

CENOZOIC ROCKS AND FAUNAS
OF TURTLE BUTTE, SOUTH-
CENTRAL SOUTH DAKOTA

MORRIS F. SKINNER, SHIRLEY M. SKINNER, AND
RAYMOND J. GOORIS

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INTRODUCTION

AT THE WEST END OF Turtle Butte in Tripp County, South Dakota, an opportunity is provided to observe in superposition five different and distinctive rock units. Four have been named previously: the ?Chadron, Rosebud, Valentine, and Ash Hollow formations. The other rock unit (early Miocene) is named here the Turtle Butte Formation (new name), and we show its stratigraphic relationship to the other four Tertiary formations as well as to the Cretaceous Pierre Shale (fig. 2). The lithologies and faunas of these rock units aid in an understanding of the eastern extensions of the Tertiary deposits and the way in which they are related to the erosional and depositional cycles that have taken place in south-central South Dakota and north-central Nebraska.

The problem of the Rosebud beds of Gidley (1904) is discussed, and a type section (fig. 6) is presented. Two new members of the Valentine Formation and one new member of the Ash Hollow Formation are described below.

Except for the Pierre Shale, the pre-Pliocene deposits at Turtle Butte have been mapped and described by some authors as the Brule Formation. We present new faunal evidence showing that the Turtle Butte Formation is biostratigraphically similar to the Monroe Creek and Harrison formations of southwestern South Dakota and northwestern Nebraska. Lithologically, however, the Turtle Butte Formation differs from the Monroe Creek and the Harrison. The Rosebud Formation, as used here, underlies the Turtle Butte Formation at Turtle Butte and is biostratigraphically similar to the Sharps Formation (early Miocene) in Shannon County, South Dakota, but, as does the Turtle Butte Formation, the true Rosebud differs lithologically from the Sharps Formation.

Numerous reconnaissances have been made by the senior author and his associates to collect fossils and to trace outcrops of the Miocene and Pliocene deposits in the Turtle Butte area. All but one of the Frick Collection specimens were collected and documented by the senior author. The strati-

graphic sections presented in this paper were made many years prior to this report but were re-examined in 1967.

ACKNOWLEDGMENTS

The late Mr. Childs Frick made this report possible by his patronage and guidance of field work. A list of the field men who assisted the senior author during the last 40 years would be too lengthy for inclusion in this paper, but we give our deep appreciation to all of them. We are grateful to all the members of the Frick Laboratory for their assistance, particularly Mr. George Krochak for help with the records and Messrs. Otto Simonis and Ernst Heying for their skillful preparation of specimens. Messrs. Beryl E. Taylor and Robert J. Emry have assisted in the identification of specimens and in the preparation of the manuscript. Dr. Claude W. Hibbard, Mr. Ted Galusha, and Dr. Michael Voorhies also contributed valuable suggestions. Dr. Richard Estes supplied the identification of the fish and reptile material. Dr. C. Bertrand Schultz has compared a cast of a *Leptauchenia* partial skull with the skulls of the Leptaucheniinae in the Frick Collection. Mr. Thompson M. Stout has supplied information on rodent specimens in the Frick Collection from Eagle Nest Butte, South Dakota, and nearby areas that compare with a specimen of *Steneofiber pansus* which was collected by Gidley in 1903. The Frick Collection of leptauchenids and South Dakota rodents are on loan to the University of Nebraska State Museum. The Department of Vertebrate Paleontology of the American Museum of Natural History has given us complete freedom to use the collections, early records, and archives, and Miss Charlotte P. Holton has generously assisted us in finding and identifying specimens.

We acknowledge with thanks the contributions of Dr. J. R. Macdonald and Mr. J. C. Harksen for their continued interest in this project and for stimulating discussions in the field on the "Rosebud problem." Although neither Dr. Macdonald nor Mr. Harksen is in complete agreement with our geologic assignment of the Rosebud Forma-

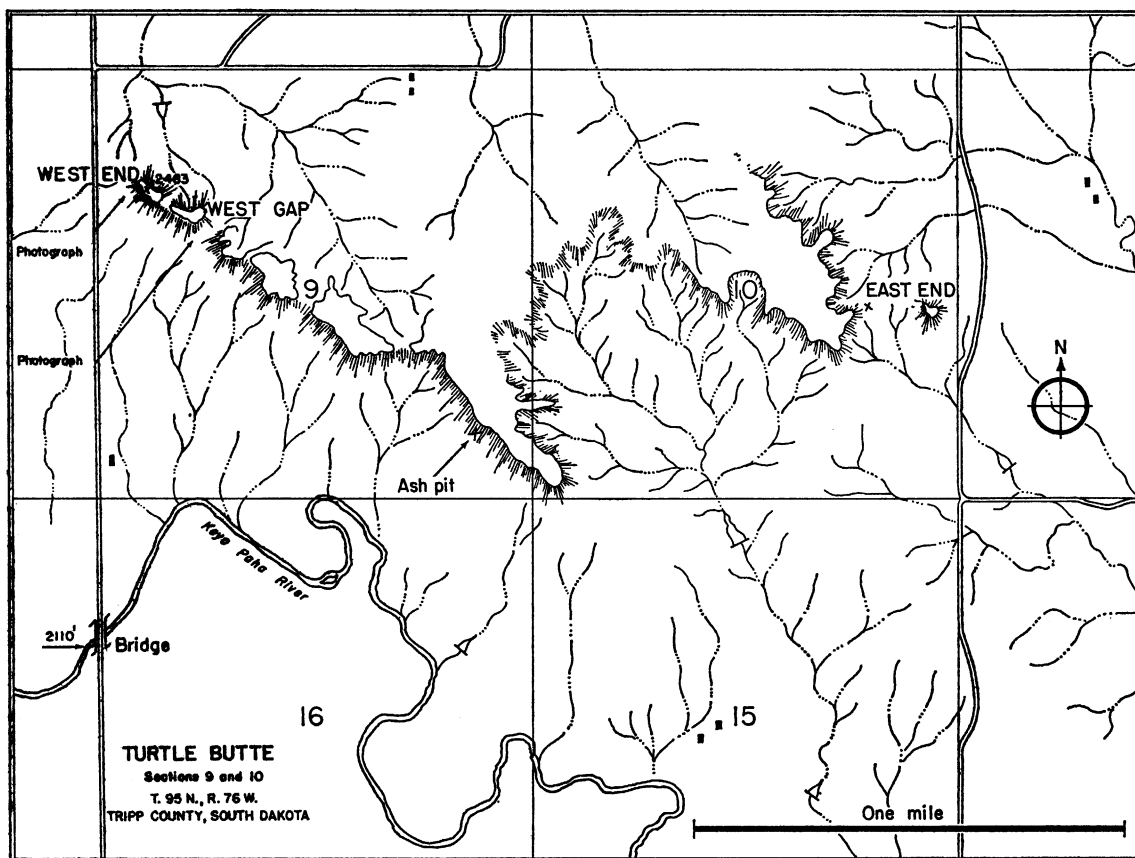


FIG. 1. Map of Turtle Butte, showing collecting localities on the west end, West Gap, and east end. Compare with plate 20.

tion, this research has been conducted with their good will and assistance.

We are deeply indebted to Dr. Malcolm C. McKenna and Dr. Richard H. Tedford who have critically read this report. Dr. Tedford has also examined most of the area covered in this report and has given generously of his time and counsel.

ABBREVIATIONS

The following abbreviations are used to designate institutional and private collections:

- A.M.N.H., the American Museum of Natural History
- A.N.S.P., Academy of Natural Sciences of Philadelphia
- C.M., Carnegie Museum, Pittsburgh, Pennsylvania
- F:A.M., Frick American Mammals, the American Museum of Natural History

- J.C.H.V.P., J. C. Harksen, Vertebrate Paleontology (private collection)
- J.R.M., J. R. Macdonald (private collection)
- S.D.G.S., South Dakota Geological Survey, Vermillion
- S.D.S.M., South Dakota School of Mines, Rapid City
- U.N.S.M., University of Nebraska State Museum, Lincoln

HISTORY OF TURTLE BUTTE

In August, 1855, Lieutenant G. K. Warren passed Turtle Butte on his way from Fort Pierre south to Fort Kearney. Warren (1856, p. 24), in his account of this trip, stated: "Turtle Hill (Keya Paha,) . . . crowned with a few scattering pine trees, now serves as a landmark toward which you proceed over rolling, grass-covered sand prairie, to Turtle Hill creek." The butte, 2

miles in length, on the north side of the Keya Paha River was well known to Sioux Indians and early settlers alike.

Two pits on top of the west end of the butte are not marks by the United States Geological Survey (fig. 2), as one might believe. These pits were dug by Sioux braves for their eagle-hunting ceremony.¹ On the southeast side of the butte is a volcanic ash deposit (figs. 1, 4) which the early settlers used for an abrasive or pumice; they often combined the volcanic ash with soap to make household scouring powder.

In more modern times the butte has been prospected for fossils, but an adequate study of the deposits and the faunas has never been made, partly because of the scarcity of fossils and partly because the deposits were not clearly understood geologically.

REGIONAL SETTING

Figure 16

Turtle Butte is north of the Keya Paha River and about 4 miles northwest of the village of Wewela in the south-central part of Tripp County, South Dakota. Broad rolling lowlands and flat-topped buttes with moderately high relief characterize the topography.

Drainage systems of the White River to the north and the Keya Paha and Niobrara rivers to the south of Turtle Butte have been incising since about middle Pleistocene time. Locally, Turtle Butte is an erosional remnant with topographic relief in the Keya Paha River valley. The most revealing outcrops are on the west end of the butte and at West Gap (local term), $\frac{1}{4}$ mile to the east (pl. 20, fig. 2; figs. 1, 3). At West Gap erosion has breached the line of the butte and exposed deposits from which the Pliocene fauna was obtained. The superposition of the formations is also easily seen at West Gap.

Three important faunal sites are present

¹ The origin of the pits was related to the senior author by Tom Cross, a Sioux Indian from the Pine Ridge Reservation. Eagle hunting among the Sioux was a sacred and manly ceremony undertaken in the fall of the year. A pit deep enough to conceal a man was hollowed out, and over this brush was spread and bait was placed. Concealed in the pit, the brave waited for an eagle to soar over the butte in search of food. When the eagle swooped down for bait the brave seized its legs and broke its neck.

on Turtle Butte (fig. 1). One is at the west end of the butte; a second, at West Gap; and a third, at the east end of the butte. Other minor sites have been found. One of these was in the Cap Rock Member of the Ash Hollow Formation, the type locality for *Ustatochoerus skinneri*. There have been no large collections from any of the faunal sites. Rather, the slow accumulation from many visits has made possible a biostratigraphic study that aids in placing the lithic deposits in their proper relationship to one another and to the other Tertiary beds in the region.

GENERAL GEOLOGY

The Tertiary history of deposition and erosion in the vicinity of Turtle Butte may be interpreted as follows:

1. An erosion surface developed on the Pierre Shale may or may not have received White River deposition, but it is certain that, by the time the Rosebud Formation was deposited, the Pierre Shale land surface beneath the butte had only remnants, if any, of the White River group on it. We have indicated this on the type section (fig. 2), on the interval from 2165 to 2210 feet, as 45 feet of deposits that may be Chadron or Brule undifferentiated. These gray-green clays were uncovered by extensive digging along the bottom of the wash to the southwest of the type section. We know of no well-exposed outcrop where these sediments could be examined and assume from Collins' (1958) description that he considered only the exposed sediments at the west end of Turtle Butte. Collins gave 88 feet as the thickness for his lower and upper units of the beds that he considered Brule. By including the sediments from 2165 to 2397 feet, some of which were exposed by digging, we measured 232 feet of pre-Pliocene sediments against Collins' 88 feet. We are unable to apply Collins' description to our stratigraphic description with any degree of assurance. Sediment samples were collected at intervals, as shown in figure 2. We do not know whether the Rosebud deposits were intervalley fills or a loess-like mantle. The regional evidence suggests that, locally, the Rosebud Formation was deposited on an undulating Pierre Shale land surface with 100 feet or more of relief.

