Taxonomy of these two genera is based on characters of the upper dentition and skull rather than the lower dentition or jaw (Macdonald 1956; Kron & Manning 1998). *Elomeryx* is distinguished from *Arretotherium* by the presence of a paraconule on the upper molars.

Albright (1999) described anthracothere material from the late Arikareean Toledo Bend lf that he referred to *Arretotherium acridens*. The upper molars lacked the paraconule of *Elomeryx*. He also confirmed the referral of the problematical early to medial Arikareean *"Ancodon" leptodus* to *Arretotherium*. Macdonald had at first (1956) declared the name a *nomen vanum* but later (1963) suggested it be placed in *Arretotherium* based on its age. The type specimen of *A. leptodus*, (American Museum 13005, from the Arikareean lower Rosebud beds, Porcupine Butte, Pine Ridge, South Dakota) has upper molars that are too worn to determine the absence of the paraconule. Albright described a skull (F:AM 132055) that is close in morphology to the type skull of *A. leptodus*, collected from the same area, that shows the absence of the paraconule and therefore argued that this anthracothere sample should be included in *Arretotherium*.

One of the characters listed under Macdonald's (1956) and Kron & Manning's (1998) diagnoses for *Arretotherium* is lack of diastemata. They do not state if this applies to the upper dentition or the lower. The type of *A. fricki* (UNSM 5764) has a significant diastema between P1 and C (15.5 mm). The material that Albright (1999) referred to *A. acridens* shows lower diastemata of variable but significant lengths (c-p1: 7.1-15.0; p1-p2: 14.0-32.5). The type skull of *A. leptodus*, AMNH 13005 also has a short diastema between the upper canine and P1 (8.5) and a longer diastema between p1-p2 (18.30-19.36).

Albright considered this variation to be a consequence of sexual dimorphism. Macdonald & Martin (1987) also described a sample of *Arretotherium* that exhibited considerable sexual dimorphism. Figure 15E-G is a comparison of three anthracothere jaw symphyses that clearly demonstrate sexual dimorphism in early Arikareean anthracotheres as well, based on size of the canines. Figure 15E is an older female, the type of *A. leptodus*; the Wagner jaw (Fig. 15F) is a younger female; and a jaw (Fig. 15G) showing much larger canines is an older male from the Gering Formation. The degree of sexual dimorphism and relatively unusual slow eruption of the molars displayed by anthracotheres (m1 is almost completely worn before wear begins on m3-see Fig. 16) makes it difficult to distinguish any of these species on dental size. Table 7 compares several specimens of anthracotheres along with the Toledo Bend sample. There are no clear divisions in size among the Arikareean mandibles when males and females are present in the sample. *Elomeryx* from the White River Group are slightly larger and the Hemingfordian *A. fricki* are slightly smaller. There is some evidence that symphyseal splay becomes more pronounced in younger taxa (Fig. 16) or this may be a function of increasing ontogenetic age. The Wagner jaw (Fig. 16C), although somewhat crushed, shows a smaller symphyseal splay than the more dentally worn type of *A. leptodus* (Fig. 15B), which in turn shows a lesser splay than an even more dentally worn individual of *A. fricki* (Fig. 15A) with a very broad splay.

There is undescribed anthracothere material from the lower Arikaree Group (e.g. F:AM 132054, Fig. 16D) collected east of Tremain, Wyoming, that is of a similar size and morphology as the Wagner Quarry material, but unfortunately there were no upper teeth or skulls in this material for comparison. The overall character of the Wagner mandible and other early Arikareean mandibles in comparison to *Elomeryx* from the White River Group is that *Elomeryx* is more robust with slightly lower crowned teeth than the early Arikareean sample. On the other hand, comparison of *A. acridens* and *A. leptodus* with *A. fricki* also shows that these earlier forms are more robust. In dental size (Table 7) and morphology of the cheekteeth (Fig. 16) there are no significant differences. Figure 15, B-D, compares calcanea among the Wagner Quarry anthracothere, the type of *A. leptodus*, and *A. fricki* from the Hemingfordian. The Wagner Quarry calcaneum is similar in morphology to *A. leptodus*, but slightly more robust. *A. fricki* is similar in morphology to *A. leptodus* but slightly more gracile.

The Wagner anthracothere and those of the early Arikareean of the Hartville uplift, and the Gering Formation of the Wildcat Ridge may be transitional between *Elomeryx* of the Whitneyan and "medial" to later Arikareean *Arretotherium*. The morphology of the teeth of Arikareean anthracotheres is more gracile with higher crowned cheek teeth than *Elomeryx* from the Whitneyan but the lineage remains conservative with few modifications in lower dentition.

The trend in the literature (Kron and Manning, 1998; Tedford et al., 2004) is to consider the early Arikareean anthracotheres closer to *Elomeryx*. Tedford et al. (2004) lists *Arretotherium* as having its first appearance in the late early Arikareean (Ar2) and *Elomeryx* as having its last appearance in the early early Arikareean (Ar1). Macdonald (1970) named a new species of *Elomeryx*, *E. garbanii*, found near the top of the Sharps Formation and also commented that lower cheek teeth previously referred to *Arretotherium* from the Sharps might also belong to *Elomeryx* because the referral to *Arretotherium* was only based on stratigraphic position. Swisher (1982) questionably reported *Elomeryx* from the Gering of the Wildcat Ridge, based on a partial ramus. Hoganson et al. (1998) reports *Elomeryx armatus* from the early Arikareean of North Dakota. A more conservative approach is taken here: without the definitive upper molars for comparison, the Wagner material is not referred to either genus. Macdonald (1956) was the last to review the anthracotheres and a new review of the group is needed.

Suborder TYLOPODA Illerger 1811
Family CAMELIDAE Gray 1821
Subfamily STENOMYLINAE Matthew 1910
Genus *PSEUDOLABIS* Matthew 1904
PSEUDOLABIS DAKOTENSIS Matthew 1904
Figure 17A-B, D, G; Table 5

Type.—AMNH 9807, female skull missing basicranium and associated atlas.

Range.—Whitneyan through early late Arikareean of the Central Great Plains

Referred Specimens.—UNSM 123222, astragalus; UNSM 123227, proximal metatarsals III-IV; UNSM (field# 6084-92), ungual phalanx, ap = 21.22, articular surface = 8.75; UNSM (field# 6061-92), ungual phalanx, ap = 20.45, articular surface = 7.79; UNSM (field# 6035-92) cuboid, tr = 25, ap = 35; UNSM (field# 6098-92) cuneiform; F:AM 141372, juvenile partial skull.

Discussion.—Referral of this material is based on comparison of the Wagner Quarry material to the large collection of *Pseudolabis* housed in the AMNH (e.g., juvenile *Pseudolabis* skull, F:AM 41814 from lower Arikaree rocks at Muddy Creek, near Lusk, Wyoming) (see dental measurements in Table 5). There is only one species of *Pseudolabis*, *P. dakotensis*, that ranges from the Whitneyan to the late Arikareean. The juvenile skull collected at Wagner Quarry possesses diagnostic characteristics listed by Honey et al. (1998) for the taxon, such as weak mesostyles on upper molars, relatively hypsodont teeth, unreduced premolars, a deeply depressed maxillary fossa, and a fully closed orbit. Honey et al. placed *Pseudolabis* in an expanded Stenomylinae because *Pseudolabis* shares derived characters with *Stenomylus*.

