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Preliminary Biostratigraphy of the White River Group (Oligocene, Chadron and Brule Formations) in the Vicinity of Chadron, Nebraska

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EARTH SCIENCES

PRELIMINARY BIOSTRATIGRAPHY OF THE WHITE RIVER GROUP (OLIGOCENE, CHADRON AND BRULE FORMATIONS) IN THE VICINITY OF CHADRON, NEBRASKA

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The White River Group in the Chadron area includes at least 400 ft (123 m) of terrigenous sediment, divisible into the Chadron Formation and Brule Formation (Orella and Whitney members) on criteria similar to those used at Toadstool Park. Fossils were collected from several levels, and are grouped into the Brecht Ranch Local Fauna (Late Chadronian), Dead Horse Local Fauna (Early Orellan), Rabbit Graveyard Local Fauna (Early Middle Orellan), and Bartlett High Local Fauna (Late Middle Orellan). No Late Orellan fauna was found, and Whitneyan fossils were scarce. Zonation of the Orellan appears to be possible on the basis of size of *Ischyromys* specimens and on development of auditory bullae of *Merycoidodon*. Statistical analysis of oreodonts in the Dead Horse Local Fauna indicates only two abundant genera and species at that level.

† † †

INTRODUCTION

The formations of the White River Group are relatively well exposed in the eastern half of Dawes County, Nebraska, but the stratigraphy and paleontology of this area have received little attention in the literature. The purpose of this paper is to place on record a standard stratigraphic section for the fossiliferous sediments in the area of Chadron, Nebraska, to document the stratigraphic positions from which two substantial collections of vertebrate fossils have been made, and to discuss in preliminary fashion the resulting biostratigraphic data and correlations.

This paper is the result of three years of field work on White River Group sediments in an area south of the White River, between Trunk Butte Creek on the west and Bordeaux Creek on the east, and north of the Pine Ridge escarpment (Fig. 1). Previous work in the area has been discussed in part by Schultz and Stout (1955). Detailed examination of the stratigraphy and collecting of fossil vertebrates in the Chadron area was begun by C. B. Schultz and T. M. Stout about 1934. Crews from the University of Nebraska State Museum, including Schultz, Stout, Grayson E. Meade, Lloyd G. Tanner, and Paul O. McGrew, as well as various graduate students, have continued to visit the area up to the present. Morris Skinner, who collected fossils in the Chadron area for Childs Frick

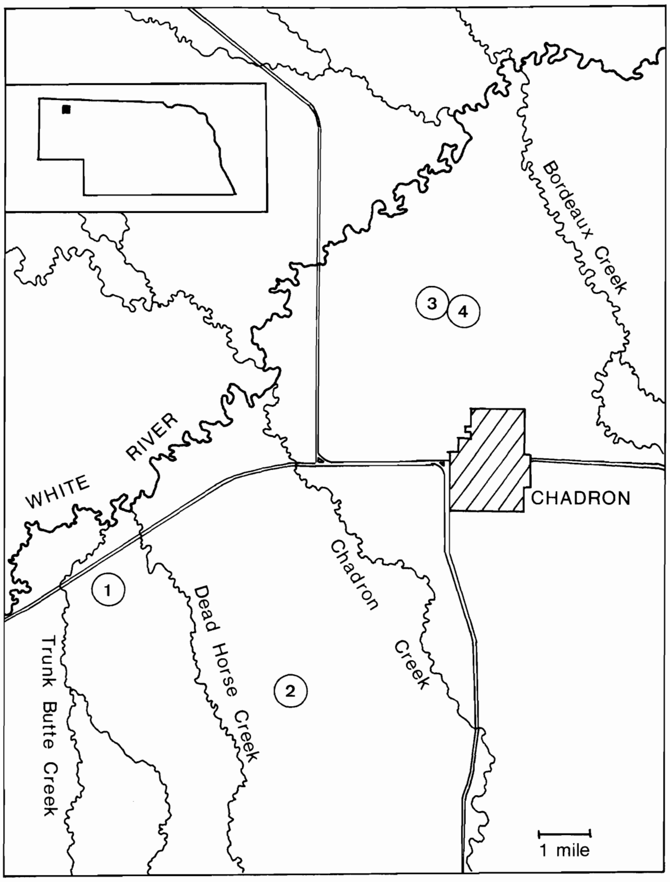


FIGURE 1.—Map of Chadron area, eastern Dawes County, Nebraska. Inset map shows general location. Circled numbers indicate locations of measured sections (Fig. 3).

beginning in 1944, measured a number of local sections to document his collection of nearly a thousand specimens. This collection is at the American Museum of Natural History. During the 1950's Carl Vondra mapped the Chadron Formation in Dawes County, and measured and interpreted a series of detailed sections which were described in an unpublished thesis and companion paper (Vondra, 1958; 1960). A paleomagnetic analysis of one local section (correlated to Skinner's unpublished measured sections) was published by Prothero *et al.* (1983) allowing paleomagnetic correlation to measured sections in other areas (Fig. 3). Occasional vertebrate fossil specimens from this area have been described (Osborn, 1929; Schultz and Stout, 1955; Schultz and Falkenbach, 1956, 1968; Levine, 1971; Hunt, 1974), though only Hunt (1974) ties a specimen collected by M.F. Skinner to local measured sections (of Skinner).

Most of my effort has been on the lower parts of the White River section and has resulted in a substantial collection of vertebrate fossils curated under locality and specimen numbers of the Earth Science Museum of Chadron State College.

STRATIGRAPHY

Schultz and Stout (1955) and Schultz, Tanner, and Harvey (1955) provided a regional classification for Oligocene sediments in western Nebraska, based upon the formation names and concepts of Darton (1899, 1903) and using detailed measured sections in the Toadstool Park area of Sioux and western Dawes County and from the Scottsbluff area.

These papers mention exposures in eastern Dawes County near Chadron, but do not describe them in detail. The Oligocene sediments are underlain by Cretaceous sediments in eastern Dawes County, primarily the Pierre Shale in this study area. Separating Cretaceous from Oligocene sediments is a well-developed paleosol complex, generally distinctively yellow in color, the Interior Paleosol (Ward, 1922; Schultz and Stout, 1955; Retallack, 1983). The Oligocene White River Group includes the Chadron Formation, which measures a maximum of 92 ft (28.4 m) in the study area (Vondra, 1958, but see note below), and the Brule Formation, which has a measured minimum thickness of 337 ft (103 m, this report). The Brule Formation was divided by Schultz and Stout (1938) into Orella and Whitney members, which can be recognized in the Chadron area (Fig. 2). Overlying the Whitney Member are the poorly-exposed sands of the Gering Formation. Because of the nature of the fossiliferous exposures, most of this study was conducted in the Chadron Formation and the Orella Member of the Brule, for which detailed measured sections are given (Fig. 3). The four measured sections of Figure 3 are those used to develop an overall generalized local section for plotting of the stratigraphic positions of fossiliferous localities (Fig. 4). No attempt is made here to describe the sediments in detail. However, some comments are necessary to elucidate the features used in correlation from place to place.