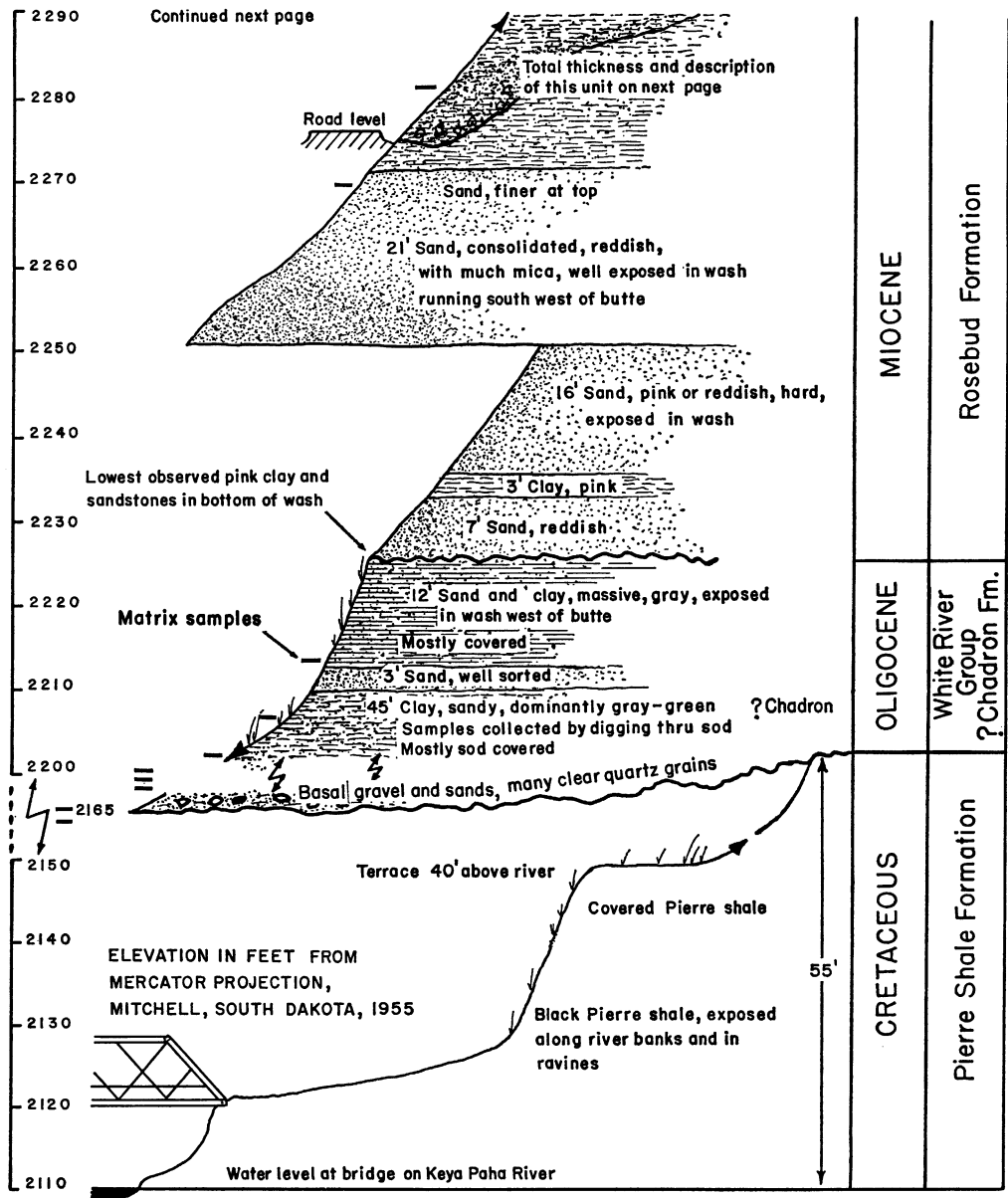


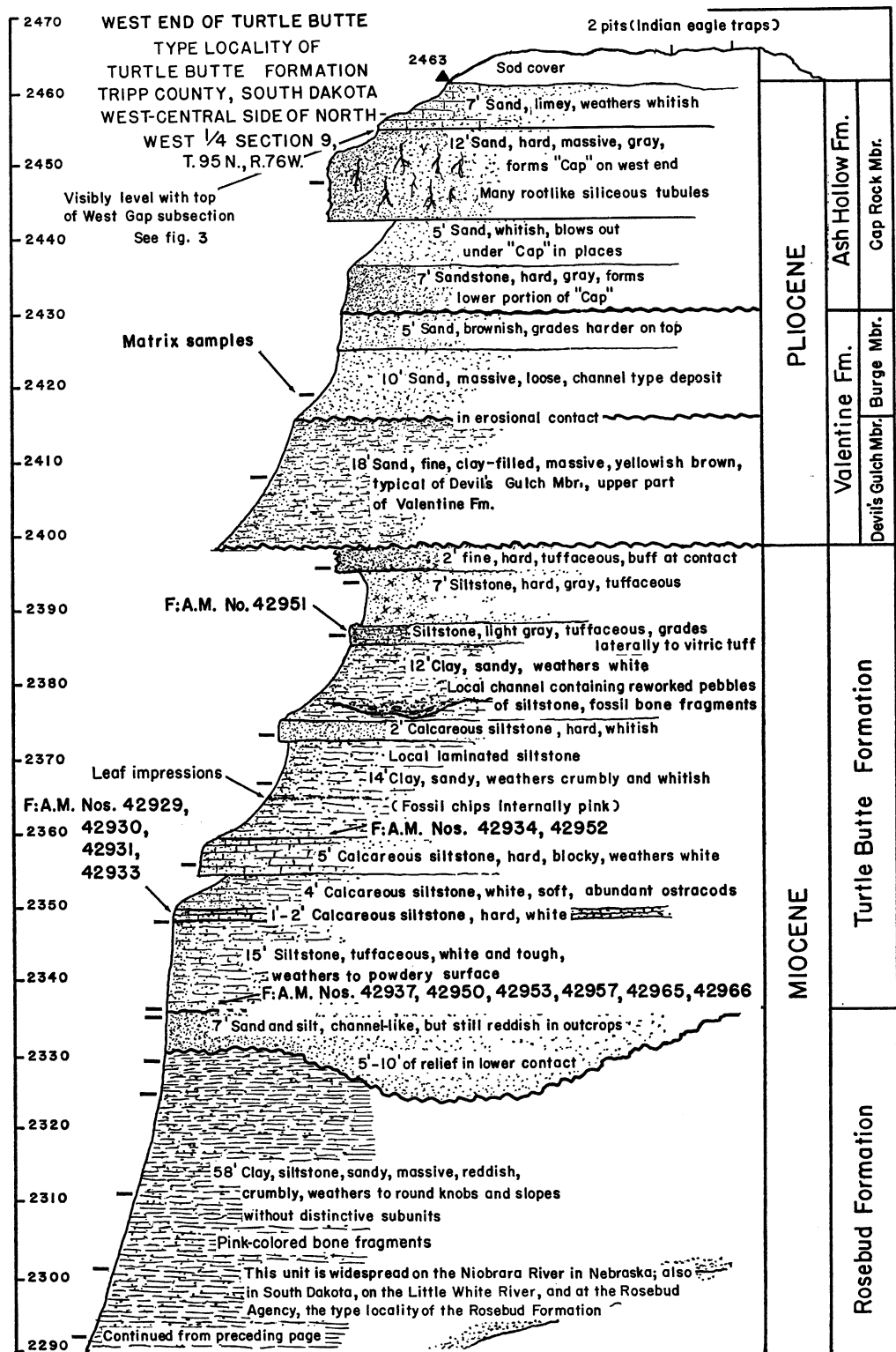
FIG. 2. (THIS PAGE AND OPPOSITE PAGE). Stratigraphic section of west end of Turtle Butte, the type locality for the Turtle Butte Formation, new name, showing superposition of beds. See plate 20, figure 1, and text figure 1.

2. Faunal studies in conjunction with radiometric dates obtained on correlative deposits elsewhere suggest that the erosional cycle (or cycles) between the Rosebud Formation and the Turtle Butte Formation was of significant time duration.

3. The contact between the Turtle Butte

and the Valentine formations (fig. 2) gives no indication of how many erosional cycles took place after Turtle Butte time. The fauna, however, shows a great change.

4. There are 33 feet of lower Ash Hollow Formation (Cap Rock Member) present on the west end of Turtle Butte (fig. 2) in a



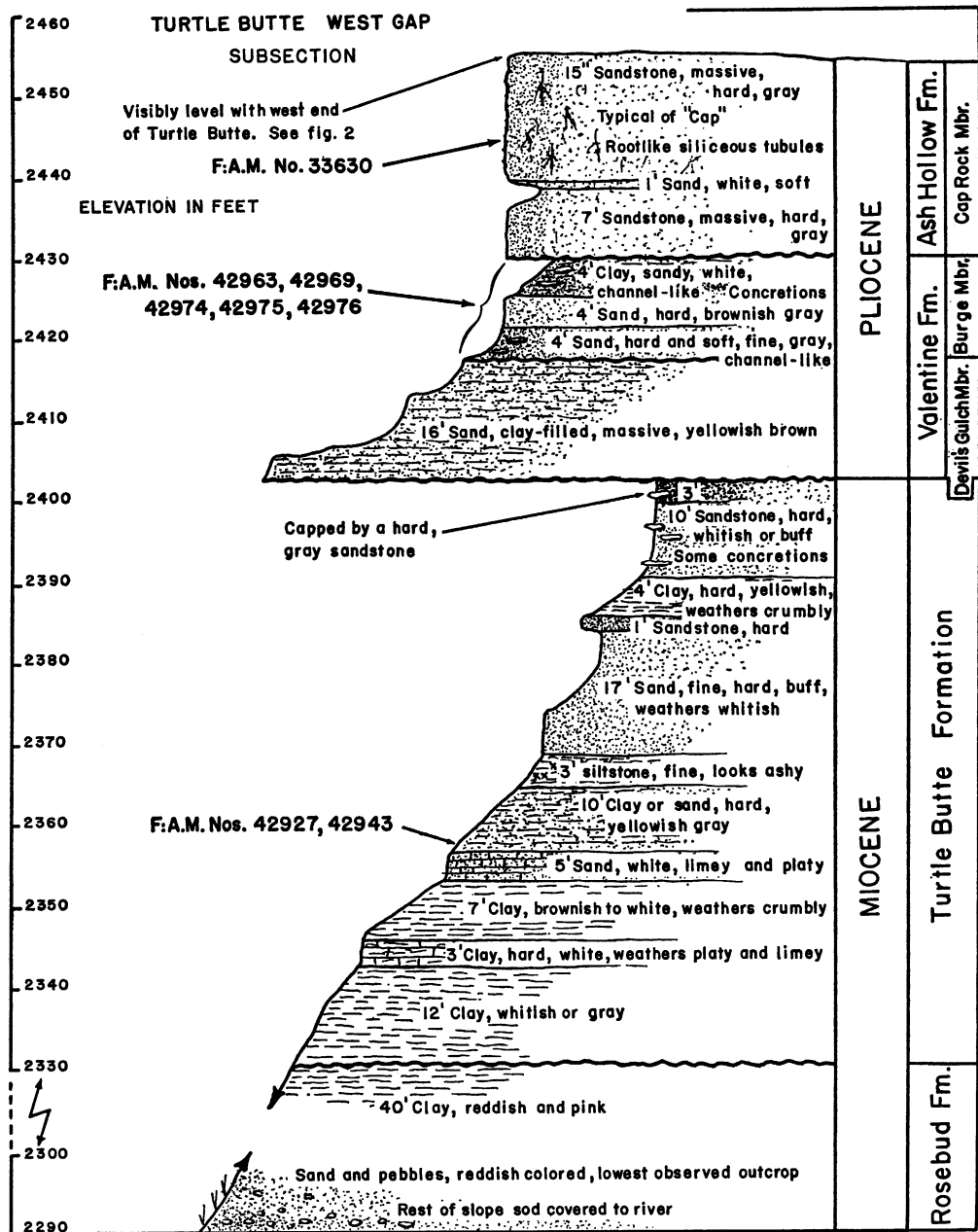


FIG. 3. Stratigraphic section at West Gap, Turtle Butte, showing superposition and faunal zones at West Gap. See plate 20, figure 2, and text figure 1.

nearly typical exposure. The configuration of Turtle Butte is controlled by this resistant unit which holds up the rim.

From most outcrops of the region the Turtle Butte Formation is absent, or it is unrecognized in them; conditions that sug-

gest a limited areal extent, similar to that of the Fort Randall Formation (Skinner and Taylor, 1967). Usually the Valentine Formation is in contact with the Rosebud Formation along the exposures in the Niobrara River valley to the south. However, in out-

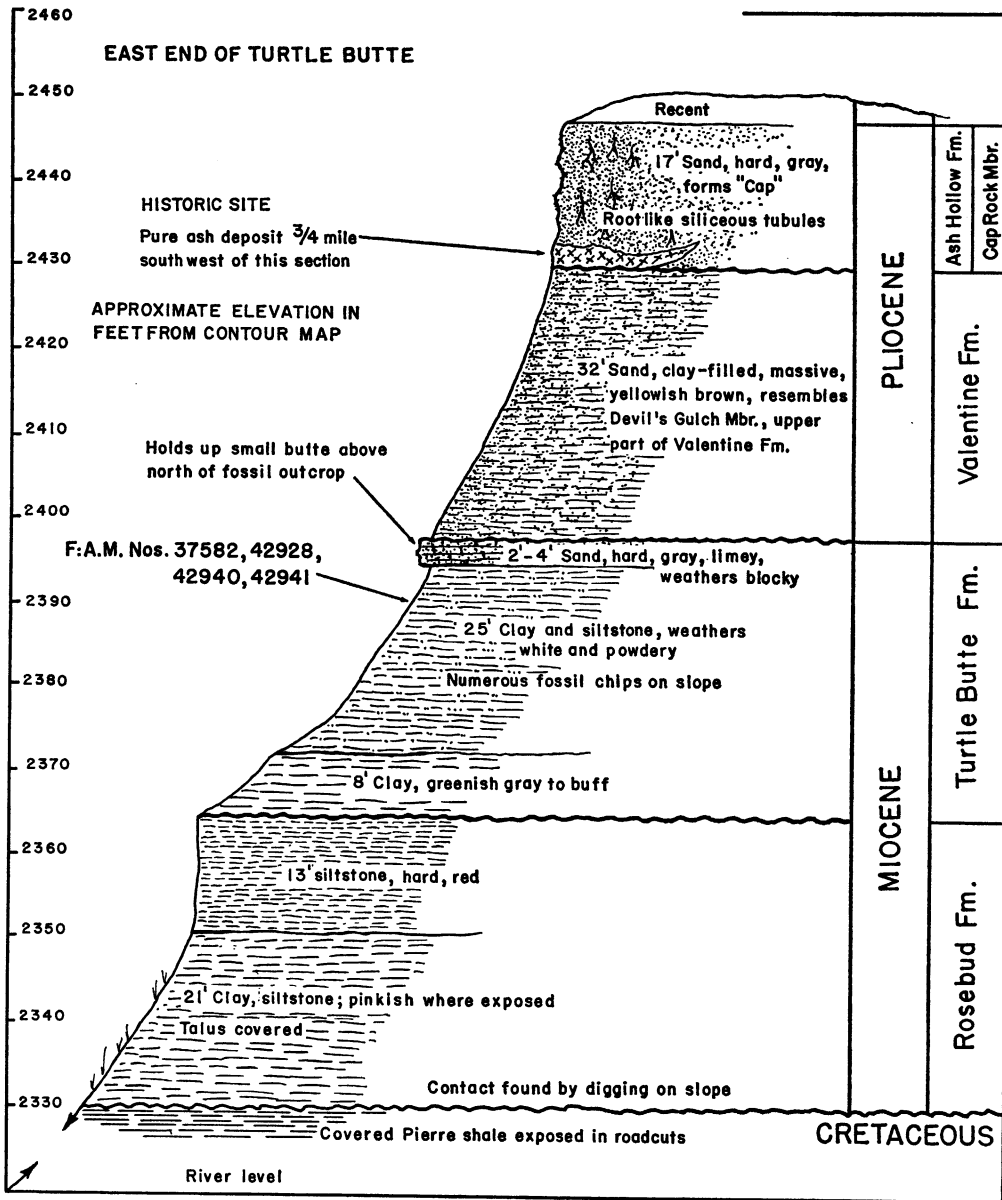


FIG. 4. Stratigraphic section of the east end of Turtle Butte.

crops about 12 miles southeast of Turtle Butte on the south side of the Keya Paha River valley at the mouth of Holt Creek, the Valentine beds are in direct contact with the Pierre Shale. At the type locality for *Trilophodon giganteus* Osborn (1921), 9 miles east and 2 miles south of Turtle Butte, the Tertiary section is thin. There, the Valentine For-

mation is in direct contact with the Pierre Shale, indicating that the Rosebud and the Turtle Butte formations were eastern, marginal, discontinuous remnants at the beginning of Valentine time.