Suborder RUMINANTIA Scopoli 1777
Family HYPERTRAGULIDAE Cope 1879
Genus *NANOTRAGULUS* Lull 1922
NANOTRAGULUS LOOMISI Lull 1922
Figure 15L-M; Table 5

Type.—YPM 10330, almost complete skull and mandibles.

Type Locality.—Castle Butte, Muddy Creek area, near Spanish Mines, Wyoming.

Range.—earliest Arikareean to medial Arikareean

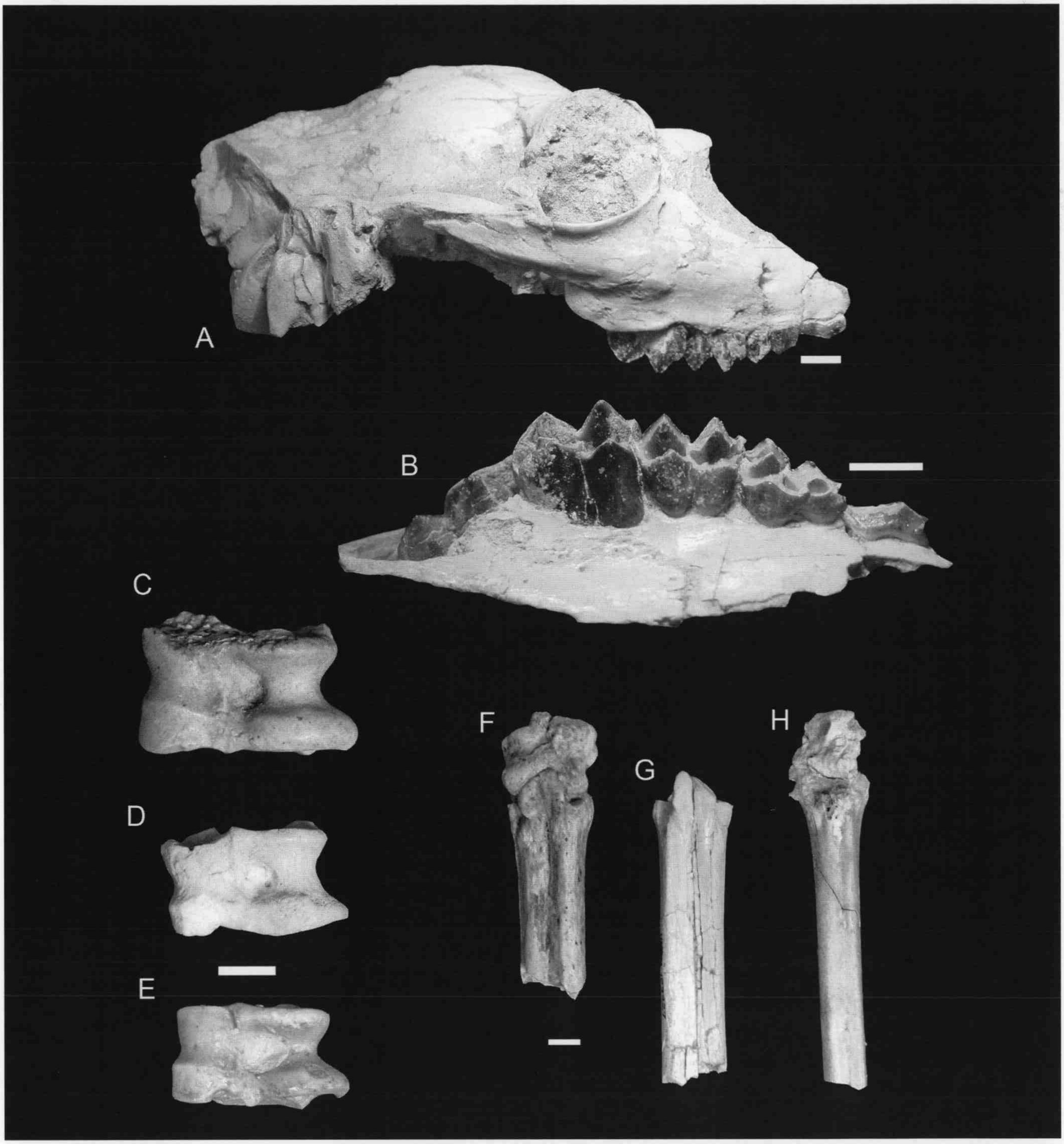

Figure 17. A-B, F:AM 141372, *Pseudolabis dakotensis*, partial juvenile skull with P3-M3, Wagner Quarry. A, lateral view; B, oblique lingual view of dentition, P3-M2, M3 unerupted. C-E, astragalus comparison. C, F:AM 41942, *Pseudolabis dakotensis*, adult, lower Arikaree Fm, Little Muddy Creek, Lusk, WY; D, UNSM 123222, *Pseudolabis dakotensis*, juvenile, Wagner Quarry; E, F:AM 47863A, *Stenomylus hitchcocki*, adult, Harrison Fm, Galusha *Stenomylus* Quarry, Sioux Co., NE. F-H, metatarsal comparison. F, F:AM 41942, *Pseudolabis dakotensis*, juvenile, lower Arikaree Fm, Little Muddy Creek, Lusk, WY; G, UNSM 123227, *Pseudolabis dakotensis*, Wagner Quarry; H, F:AM 47863A, *Stenomylus hitchcocki,* Harrison Fm, Galusha *Stenomylus* Quarry, Sioux Co., NE. Scale bars = 10mm.

(Hunt, pers. comm., 2004)

Referred Specimens.—F:AM 141242, R maxilla with P3-M3, "upper fossil channel" Wagner Quarry section; UNSM 48449, L p4-m2, 123296 L dP4; UNSM 123297 lower molar; UNSM 123298, R M2; UNSM 123299, L M2; UNSM 123237, astragalus.

Discussion.—*Hypertragulus* and *Nanotragulus* both correspond in size and general morphology to the small hypertragulid recovered from Wagner Quarry and the "upper fossil channel". *Hypisodus* is much smaller, and the absence of mesostyles on the upper molars separates it from *Leptomeryx*. Frailey (1979: 157, Table 5) listed dental characteristics that distinguish *Nanotragulus* and *Hypertragulus*. The P4 in *Nanotragulus* has 2 almost equal fossettes, whereas in *Hypertragulus* the posterior fossette is smaller than the anterior fossette. *Nanotragulus* is more hypsodont than the brachyodont *Hypertragulus*. In *Nanotragulus* the M3 metastyle is large (larger than the other styles) and anteriorly slanted. *Hypertragulus* has a small metastyle (smaller than the other styles) which is parallel to the other styles or ribs. Intercolumnar cingula are not usually present in *Nanotragulus*; intercolumnar styles are present. *Hypertragulus* usually develops long intercolumnar cingula. Based on these morphological differences the dental material from Wagner (Fig. 15L-M) can clearly be referred to *Nanotragulus*.