Chadron Formation.—The Chadron Formation is here recognized as those sediments between the Interior Paleosol and the top of the Upper Purplish-White Layer, following Schultz and Stout (1955). The Chadron Formation sediments in the Chadron area are not accepted by me as type exposures of the formation, despite statements by Wilmarth (1938) and Schultz and Stout (1955). Darton's early descriptions of the Chadron Formation (1899, 1903) show clearly that he simply applied a geographical name to the old concept of the "*Titanotherium* beds". Harksen and Macdonald (1969) have examined the type-area concepts for the Chadron Formation and designate an exposure near Scenic, South Dakota as the most acceptable type section. I agree with their logic and accept their proposed type section.

Singler and Picard (1980) contested Harksen and Macdonald's type sections and recommended following Schultz and Stout (1955) and using a type section along the Pine Ridge near Toadstool Park in northern Sioux County, Nebraska. The exposures in this area are admittedly among the best available, but a type section in Nebraska would conflict with the historical origins of the *Titanotherium* Beds–Chadron Formation con-

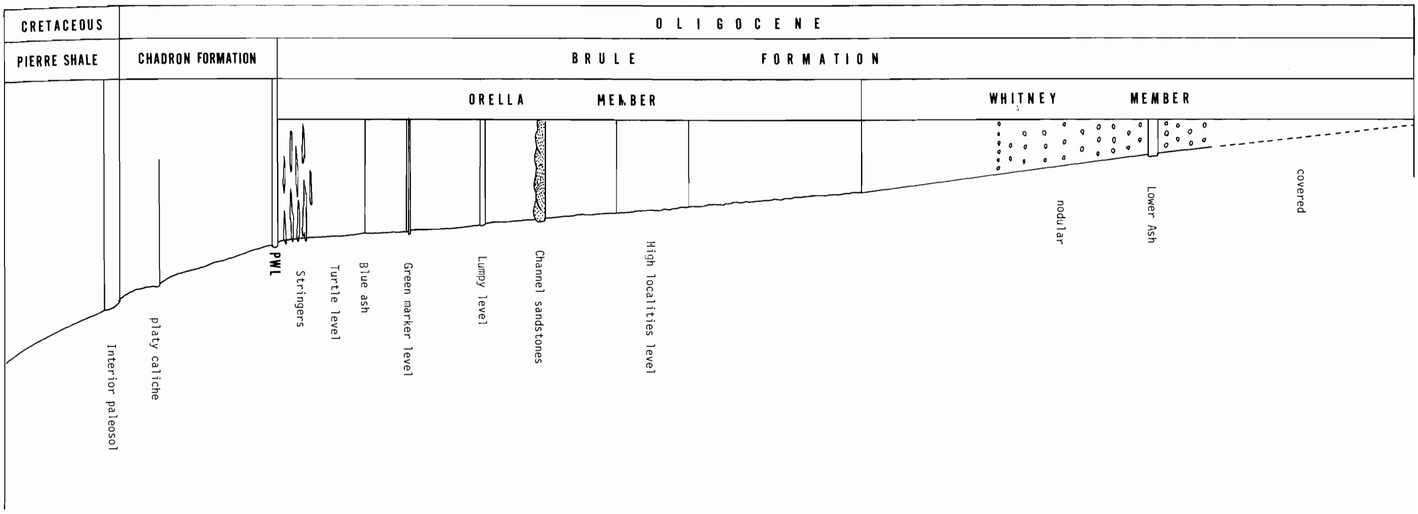


FIGURE 2.—Generalized stratigraphic section, Chadron area, eastern Dawes County, Nebraska. This section was developed from a series of isolated exposures north of and west of Chadron, and does not include the Pine Ridge escarpment section. Scale is not given as thicknesses vary from place to place, but the Whitney Member below the Lower Ash is approximately 100 ft (30.5 m) thick.

cept, which for most of the 19th century was centered on the Big Badlands of South Dakota.

The maximum thickness of the Chadron Formation in the Chadron area may be as much as 92 ft (28.4 m) as measured at Trunk Butte (Fig. 3, Section 1), but it is usually thinner. The lower parts of the formation weather with dark to light green and gray colors and rounded topography which are typical of the formation both in Nebraska and South Dakota. As in the Toadstool Park area about 25 miles (40.2 km) directly west of Chadron, the upper sediments (pink and green siltstones and clay-siltstone conglomerates) of the Chadron Formation are almost indistinguishable from the lowermost sediments referred to the Brule Formation. At least one, and occasionally two or more white layers are consistently present near or at the boundary everywhere in the study area (Schultz and Stout, 1955, Fig. 5), and correlations using the uppermost of these appear to give consistent results. This upper layer is here correlated with the Upper Purplish White Layer of Schultz and Stout (1955); also with the Persistent White Layer (PWL) of Skinner (collecting notes, 1944 and later).

Although a single white bed is easily interpreted as the PWL in most sections, there is some conflict about the identification of the PWL in the section on the northeast face of Trunk Butte. A thick (4.5 ft; 1.4 m) lens of volcanic ash is very prominent in that exposure, and at first glance it appears to be the PWL (Fig. 3, Section 1, Bed 11). This bed is followed by a series of thin calcitic stringers as is the case with the PWL and its immediately overlying beds in other sections. However, Vondra (1958) designated this very obvious white layer as the Lower Purplish White Layer, and indicated that a less prominent (and less obviously white) bed about 19 ft (5.8 m) higher should be designated as the PWL (Fig. 3, Section 1, Bed 16). The latter bed also is followed upsection by a series of thin caliche beds. Vondra's designations are indicated in Figure 3, Section 1. The only titanothere material from this exposure is from below the massive white ash, and no other identifiable specimens were found. If the massive ash (Fig. 3, Section 1, Bed 11) is properly correlated with the PWL, maximum thickness for the Chadron Formation in this area is reduced to about 71 ft (21.6 m).

Although fossils occur sparsely within much of the thickness of the Chadron Formation in the study area, the vast majority and the best specimens are concentrated in the uppermost part of the Chadron sediments, including some specimens found within the PWL. Hunt (1974) named the *Brecht Ranch Local Fauna* from localities west of the town of Chadron, including specimens from the uppermost 20 ft (6.2 m) of the Chadron Formation. Hunt's Brecht Ranch Local Fauna is named in accordance with the definition of "local fauna" of Tedford (1970), namely a series of fossil samples from a series of closely-associated sites having limited geographic and stratigraphic distribution. This local fauna name is here extended to include samples taken from the same stratigraphic level, north of the town of Chadron.