The section at the east end of Turtle Butte (fig. 4) shows that, in 2 miles, the Rosebud-Turtle Butte section is thinned

about 100 feet, as compared with the section on the west (fig. 2). There are 103 feet of Rosebud deposits on the west end and only 34 feet on the east end. Likewise, there are 67 feet of Turtle Butte deposits on the west end and only 33 feet on the east.¹

¹ There are no contour maps of this area, and it is impractical to give accurate elevations of the contacts without an alidade survey. The elevations have been established by a hand level, with the use, as base points, of the water level of the Keya Paha River at the bridge (fig. 1) and the elevations given on United States Geo-

The superposition of the Turtle Butte Formation on the Rosebud Formation is of great value in clarifying the eastern and southern extensions of the Rosebud Formation. Much credit is due to Dr. J. R. Macdonald and Mr. J. C. Harksen for their interest in this problem and their discovery of new biostratigraphic evidence from the deposits in the Rosebud type area.

logical Survey Mercator projections of the Mitchell, South Dakota, Quadrangle, 1955 edition.

STRATIGRAPHY

TERTIARY SYSTEM

WHITE RIVER GROUP AT TURTLE BUTTE

IN THE VICINITY OF Turtle Butte, particularly at the west end, the Oligocene deposits are here referred to the White River Group, and questionably to the Chadron Formation (shown on the section, fig. 2, as transitional). In this area, the White River Group is not invariably present.

A thin deposit of White River beds may once have covered the ancient Pierre Shale land surface in the Turtle Butte area during pre-Rosebud time. About 62 feet of White River beds were exposed by numerous test pits in the southwest drainage below the referred Rosebud Formation and the type section of the Turtle Butte Formation. The lithologic characters of these sediments strongly suggest that they are referable to the Chadron Formation and not the Brule Formation. Gray to green clay and silt were encountered in most of the test pits, and toward the base we found clear quartzitic sand and gravel similar to that in other Chadron outcrops of the region, particularly to the west toward Millboro, South Dakota.

When Collins (1958) mapped the Wewela Quadrangle, including Turtle Butte, he considered the ?Chadron and the overlying Rosebud formations as two units of the Brule Formation on the grounds that Agnew (1957) had recognized the Brule and the underlying Chadron formations only 50 miles to the northwest. Collins reasoned that, "as paleontologic evidence is lacking and the lithologic characteristics of the Chadron Formation are either absent in the Wewela quadrangle or so poorly developed as to escape notice, all the Oligocene sediments are arbitrarily assigned to the Brule Formation, which is divided into two lithologic units."

Except for a pinkish buff color that the Brule and Rosebud have in common, there are few lithologic similarities. The Brule Formation is made up of fine clays and consolidated siltstones with occasional channel deposits. The texture of the Rosebud deposits is coarser, with sand of larger grain size

and some clay. It is unlikely that the Rosebud at Turtle Butte is a coarser facies of the Brule, for if it be assumed that wind direction was from the west to the east, as well as the evidence from stream deposition, the coarser material of the Rosebud should have been deposited in areas now occupied by the Brule to the west and up gradient rather than the reverse.

Collins' (1958) statement that "paleontologic evidence is lacking" at the Turtle Butte was in error, for Schultz and Falkenbach (1949, p. 131) had reported the occurrence of *Promerycochoerus* (*Pseudopromerycochoerus*) *montanus pinensis* from the deposits here called the Turtle Butte Formation.¹ Schultz and Falkenbach gave none of the stratigraphic data that were available with the Turtle Butte specimen, but, by referring it to a species of which the only known occurrence was in Monroe Creek time, the authors strongly hinted at an early Miocene age for some of the deposits on Turtle Butte.

THE ROSEBUD FORMATION AT TURTLE BUTTE

The eastern extension of the Rosebud Formation and its stratigraphic relationship to the overlying Turtle Butte Formation (new) are well shown at the west end of Turtle Butte (pl. 20, fig. 1). At this place the Rosebud sediments are 167 feet thick and present a nearly typical sequence of fine sandy silts, alternating with a few thin, horizontal, clay layers.

A local channel deposit (at 2282 feet to 2302 feet on the stratigraphic section; fig.

¹ The identification of *Promerycochoerus* (*Pseudopromerycochoerus*) *montanus pinensis* was made from a partial skull with preserved palate (F:A.M. No. 37582). A complete skull of *Megoreodon hollandi* (Douglass, 1907), and other partial skulls and dentition referable to *M. hollandi*, have been collected from the Turtle Butte Formation since 1949. These specimens have led us to change the identification of the partial skull (Schultz and Falkenbach, 1949, p. 131) from *P. (P.) montanus pinensis* to *Megoreodon hollandi*. Examples of *M. hollandi* are common in the Monroe Creek Formation.

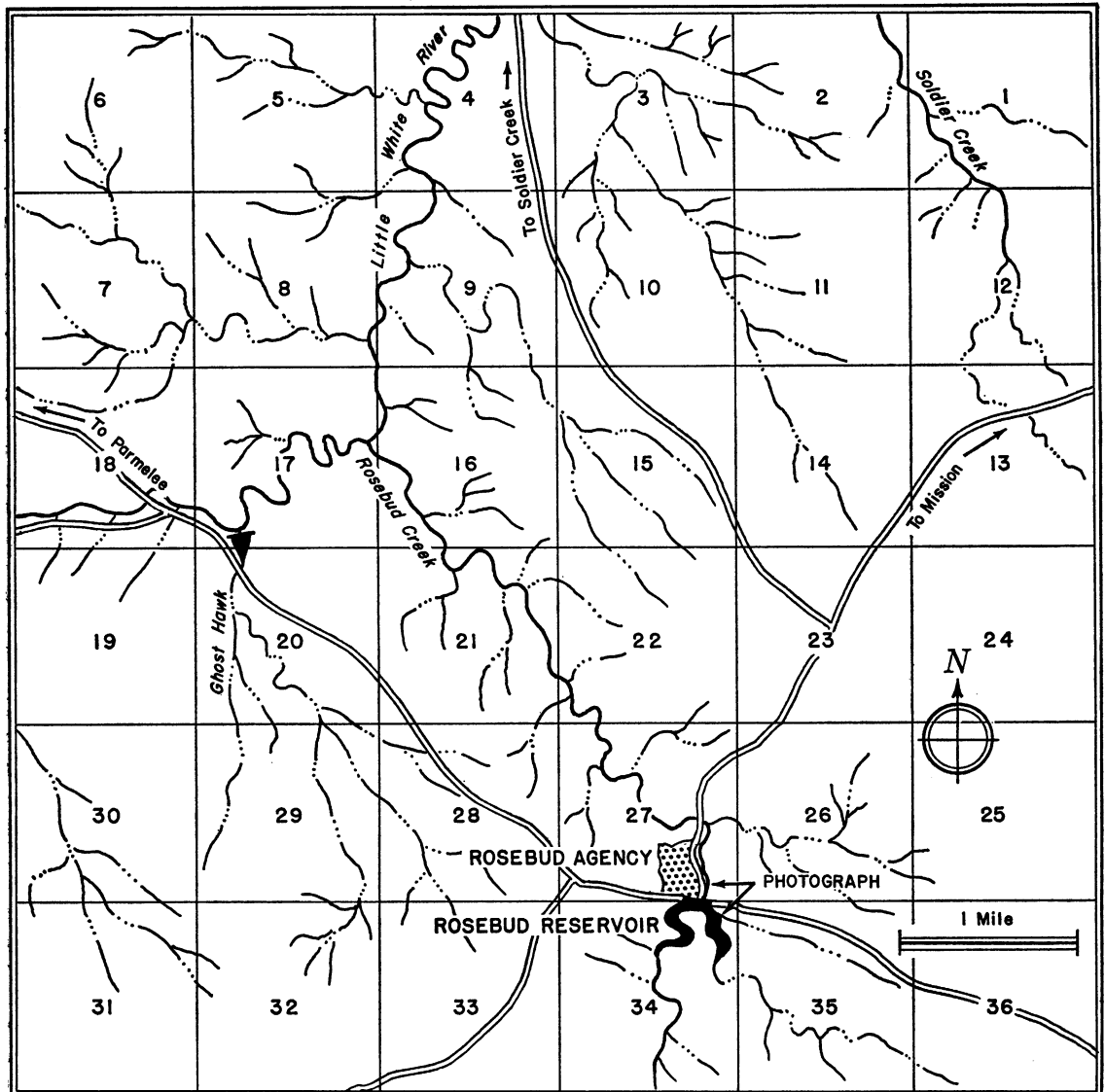


FIG. 5. Township map of Rosebud Agency and the Little White River area, showing the type locality of the Rosebud Formation southeast of the Rosebud Agency buildings on Rosebud Creek, T. 38 N., R. 30 W., Todd County, South Dakota. Drawn from United States Department of Agriculture, Agricultural Stabilization and Conservation Service, 1963, aerial photographic index sheets (nos. 2 and 5 of six sheets). See plate 21 and text figure 6.

2) is exposed on the road cut at the west end of the butte. This channel has very little sand and is composed primarily of locally derived, reworked claystone and sandstone pellets and pebbles from $\frac{1}{4}$ inch to 2 inches in diameter, and large angular claystones at least 10 inches or more in diameter. Chips of water-worn, pink fragments of fossil bone

were found but could not be identified. From the top of the channel to the contact with the overlying Turtle Butte Formation, the Rosebud deposits are the typical reddish siltstone and occasional thin beds of clay. Here the surface of the uppermost part of the Rosebud does not weather deeply and is covered with angular crumbly particles. The

local outcrop has a surface contour of hummocks and slopes that grade into a semi-vertical escarpment, unlike the characteristic vertical bluffs along stream banks, as observed at the type locality of the Rosebud Formation.

A complete set of samples was collected from the exposures at Turtle Butte for comparison with samples from the type section of the Rosebud Formation in Todd County (fig. 6). Comparisons were also made with samples from Macdonald's 1963 "Rosebud" from the Wounded Knee and Porcupine Creek areas, where the matrix is sandier and coarser, with less clay and less consolidation. (We refer these deposits to the Marsland Formation.) Minor lithic differences account in part for the distinctly different weathering characteristics of this area as compared with the Rosebud at the type locality, Turtle Butte, and along the Niobrara River.

We contend that the distinct lithology of the Turtle Butte Formation and the fauna derived from it limit the temporal range of the Rosebud Formation to a period of time similar to that of the Sharps or Gering formations in western South Dakota and western Nebraska.

During the past 60 years paleontologists and geologists have identified the Rosebud rocks of Gidley (1904) with almost every early to middle Miocene formation in south-central South Dakota as well as with the Brule Formation. These misapplications are probably due to the fact that identifiable fossil remains from the Rosebud beds were virtually unknown. We present a measured stratigraphic section and description of the type locality with as many data concerning the history of the type set of rocks as seem pertinent and useful, as well as the fauna from the type Rosebud rocks.

THE ROSEBUD FORMATION

TYPE SECTION: The Rosebud Formation is well exposed on the Little White River and on Rosebud Creek around the town of Rosebud, Todd County, South Dakota, in the type locality set by Skinner and Taylor (1967, p. 12). These exposures are in the vicinity of the Rosebud Agency buildings on both sides of Rosebud Creek in the E. $\frac{1}{2}$, sect. 34, and the W. $\frac{1}{2}$, sect. 35, T. 38 N., R. 30 W.

The vicinity of the Rosebud Agency buildings on Rosebud Creek was selected as the type locality, because this was the only spot that could be identified positively from Gidley's (1904, pp. 245-246) description. Gidley did not indicate the location of the beds that he considered to be Rosebud in the valley of the Little White River, where deposits ranging in age from Cretaceous to Pleistocene are present.

LITHOLOGIC CHARACTERS: The main body of the Rosebud sediments on Rosebud Creek around the Rosebud Agency (figs. 5, 6; pl. 21) is composed of tan to pink siltstones that show horizontal bedding planes when weathered. These siltstones are argillaceous and in many places may be considered more properly as clay. The clay bands are colored more strongly than the silts and are particularly apparent when the sediments are wet.

In the valley of the Little White River and along Rosebud Creek, the Rosebud Formation characteristically forms resistant vertical bluffs adjacent to the streams (pl. 21). Owing to the extreme uniformity of the sediments we were unable to select any distinctive lithologic units or marker beds that could be used for regional correlation. A set of matrix samples was collected at 5-foot intervals for sedimentary analysis and comparison with samples from Porcupine and Wounded Knee creeks, Turtle Butte, and exposures near Fort Niobrara.