Size is one of the most reliable characters used to differentiate the various species of *Nanotragulus*. The Wagner specimens fall within the size range of *N. loomisi* reported by Frailey (1979:162-165). Frailey demonstrated that *N. intermedius* and *N. lulli* were synonymous with *N. loomisi*. This is the common early Arikareean taxon, and Tedford et al. (2004) use its first appearance to characterize the beginning of the age. The Wagner material also has more rounded labial cusps in comparison to younger *Nanotragulus* species that have V-shaped labial cusps, as reported by Albright (1999).

AGE AND CORRELATION

Previous reports on the Wagner Quarry (Tedford et al. 1985) placed the local fauna in the early Arikareean and faunal analysis here agrees with this correlation.

Wagner Quarry has all of the same micro-mammal taxa as the Ridgeview lf (Bailey, 2004: Table 1) and is stratigraphically equivalent to it as part of the basal fluvial Arikaree facies resting unconformably above the White River Group. Bailey demonstrated that the Ridgeview lf, which is more diverse and numerous in micro-mammals (35 mammal species), could be correlated with high precision to the "Gering A and B" lfs of Swisher (1982). Based on faunal list comparison between localities, Bailey suggested that the Ridgeview lf was slightly older than the "Gering B" lf but younger than the "Gering A" lf= "Brown Siltstone" giving it an approximate age of 29 Ma (Tedford et al. 2004).

The update by Tedford et al. (2004) of the Arikareean NALMA characterizes the earliest Arikareean (Ar1) with the first appearance of *Nanotragulus loomisi* along with the beavers *Capacikala* and *Capatanka*. *Ocajila* is also used as one of the taxa characteristic of the interval. *Ocajila* is confined to the earliest Arikareean (Ar1) in the central Great Plains by Tedford et al. (1996). Bailey (2004) recognized *O. makpiyahe* in the Whitneyan Cedar Ridge lf (Setoguchi 1978) from Wyoming, and Korth (1992) described an m1 from the McCann Canyon lf that might be included in this genus but was larger than *O. makpiyahe*. Whether the range of *Ocajila* is confined to the earliest Arikareean is uncertain yet the restriction of the type species in the Great Plains to the early Arikareean may still be valid.

Tedford et al. (2004) further listed genera that were confined to the early early Arikareean such as *Palaeolagus hypsodus* and *Palaeocastor nebrascensis*. Wagner Quarry lf contains *Palaeolagus hypsodus* and a castorid that is similar in size and morphology to *P. nebrascensis*. Last occurrences of taxa in the Great Plains for the early early Arikareean (Ar1) include *Agnotocastor*, present in the Wagner lf, and the cricetid *Eumys*. *Eumys*, a common genus of the Chadronian, Orellan, and Whitneyan, is only found in the Arikareean "Brown Siltstone" faunas of the central Great Plains and is therefore restricted to the earliest part of the age. *Eumys* is replaced by the cricetids *Geringia mcgregori* and *Leidymys* in the central Great Plains (Martin 1974). Tedford et al. (1996) and Bailey (2004) restrict *Geringia mcgregori* and *Leidymys blacki* to the early early Arikareean (Ar1) in Nebraska. Both taxa are reported from "Brown Siltstone" localities (Martin 1974; Swisher 1982), the Blue Ash lf (Martin 1974), and the Gering Formation (Martin 1973; Swisher 1982). *Geringia mcgregori* is also reported from the northern plains Kealey Springs lf in the late early Arikareean (Ar2).

One of the aplodontids in the Wagner lf, *Downsimus chadwicki*, is reported from UNSM locality Mo-108 in the Gering Formation of the Wildcat Ridge and from the Ridgeview lf, but not from the "Brown Siltstone" or any other localities stratigraphically above the Gering Formation or its equivalents (Bailey 2004). Elsewhere, *Downsimus* was named for material from the Sharps Formation (Macdonald 1970), and Storer's (2002) faunal identifications of the Kealey Springs lf

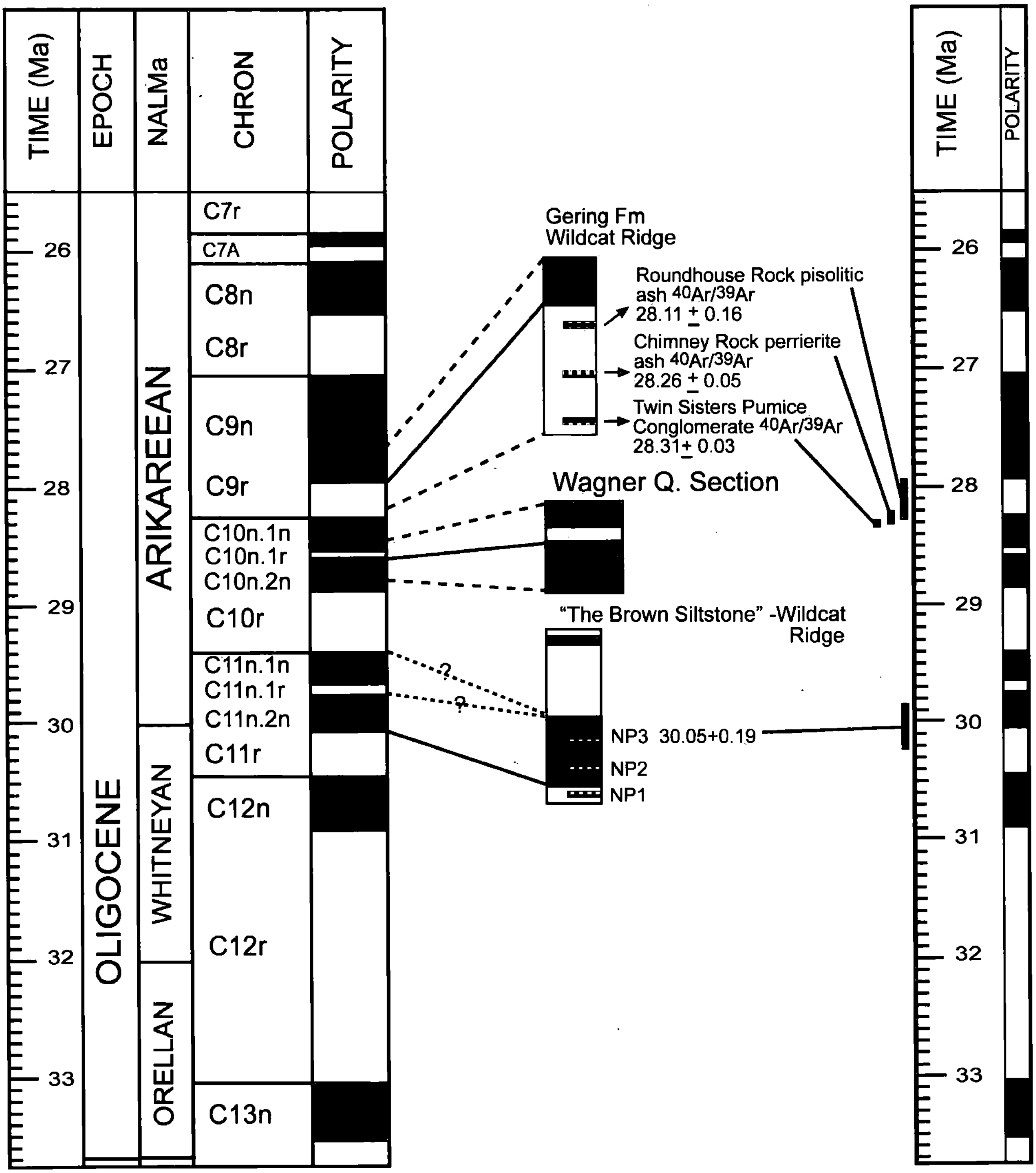

Figure 18. Correlation of the Wagner Quarry section to the Global Polarity Time Scale. (Berggren et al., 1995)