Sediments throughout the upper part of the Chadron Formation and lower Orella sections are primarily siltstones, clay-siltstones, and silty-claystones. Most levels show frequent large silt or clay clasts, and these are frequently abundant enough to characterize the rock as a siltstone or claystone conglomerate or breccia. Most variation in this part of the section seems to

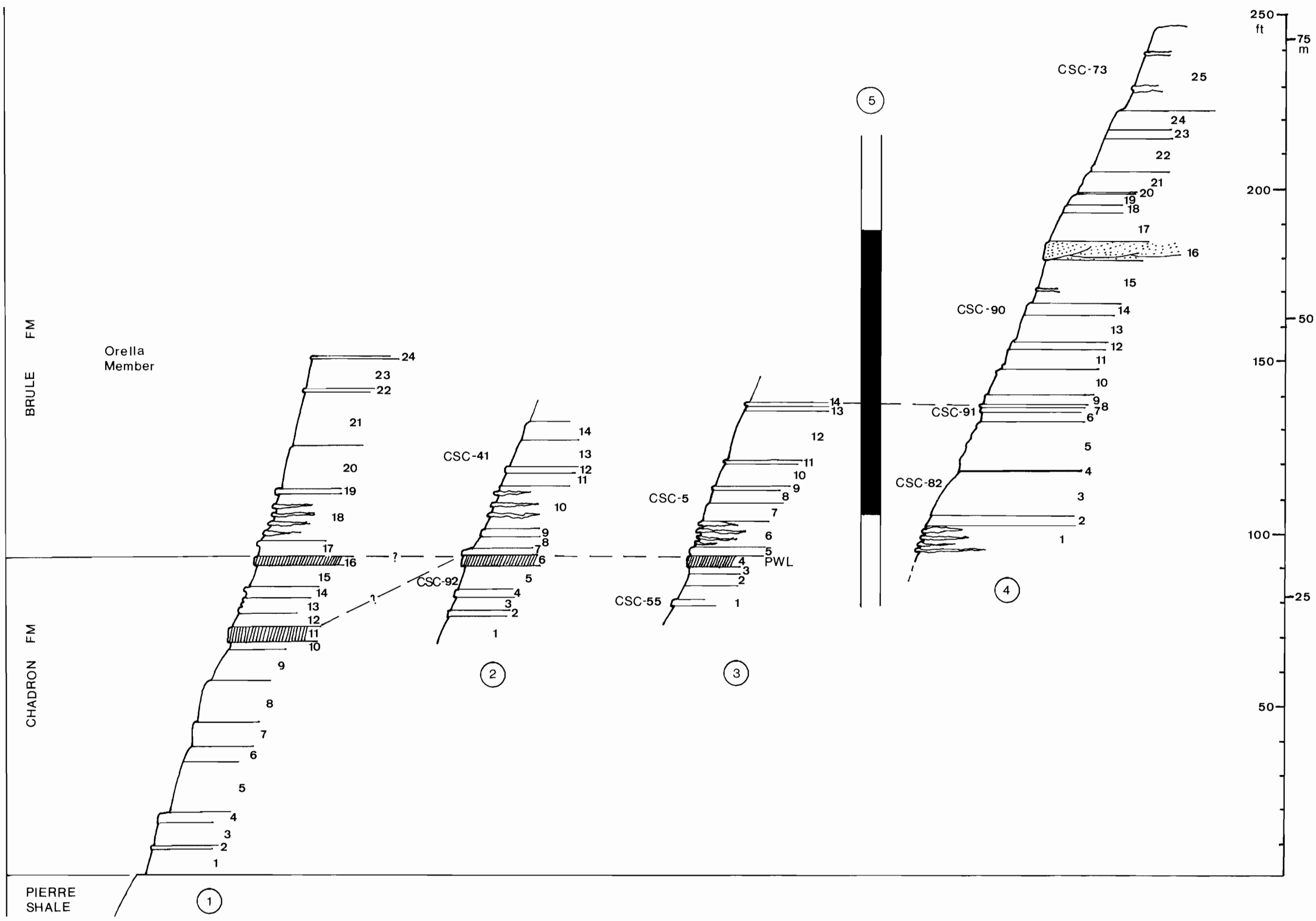


FIGURE 3.—Measured stratigraphic sections used in construction of the local standard section, Figure 4. Locations of these sections are indicated on Figure 1. Stratigraphic positions of Chadron State College localities are indicated on the section measured closest to the locality. Scale at right indicates distance above Pierre Shale only for Section 1; Sections 2-4 are tied in by means of marker beds indicated.

Section 1: measured on the northeast face of Trunk Butte, SW.¼ of NW.¼, Sec. 31, T. 33 N., R. 49 W., Dawes County, Nebraska (after Vondra, 1958).

Bed 24—siliceous limestone, whitish gray, 0.5 ft (0.15 m), top of section

23—silty claystone, grayish green, 8.5 ft (2.6 m)

22—siliceous limestone, gray, thin platy fracture, 1 ft (0.3 m)

21—silty claystone, buff grading upward into grayish green, 16.7 ft (5.1 m)

20—silty claystone, buff to pink, 12 ft (3.7 m)

19—volcanic ash, bluish gray, platy fracture, up to 1.2 ft (0.4 m)

18—clay-siltstone, with numerous resistant lenses of caliche ("stringers"), capped by a resistant calcareous pink siltstone, 15.5 ft (4.7 m)

17—clay-siltstone, calcareous, weathers into small nodules, forms resistant ledge of buff-green, 4 ft (1.2 m)

16—massive siltstone, grayish-white with small buff clayballs, 2 ft (0.6 m). Vondra's Upper Purplish White

15—clay-siltstone, buff mottled with green, 7 ft (2.1 m)

14—claystone, slightly silty, capped by a thin layer of caliche, buff mottled with green, 3.2 ft (1 m)

13—claystone, silty, numerous thin lenses of caliche, buff mottled with green, 4.7 ft (1.4 m)

12—siltstone, ashy buff, 3.5 ft (1.1 m)

11—ashy siltstone, massive, resistant, grayish-white, 4.5 ft (1.4 m). Vondra's Lower Purplish White Layer

10—claystone, light green, 2.5 ft (0.8 m)

9—claystone, light grayish buff, 8.5 ft (2.6 m)

8—clay-siltstone, smooth weathered surface, contains a thin layer of white calcareous clay nodules, buff to pink, 11.9 ft (3.6 m)

7—clay-siltstone, calcareous, resistant, dark green

at base and top, light whitish green in middle ("Third Purplish White Layer"), 7 ft (2.1 m)
6—siltstone, smooth weathering, light grayish green, 4.5 ft (1.4 m)
5—clay-siltstone, olive green, 15 ft (4.6 m)
4—caliche, grayish green, forms a resistant rust-colored ledge, up to 2.7 ft (0.8 m)
3—claystone, silty, olive-green, 8 ft (2.4 m)
2—siliceous limestone, grayish-white, 0.7 ft (0.2 m)
1—claystone, silty, olive-green, 6.9 ft (2.1 m), resting on Interior Paleosol Complex (yellow claystone grading into maroon red at top)

Section 2: measured in the NW.¼ of Sec. 9, T. 32 N., R. 49 W., Dawes County, Nebraska.