HISTORY OF THE ROSEBUD BEDS: The deposits later described as the Rosebud beds were first prospected for fossil vertebrates by Gidley in 1902 and by Matthew and Gidley in 1903. Gidley (*in* Matthew and Gidley, 1904, pp. 245-246) recognized the distinct lithology of these beds as compared with that of the overlying Pliocene deposits (Gidley's "Loup Fork Beds") and stated: "The lower *formation* [italics ours] . . . for which we propose the local term *Rosebud Beds*, is best exposed along the Little White River and in the vicinity of the Rosebud Agency. These beds closely resemble portions of the upper Oligocene beds, both in character and general appearance, except that they contain a little more sand. . . . The Rosebud Beds are possibly equivalent to the formation of similar appearance (Gering Beds, of Darton) so abundantly exposed in

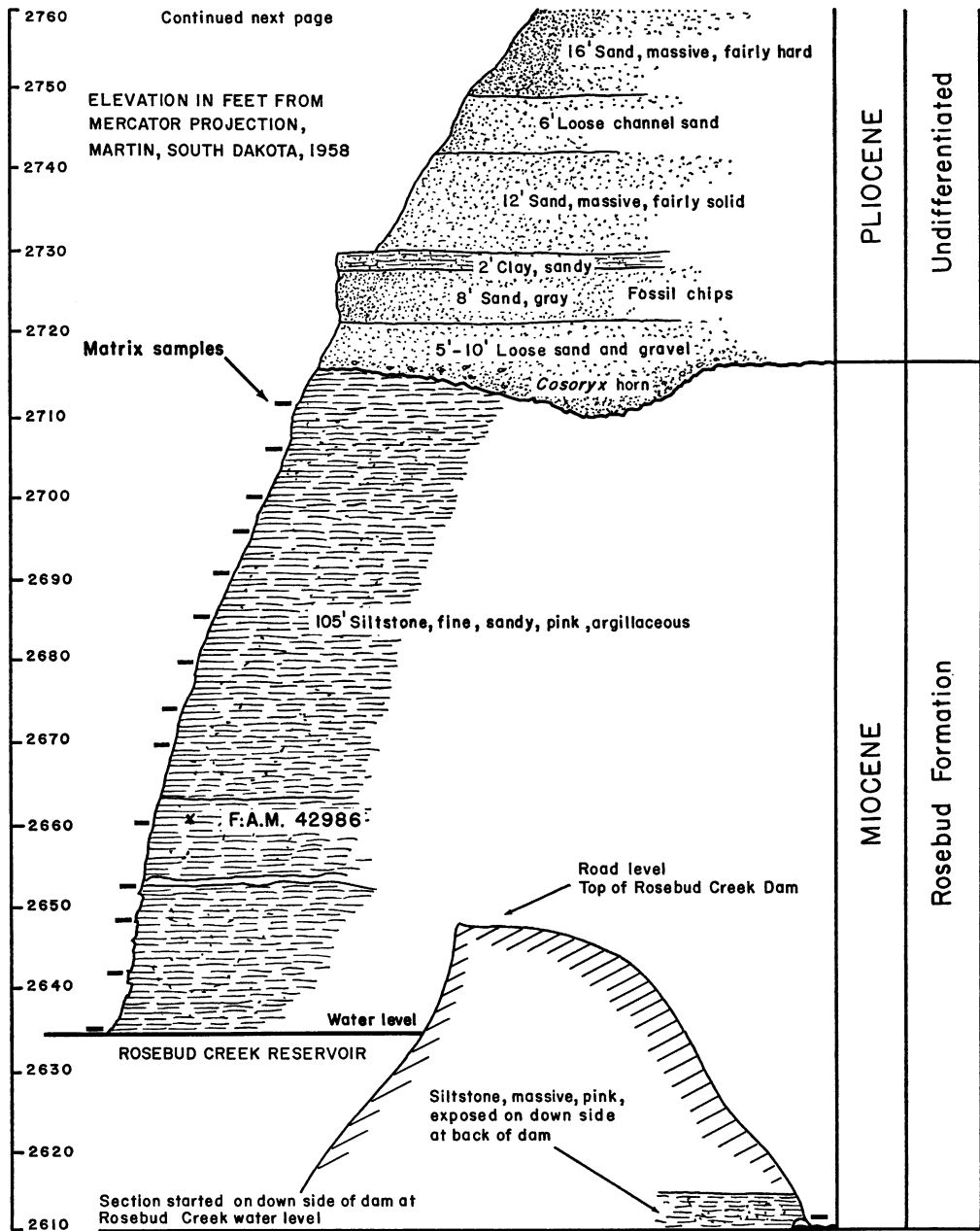


FIG. 6. (THIS PAGE AND OPPOSITE PAGE). Stratigraphic section of outcrops southeast of Rosebud Agency buildings, the type locality for the Rosebud Formation, showing also the overlying Pliocene beds. The section was measured in 1935 on the fresh road cut of the Rosebud, South Dakota, to Crookston, Nebraska, highway, no longer extant.

the northwest corner of Nebraska.” (Note Gidley’s interchange of the terms “beds” and “formations.” He specifically treated the Loup Fork beds as a set of rocks, not time [1904, pp. 241-244].)

In 1906 W. D. Matthew and Albert Thomson of the American Museum of Natural History spent an entire season prospecting for fossils in the area along the Wounded Knee and Porcupine Creek drainages some

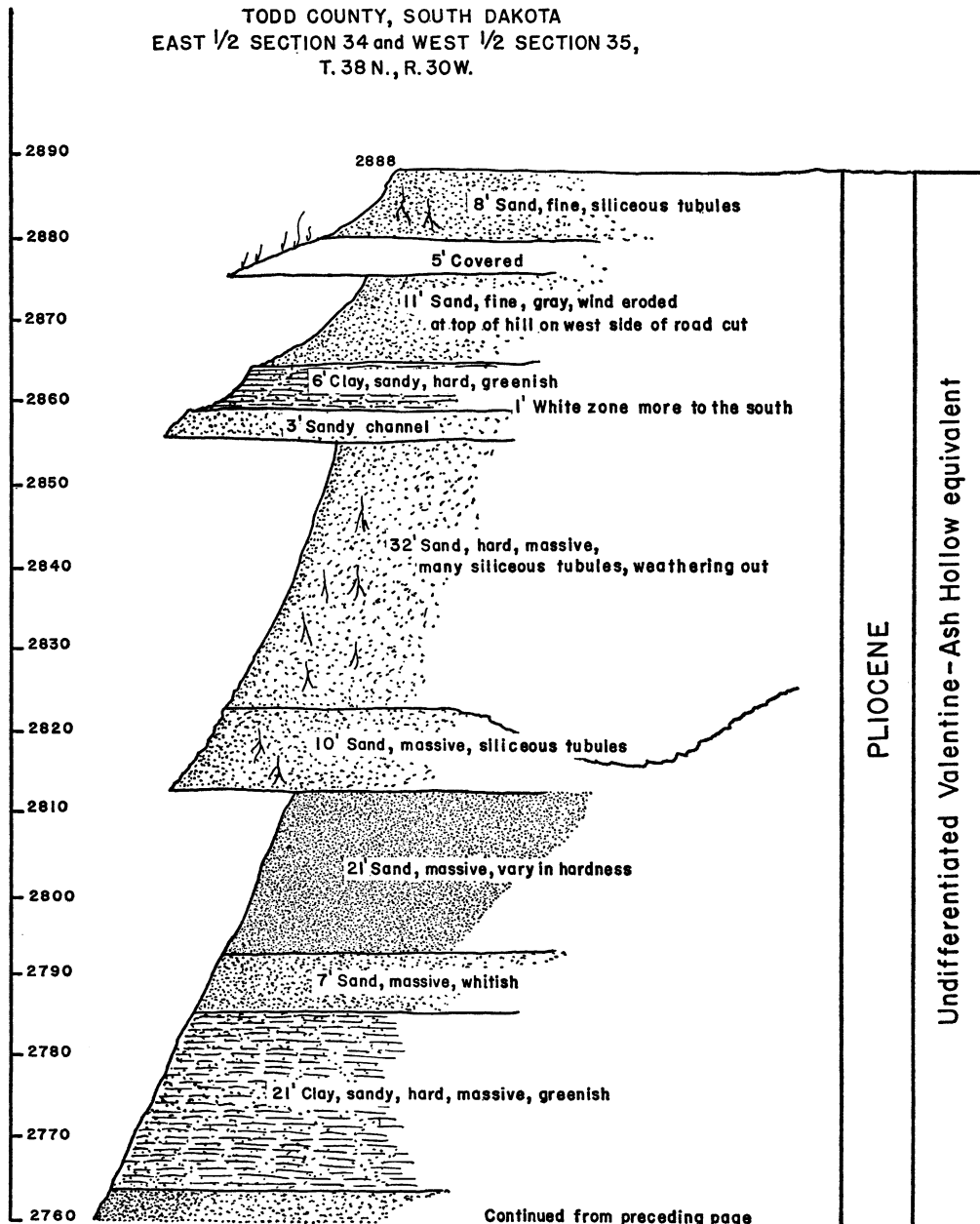
70 miles west of the Rosebud type locality.¹ The 1906 expedition resulted in a much larger Miocene collection than had been ob-

tained by Gidley and Matthew in 1902-1903 at the type area. On the basis of the 1906

¹ Macdonald (1963, pp. 144-149) gave an excellent account of the history of exploration in the Wounded Knee area and quoted pertinent data from the diary and annual report of Albert Thomson and the 1907 report of

Matthew. Macdonald's knowledge of the area and faunas in the Wounded Knee and Porcupine Creek drainages is well founded. The present writers differ from Macdonald only in his use of the name "Rosebud" for upper beds at the heads of these drainages.

SOUTHEAST OF ROSEBUD AGENCY
 TYPE LOCALITY OF ROSEBUD FORMATION
 ON ROSEBUD CREEK
 TODD COUNTY, SOUTH DAKOTA
 EAST 1/2 SECTION 34 and WEST 1/2 SECTION 35,
 T. 38 N., R. 30 W.



Continued from preceding page

fauna, Matthew (1907, pp. 169–219) and Osborn (1907, p. 238, figs. 1, 2), disregarding lithologic dissimilarities, transferred both the lithic and the biostratigraphic concept of the original Rosebud of Gidley (1904) to the more fossiliferous deposits along Porcupine and Wounded Knee creeks and adjacent areas. These deposits yielded a fauna that Matthew (1907, p. 173) found was clearly related to the John Day, and he noted further that, with adequate comparison, the 1906 expanded "Rosebud" fauna showed "... a very considerable advance upon the species of the John Day." Indeed it should, for Matthew was dealing with a faunal complex from five different post-Oligocene formations: Sharps, Monroe Creek, Harrison, Marsland, and Ash Hollow (fig. 7).

In August, 1906, Osborn visited the Wounded Knee and Porcupine Creek area with Thomson and Gregory (Thomson, MS). From his own observations and Matthew's and Thomson's notes and photographs, Osborn (1907, fig. 2) showed exactly which deposits were included in the expanded "Rosebud" and gave a graphic interpretation of the transferred Rosebud concept (see fig. 7 of the present paper). Osborn's chart was repeated in subsequent publications and is probably one of the first North American vertebrate biolithostratigraphic charts to be published for continental deposits. Basically, it is still correct except for the transfer of the rock name "Rosebud." Later and more detailed studies have added only the necessary refinements.

		Original concept and rocks	"Rosebud" transferred concept - Different rocks				This paper
		GIDLEY, 1904	MATTHEW, 1907	OSBORN, 1907	MACDONALD, 1963		
		Little White River and Rosebud Agency, TYPE AREA Todd County, S.D.	Porcupine Creek, etc., Shannon County, S. D. pages 170, 171	page 238, figs. 1, 2	Interpretation of Matthew, 1907, fig. 1	in Wounded Knee, Porcupine Creeks Area, fig. 1	
PLIOCENE	UPPER						
	MIDDLE						ASH HOLLOW ref.
	LOWER					ASH HOLLOW Fm.	
MIOCENE	UPPER	LOUPFORK BEDS					
	MIDDLE				UPPER ROSEBUD	ROSEBUD Fm.	MARSLAND Fm.
	LOWER	ROSEBUD BEDS	UPPER ROSEBUD	<i>Merycochoerus</i>	LOWER ROSEBUD	HARRISON Fm.	HARRISON Fm.
			LOWER ROSEBUD	<i>Steno fiber</i> <i>Promerycochoerus</i>		MONROE CREEK Fm.	MONROE CREEK Fm.
OLIGOCENE	UPPER		LEPTAUCHENIA BEDS	<i>Leptauchenia</i>	LEPTAUCHENIA BEDS	"LEPTAUCHENIA BEDS"	BRULE Fm. Top of Poleslide Mbr.
	MIDDLE					BRULE Fm.	
	LOWER					"OREODON BEDS"	
						CHADRON Fm.	

FIG. 7. Gidley's (1904) original concept of the Rosebud rocks and faunas compared with that of other authors who transferred the concept of the Rosebud to the area of Wounded Knee and Porcupine creeks. The far-right column shows rocks present in the same area as herein postulated.

Matthew (1907, p. 170) also erred in correlating a silicified zone at the mouth of Porcupine Creek with the "strong white layer . . . at the top of Sheep Mountain" of the Big Badlands, now known as the Rockyford Ash Member of the Sharps Formation. Following Matthew, Wanless (1923, pp. 235–236) expanded the distribution of the Rosebud beds to include deposits at Cedar Pass, Interior, Sheep Mountain, and for 6 miles northeast of Imlay. Wanless' distribution further transferred the concept of the Rosebud to beds that are now known as the Rockyford Ash Member and the Sharps Formation.

Macdonald (1958, p. 113) clearly stated the problem that arose from Matthew's use of the name "Rosebud" for faunas not derived from the type Rosebud sediments: "There would have been no difficulty over the use of this name if Matthew . . . had not transferred it to the exposures along Porcupine and Wounded Knee Creeks in the area generally to the north of Wounded Knee. Applying the name Rosebud Beds to the strata in this area, and using the names Lower and Upper Rosebud Faunas for the mammalian assemblages has resulted in a great deal of confusion." In the same paper (p. 114) Macdonald proposed that ". . . until the faunas from the Wounded Knee and Porcupine Creek drainages can be restudied, the assemblages from this area, which formed the greater part of Matthew and Gidley's Rosebud Faunas, be known as the Wounded Knee Fauna." Macdonald might have stated, "Matthew's 1907 *extension* of the Rosebud faunas," for Gidley was not a co-author in 1907.