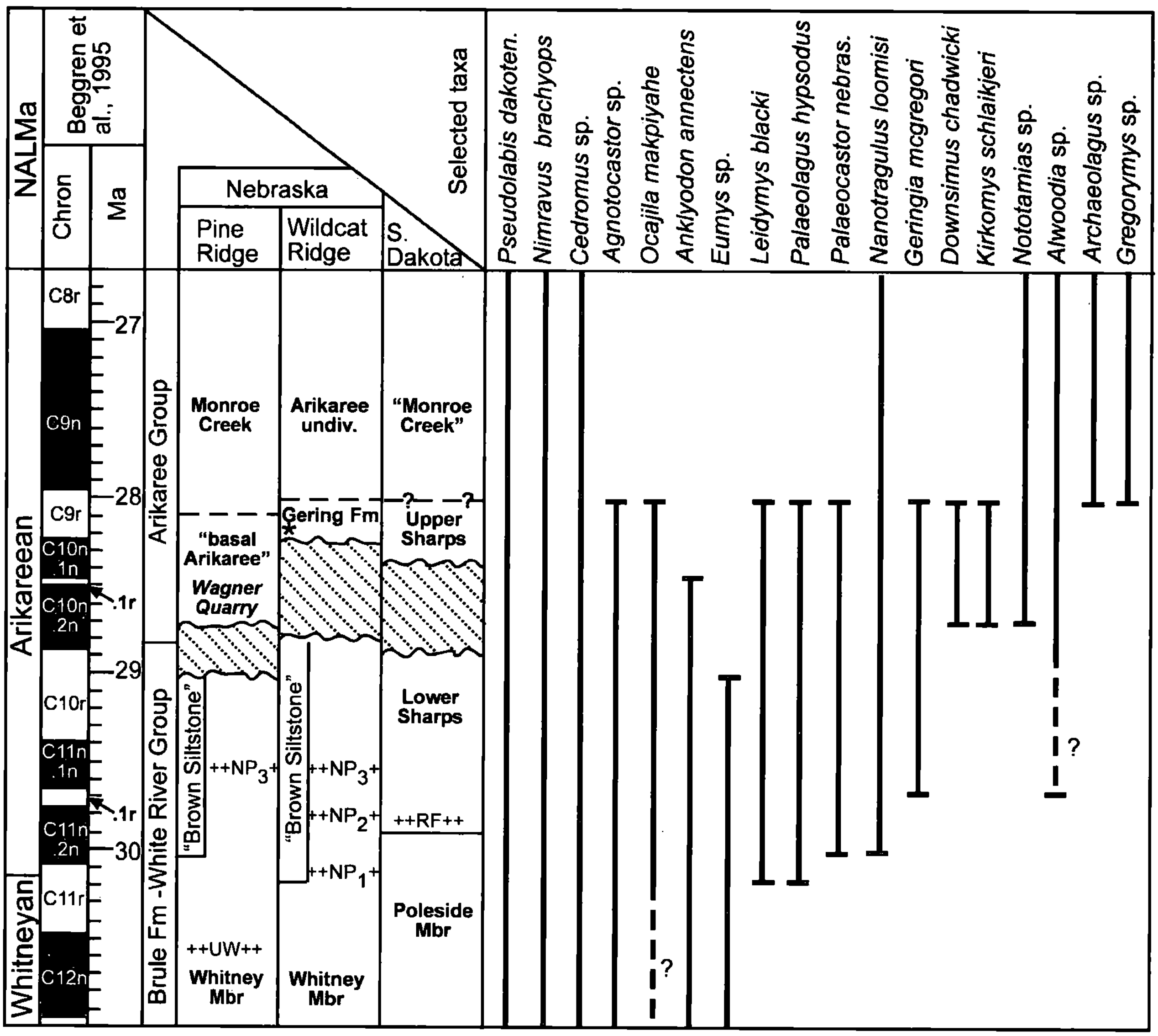

Figure 19. Composite chronostratigraphic chart of selected taxa in Nebraska and South Dakota. (modified from Tedford et al., 1996). "Brown Siltstone in Pine Ridge is correlated using Toadstool Section (Tedford et al., 1996: Fig. 7:324). * Gering Fm dated ashes in Fig. 18.

extended the range of *Downsimus* in the northern Great Plains into the late early Arikareean. The other aplodontid, *Alwoodia,* is listed by Tedford et al. (2004) as having its first appearance in the Great Plains during the late early Arikareean. The recognition of this taxon in the Wagner Quarry lf extends the range down into the early early Arikareean (Ar1) for the Great Plains, which would agree with the genus' first appearance in the John Day region at ~ 28.7 Ma.

Some of the larger taxa in Wagner lf are not as restrictive in age determination in comparison to the small mammals, but they do provide support for assignment to the early Arikareean. *Paradaphoenus tooheyi* (Hunt 2001) is transitional between the Orellan *P. minimus* and the late early to "medial" Arikareean *P. cuspigerus*. *Nimravus* has its last appearance in the late early Arikareean (Tedford et al. 2004). The oreodonts belong to genera that are common to other early Arikareean localities in the Great Plains. *Pseudolabis* is a common camel in the Whitneyan and early Arikareean (McKenna 1966) and is the beginning of the stenomyline radiation of camels that became dominant in the later Arikareean of the Great Plains (Honey et al. 1998).

Based on the definition and characterization of the early early Arikareean (Ar1) as reported by Tedford et al. (2004), the presence of *Nanotragulus loomisi*, *Agnotocastor*, *Geringia mcgregori*, *Leidymys blacki*, and *Palaeolagus hypsodus* firmly places the Wagner Quarry lf in this time period. None of the defining or first appearance taxa (except *Alwoodia*) of the late early Arikareean (Ar2) such as *Amphechinus*, *Parvericius*, *Gripholagomys*, *Archaeolagus*, *Promylagaulus*, *Gregorymys*, and *Stenomylus* are present in the Wagner fauna.

Based on this study, which adds to the work of Tedford et al. (1996) and Bailey (2004), the early early Arikareean (Ar1) can be resolved into three phases: the first phase of the early Arikareean is represented by the faunas of, or equivalent to, the "Brown Siltstone" or lower Sharps (Blue Ash lf, Martin 1974; Simpson 1985; Gering A, Swisher 1982; lower Cabbage Patch faunas, Rasmussen 1977). This is followed by the next phase exemplified by the Pine Ridge basal Arikaree faunas from Wagner lf and Ridgeview lf, and possibly the Gering B lf of Swisher (1982). The upper Gering Formation(as defined by Swinehart et al. 1985) faunas and their equivalents in the upper Sharps represent a third phase. These phases exhibit a step-wise transition of change between White River taxa and taxa of the early Arikareean as suggested by Bailey (2004:104). The earliest phase faunas retain c. 25% White River taxa. The faunas equivalent to Wagner include only about 10% relict taxa; and in the third phase there are practically no White River taxa.