Bed 14—laminated pinkish siltstone, top of section
13—pinkish-tan siltstone, greenish at top
12—green and tan mudstone breccia
11—pinkish-tan siltstone
10—tan siltstone with numerous caliche stringers
9—green and brown mudstone breccia
8—tan siltstone
7—green and brown mudstone breccia
6—PWL, White Layer, top often gradational, calcite-rich; much volcanic ash
5—tan siltstone, green in top foot
4—calcified mudstone breccia
3—tan siltstone
2—brown siltstone with lesser green patches
1—mottled green and tan siltstone

Secton 3: measured in the SW.¼ of Sec. 31, T. 34 N., R. 48 W., Dawes County, Nebraska (after Vondra, 1958)

Bed 14—clay-siltstone, ashy and highly calcareous, pinkish-white, grades laterally into a siliceous limestone
13—claystone, slightly silty, light green (Green Marker Bed)
12—siltstones, weathering in nodules, interbedded with smooth-weathering clays, pink to buff
11—volcanic ash, bluish gray (Blue Ash of Skinner)
10—claystone, slightly silty, pinkish buff mottled with green
9—siltstone, hard, calcareous, weathers into nodules
8—claystone, silty, green to buff
7—claystone, light pinkish buff
6—claystone, light brown to greenish buff, contains lenses (stringers) of calcareous caliche
5—clay-siltstone, calcareous, forms a resistant ledge, yellowish-green
4—PWL (Purplish White Layer), massive ashy siltstone, contains small brown clayballs, grayish-white
3—clay-siltstone, contains small light brown clayballs, olive-green
2—clay-siltstone, contains small light brown clayballs, olive-green
1—clay-siltstone, contains heavy ledges of caliche and calcareous clay nodules, pinkish-buff mottled with light green

Section 4: measured in the NE.¼ of Sec. 6, T. 33 N., R. 48 W.

Bed 25—siltstone, massive, sparsely nodular; at least two nodular ledges, very light brown
24—sandy siltstone, buff to light green
23—clay-siltstone, orange-buff
22—siltstone, very pale greenish
21—siltstone, brown, lumpy texture, rounded weathering
20—fine sand, ashy-gray
19—siltstone, brown-buff, lumpy texture
18—clay-siltstone, orange-buff
17—siltstone and sandy siltstone with occasional thin ashy layers
16—channel sandstone, irregular foreset beds, clean quartz sandstone to arkose, coarse sand in places
15—siltstone, pale buff, with irregular, ashy-white sandier layers
14—clay-siltstone, prominent lumpy texture, brown (Lumpy Level)
13—sandy siltstone, laminated, very light buff
12—siltstone, orange-buff, rounded weathering surface
11—siltstone, rounded surface, darker buff
10—siltstone, granular, lighter color than 9
9—siltstone, granular texture, buff
8—sandy siltstone, buff, easily eroded
7—clay-siltstone, light green (Green Marker Bed)
6—clay-siltstone, pinkish buff
5—siltstone and sandy siltstone, irregular ledge-former, light brown
4—volcanic ash, grayish white (Blue Ash of Skinner)
3—siltstone, pinkish buff
2—siltstone, light brown
1—siltstone, buff and green, containing numerous calcareous caliche lenses (stringers)

Secton 5: Paleomagnetic section, based on Prothero (1983 and personal communications). Black indicates normally polarized samples; white indicates reversely magnetized samples.

have been produced by volcanic-ash falls (likely with the PWL) and by varying soil processes. Particularly prominent are soil features characteristic of the Gleska and Conata Series paleosols initially described from the Chadron and Brule formations in Badlands National Park (Retallack, 1983). In the Chadron area sections, numerous superimposed green layers are seen, resembling the ''A'' horizons of Gleska Series paleosols. These are commonly calcareous, mottled with greenish root-traces. Soil features are particularly strong at Locality CSC-55 (Bartlett West #1) which produced fossils from a coarse clay-siltstone conglomerate, heavily cemented with calcite and with very common root traces. Common fossils there are *Mesohippus, Merycoidodon* and turtles, partly matching the list of expected fauna from this paleosol type suggested by Retallack (1983:32). Most of the animals on his list (and at CSC-55) are large forms, which with the coarse texture of the sediment suggests relatively strong current-force and substantial hydraulic sorting. Such sorting is also indicated by the excessive abundance of skulls, jaws and teeth as opposed to postcranial skeletal elements. Voorhies (1969) demonstrated by experiment that these mammalian skeletal elements are among those least moved by stream currents. Few of the abundant turtle specimens have much preserved other than the heavy carapace and plastron. Turtle vertebrae, many limb bones, and especially skulls, tend to be absent or sparsely represented. This circumstance is additional evidence for sorting by some agency. Suitable current strength (taking into consideration the absence of distinct stream-channel features in the area) should occur during flood in near-channel areas. Retallack characterizes the Gleska Series paleosol environment as ''intimately associated with distal levee deposits and probably formed in broad zones on either side of streams.''

Brule Formation, Orella Member.—As in the case of the Toadstool Park section of the Brule, two members can be distinguished. Singler and Picard (1980) recommended upgrading the Orella and Whitney members to formational status. I regard this change as unnecessary and have used the terminology of Schultz and Stout (1955). The lower, Orella Member, is bedded and lithologically variable, produces relatively irregular exposures, and shows occasional fairly large-scale stream-channel features. The upper, Whitney Member, produces smooth steep slopes, is lithologically less variable, contains numerous potato-sized concretions and (in the Chadron area) has at least one ash bed useful for correlation.

The Orella member is approximately 200-215 ft (60.8-65.5 m) thick in the area immediately north of Chadron. The lowest part of the Orella Member is characterized by locally abundant but areally restricted thin calcareous lenses, producing a level of ''stringers'' of a very distinctive nature, not found in other parts of the overall section. Such stringers are particularly abundant in the central part of Sec. 9, T.32N., R.49W. (though they disappear rapidly to the south and west); on Trunk Butte; and on the west sides of Sec. 31, T.34N., R.48W. and of northern Sec. 6, T.33N., R.48W. Retallack (1983) describes such stringers as a common feature of a variant of the Gleska Series paleosols (Gleska silty clay petrocalcic stringer variant). Development of such calcareous lenses suggests a relatively high water-table and their localized nature suggests development in marshy areas or other swales near streams. Paleosols above the stringers level within the Orella Member are often difficult to characterize as either Gleska or Conata Series paleosols, as features of both series may be present. This is not unexpected, as both paleosol types apparently formed on the same floodplains or low terraces.