Toohy (1959, p. 85) was of the same opinion as Macdonald (1958) and observed: "In 1907 Matthew (p. 170) extended the name 'Rosebud' to include certain deposits along Porcupine Creek in the southern part of Shannon County, South Dakota. This is not the type Rosebud as believed by some authors. . . . Until the Rosebud is considered in its proper perspective, it is inadvisable at this time to include rocks mentioned by Matthew in 1907, and by Wanless in 1923, as representative of the Rosebud."

Later, Macdonald (1963, p. 148) stated that the Rosebud Formation could be traced

from the type area where it ". . . is exposed above the Brule and below the Valentine formations . . . along most of the southern border of South Dakota . . . [to the] Porcupine Creek and Wounded Knee Creek area . . . [where] the Rosebud formation overlies the Harrison formation and is the most widely exposed lithic unit in the southern part of the area." In essence, Macdonald also transferred the name "Rosebud" from beds that we contend are Sharps faunal equivalent in the type area at the Rosebud Agency on Rosebud Creek to beds that are substantially younger, at the heads of Porcupine and Wounded Knee creeks, 70 miles to the west, and in adjacent areas. We maintain that the "Rosebud" shown on Macdonald's correlation charts (1963, pp. 150, 161) as the unit above the Harrison is not the true Rosebud, but another set of beds which are lithologically similar to the Marsland Formation. The beds at the heads of Porcupine and Wounded Knee creeks are not lithologically traceable along most of the southern border of South Dakota to the beds in the type area of the Rosebud Formation.

For about 15 miles east and south of Wounded Knee Creek and Porcupine Butte, the Little White River drainage is an area of low relief and few if any outcrops. The first identifiable outcrops begin to appear just north of the Big Spring fossil locality, south of the post office of Swett, South Dakota. Continuing eastward to southeast of the town of Martin, the Little White River carries outcrops of beds temporally similar to the Marsland and Runningwater formations, based on biostratigraphic evidence.¹

An examination of the exposed rocks 2 to 3½ miles southeast of Martin, South Dakota, is very revealing. On the north side of the Little White River there are extensive outcrops made up of Monroe Creek sediments without overlying "Rosebud." The

¹ The Flint Hill fossil site is 3 miles east and about 1¼ miles north of the Big Spring fossil site—more specifically in the SW. ¼, sect. 31, T. 37 N., R. 38 W., Bennett County, South Dakota. Equids from the Flint Hill fauna correlate best with those from the Runningwater Formation, beds that were formerly known as the Upper Marsland. The University of California has collections from both the Big Spring and the Flint Hill sites.

southeast part of this region is near the La Creek¹ area and may have been the place where Matthew and Gidley obtained a skull of *Steneofiber pansus* (A.M.N.H. No. 10818). This specimen is preserved in a manner similar to other specimens derived from Monroe Creek deposits on Eagle Nest Butte and southeast of Long Valley, South Dakota.

Downstream and east of these outcrops, near Tuthill, South Dakota, the Little White River valley is covered with a local deposit of late Pleistocene age, which has yielded the horn cores of *Symbos* or muskox and bison. Farther downstream outcrops are to be found south and east of Vetal. Here, in an area covered mostly by sandhills, the exposed beds are only along the river, but again are referable to the Monroe Creek Formation.

Three miles southwest of Harrington, South Dakota, the Monroe Creek Formation was found at river level covered by Pliocene and Recent deposits. On the Bennett-Todd County line where the river can be reached, we examined a limited outcrop of the Rosebud Formation in a barrow pit overlain by Pliocene deposits. Our observations indicate that within the 3-mile area between the last-exposed Monroe Creek and first-exposed Rosebud outcrops, the Monroe Creek overlies the Rosebud.

At no point along the course of the Little White River could we find interfingering of the referred Monroe Creek sediments with the underlying Rosebud. Furthermore, we could not find interfingering in the more extensive outcrops 12 to 15 miles to the north in southern Washabaugh County. Here, as along the Little White River, the Rosebud rocks are overlain by referred Monroe Creek sediments. But, overlying the Monroe Creek, there are also referred Harrison and Pliocene

deposits, each separated from the preceding by an erosional unconformity. No outcrop known to us shows the Rosebud rocks interfingering with the Monroe Creek and Harrison formations in such a way that they are both underlain by Gidley's 1904 Rosebud and overlain by Macdonald's 1963 "Rosebud." We consider Macdonald's 1963 "Rosebud" different lithically, temporally, and faunally from Gidley's Rosebud.

Harksen (1967), in his geology of the Porcupine Butte Quadrangle, stated: "Matthew (1907) reported on the geology south of the White River in the Wounded Knee area. To the sequence of strata found there, Matthew applied the names 'Upper Rosebud' and 'Lower Rosebud.' These names are an incorrect lithologic extension of the Rosebud Beds of Gidley (1904). The name Rosebud was first applied to beds along the Little White River some 60 miles east of the Porcupine Butte Quadrangle." In the same paper, under the heading "Rosebud Formation," Harksen (1967) stated: "Matthew's 'Upper Rosebud' included the lower part of the Harrison Formation, the entire Monroe Creek Formation, and the upper part of the Sharps Formation." Harksen then referred the beds that "conformably overlie the Harrison Formation and are unconformably overlain by the Ash Hollow Formation" to the Rosebud Formation of Gidley (1904).

A detailed examination of the beds that overlie Harksen's "Harrison Formation" in the area of Wounded Knee Creek shows similarities in texture, structure, and weathering characteristics that strongly recall the Marsland Formation of Nebraska. In Nebraska the Marsland Formation is extensively exposed about 15 miles south of Porcupine Butte. Harksen's description of these beds could very well be a description of the Marsland Formation (Upper Harrison of Peterson, 1906), but not the Rosebud of Gidley.

Until recently there has been no fauna from the Rosebud of Gidley. The discovery, by Macdonald and Harksen, of three identifiable oreodont skulls (two referable to *Desmatochoerus*, the other to *Leptauchenia*) along the Little White River from the Rosebud Formation, and our own discovery of a skull of *Desmatochoerus* in the type section of the Rosebud Formation (fig. 6, at 2661 feet)

¹ At the time Matthew and Gidley prospected the Little White River, a county seat for Bennett County had not been established. There was considerable controversy over the site for the county seat, and one faction partially built a courthouse southeast of the present town of Martin (the present county seat) and used the name "La Creek." The site was abandoned, but it is probably the "La Creek" mentioned in Matthew's field lists. Matthew made no mention of Martin. There is now a La Creek Migratory Waterfowl Refuge named for the stream La Creek. Local residents of Martin related the details of the controversy over the county seat, but no attempt has been made to verify the story from documented records.

place the Rosebud rocks of Gidley in a biostratigraphic unit equal to the Sharps and Gering, which are definitely pre-Monroe Creek and pre-Harrison in time.

GEOGRAPHIC EXTENT AND ELEVATIONS: The Rosebud beds are well exposed in the type locality, on the Little White River, and for some miles eastward in the vicinity of Mission, South Dakota. They are equally well exposed in the Niobrara River valley near Valentine, Nebraska, and for 40 miles eastward downstream. From Valentine to Meadville, Nebraska, the Rosebud beds are exposed intermittently and reflect the ancient undulating land surface on which the overlying Turtle Butte and Valentine formations were deposited. About 5 miles west of Meadville, the base of the Rosebud is exposed in unconformable contact with the underlying Pierre Shale, and again the contact is irregular. The thickness of the Rosebud beds often changes greatly within a short distance because of the irregularity of the upper and lower contacts.

In addition to the type section (figs. 5 and 6), we have measured a stratigraphic section on the Little White River extending from the Rosebud-Parmelee road where it crosses the Little White River to near the top of the deposits on the west side of the Little White River valley. We established elevations for these sediments from the water level of the river as shown on the Martin, South Dakota, map (United States Geological Survey, 1958). Rosebud sediments on the west side of the Little White River range in elevation from 2420 feet at the Lambert Bridge to 2665 feet and more at the top of the hill, thus indicating 245 feet in one outcrop along the Rosebud-Parmelee road.

The eroded top of the Rosebud Formation shown on the type section on Rosebud Creek (fig. 6) 6 miles east has an elevation of 2710 feet which suggests that the Rosebud sediments are at least 300 feet thick and may be as much as 370 feet.

What is apparently the base of the Rosebud beds may be observed down the Little White River in the vicinity of the Soldier Creek Community, 6 miles north of the Rosebud type section, where the top of the Brule deposits and the base of the Rosebud appear at an elevation of approximately

2350 feet. Outcrops in the valley of the Little White River, 1 to 2 miles below the Soldier Creek Community, show that the Rosebud sediments rest unconformably on the Brule with no intervening sediments of Harrison or Monroe Creek type such as were postulated by Macdonald (1963) and Harksen (1967) in the area of the Porcupine and Wounded Knee creeks (fig. 8). The Sharps Formation also holds the same stratigraphic position relative to the Brule Formation in its type area.

The top of the pink silts at Porcupine Butte (equated with the Rosebud by Macdonald, 1963, fig. 1, and by Harksen, 1967) is at an elevation of 3665 feet. South of the post office of Wounded Knee, Macdonald's (1963, p. 162) locality S.D.S.M. V544, the pink silts, is at about 3500 feet in elevation. The top of the Rosebud Formation at the type locality southeast of the Agency buildings on Rosebud Creek is at 2710 feet. Our stratigraphic data of the type section (fig. 6) show at least 100 feet of pink sandy silts exposed southeast of the Agency buildings in the valley of the Rosebud Creek. The difference in elevation between the "Rosebud" at Porcupine Butte and the Rosebud in the type locality is about 950 feet.¹ The beds that Macdonald (1963, p. 150, fig. 1) and Harksen (1967, map) considered to be Rosebud above their "Harrison Formation" in the Wounded Knee area we believe are equivalent to the Marsland (Upper Harrison of Peterson, 1906) Formation. The type Rosebud rocks are biostratigraphically equivalent to the Sharps Formation.

FAUNA: Two partial oreodont skulls were collected in 1965 by Macdonald and Harksen from the Rosebud beds along the Little White River at an approximate elevation of 2450 to 2470 feet. These specimens are referable to the Desmatochoerinae. One, an immature skull (J.R.M. No. 1490), is hardly separable from specimens that we collected from the Sharps Formation on Porcupine Creek and at Quiver Hill in Washabaugh County, South Dakota.

In 1966 Harksen sent us a skull of *Leptauro-*

¹ J. R. Macdonald (personal communication) states: "These present-day differences in elevation are not relevant to the problem as they surely are not correlative to the elevations at time of deposition."

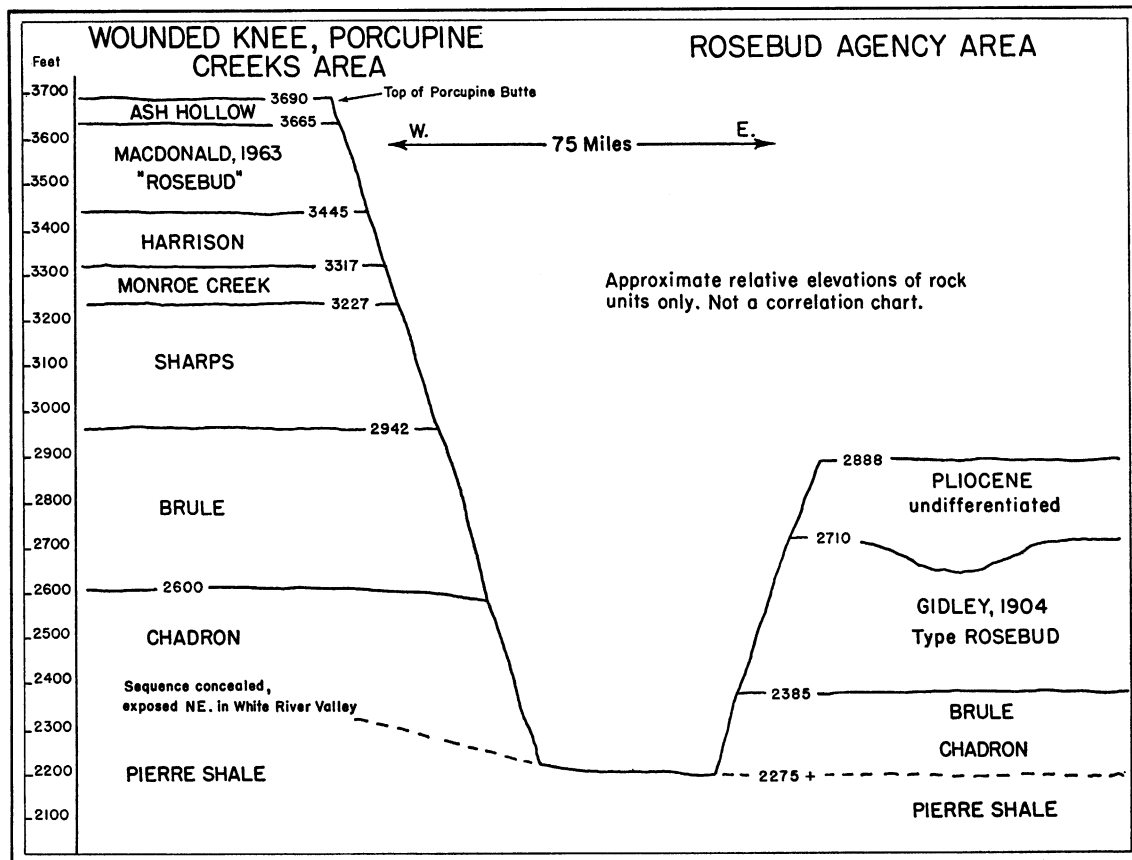


FIG. 8. Diagrammatic elevational relationship of rock units present in the Rosebud Agency area compared with the rock units in the Wounded Knee and Porcupine Creek area. The elevations are approximate, because no detailed contour maps are available.

chenia cf. *major* that he had collected from the Rosebud deposits along the Little White River at an elevation of about 2400 feet. Harksen also supplied some isolated, large oreodont teeth that are comparable to those of *Megoreodon hollandi*. These isolated teeth were collected from a geographic locality that would place the site higher in elevation than that of the *Leptauchenia* and *Desmatochoerus* specimens. (Harksen, personal communication.)