Some further discussion regarding the Kealey Springs lf is warranted here given the above problems with range extensions (e.g. *Downsimus*, *Geringia*, and also *Nanodelphys*) outside of the central Great Plains. The Kealey Springs lf was correlated to the late early Arikareean (Ar2) and it is believed to be equivalent to the "Monroe Creek" sediments in Nebraska (Storer 2002; Tedford et al. 2004). Some of these problems may be due to the fact that the Monroe Creek Formation of the Pine Ridge and its equivalents in Nebraska have produced little in the way of comparative fossils (Bailey [2004] uses the South Dakota Wewela lf [Skinner et al. 1968] to represent this interval). However, the "Monroe Creek" sediments of the Wildcat Ridge have yielded several micro-mammal ant hill collections that have never been studied. The study of the *Cedromus* and *Alwoodia* material of this report indicates that some of the early Arikareean taxa could extend upward into the late early Arikareean and may more closely match the Kealey Springs lf than previously thought. Preliminary study here indicates that the faunas contain mylagaulid rodents similar to the Kealey Springs lf as well as cricetid rodents. These "Monroe Creek Ant Hill" faunas should be further investigated to help refine the characterization of the late early Arikareean in the central Great Plains.

The basal Arikaree sediments and the overlying Monroe Creek Formation in the Pine Ridge do not have any radioisotopic dates at present. As mentioned previously the Wagner Quarry section is in proximity to an outcrop of the Nonpareil Ash. This ash has been magnetically correlated to the NP_3 ash of the Wildcat Ridge (Tedford et al. 1996) which has been dated from outcrops there (Swisher & Prothero 1990). At the Wildcat Ridge, the Gering Formation and "Brown Siltstone" are constrained in age by several radioisotopic dates (Tedford et al. 1996). The oldest of these ages is represented by the NP_3 ash (30.05 +/- 0.19 Ma) in the upper part of the "Brown Siltstone". The youngest dated ash in the Gering Formation (Roundhouse Rock pisolitic ash) establishes an upper boundary at 28.11+/- 0.18 Ma. Two other ashes within the Gering further constrain the age of this formation: the Twin Sisters Pumice Conglomerate (28.31 +/- 0.03 Ma) near the base and the Chimney Rock perrierite ash (28.26+/- 0.05 Ma).

Work in the Wildcat Ridge by D. Prothero (Tedford et al. 1996) has shown that fluvial basal Arikaree deposits of the pumice-bearing Gering Formation are reversely polarized at their base and do not change into normal polarity until the uppermost part of the formation. Using the above geochronology, Prothero correlated the Gering

Formation to the lower part of Chron 9 and the upper part of the "Brown Siltstone" to Chron 11n and part of Chron 10r (paleomagnetic time scale of Berggren et al. 1995). "The Nebraska sections show a hiatus in Chron C10r with Chron C10n missing" (Tedford et al. 1996:317).

The paleomagnetic results of the Wagner Quarry section show that most of the section is normally polarized, unlike the top of the "Brown Siltstone" or the majority of the Gering Formation. A single section of normal polarity in the Pine Ridge is not strong evidence that the basal Arikaree deposition there is entirely different from the Gering Formation. However, this normal signature is supported by the same polarity signature of the lithologically similar basal fluvial sediments exposed at the bottom of the Monroe Creek Canyon section (the type section for Hatcher's [1902] Monroe Creek beds and Harrison beds) located to the east of Wagner Quarry north of Harrison, Nebraska (Hayes 2004). MacFadden & Hunt (1998) correlated the base of their composite Arikaree section to Chron C9r (Berggren et al. 1995), similar to the Gering Formation, because they suggested that the fluvial sediments at the foot of the Pants Butte section represented the same interval as the Gering Formation in the Wildcat Ridge. In Monroe Creek Canyon there are considerable (~ 40m) Arikaree fluvial sediments, referred to above, that are not represented in the Pants Butte section and occur stratigraphically below the cross-bedded sandstones at the bottom of the Pants Butte section.

Faunal comparison with the Ridgeview lf and Gering faunas in Nebraska places the Wagner Quarry lf firmly in the early Arikareean (Ar1) or between 30-28 Ma. Detailed comparison with the faunas of this interval and stratigraphic correlation with the Ridgeview lf suggests an older age than the upper Gering faunas. The Wagner Quarry section is constrained in its lower placement by the Nonpariel Ash 3 date. These parameters leave one normal chron of appropriate age that would fit the polarity signature of the Wagner Quarry Section— Chron 10n (Berggren et al. 1995). This correlation is also supported by the small reversal within C10n— C10n.1r, which is probably represented in the short reversal of the Wagner section (see Fig. 18). The basal Arikaree of the Pine Ridge therefore helps to fill the gap in time that may not be recorded by sediments in the Wildcat Ridge and extend the range of several taxa into this interval.

SUMMARY AND CONCLUSIONS

The Wagner Quarry fauna is the first large mammal concentration described from the historically important Pine Ridge basal Arikaree Group and the first paleomagnetic study of the basal Arikaree in the Pine Ridge. These two studies provide a more accurate correlation than was previously possible of the basal Pine Ridge Arikaree Group to the basal Arikareean sediments in the Wildcat Ridge, as well as to early Arikareean sediments and faunas outside of Nebraska. The independent paleomagnetic correlation shows that the initial basal fluvial deposition of the Pine Ridge Arikaree paleovalley was not synchronous with the Gering Formation, Arikaree Group, deposition in the Wildcat Ridge.

The Wagner Quarry section represents a stack of fluvial sediments, from main channel fills (Wagner Quarry, the "upper fossil channel" and the "top channel"), through distal channel point bar deposits (uniform ripple layers), to flood plain or over-bank deposits that are separated by diastems when pedogenic alteration took place. The fossils of Wagner Quarry represent a relatively wet riparian environment that became increasingly drier by the time the "upper fossil channel" was deposited. Channel sediments become increasingly better sorted and mineralogically similar towards the top of the section as indicated by less influx of allocthonous lithic material in the Wagner Quarry channel and reworking of completely intraformational sediments in the "top channel".

Comparison of the Wagner Quarry lf to the faunas of the Gering Formation, the "Brown Siltstone", the Ridgeview lf, and the faunas of the Sharps in South Dakota as well as to Tedford et al.'s (2004) defining and characterizing taxa of the early early Arikareean, place the Wagner lf biochronologically in this interval (Ar1), or approximately 30-28 Ma.

The Wagner Quarry section is predominantly magnetically normal. This is different from the Gering Formation in the Wildcat Ridge, which is mostly magnetically reversed and the "Brown Siltstone," which is also reversed in its upper section. Faunal correlation places the Wagner Quarry in the early early Arikareean NALMA, slightly older than the radioisotopically calibrated Gering Formation faunas and slightly younger than the "Brown Siltstone" lfs. This constrains the magnetostratigraphy to Chron 10n (28.25-28.87 Ma, Berggren et al. 1995). The section records the short reversal of C10n.1r.