The stringers level (lower part of the Orella) is commonly overlain by a series of very highly fossiliferous pink and green siltstones with pink predominating, characterized by the exceptionally high abundance of large tortoises and oreodonts and known in field notes as the *Turtle Level*. Skulls of mammals at this level commonly are associated with partial postcranial skeletons. Most of the fossils occur within the 30 ft (9.2 m) of sediment immediately above the PWL, and most lie below a thin Blue Ash which Skinner has used as a marker (Fig. 3). Fossils from this zone (between the PWL and the Blue Ash) are here termed the *Dead Horse Local Fauna* after Dead Horse Road, near several of the localities. The Blue Ash is not always present, and its level is not apparent at the localities in Sec. 9, T.32N., R.49W. (Fig. 3, Section 2).

A distinctive and widespread marker bed, termed the *''Green Marker Bed''* in collection notes, occurs 40 to 50 ft (12.1-15.2 m) above the PWL, most characteristically in the exposures north of Chadron. At many exposures north of Chadron the Green Marker Bed is capped by a resistant ledge-forming calcareous or siliceous layer which weathers into a coarse rubble and obscures the underlying exposures. A similar resistant bed occurs at a similar level in the Orella near the top of Trunk Butte and on a hill in the southeast quarter of Sec. 28, T.33N., R.49W.

Localities CSC-79 and CSC-80 (Rabbit Graveyard and Scratching Post, both at the Green Marker Level) show a standard Gleska Series paleosol profile; a strongly green clayey siltstone ''A'' horizon underlain by a pink clayey siltstone ''B'' horizon. The ''A'' horizon is locally overlain by a variably thick (up to 12 in [0.3 m]) calcitic or chalcedony resistant layer, but the green-pink combination occurs whether the resistant layer is present or not. However, the fauna is a nice match for Retallack's Conata Series fauna (mainly rabbits, *Ischyromys, Leptomeryx, Hypertragulus,* and less common *Hyracodon* and *Merycoidodon* with abundant tortoises).

Localities within the Orella Member above the Green Marker Level are restricted to the exposures north of Chadron. About 30 ft (9.2 m) above the Green Marker Level is a fossiliferous dark brown clay-siltstone termed the *''Lumpy Level''* because of the characteristic lumpy texture of the bed. Like the Green Marker Level, it produces mainly microfauna. The fauna from these two restricted fossiliferous levels is here named the *Rabbit Graveyard Local Fauna*.

A few feet above the Lumpy Level the grain size abruptly coarsens into a fine-to-coarse channel sandstone. Channel features are widespread, though the deepest filled-channel form is only about 5 ft (1.6 m) thick. Current directions seem to be consistently from west to east. Some layers within the channel sands are well-cemented and weather into toadstool forms. Above the channel sands is a repetitive sequence of pink and tan siltstones, generally unfossiliferous. A massive light brown siltstone about 20 to 25 ft (6.2-7.7 m) thick, beginning 135 ft (41.2 m) above the PWL, has produced a small assemblage of fossils here named the *Bartlett High Local Fauna*. The beds containing the Bartlett High Local Fauna seem to end about 60 ft (18.3 m) below the top of the Orella Member.

Brule Formation, Whitney Member.—The Whitney Member is exposed in the northern parts of Sections 8 and 9, and the southern part of Sections 4 and 5, T.33N., R.48W. The lower part of the section weathers to a smooth surface with occasional green paleosols. Above the 45 ft (13.7 m) level, potato-sized concretions or nodules become common, as do fossil snail steinkerns. A prominent White Ash, 4 ft thick, occurs about 100 ft (30.5 m) above the base, probably equivalent to the Lower Ash of Schultz and Stout (1955). Only 15 ft (4.6 m) of section were measured above the Lower Ash. Few fossils are available from the Whitney Member. The lowest specimens of *Leptauchenia* seen here were within the Lower Ash. The Whitney Member is seen in sparse exposures along the face of Pine Ridge, but they were not explored for this study.

FAUNA

Specimens collected from the described section have been taxonomically identified but no attempt is made at a revision of names. Stratigraphic distribution of mammalian faunas is shown in Figure 4. With one exception (*Daphoenictis*), only specimens with Chadron State College numbers have been examined or counted.

MAMMALIA

Order Marsupialia

Family Didelphidae

Peratherium sp.

Eight specimens of a small *Peratherium*, including upper and lower molars, all come from the Green Marker Level.

Order Insectivora

Family Leptictidae

Leptictis sp.

Only one specimen was found, a partial lower jaw with deciduous P_4 and M_1 from the Rook Ranch Locality (CSC-41).

Order Rodentia

Family Ischyromyidae

Ischyromys typus

Ischyromys parvidens

Stout (1937) and Howe (1966) examined measurements for stratigraphically-arranged samples of *Ischyromys* and discovered a general increase in size. Howe referred specimens to species using a population concept, based on size statistics for each stratigraphic level. This approach was used on the Chadron area samples. An increase in size of *Ischyromys* is present between the samples from the Dead Horse Local Fauna and Rabbit Graveyard Local Fauna. The lowest sample (Dead Horse Local Fauna) falls within the statistical parameters of *Ischyromys parvidens*. All higher samples fall within the statistical parameters Howe presented for *Ischyromys typus* and are so assigned.

Family Castoridae

Agnotocaster praetereadens

One lower jaw from the Green Marker Bed shows the characters of this genus. The teeth are not as complex as in *Agnotocastor coloradensis*.

Family Eutypomyidae

Eutypomys thomsoni

Only a single jaw shows the peculiarly complex tooth-patterns characteristic of *Eutypomys*. As with *Agnotocastor*, it was found in the Green Marker Bed.

Family Eomyidae

Paradjidaumo trilophus

Two specimens, both lower jaws, come from the two lower levels in the Orella. The teeth are larger and simpler than in *Adjidaumo* and are referable to Cope's species, *P. trilophus*.

Adjidaumo minutus

Eight specimens, all jaws or maxillaries with teeth, are referable to this taxon, all from a single locality at the Green Marker Level.

Family Heteromyidae

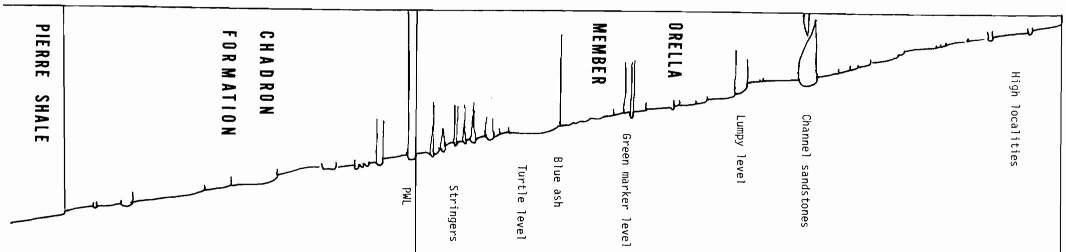
Heliscomys hatcheri

Two specimens are available, both maxillary fragments with teeth, from the Rabbit Graveyard Local Fauna. They fit the characteristics of this species.