We collected a partial oreodont skull from the type section of the Rosebud Formation, 26 feet above the water level of the Rosebud Reservoir at an elevation of 2661 feet (fig. 6). This specimen (F:A.M. No. 42986, fig. 14) is readily comparable to specimens referable to *Desmatochoerus* (*Paradesmatochoerus*) *wyomingensis* or *sanfordi* from the Sharps Formation.

CONCLUSION: The transfer of the concept of the Rosebud Formation to a different area and a different set of rocks from those of the type area is an accomplished fact as far as published maps and paleontological records go. Unfortunately, the true Rosebud beds have proved to be extremely barren of fossils—a criterion for biostratigraphic correlations. This, however, is not the lithologic criterion. The Rosebud beds are characteristically buff to reddish buff sands and silts (as noted by Gidley, 1904, p. 246), unrelated except by color to those referred to the "Rosebud Formation" on Porcupine Creek. The wide and uncritical use of the term "Rosebud" has resulted in its application to various deposits temporally equivalent to the Sharps, Monroe Creek, Harrison, and Marsland formations. The extended use of the name "Rosebud" even includes faunas

temporally equivalent to part of the Running-water Formation of Cook, 1965.¹ Thus a long period of time is represented by the rocks and faunas of various authors that have been included erroneously under the term "Rosebud."

We hope that this analysis of past concepts of the Rosebud Formation will place the deposits in their proper temporal and geographic relationships. Modern means of travel from one place to another has led to a better understanding of this set of interesting Tertiary deposits and their extremely complex relationships.

The faunal list Gidley presented for these deposits (see below, p. 411) cannot be allocated positively to definite lithologic units and can be assigned only to general geographic localities. All that can be stated definitely is that the beds yielding the specimens were older than those Gidley considered the "Loup Fork Beds."

TURTLE BUTTE FORMATION, NEW NAME

TYPE SECTION: We use a new name, "Turtle Butte Formation," for a rock unit composed of sandy siltstone and claystones of early Miocene age that unconformably overlies the Rosebud Formation (also early Miocene) and is overlain unconformably by Pliocene rocks in the type locality. The type locality (figs. 1, 2; pl. 20) is at the west end of Turtle Butte (from which the name was derived) and is in the NW. ¼, sect. 9, T. 95 N., R. 76 W., 4 miles northwest of the village of Wewela, Tripp County, South Dakota. The Turtle Butte Formation is biostratigraphically similar to the Monroe Creek and Harrison formations in western Nebraska and southwest South Dakota but is distinctly different lithologically and cannot be associated with these formations or the underlying buff to pink-colored Rosebud Formation.

LITHOLOGIC CHARACTERS: The dominantly gray to white tuffaceous clastic sediments making up the Turtle Butte Formation are primarily siltstone and calcareous siltstone,

¹ Field labels with specimens called *Merychys* (possibly part of Gidley's faunal list, 1904, p. 246) state: "No. 1. *Merychys* skull forelegs, etc. Little White River, 3 miles below Big Springs Canyon, S. D. Lower Loup Fork. W.D.M. 6/28/'03." This locality would be very near the Flint Hill fossil site. The fauna from here correlates well with the Runningwater fauna.

		GIDLEY, 1904	This paper
		Little White River and Rosebud Agency, Todd County, S. D.	TURTLE BUTTE AREA Tripp County, S. D.
PLIOCENE	UPPER		
	MIDDLE		Lower part of ASH HOLLOW Fm. Cap Rock Mbr.
	LOWER		Upper part of VALENTINE Fm. Burge Mbr. Devil's Gulch Mbr.
MIOCENE	UPPER	LOUP FORK BEDS	
	MIDDLE		
	LOWER	ROSEBUD BEDS	TURTLE BUTTE Fm. ROSEBUD Fm.
OLIGOCENE	UPPER		WHITE RIVER GROUP
	MIDDLE		?
	LOWER		?
			CRETACEOUS

FIG. 9. Gidley's (1904) temporal concept of rocks along the Little White River and near the Rosebud Agency compared with the present authors' concept of rock units present at Turtle Butte, Tripp County, South Dakota.

with locally abundant ostracods and some charophyte spores. In the type section a local thin channel with rounded siltstone and clay pebbles is present, and near the top is a 7-foot layer of sandstone with a high volcanic ash content, indicating volcanism during part of Turtle Butte time. The weathering characteristics and over-all finer texture of the Turtle Butte Formation bear no resemblance to deposits of the Monroe Creek or the Harrison formations, although the three formations have biostratigraphic affinities.² The Monroe Creek and Harrison for-

² Monroe Creek and Harrison deposits seem to be eolian in part, similar to the recent Sandhills of central Nebraska. There may have been ponds and lakes with occasional stream and surface drainage—a typical aggrading land surface. This condition must have existed for a long time, with at least one cycle of degradation. The Monroe Creek-Harrison contact has considerable relief at the head of the White River near the former post office of Andrews, Nebraska, and near the type locality of the Runningwater Formation in western Nebraska.

mations contain much more sand of coarser grain size and show more extensive compaction and secondary cementation (hard sandstone ledges, pipey concretions, and nodular zones) than the Turtle Butte Formation.

Recognition of the Turtle Butte Formation brings into sharper focus the lithologic and faunal relationships of the eastern extension of early Miocene deposits of northern Nebraska and south-central South Dakota (fig. 9). The Turtle Butte Formation overlies the lithologic equivalent of the Rosebud Formation, the type locality of which is less than 50 miles to the west. The unconformity between these two formations represents the time accounted for (at least in part) by the Gering¹ and part of the Monroe Creek Formation. At Turtle Butte, the unconformity between the Turtle Butte and the Valentine formations represents the time required to account for the deposition of part of the Harrison, Marsland, Runningwater, Box Butte, Sheep Creek, Lower Snake Creek, and most of the Crookston Bridge Member of the Valentine Formation.

Collins (1958) included the beds which are here named the Turtle Butte Formation in his "lower Valentine," describing in detail the lower 25 feet with the two limey zones (this paper, fig. 2, at 2336 feet to 2360 feet). Collins stated, "The lower part shows considerable variation, containing local interbedded lentils of clay, limestone, and siliceous arkosic sandstone." In fact, Collins' "lower Valentine" bears no resemblance to the loose unconsolidated sands of the lower Valentine of north-central Nebraska, and there are none of the "tuffaceous clays and silts . . . and limey tuffaceous silt" that Collins observed, but these are present in the Turtle Butte Formation. From this zone and site that Collins described as lower Valentine, we have collected the early Miocene Wewela fauna.

¹ The Gering of Darton (1899) was deposited in northwestern Nebraska after an erosion cycle that followed the deposition of the Sharps Formation. This erosion cycle degraded the area south of a fault system that occurred post-Rockyford Ash (lowest member of the Sharps), known as the White Clay Fault. This fault can be traced on the surface from north of Gordon, Nebraska, to the vicinity of Oelrichs, South Dakota. No true Gering sediments have been observed in South Dakota, previous reports notwithstanding.

Because Collins considered the Turtle Butte Formation as lower Valentine, he erroneously reported the presence of large quantities of volcanic ash in the Valentine Formation (Collins, 1958, subheading "Economic Geology"). So far we have never observed volcanic ash in the Valentine Formation. The only Pliocene ash at Turtle Butte is the ash pit in the Cap Rock Member of the Ash Hollow Formation (fig. 1), which Collins also mentioned.

THE WEWELA FAUNA: The vertebrate fauna from the Turtle Butte Formation is here designated the Wewela fauna after the town of Wewela, 4 miles southeast of Turtle Butte. The Wewela fauna (table 1) is characterized by a predominance of *Megoreodon hollandi* (at least 15 specimens). One uncrushed skull, comparable with the type of *M. hollandi* (table 2), was found in the type section of the Turtle Butte Formation in association with *Archaeohippus equinanus*. (*Megoreodon hollandi* is also found at the base of the Monroe Creek Formation at the mouth of the canyon on the east side of Porcupine Creek. The Monroe Creek Formation overlies the Sharps Formation at this place.) Other taxa in the fauna are *Enhydrocyon crassidens*, ?*Leptocyon*, *Archaeotherium trippensis*, new species, ?"*Protomeryx*" *leonardi*, and cf. *Merychyus siouxensis*. An unknown carnivore was represented by a metacarpal; and another, by median phalanges. An extraordinarily large radius marked the occurrence of a form of rhinoceros which cannot be further identified.

The Wewela fauna is most nearly duplicated by a fauna from the Tunnel Hill locality at the Ledingham ranch in Sioux County, Nebraska. That fauna is derived from deposits of uppermost Monroe Creek or lowermost Harrison or both.

PRELIMINARY REVIEW OF THE VALENTINE FORMATION²

The middle and upper parts of the Valentine Formation and the lower part of the Ash Hollow Formation are present on Turtle

² "Valentine Formation" is a term proposed in 1919 for a sequence of Ordovician rocks in southern Pennsylvania. However, the name "Valentine" has priority (1917) for Tertiary rocks in north-central Nebraska. No confusion is likely, however, because of the span of geo-

Butte, and a small number of fossil mammals was collected from these deposits. Because stable nomenclature for a part of these two formations is lacking and future paleontological reports are planned, a review of the Valentine and a definition for the lower member of the Ash Hollow are introduced here.

From the early 1900's well into the 1930's the use of names for the late Tertiary deposits in north-central Nebraska was admittedly disjointed. Most authors were about equally divided between the names "Fort Niobrara" of Osborn (1909), "Devil's Gulch Beds" of Barbour (1913), and "Valentine Beds" of Barbour and Cook (1917). By the 1930's the Valentine problem, with its many names, had become a vexing one.

As proposed by Barbour and Cook (1917, p. 173), the term "Valentine Beds" constituted a valid name for a set of geologic deposits. Barbour and Cook compared the Valentine Beds with related deposits and supplied a faunal list. In 1936 Johnson (p. 467) reviewed the Valentine problem and established a type locality for the Valentine beds as a site "... on the south side of a drainage cut between the old and new railroad grades ... in the NE $\frac{1}{4}$ sec. 17, T. 33 N., R. 27 W., Cherry County, Nebraska. It is the site of a vertebrate-fossil quarry which was discovered by Mr. J. B. Burnett in 1915." Johnson (1936, p. 467) tentatively considered the Valentine beds as a member of the Ogallala Formation.

In 1938 Lugn (p. 225) stated that the deposits recognized as the Valentine beds were to be treated as the Valentine Formation, a decision made in March, 1936, at a conference of members of the Nebraska and Kansas state geological surveys. In raising the Valentine to formation status, Lugn described its components as the "*Stipidium* fossil seed zone; Burge channel member and the 'Burge' fauna at the top; the *true* Valentine fauna occurs well down in the formation." Lugn did not include the Devil's Gulch beds of 1913 on the grounds that they

logic time and the geographic distance that separate the two formations. The firm establishment of the term "Valentine Formation" in the literature and the fact that it has priority for early Pliocene deposits in north-central Nebraska are, we believe, sufficient justification for the maintaining of this term for these deposits.

were equivalent to the Valentine and had only slightly prior and not yet widespread usage.

The type locality that Johnson set was ideal, for at that place the three members of the Valentine Formation, the Crookston Bridge Member (new name), the Devil's Gulch Member (new usage for an old name), and the Burge Member, are in superposition, and are overlain unconformably by the Cap Rock Member (new usage for an old name) of the Ash Hollow Formation.

The unconformity at the top of the Valentine Formation is believed to represent a fairly long hiatus which may be represented by distinctly different Pliocene sediments along the southern border of South Dakota, such as the deposits on Wolf Creek and at Big Spring. A part of these deposits appear to be slightly earlier than the Cap Rock Member of the Ash Hollow Formation and later than the Valentine Formation of Nebraska and are derived from a different drainage area to the northwest.

The controversy over the use of terms for the Valentine Formation extended to the faunas as well, particularly to the fauna from the lowermost unit. Johnson (1936 and 1938), Colbert (1938), and Lugn (1938) proposed that the name "Valentine" be retained for the lowermost deposits and contained fauna of the Valentine Formation and contended that the term "Niobrara River" as applied to the fauna from the lowermost part of the Valentine was confusing and contrary to the rules of well-established usage.

On the other hand, McGrew and Meade (1938) followed Stirton and McGrew (1935) and applied the term "Niobrara River fauna" to the fauna from the lowermost Valentine, "Burge" to the intermediate fauna, and "Valentine fauna" to the fauna from the base of the Ash Hollow Formation (Cap Rock Member, new usage in this paper).

For the most part, the faunas from the lower part of the Valentine Formation and from the Burge Member of the Valentine were in the collections of the University of Nebraska State Museum and the Frick Laboratory. Except for the deer (Frick, 1937), these collections have been virtually unstudied and therefore have been universally misunderstood. Faunas from the

three members of the Valentine Formation (Crookston Bridge Member, Devil's Gulch Member, and Burge Member, this paper) are unlike the late Miocene faunas from the Barstow syncline of California, those of the Lower Snake Creek deposits of Sioux County, Nebraska, and those from the Clarendon localities of Donley County, Texas. The Clarendon faunas correlate easily with Ash Hollow faunas from north-central Nebraska and south-central South Dakota.

Faunal evidence provided by the stratigraphically controlled Frick Collection supports the recognition of a geologic time term "Valentinian," as illustrated in a chart by Schultz and Stout (1961, fig. 3). Obviously such a time term cannot be applied until an accurate stratigraphic range of life forms is included within a study of the rock sequence. This will be supplied as soon as possible.