Correlation using the Wagner lf and the Wagner Quarry magnetostratigraphy shows that there is a three phase transition within the early early Arikareean. The first phase is characterized by the local faunas of the "Brown Siltstone"; the second phase by the Wagner lf and the Ridgeview lf; and the third by the Gering faunas. Characteristic White River taxa become increasingly rarer in each phase.

The recognition of a new species of *Cedromus* in the Wagner lf and the assignment of the Gering Formation "*Miospermophilus*" (Martin 1973) to *Oligospermophilus* extends the range of the Cedromurinae into the early Arikareean. *Alwoodia* is also recognized for the first time in the early early Arikareean (Ar1) of the central Great Plains.

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REFERENCES

Albright, L. B., III. 1999. Ungulates of the Toledo Bend Local Fauna (Late Arikareean, Early Miocene), Texas Coastal Plain. Bulletin of the Florida Museum of Natural History, 42:1-80.

Bailey, B. E. 1992. A new early Arikareean microfauna from northwestern Nebraska. Proceedings of the Nebraska Academy of Sciences, 102nd Annual Meeting, 1992:65.

Bailey, B. E. 1999. New Arikareean/Hemingfordian micromammal faunas from western Nebraska and their biostratigraphic significance. Journal of Vertebrate Paleontology, 19:30A-31A.

Bailey, B. E. 2004. Biostratigraphy and biochronology of early Arikareean through late Hemingfordian small mammal faunas from the Nebraska panhandle and adjacent areas. Paludicola, 4:81-113.

Berggren, W. A., D. V. Kent, C. C. Swisher, & M. P. Aubry. 1995. A revised Cenozoic geochronology and chronostratigraphy. Pp. 129-212 *in* W. A. Berggren, Kent, D. V., Aubry, M. P., & J. Hardenbol, eds. Geochronology, Time Scales, and Global Stratigraphic Correlation: Tulsa, SEPM Special Publication 54.

Black, C. C. 1963. A review of the North American Tertiary Sciuridae. Bulletin of the Museum of Comparative Zoology, Harvard, 130(3):110-248.

Bryant, N. H., 1996. Nimravidae. Pp. 453-475 in D. R. Prothero & R. J. Emry, eds.The terrestrial Eocene-Oligocene Transition in North America. Cambridge University Press, United Kingdom.

Butler, R. F. 1992. Paleomagnetism: magnetic domains to geologic terranes. Blackwell Publishers, Boston, Massachusetts, 319 p.

CoBabe, E. A. 1996. Leptaucheniinae. Pp. 574-580 *in* D. R. Prothero & R. J. Emry, eds.The terrestrial Eocene-Oligocene Transition in North America. Cambridge University Press, United Kingdom.

Darton, N. H. 1899. Preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian. United States Geological Survey, 19th Annual Report 1897-1898, 4:719-785.

Dawson, M. R. 1958. Later Tertiary Leporidae of North America. University of Kansas Palaeontological Contributions, Vertebrata, Article 6:1-75.

Effinger, J. A., 1998. Entelodontidae. Pp. 375-380 *in* C. M. Janis, K. M. Scott, & L. L. Jacobs, eds. Evolution of Tertiary Mammals of North America, Volume 1, Terrestrial Carnivores, Ungulates, and Ungulatelike Mammals. Cambridge University Press, United Kingdom.

Fisher, R. A. 1953. Dispersion on a sphere. Royal Society of London Proceedings, 217: 295-305.

Frailey, D. 1979. The large mammals of the Buda Local Fauna (Arikareean: Alachua County, Florida). Bulletin of the Florida State Museum, Biological Science, 24(2):123-173.

Galbreath, E. C. 1953. A contribution to the Tertiary geology and paleontology of northeastern Colorado. University of Kansas Paleontological Contributions, Vertebrata, Article 4:1-120.

Green, M. 1958. Arikareean rhinoceroses from South Dakota. Journal of Paleontology, 32:587-594.

Hayes, F. G. 2000. The Brooksville 2 Local Fauna (Arikareean, latest Oligocene):Hernando County, Florida. Bulletin of the Florida Museum of Natural History, 43(1):1-47.

Hayes, F. G. 2004. Paleomagnetics and biostratigraphy of the Pine Ridge Arikaree Group (late Oligocene-early Miocene), Nebraska. Dissertation, University of Nebraska- Lincoln, 211 p.

Hayes, F. G. 2005. Arikareean (Oligocene- Miocene) *Herpetotherium* (Marsupialia, Didelphidae) from Nebraska and Florida. Bulletin of the Florida Museum of Natural History, 45(4):335-353.

Hatcher, J. B. 1902. Origin of the Oligocene and Miocene deposits of the Great Plains.Proceedings of the American Philosophical Society, 41:113-131.

Hoganson, J. W., E. C. Murphy, & N. F. Forsman. 1998. Lithostratigraphy, paleontology, and biochronology of the Chadron, Brule, and Arikaree Formations in North Dakota. Pp. 185-196 *in* D. O. Terry, Jr., H. E. LaGarry, & R. M. Hunt, Jr., eds. Depositional Environments, Lithostratigraphy, and Biostratigraphy of the White River and Arikaree Groups (Late Eocene to Early Miocene, North America), Geological Society of America Special Paper 325.

Honey, J. G., J. A. Harrison, D. R. Prothero, & M. S. Stevens. 1998. Camelidae. Pp. 439-462 *in* C. M. Janis, K. M. Scott, & L. L. Jacobs, eds. Evolution of Tertiary Mammals of North America, Volume 1, Terrestrial Carnivores, Ungulates, and Ungulatelike Mammals. Cambridge University Press, United Kingdom.

Hunt, R. M., Jr. 2001. Small Oligocene amphicyonids from North America (*Paradaphoenus*, Mammalia, Carnivora). American Museum Novitates, 3331:1-20.

Hunt, R. M., Jr. 2002. New amphicyonid carnivorans (Mammalia, Daphoeninae) from the Early Miocene of southeastern Wyoming. American Museum Novitates, 3385:1-41.

Kirschvink, J. L. 1980. The least-square line and plane and the analysis of paleomagnetic data, Geophysical Journal of the Royal Astronomical Society, 62:699-718.

Korth, W. W. 1981. New Oligocene rodents from western North America. Annals of Carnegie Museum, 50:289-318.

Korth, W. W. 1987. Sciurid rodents (Mammalia) from the Chadronian and Orellan (Oligocene) of Nebraska. Journal of Paleontology, 61:1247-1255.

Korth, W. W. 1989. Aplodontid rodents (Mammalia) from the Oligocene (Orellan and Whitneyan) Brule Formation, Nebraska. Journal of Vertebrate Paleontology, 9: 400-414.

Korth, W. W. 1992. Fossil small mammals from the Harrison Formation (late Arikareean: earliest Miocene), Cherry County, Nebraska. Annals of the Carnegie Museum, 61:69-131.

Korth W. W. 1994a. The Tertiary Record of Rodents in North America. Plenum Press, New York, 319 pp.

Korth, W. W. 1994b. Middle Tertiary marsupials (Mammalia) from North America. Journal of Paleontology, 68:376-397.

Korth, W. W., & R. J. Emry. 1991. The skull of *Cedromus* and a review of the Cedromurinae (Rodentia, Sciuridae). Journal of Paleontology, 65:984-994.