Family Cricetidae

Eumys elegans

Eumys was unexpectedly scarce at the Chadron area localities. Only a single jaw was found at the Green Marker Level, and no specimens were found at other localities. This genus is very abundant, particularly in Middle to Upper Orellan localities at Toadstool Park and in the Big Badlands in South Dakota. Its absence at most Chadron area localities may be due to conditions of deposition or to collection techniques,



Taxon	Brecht Ranch local fauna	Dead Horse local fauna	Rabbit Graveyard local fauna		Bartlett High local fauna
Peratherium sp.			8		
Leptictis sp.		1			
Ischyromys typus			6	1	6
Ischyromys parvidens		8			
Agnotocastor praetereadens			1		
Eutypomys thomsoni			1		
Paradjidaumo trilophus		1	1		
Adjidaumo minutus			8		
Heliscomys hatcheri			1	1	
Eumys elegans			1		
Paleolagus haydeni	1	36	73	10	2
Megalagus turgidus		2	4		
Hyaenodon crucians	2	1	1		
Daphoenocyon dodgei	3				
Daphoenus hartshornianus				1	2
Daphoenictis tedfordi	1				
Hesperocyon gregarius	1	4	3		1
Hoplophoneus primaevus		2			
Dinictis felina	1	2			
Brontotheriidae	5				
Mesohippus bairdi	13	18	4	1	1
Mesohippus proteulophus	1				
Hyracodon nebraskensis	1	5	4	1	2
larger rhino		3	3		1
Stibarus lemurinus		1			
Archeotherium mortoni	1	3			
Agriochoerus antiquus	1				
Merycoidodon culbertsoni	21	79			
Merycoidodon sp.			3	2	16
Miniochoerus gracilis	3	54		1	3
Poebrotherium wilsoni		23	5		1
Pseudoprotoceras longinaris	5				
Hypisodus minimus		3			1
Hypertragulus calcaratus	1	7	2	1	
Leptomeryx evansi	9	48	13	3	6
Leptomeryx sp. (large)	2	4	1	2	

FIGURE 4.—Faunal checklist. Numbers indicate total number of recorded specimens (Chadron State College Collection) from a particular stratigraphic level. The *Daphoenictis tedfordi* specimen is F:AM 25,242, Frick Collection, American Museum of Natural History. Chadron State College localities used in local fauna specimen counts include:

Brecht Ranch Local Fauna:
- CSC-55, Bartlett West #1
- CSC-92, Rook Ranch lower levels
- CSC-99, White's south end
- CSC-26, Hawthorne A
- CSC-27, Hawthorne B
- in part CSC-5, Schommer Ranch (lower level)

Dead Horse Local Fauna:
- CSC-5, Schommer Ranch
- CSC-6, Bartlett Ranch
- CSC-8, White Ranch
- CSC-41, Rook Ranch
- CSC-44, Hawthorne Ranch
- CSC-81, Horse Island
- CSC-82, Central Turtle Level

Rabbit Graveyard Local Fauna:
- CSC-75, Bartlett South Central
- CSC-79, Rabbit Graveyard
- CSC-80, Scratching Post
- CSC-83, Central Marker Bed
- CSC-85, Anderson's Lumpy Level
- CSC-90, Bartlett's Lumpy Level
- CSC-91, Midwest Valley

Bartlett High Local Fauna:

CSC-73, Bartlett High
CSC-77, Bartlett Dike Valley (highest level)
CSC-86, Anderson High

through the latter seems unlikely in the more heavily-exploited localities. Schultz and Stout (1955: 43) remark the total absence of *Eumys elegans* in Orella A and its first appearance in Orella B. This has been also noted by Alker (1967).

Order Lagomorpha

Family Leporidae

Paleolagus haydeni

Paleolagus was found at every fossiliferous level below the top of the Orella Member. At first, following Galbreath (1953) I had intended to refer *Paleolagus* specimens to two species, *P. haydeni* (the smaller) and *P. intermedius* (the larger). However, analysis of measurements of *Paleolagus* showed no tendency to divide into two distinct populations. Close examination of specimens initially assigned to *P. intermedius* showed that all were relatively old individuals, apparently of *P. haydeni*. As I have not examined the type material of *P. intermedius*, I cannot synonymize the species, but this possibility must be considered in the future. None of the specimens from the Chadron area falls within the measurement range of *P. burkei*, a smaller species. The single specimen from the Brecht Ranch Local Fauna is indistinguishable from Orellan *P. haydeni*.

Megalagus turgidus

Megalagus, as is usually the case, is relatively scarce compared to *Paleolagus*, but the teeth are easily distinguished. All specimens found were within the lower two fossiliferous levels within the Orella Member.

Order Creodonta

Family Hyaenodontidae

Hyaenodon crucians

Four specimens show considerable variation in age, but all fall within the size range of *H. crucians* given by Mellett (1977). A fifth specimen of *Hyaenodon*, a partial upper dentition from the lower part of the Whitney Member, has not been identified to species and is not shown on Figure 4.

Order Carnivora

Family Daphoenidae

Daphoenocyon dodgei

The Chadronian genus *Daphoenocyon* has been poorly known and often confused with *Daphoenus*. Two excellent skulls and a lower jaw of *D. dodgei* from CSC-55 (Bartlett West #1, Brecht Ranch Local Fauna) promise to greatly improve our knowledge of this taxon.

Daphoenus hartshornianus

Three partial skulls with partial dentitions are referable to the smaller of the two Orellan species of *Daphoenus*. All are from the Bartlett High and Rabbit Graveyard local faunas.

Daphoenictis tedfordi

Hunt (1974) described one lower jaw of this carnivore from the Brecht Ranch Local Fauna. No further specimens have been found.

Family Canidae

Hesperocyon gregarius

Hesperocyon occurs throughout the section (Fig. 4), though the material is generally very fragmentary. A total of nine specimens makes it the most abundant carnivore.

Family Felidae

Hoplophoneus primaevus

Two excellent skulls, both from the Turtle Level (Dead Horse Local Fauna) are referable to this species.

Dinictis felina

Specimens of *Dinictis* include three lower jaws and one P^4, from the Brecht Ranch and Dead Horse local faunas. The smallest jaw (one of two specimens from the Turtle Level) is small for *D. felina* and could be referred to *D. squalidens*.

Order Perissodactyla

Family Brontotheriidae

None of the titanothere specimens is yet identified to genus level. Most specimens are tooth fragments. These are, however, very distinctive and useful in determining the stratigraphic range of titanotheres. The highest titanothere tooth-fragments from the Chadron area were found only two ft (0.6 m) below the PWL. This was also found true in the Lance Creek area of Wyoming by Stout (*in* Luebke, 1964: 65 and Fig. 2-x). At one section in Wyoming, titanothere tooth fragments have been found just above a bed designated as the PWL (Prothero, 1982). Also, a titanothere metapodial was reported at perhaps this same horizon in the basal Orella at the Scottsbluff National Monument by Schultz and Stout (1955: Fig. 10-1).