CROOKSTON BRIDGE MEMBER OF THE
VALENTINE FORMATION, NEW NAME

Plate 22

The lower part of the Valentine Formation (Crookston Bridge Member) is not present at Turtle Butte, but a review of the Valentine is not complete without it. Local faunas, particularly those composed of lower vertebrates, and flora have been reported on from several different quarries in the lower part of the Valentine Formation.

TYPE LOCALITY AND SECTION: "Crookston Bridge Member" is a new name for the lower 150 to 175 feet of unconsolidated sand of the Valentine Formation. The type locality is at the Crookston Bridge Quarry, $\frac{1}{8}$ mile below the confluence of the Snake and Niobrara rivers, in the SW. $\frac{1}{4}$, NW. $\frac{1}{4}$, sect. 1, T. 32 N., R. 30 W., northern Cherry County, Nebraska (fig. 16). Johnson (1936, fig. 2) published a section of the Crookston Bridge Quarry which is here considered the type section for the Crookston Bridge Member.

The photograph (pl. 22) of the type locality was taken in 1954, 19 years after the Crookston Bridge Quarry was opened by the Frick Laboratory for the University of Nebraska State Museum field party. All indications of quarrying have been obliterated by slumpage, but an arrow on the photograph marks the quarry site.

LITHOLOGIC CHARACTERS: The Crookston Bridge Member is composed of massive, unconsolidated channel sand, with numerous local lenses of greenish sandy clay, some of which is diatomaceous. The sand is clear, quartzitic, highly permeable, and brownish to gray in color. Fossils from the Crookston Bridge Member are usually reddish chocolate brown and vary in degree of hardness. Orthoquartzite is formed in this member at numerous horizons and various geographic localities and usually occurs in large, irregular, or rounded masses within the sand. These silicified masses are in some areas extensive enough to hold up small buttes, particularly in South Dakota, which have been called "Bijou Quartzite" (Skinner and Taylor, 1967, p. 5).

STRATIGRAPHIC RELATIONSHIPS: The base of the Valentine Formation and the underlying unidentified beds on which the Valentine rests at the Crookston Bridge type locality may also be observed in rather poorly exposed outcrops about $\frac{1}{2}$ mile down the Niobrara River. The overlying deposits, the Devil's Gulch and Burge members, the Cap Rock Member of the Ash Hollow Formation, and one of the middle Ash Hollow channel deposits, are well exposed about $\frac{1}{4}$ mile south of the type locality of the Crookston Bridge Member in the SW. $\frac{1}{4}$, sect. 1, T. 32 N., R. 30 W., Cherry County, Nebraska. These exposures are in the first side canyon above the mouth of the Snake River, on the east side. The superposition of the three members of the Valentine Formation may also be observed at this place.

There is no abrupt lithologic change between the Crookston Bridge Member and the Devil's Gulch Member, but, wherever a stratigraphic section of any thickness is exposed, there is a definite change in sediment type from the loose sands of the Crookston Bridge to the finer, slightly more consolidated, yellowish, clay-filled sand of the Devil's Gulch Member.

The fauna from the Crookston Bridge Member has been referred to as the "Niobrara River fauna" (Teilhard and Stirton, 1934, p. 278), the "Valentine fauna" (Johnson, 1936, p. 471), and "Crookston Bridge L.F." (Schultz and Stout, 1961, fig. 3). Five

localities in north-central Nebraska are known in literature that carry a lower Valentine fauna or flora: the Valentine Railroad Quarry, the University of California Fort Niobrara Game Preserve locality No. V-3218, Crookston Bridge Quarry, Norden Bridge Quarry, and the Kilgore flora locality. The Frick Laboratory has collections of fossil vertebrates from four of these (not the Kilgore locality) and others that are as yet unrecorded.

VALENTINE RAILROAD QUARRY (FIG. 16): Barbour and Cook (1917) described *Aelurodon platyrhinus* from the Valentine Railroad Quarry, and Johnson (1936, fig. 2) published a section of the site. Collections were made by the University of Nebraska in 1930 and 1931 and by the Frick Laboratory in 1935. These collections are held under the original name, "Valentine Railroad Quarry." In the University of California collections, this site is known as "V-337" after Stirton and McGrew (1935). Estes and Tihen (1964) reported on lower vertebrates which they believed came from the Valentine Railroad Quarry, but on the chance that their material might not have originated from the identical site, they referred to it as "Locality V-337 ND." Wood (1935, pp. 118-145) established a new genus and species of heteromyid rodent, *Cupidinimus nebraskensis*, from the "lowest Pliocene Valentine beds of Nebraska." The holotype (C.M. No. 10193) and referred specimens were collected from exposures less than $\frac{1}{4}$ mile west of the Valentine Railroad Quarry.

UNIVERSITY OF CALIFORNIA LOCALITY No. V-3218: This is the Fort Niobrara locality of Stirton and McGrew (1935) who reported briefly on the mammalian specimens. Estes and Tihen (1964) described fish and amphibians from this locality.

THE CROOKSTON BRIDGE QUARRY: Large collections of fossil mammals were made by the University of Nebraska and the Frick Laboratory, and these are housed in the Nebraska State Museum and in the Frick Collection of the American Museum of Natural History. Frick (1937, pp. 362, 464) described *Meryceros warreni johnsoni* from this quarry.

NORDEN BRIDGE QUARRY: This quarry

was discovered in 1929 by the Frick Laboratory and was visited periodically, thereafter, by the senior author. The importance of the Norden Bridge Quarry lies in the relatively large number of herpetological specimens in the fauna. A large tortoise from this site was presented to Claude W. Hibbard who reported it (1960) as *Geochelone orthopygia*. Smith (1962, pp. 506-508) recorded the occurrence of fossil bowfin, gar, channel catfish, and redear sunfish, which were recovered from the matrix within the shell of the tortoise.

In a review of New World fossil hylids, Tihen (1962, p. 23) briefly mentioned the occurrence of a fragmentary ilium which he tentatively referred to his new species *Bufo suspectus*. In 1962 and 1963, Tihen and his associates made collections from the Norden Bridge Quarry in the hope of gaining more abundant, and perhaps new, material of the lower vertebrates. Six more reports on the Norden Bridge collections have added to the faunal components of the Crookston Bridge Member of the Valentine Formation.

Tihen and Chantell (1963) described two new species of salamander, *Cryptobranchius mcalli* and *Ambystoma minshalli*. Chantell (1964) reviewed the herpetofaunal material and named a new species of fossil hylid, *Pseudacris nordensis*. Estes and Tihen (1964) published a comprehensive summary of the fish, amphibian, and reptile faunas, and Holman (1964) reviewed the snake fauna, which he considered the earliest known that is essentially modern. Colubrid vertebrae were the basis of Holman's new genus and species *Paleoheterodon tiheni*, a new species of *Elaphe*, *E. nebraskensis*, and one of *Lampropeltis*, *L. similis*. Meszoely (1966) discussed the fossil cryptobranchid salamanders. Klingener (1966, pp. 3-9) recorded the occurrence of a new genus and species of dipodoid rodent, *Magasminthus tiheni*, and a fragmentary specimen tentatively referred to *Plesiosminthus* sp.

THE KILGORE LOCALITY: In 1962 MacGinitie published a detailed report on the Kilgore flora from a locality 22 miles west of the town of Valentine, Nebraska. MacGinitie's report included the geology of the lower Valentine

deposits as well as the flora and vertebrate fauna.

DEVIL'S GULCH MEMBER OF THE VALENTINE
FORMATION, NEW USAGE FOR
AN OLD NAME

Plates 23, 24

The Devil's Gulch Member of the Valentine Formation is present at Turtle Butte and is frequently encountered throughout south-central South Dakota as well. Where the Devil's Gulch Member is in direct superposition on the Turtle Butte Formation, as it is on Turtle Butte, the characteristic yellowish color and mud-cracked surface make it readily distinguishable from the gray, tuffaceous, powdery-weathering Turtle Butte Formation. No fauna was found in the Devil's Gulch Member at Turtle Butte.

TYPE LOCALITY: The Devil's Gulch Member of the Valentine Formation is a new usage for an old name. The type locality is in Devil's Gulch of Dutch Creek in the SE. $\frac{1}{4}$ of sect. 28, T. 32 N., R. 21 W., Brown County, Nebraska (fig. 16). The type fauna of the Devil's Gulch Member was derived from the south side of Devil's Gulch canyon, from Devil's Gulch Horse Quarry (pl. 23) which was developed in 1933 by the Frick Laboratory.

LITHOLOGIC CHARACTERS AND RELATIONSHIPS: The Devil's Gulch Member is composed of yellowish, fine-grained, clay-filled, massive sand that is much finer than that of the Burge and Crookston Bridge members. In places (i.e., the type locality), it is sufficiently consolidated to hold up a low, vertical escarpment. Siliceous and limy tubules are present in places but seldom developed into nodules. The surface often cracks and peels upon weathering because of the high clay content in the sand. The clay, which rises to the surface by capillary action, in many places masks the true texture of the deposits, which is revealed by removal of the thin clay cover. The Devil's Gulch Member ranges in thickness from 30 feet to 60 feet.

The transition between the underlying Crookston Bridge and Devil's Gulch Members is gradational. The Crookston Bridge Member is well exposed in the bottom of Devil's Gulch, where it directly underlies the Devil's Gulch Member and rests unconform-

ably upon the (correlated) Rosebud Formation. The contact of the Devil's Gulch Member with the Burge, or, if the Burge is absent, with the Cap Rock Member of the Ash Hollow, is not at any place gradational. Instead, this contact is sharply defined by an unconformity and a textural change from the yellowish clay-filled sand to the loose channel sands of the Burge, where it is present. Where the Devil's Gulch Member is in unconformable contact with the Cap Rock Member, there is a sharp demarcation between the yellow, clay-filled sand and the coarser, gray sand of the Cap Rock.

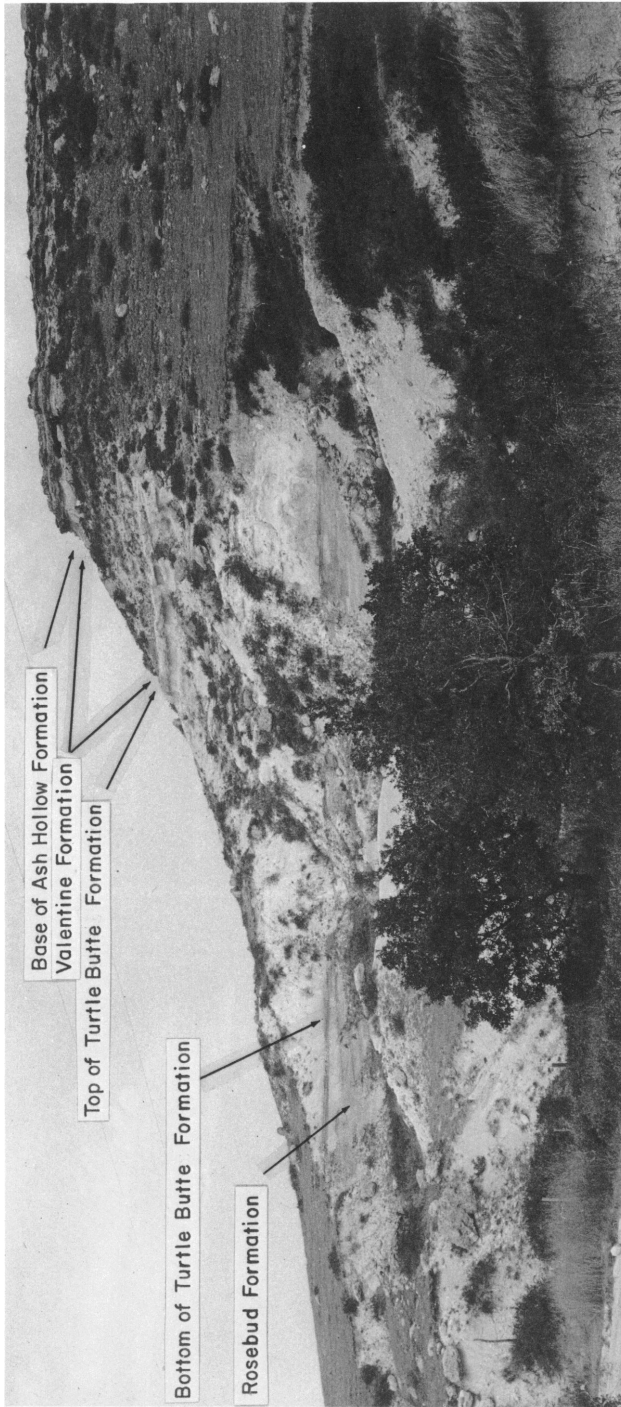
HISTORY AND FAUNA: The fauna from the Devil's Gulch Horse Quarry is not to be confused with the collection made by the University of Nebraska in 1913, from the north side of the Gulch (pl. 24). Barbour (1913) reported on this mammalian assemblage, which was derived mostly from the Burge Member. On the north side of the Gulch the Burge Member is best developed in outcrops, figured by Barbour (1913, pl. 1), where a sloping outcrop of Burge sand lies above a vertical escarpment of the Devil's Gulch Member.

The fauna from the Devil's Gulch Member is usually found in isolated prospects. The 1933 Devil's Gulch Horse Quarry (pl. 23), rich in mammalian remains, is one of the rare stream-channel deposits in this part of the Valentine Formation. This channel grades out laterally to about 15 feet below the Burge channel on the north and south sides of the Gulch.