Kron, D. G., & E. Manning. 1998. Anthracotheriidae. Pp. 381-388 *in* C. M. Janis, K. M. Scott, & L. L. Jacobs, eds. Evolution of Tertiary mammals of North America, Volume 1, Terrestrial Carnivores, Ungulates, and Ungulatelike Mammals. Cambridge University Press, United Kingdom.

Lander, B. 1998. Oreodontoidea. Pp. 402-425 *in* C. M. Janis, K. M. Scott, & L. L. Jacobs, eds. Evolution of Tertiary mammals of North America, Volume 1, Terrestrial Carnivores, Ungulates, and Ungulatelike Mammals. Cambridge University Press, United Kingdom.

Macdonald, J. R. 1956. The North American anthracotheres. Journal of Paleontology, 30:615-645.

Macdonald, J. R. 1963. The Miocene faunas from the Wounded Knee area of western South Dakota. Bulletin of the American Museum of Natural History, 125:139-238.

Macdonald, J. R. 1970. Review of the Miocene Wounded Knee faunas of southwestern South Dakota. Bulletin of the Los Angeles County Museum of Natural History, 8:1-82.

Macdonald, J. R., & C. B. Schultz. 1956. *Arretotherium fricki*, a new Miocene anthracothere from Nebraska. Bulletin of the University of Nebraska State Museum, 4(3):53-67.

Macdonald, J. R., & Martin, J. E. 1987. *Arretotherium fricki* (Artiodactyla, Anthracotheriidae) from the Hemingfordian (Miocene) Flint Hill local fauna in South Dakota. Pp. 57-62 *in* J. E. Martin, ed., Papers in Vertebrate Paleontology in Honor of Morton Green, Dakoterra, 3:57-62.

Macdonald, L. J. 1972. Monroe Creek (early Miocene) microfossils from the Wounded Knee area, South Dakota. South Dakota Geological Survey Report of Investigations, 105:1-43.

MacFadden, B. J. 1998. Equidae. Pp. 537-559 *in* C. M. Janis, K. M. Scott, & L. L. Jacobs, eds. Evolution of

Tertiary Mammals of North America Volume 1, Terrestrial Carnivores, Ungulates, and Ungulatelike Mammals. Cambridge University Press, United Kingdom.

MacFadden, B. J., & R. M. Hunt. Jr. 1998. Magnetic polarity stratigraphy and correlation of the Arikaree Group, Arikareean (late Oligocene to early Miocene) of northwestern Nebraska. Pp.143-166 *in* D. O. Terry, Jr., H. E. LaGarry, & R. M. Hunt, Jr., eds. Depositional Environments, Lithostratigraphy, and Biostratigraphy of the White River and Arikaree Groups (Late Eocene to Early Miocene, North America), Geological Society of America Special Paper 325.

Martin, J. E., & Green, M. 1984. Insectivora, Sciuridae, and Cricetidae from the early Miocene Rosebud Formation in South Dakota. Special Publications of the Carnegie Museum of Natural History, 9: 28-40.

Martin, L. D. 1973. The mammalian fauna of the lower Miocene Gering Formation of western Nebraska and the early evolution of the North American Cricetidae. Unpublished Ph. D. dissertation, University of Kansas, 219 pp.

Martin, L. D. 1974. New rodents from the lower Miocene Gering Formation of western Nebraska. Occasional Papers Museum of Natural History University Kansas, 32:112.

Martin, L. D. 1980. The early evolution of the Cricetidae in North America. The University of Kansas Paleontological Contributions Paper 102:1-42.

Martin, L. D. 1998. Nimravidae. Pp. 228-235 *in* C. M. Janis, K. M. Scott, & L. L. Jacobs, eds. Evolution of Tertiary mammals of North America, Volume 1, Terrestrial Carnivores, Ungulates, and Ungulatelike Mammals. Cambridge University Press, United Kingdom.

McKenna, M. C. 1966. Synopsis of Whitneyan and Arikareean Camelid Phylogeny. American Museum Novitates, 2253:1-11.

Minjin, B. 2004. An Oligocene sciurid from the Hsanda Gol Formation, Mongolia. Journal of Vertebrate Paleontology, 24:753-756.

Opdyke, N. D. 1990. Magnetic stratigraphy of Cenozoic terrestrial sediments and mammalian dispersal. Journal of Geology, 98:621-637.

Opdyke, N. D., & J. E. T. Channel. 1996. Magnetic Stratigraphy. Academic Press, San Diego, California, 346 pp.

Opdyke, N. D., Lindsay, E. H., Johnson, N. M., & T. Downs. 1977. The paleomagnetism and magnetic polarity stratigraphy of the mammal-bearing section of Anza-Borrego State Park, California. Quaternary Research, 7:316-329.

O'Sullivan, J. A. 2003. A new species of *Archaeohippus* (Mammalia, Equidae) from the Arikareean of central Florida. Journal of Vertebrate Paleontology, 23:877-885.

Peterson, O. A. 1907. The Miocene beds of western Nebraska and eastern Wyoming and their vertebrate faunae. Carnegie Museum Annals, 4:21-72.

Peterson, O. A. 1920. The American diceratheres. Memoirs of the Carnegie Museum, 7:399-476.

Pratt, A. E, & G. S. Morgan. 1989. New Sciuridae (Mammalia: Rodentia) from the early Miocene Thomas Farm local fauna, Florida. Journal of Vertebrate Paleontology, 9: 89-100.

Prothero, D. R. 1998. Rhinocerotidae. Pp. 595-605 *in* C. M. Janis, K. M. Scott, & L. L. Jacobs, eds. Evolution of Tertiary Mammals of North America, Volume 1: Terrestrial Carnivores, Ungulates, and Ungulatelike Mammals. Cambridge University Press, Cambridge, United Kingdom.

Prothero, D. R., C. Guerin, & E. Manning. 1989. The history of the Rhinocerotoidea. Pp. 321-340 *in* D. R. Prothero & R. M. Schoch, eds. The Evolution of Perissodactyls. Oxford Monographs on Geology and Geophysics No. 15, Oxford University Press, Inc. New York, New York.

Prothero, D. R., & N. Shubin. 1989. The evolution of Oligocene horses. Pp. 142-175 *in* D. R. Prothero & R. M. Schoch, eds. The Evolution of Perissodactyls.Oxford Monographs on Geology and Geophysics No. 15, Oxford University Press, Inc. New York, New York.

Prothero, D. R., & K. E. Whittlesey. 1998. Magnetic stratigraphy and biostratigraphy of the Orellan and Whitneyan land-mammal "ages" in the White River Group; Pp. 39-61 *in* D.O. Terry, Jr., H. E. LaGarry, & R. M. Hunt, Jr., eds. Depositional Environments, Lithostratigraphy, and Biostratigraphy of the White River and Arikaree Groups (Late Eocene to Early Miocene, North America), Geological Society of America Special Paper 325.

Rasmussen, D. L. 1977. Geology and mammalian paleontology of the Oligocene-Miocene Cabbage Patch Formation, central-western Montana. Unpublished Ph.D. dissertation, University of Kansas, 775 p.

Rensberger, J. M. 1983. Successions of meniscomyine and allomyine rodents (Aplodontidae) in the Oligo-Miocene John Day Formation, Oregon. University of California Publications in Geological Sciences, 124:1-157.