Family Equidae

Mesohippus bairdi

Mesohippus proteulophus

Mesohippus was found through the Orellan and Chadronian localities. Most of the specimens were assignable to the common species, *M. bairdi*. One specimen, a partial lower jaw, is much larger than specimens of *M. bairdi*, and I follow Forsten (1970) in assigning this specimen to *M. proteulophus*. The latter species is apparently restricted to the Chadronian.

Family Hyracodontidae

Hyracodon nebraskensis

All of the identifiable rhinocerotoid material, including a nice late-juvenile skull from the Green Marker Level, is assignable to a single species, *H. nebraskensis*. A number of tooth fragments seems to pertain to a larger rhinoceros, but none of the fragments is generically identifiable.

Order Artiodactyla

Family Leptochoeridae

Stibarus lemurinus

The single specimen of *Stibarus* is a lower jaw with M_{2-3} from the Turtle Level (Dead Horse Local Fauna).

Family Entelodontidae

Archaeotherium mortoni

Specimens of entelodonts are scarce and fragmentary. All specimens include teeth or tooth fragments from animals the size of *A. mortoni*. All are from low in the Orella or in the Chadron Formation.

Family Agriochoeridae

Agriochoerus antiquus

A single partial skull of this species was found at Bartlett West #1, Locality CSC-55 (Brecht Ranch Local Fauna).

Family Merycoidodontidae

Merycoidodon culbertsoni

Merycoidodon sp.

Miniochoerus gracilis

Merycoidodonts (or oreodonts) are relatively abundant at all levels within the Chadron area sections. The oreodonts of the Upper Chadron (Brecht Ranch Local Fauna) and the lower parts of the Orella are very similar. The Orellan oreodonts in the Chadron State College collection all have minute bullae and so all localities fall within Schultz and Falkenbach's Oreodont Zone "Brule A". Schultz and Falkenbach (1954, 1956, 1968) list a total of 10 genera and 14 species from their Oreodont Faunal Zone "Brule A". The samples from the Chadron area suggest much less taxonomic diversity. The very large number of taxa proposed by Schultz and Falkenbach was criticized by Lander (1978), who suggests that species and genera were established in part on skull forms which are commonly altered by postburial processes such as compaction of sediments.

In an effort to provide some objective criteria for establishing the true number of taxa, I applied the method promoted by Gingerich (1974). Gingerich analyzed dental measurements relative to degree of variability (using coefficients of variation) and demonstrated that the statistics of M_1^1 (the least variable teeth in most mammalian dentitions) could be used to separate closely-related species if a sufficient sample was available. I measured the length and posterior width of M_1 (which gave the largest available sample, N=48 teeth) from all localities in the Dead Horse Local Fauna, including all from the Turtle Level and a few specimens above the PWL but below the Turtle Level, and plotted $\log_e$ (AP length × T width) on a histogram (Fig. 5). This plot shows two size groups. These two groups were then analyzed statistically and it was found that the coefficient of variation of each group falls within the normal range for a single species (Gingerich, 1974). Thus, it can be demonstrated that two dental size-groups are present at this stratigraphic level and that each size group is no more variable than expected for a single species. I have emphatically *not* demonstrated that only two species are present. Nevertheless, all specimens from this level are provisionally assigned to either the common large species (*Merycoidodon culbertsoni*) or to the small species (*Miniochoerus gracilis*).

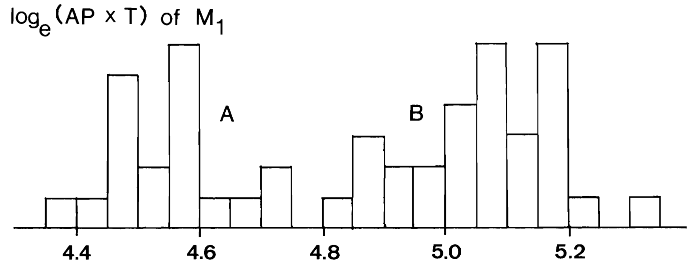


FIGURE 5.—Histogram of $\log_e$ (AP, anteroposterior length × T, transverse width) for lower first molars (no more than one measurement per individual was used) for all measureable oreodont specimens from the Dead Horse Local Fauna. Specimens falling below 4.75 were sorted into one group, those above 4.8 were sorted into a second group. Standard statistics for these groups are as follows:

A. Smaller group, assigned to *Miniochoerus gracilis:* $N=19$, $\bar{X}=10.979$ mm, observed range (AP length of M_1)=9.9-12.3 mm, s=.625, coefficient of variaton V=5.69.

B. Larger group, assigned to *Merycoidodon culbertsoni:* $N=29$, $\bar{X}=13.741$ mm, observed range (AP length of M_1)=12.3-15.4 mm, s=.754, coefficient of variation V=5.54.

Merycoidodonts from below or within the PWL appear taxonomically identical to those in the Turtle Level, and are so identified. Adequate material from the Rabbit Graveyard Local Fauna is lacking, and the two adequate skulls of *Merycoidodon* from the Bartlett High Local Fauna appear to represent a slightly smaller and shorter-skulled *Merycoidodon* which is left unallocated to a species. Both skulls from the Bartlett High Local Fauna have minute bullae. Prothero (1982) suggested that a rapid decrease in size occurs within *Miniochoerus*, and he would divide the genus into three successive species. As no evidence was presented to support this, I retain a conservative interpretation. I detected no discernable decrease in size in my samples.

Family Camelidae

Poebrotherium wilsoni

Poebrotherium is common above the PWL, with considerable variation present. As a statistical sample is unavailable, I have lumped all specimens into a single species. More than one species may actually be present.

Family Protoceratidae

Pseudoprotoceras longinaris

Pseudoprotoceras occurs only in the Brecht Ranch Local Fauna in the Chadron area. Four of the specimens are lower jaws, one of which includes most of the cheek teeth, and one specimen is an upper molar.

Family Hypertragulidae

Hypisodus minimus

Hypisodus is scarce in the study area, with the available three specimens (one partial skeleton and two lower jaws) close to the size of the type of *H. minimus*.

Hypertragulus calcaratus

Hypertragulus is much less common than *Leptomeryx* in the Chadron area sample. All specimens are easily included in *H. calcaratus*. One specimen, found float a few feet below the PWL, appears to belong to the Chadronian Brecht Ranch Local Fauna.

Family Leptomerycidae

Leptomeryx evansi

Leptomeryx sp. (large species)

Leptomeryx is the second most abundant taxon (after *Merycoidodon*) partly because its size range allows it to be found as elements in both large and small element-size localities. All specimens are fragmentary. Two groups of specimens are found. The more common appears to be *L. evansi;* the less common is a larger form to which I have not applied a specific name. The distinction of two size groups has not yet been demonstrated statistically, but it appears to be real.