Schultz, C. B., & C. H. Falkenbach. 1954. Desmatochoerinae, a new subfamily of oreodonts. Bulletin of the American Museum of Natural History, 105:143-256.

Setoguchi, T. 1978. Paleontology and geology of the Badwater Creek area, central Wyoming. Part 16. The Cedar Ridge local fauna (late Oligocene). Bulletin of the Carnegie Museum of Natural History, 9:1-61.

Simpson, W. F. 1985. Geology and paleontology of the Oligocene Harris Ranch Badlands, southwestern South Dakota Pp. 303-333 *in* J. E. Martin, ed. Fossiliferous Cenozoic Deposits of Western South Dakota and Northwestern Nebraska, Dakoterra, volume 2, South Dakota School of Mines and Technology.

Skinner, M. F., M. S. Skinner, & R. J. Gooris. 1968. Cenozoic rocks and faunas ofTurtle Butte, south-central South Dakota. Bulletin of the American Museum of Natural History, 138:379-436.

Storer, J. E., 2002. Small mammals of the Kealey Springs local fauna (early Arikareean; late Oligocene) of Saskatchewan. Paludicola, 3:105-133.

Swinehart, J.B., V. L. Souders, H. M. DeGraw, & R. F. Diffendal, Jr. 1985. Cenozoic Paleogeography of Western Nebraska. Pp. 209-229 *in* R. M. Flores & S. S.Kaplan, eds. Cenozoic Paleogeography of West-Central United States. Special Publications, Rocky Mountain Section-S.E.P.M., Denver, Co.

Swisher, C. C., III. 1982. Stratigraphy and biostratigraphy of the eastern portion of the Wildcat Ridge, western Nebraska. Unpublished M. S. thesis, University of Nebraska- Lincoln, 172 p.

Swisher, C. C., III, & D. R. Prothero. 1990. Single crystal $^{40}Ar/^{39}Ar$ dating of the Eocene-Oligocene transition in North America. Science, 249:760-762.

Tedford, R. H., L. B. Albright, III, A. D. Barnosky, I. Ferrusquia-Villafranca, R. M. Hunt, Jr., J. E. Storer, C. C. Swisher, III, M. R. Voorhies, S. D. Webb, & D. P. Whistler. 2004. Mammalian biochronology of the Arikareean through Hemphillian interval (Late Oligocene through Early Pliocene Epochs). Pp 169-231 *in* M. O. Woodburne, ed. Late Cretaceous and Cenozoic Mammals of North America, Biostratigraphy and Geochronology. Columbia University Press, New York, New York.

Tedford, R. H., M. F. Skinner, W. Fields, J. M. Rensberger, D. P. Whistler, T. Galusha, B. E. Taylor, J. R. Macdonald, & S. D. Webb. 1987. Faunal succession and biochronology of the Arikareean through Hemphillian interval (late Oligocene through earliest Pliocene epochs) in North America. Pp. 153-210 *in* M. O. Woodburne, ed. Cenozoic Mammals of North America, Geochronology and Biostratigraphy. University of California Press, Berkeley, California.

Tedford, R. H., J. B. Swinehart, R. M. Hunt, Jr., & M. R. Voorhies. 1985. Uppermost White River and lowermost Arikaree rocks and faunas, White River valley, northwestern Nebraska, and their correlation with South Dakota. Pp. 335-352 *in*, J. E. Martin, ed. Fossiliferous and Cenozoic deposits of western South Dakota and northwestern Nebraska. Dakoterra, volume 2, South Dakota School of Mines and Technology.

Tedford, R. H., J. B. Swinehart, C. C. Swisher, III, D. R. Prothero, S. A. King, & T. E. Tierney. 1996. The Whitneyan-Arikareean transition in the High Plains. Pp. 312-334 *in* D. R. Prothero & R. J. Emry, eds. The Terrestrial Eocene-Oligocene Transition in North America. Cambridge University Press, New York, New York.

Toohey, L. 1959. The species of *Nimravus* (Carnivora, Felidae). Bulletin of the American Museum of Natural History, 118:71-112.

Vondra, C. F., C. B. Schultz, & T. M. Stout. 1969. New members of the Gering Formation (Miocene) in western Nebraska including a geological map of Wildcat Ridge and related outliers. Nebraska Geological Survey Paper 18: 1-18.

Wang, X., R. H. Tedford, & B. E. Taylor. 1999. Phylogenetic systematics of the Borophaginae (Carnivora: Canidae). Bulletin of the American Museum of Natural History, 243:1-391.

Williams, M. R., & J. E. Storer. 1998. Cricetid rodents of the Kealey Springs local fauna (early Arikareean; late Oligocene) of Saskatchewan. Paludicola, 1:143-149.

Wilson, R. A., 1949. On some White River fossil rodents. Carnegie Institution of Washington Publication 584:27-50.

Wood, A. E. 1937. The mammalian fauna of the White River Oligocene: Part II. Rodentia. Pp. 155-269 *in* W. B. Scott, G. L. Jepsen, & A. E. Wood, eds. The Mammalian Fauna of the White River Oligocene.Transactions of the American Philosophical Society, 28: 155-269.

Wood, A. E. 1980. The Oligocene Rodents of North America.Transactions of the American Philosophical Society, 70, Part 5: 1-68.

Wood, H. E., II (chairman), R. W. Chaney, J. Clark, E. H. Colbert, G. L. Jepsen, J. B. Reeside, Jr., & C. Stock. 1941. Nomenclature and correlation of the North American continental Tertiary: Bulletin of the Geological Society of America, 52:1-48.

Woodburne, M. O., and Swisher, C. C., III., 1995. Land mammal high resolution geochronology, intercontinental overland dispersals, sea-level, climate, and vicariance, *in* Berggren, W. A., D.V. Kent and J. Hardenbol, eds. Geochronology, time scales and global stratigraphic correlations: A unified temporal framework for an historical geology: SEPM (Society for Sedimentary Geology) Special Publication 54: 329–358.

Xu, X. 1996. Castoridae. Pp. *in* D. R. Prothero & R. J. Emry (eds. The Terrestrial Eocene-Oligocene Transition in North America. Cambridge University Press, New York, New York.

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Hulbert, R.C. Jr., G.S. Morgan, and J.A. Baskin (Editors). 2005. Cenozoic vertebrates of the Americas: Papers to honor S. David Webb. Bull. Florida Museum Nat. Hist. 45(4):125-562. Price $50.00 (Add $5.00 for shipping)

Thompson, F.G., & E.L. Mihalcik. 2005. Urocoptid landsnails of the Genus *Holospira* from southern Mexico. Bull. Florida Museum Nat. Hist. 45(3): 65-124. Price $8.50

Neubert, E., & H. Nordsieck. 2005. New South American Clausiliidae from the collections of the Florida Museum of Natural History (Gastropoda, Clausiliidae, Neniidae). Bull. Florida Museum Nat. Hist. 45(2): 45-64. Price $5.00

Dilcher, D.L. & T.A. Lott. 2005. A Middle Eocene fossil plant assemblage (Powers Clay Pit) from western Tennessee. Bull. Florida Museum Nat. Hist. 45(1):1-43. Price $7.00

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