CORRELATIONS

Brecht Ranch Local Fauna.—Most of the specimens of the Brecht Ranch Local Fauna come from the 10 ft (3 m) of sediment immediately below the PWL or from within the PWL itself. By the local formational definitions, this is the uppermost part of the Chadron Formation, equivalent to Chadron C of Schultz and Stout (1955), and very likely equivalent to the upper part of Chadron C as exposed at Toadstool Park. Because of this position, it appears to be the latest-possible fossil sample in the Chadron Formation in northwestern Nebraska.

Faunally, the Brecht Ranch Local Fauna belongs within the Chadronian Land Mammal Age, defined in part by Wood *et al.* (1941) as the time during which *Mesohippus* and titanotheres coexisted. Titanothere-tooth fragments are relatively common in sediments below the PWL and the highest fragments found in this study came from only 2 ft (0.6 m) below the PWL. None were found within or above the PWL. Other taxa characteristic of Chadronian age are *Pseudoprotoceras longinaris, Daphoenictis tedfordi, Daphoenocyon dodgei*, and *Mesohippus proteulophus*.

Faunal evidence for a relatively late Chadronian age is provided by a substantial similarity, especially at the species level, to Orellan faunas. Species clearly identified in the Brecht Ranch Local Fauna but better known from the Orellan include *Paleolagus haydeni, Hyaenodon crucians* (listed by Mellett, 1977 as being especially common in the Late Chadronian and Early Orellan), *Hesperocyon gregarius, Dinictis felina, Mesohippus bairdi, Agriochoerus antiquus, Merycoidodon culbertsoni, Miniochoerus gracilis, Leptomeryx evansi*, and *Hypertragulus calcaratus*. The last of these has not previously been identified from a Chadronian fauna, and some question might be attached to the single specimen assigned here. The specimen (a partial maxilla with molars) was found float near the stock dam (Brecht Dam of Schultz and Falkenbach, 1968: 419) in Sec. 9, T. 32 N., R. 49 W., in an area where the PWL is exposed along with underlying sediments, but where practically no overlying sediments are exposed.

Dead Horse Local Fauna.—The Dead Horse Local Fauna comes from the lowest part of the Orella Member, from the top of the PWL to about 30 ft (9.2 m) above the PWL. This local fauna is below a thin Blue Ash Layer which occurs about 25 to 30 ft (7.7-9.2 m) above the PWL. This interval appears to correlate with Schultz and Stout's (1955) Orella A, which at Toadstool Park is about 33 ft (10 m) thick. Deposition seems to have been relatively continuous across the Chadron Fm.-Orella Mbr. boundary.

The fossil fauna is dominated by tortoises and oreodonts. This level resembles the lowermost strata in the Brule in South Dakota in this peculiar and distinctive combination, and the name "*Turtle-Oreodon Layer*" has been used there for parts of the lower Brule (Sinclair, 1921). No relict Chadronian forms have been found in this stratigraphic zone. The fauna is a very typical Orellan assemblage.

Faunas appear to change gradually through the Orella Member in most areas where it or its temporal equivalents (Orellan Land Mammal Age) exist. For example, Galbreath (1953) was able to subdivide his Orellan Cedar Creek Fauna into lower, middle and upper "parts" with at least some faunal change between each part. He particularly noted the disappearance of *Paleolagus haydeni* in the middle and upper "parts" and its replacement by *P. burkei*. Schultz and Falkenbach (1968) recognized a major change in oreodonts between their Orella C and Orella D. In the lower stratigraphic levels (Orella A through C, Brule Faunal Zone A) *Merycoidodon* specimens have small or minute otic bullae. In the upper level (Orella D, Brule Faunal Zone B) *Merycoidodon* specimens consistently have enlarged or inflated bullae. Howe (1966), using *Ischyromys,* published one of the few studies to date to consider both detailed stratigraphy (tied to a local section at Toadstool Park) and population variation in the fashion needed to elucidate the details of faunal change in the Orellan. Howe (1966, following information previously developed by Stout, 1937, unpublished thesis) demonstrated two things: first, that at any one level variation in *Ischyromys* fits the expected structure for a single population, and second, that succeeding populations increased in size significantly during the Orellan.

The Dead Horse Local Fauna contains *Ischyromys* specimens falling within the parameters of the small species, *I. parvidens*. Using Howe's correlations, *I. parvidens* in the Toadstool Park area characterizes the Orella A and Orella B of Schultz and Stout (1955). The Dead Horse Local Fauna on this basis is a correlative of the Lower Orella fauna of the Toadstool Park area.

Rabbit Graveyard Local Fauna.—This local fauna consists of specimens from two distinct levels, the Green Marker Level and the Lumpy Level. Both levels produce a relatively large number of microfaunal taxa, especially rabbits, and significant faunal differences between the two levels are not apparent with present evidence. Both faunas include *Ischyromys typus,* which Howe indicated was restricted to Orella C (Middle Orella).

Bartlett High Local Fauna.—The Bartlett High Local Fauna comes from a restricted zone approximately 25 ft (7.7 m) thick, 60 ft (18.3 m) below the top of the Orella Member. Oreodont skulls (*Merycoidodon*) from this fauna have minute bullae and thus fall within Schultz and Falkenbach's Brule Faunal Zone A, below the top of the Middle Orella (Orella C). It appears that this fauna will correlate with the upper part of Zone A. *Ischyromys* specimens from this local fauna are large for *I. typus* but fall within the range of that species.

Prothero (1982) has attempted a more detailed biostratigraphy of the Chadronian and Orellan, but his publications lack documentation needed to compare the faunas used here.

Paleomagnetic correlations.—Prothero (1982) and Prothero *et al.* (1982, 1983) have attempted a paleomagnetic correlation of White River sediments in Wyoming, Nebraska, South Dakota, and Colorado. One of their published sections (Prothero, *et al.* 1983, Fig. 7-H) was measured and tested in the area of my Sections 3 and 4 of Figure 3 (this paper). This shows the central part of the Chadron area section having normal polarity. Prothero correlates this normally-magnetized part of the section to Chron 11N of the standard paleomagnetic time scale, which can be dated as approximately 31 to 32 million years old. Chron 11N was also detected at Toadstool Park, where the lower boundary is above the PWL in Orella A sediments, and the upper boundary is just above the Upper Nodules in Orella C sediments. Using these boundaries to compare with the Chadron area section (Fig. 3), the Dead Horse Local Fauna overlaps the lower boundary of Chron 11N and should be equivalent to the Orella A fauna at Toadstool Park The Rabbit Graveyard Local Fauna falls below the uppe boundary of Chron 11N and should be no younger than th fauna of the Upper Nodules at Toadstool Park. This interpretation agrees well with the strictly biostratigraphic correlation presented above.

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