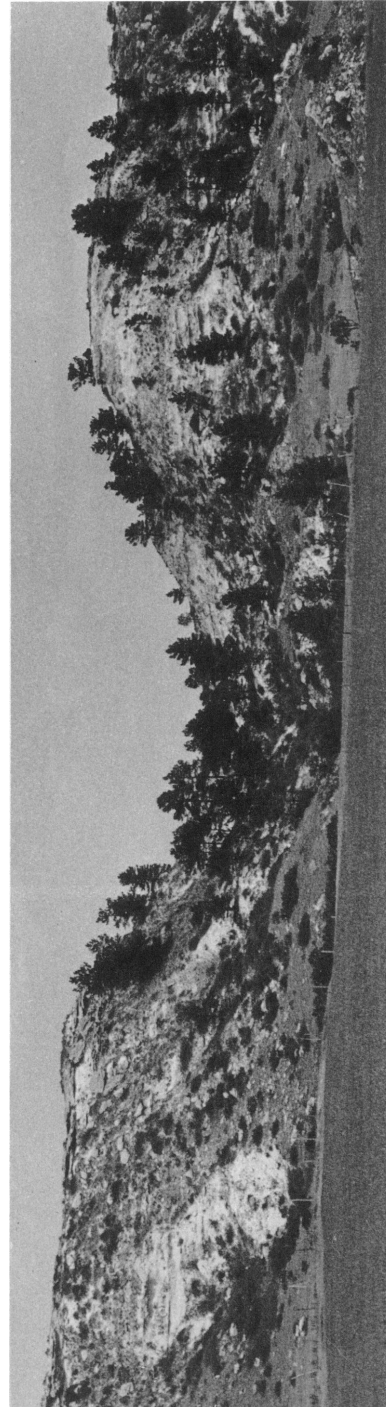
The major part of the fauna known to us from the Devil's Gulch Member is in the Frick Collection and includes *Mylagaulus* and other rodents, *Leptarctus*, *Aelurodon*, *Ischyrocyon*, *Tomarctus*, *Plionictis*, *Prosthennops*, *Trilophodon*, *Teleoceras*, *Hypohippus*, *Mega-hippus*, *Pseudhipparion*, *Calippus*, *Protohippus*, *Pliohippus*, *Hipparion*, *Ustatochoerus*,¹ *Procamelus*, *Protolabis*, *Homocamelus*, *Aepy-*

¹ Schultz and Falkenbach (1941, p. 23) assigned a group of six associated specimens of *Ustatochoerus medius* from the 1931 Devil's Gulch Quarry to the "lower Valentine deposits of Devil's Gulch." Field data (1931) for these specimens were specific: "From Devil's Gulch Quarry, Brown Co., Nebraska, 'horizon' upper Valentine beds. Note, this quarry is part of the same channel as the 1933 Devil's Gulch Horse Quarry." (See pl. 24.)

PLATES 20-25



1

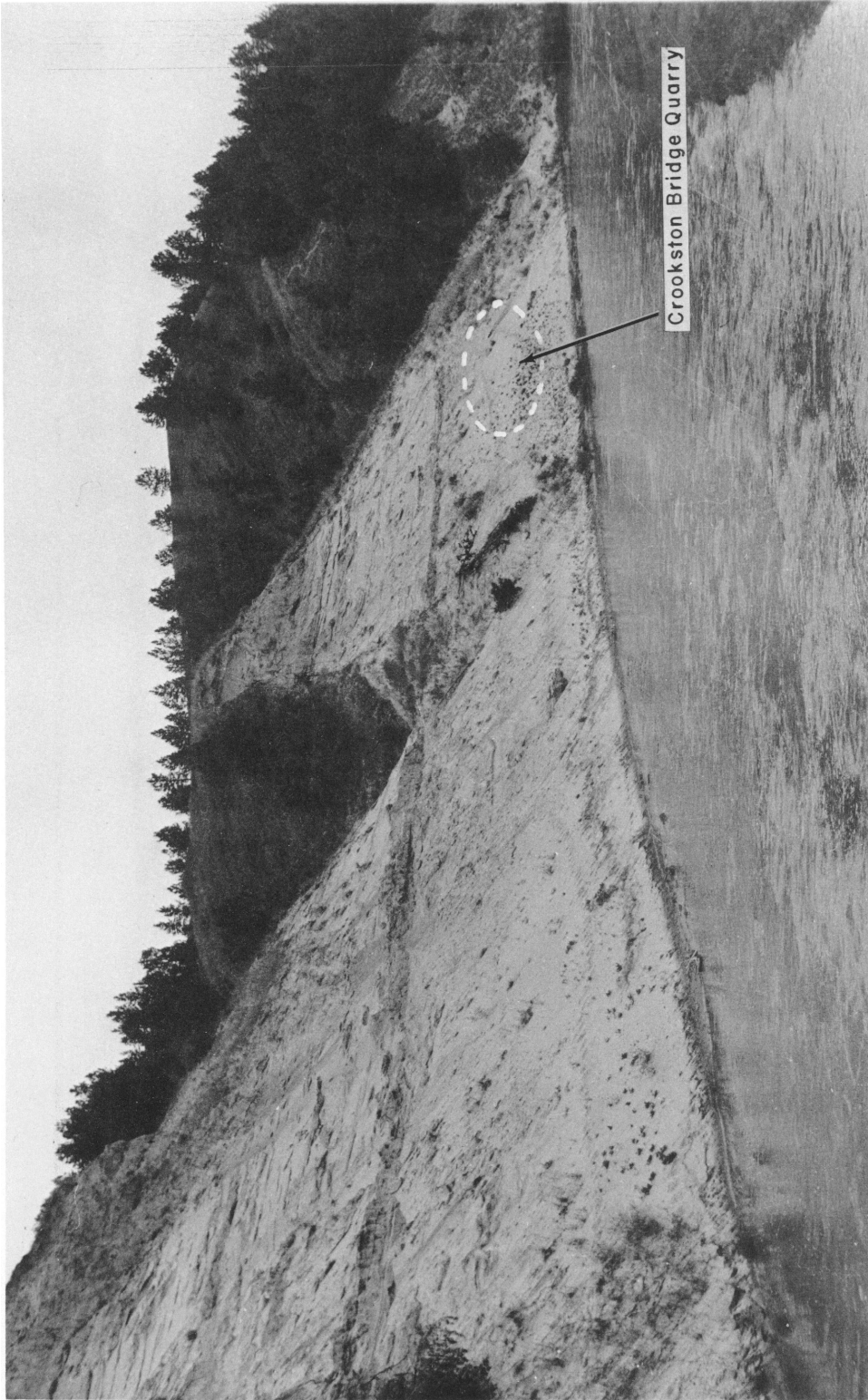


2

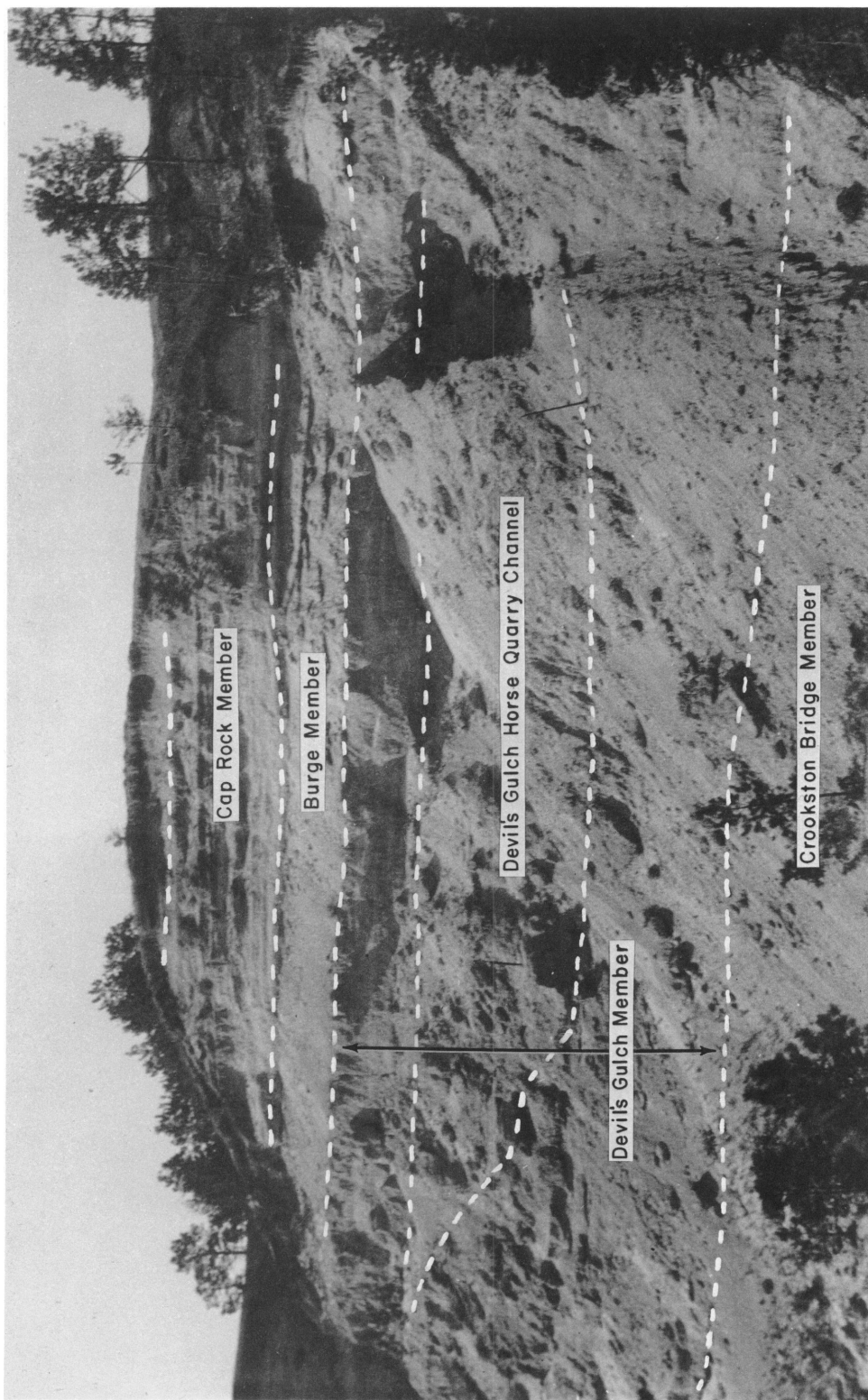
1. West end of Turtle Butte, looking northeast, showing superposition of beds in relation to type exposures of Turtle Butte Formation. 2. West Gap on west end of Turtle Butte, looking northeast. See also text figures 1-3



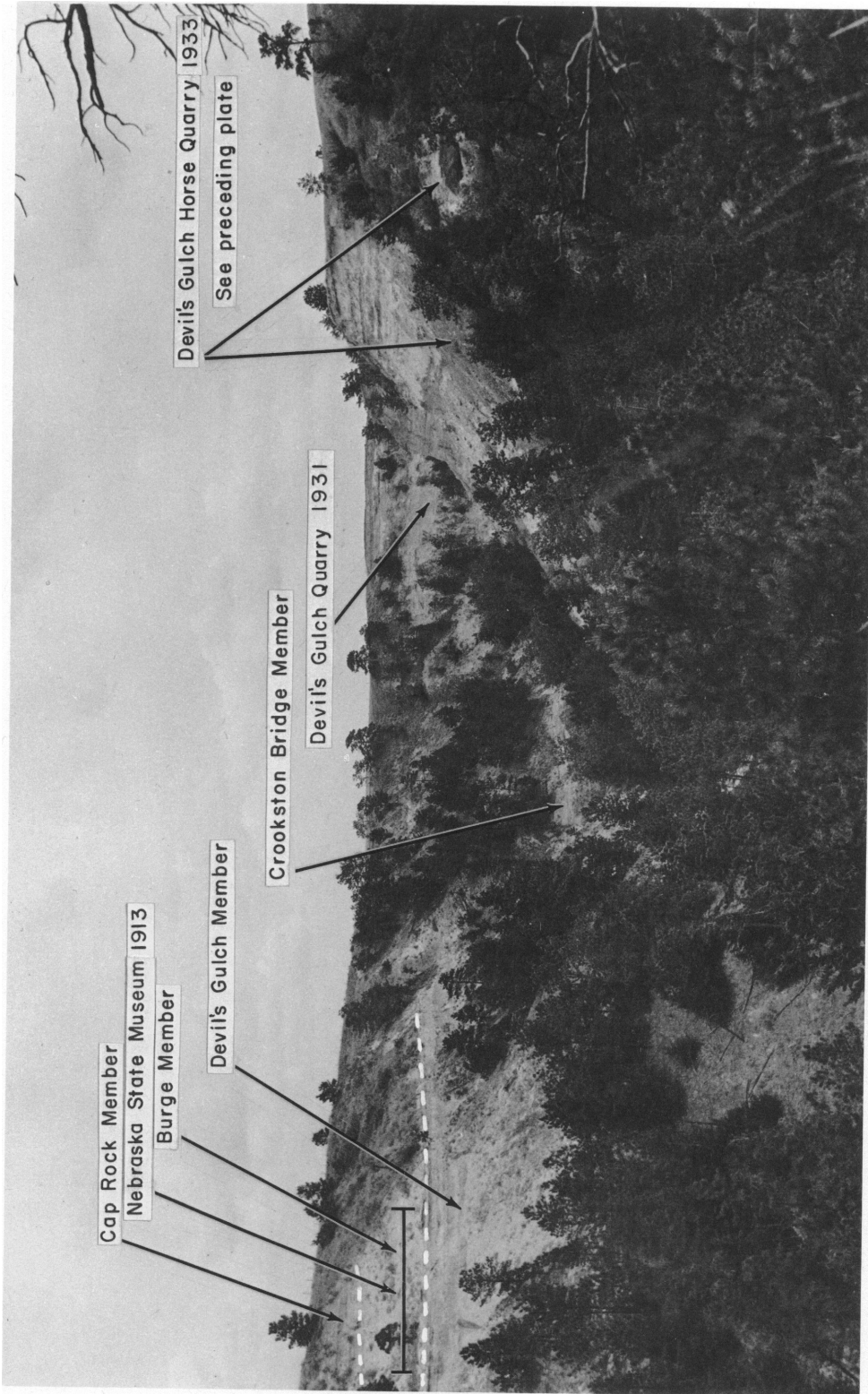
Outcrops at the type locality of the Rosebud Formation on Rosebud Creek, looking westward from the east side of the Rosebud Reservoir. The Rosebud Agency building is on the right. See text figures 5 and 6



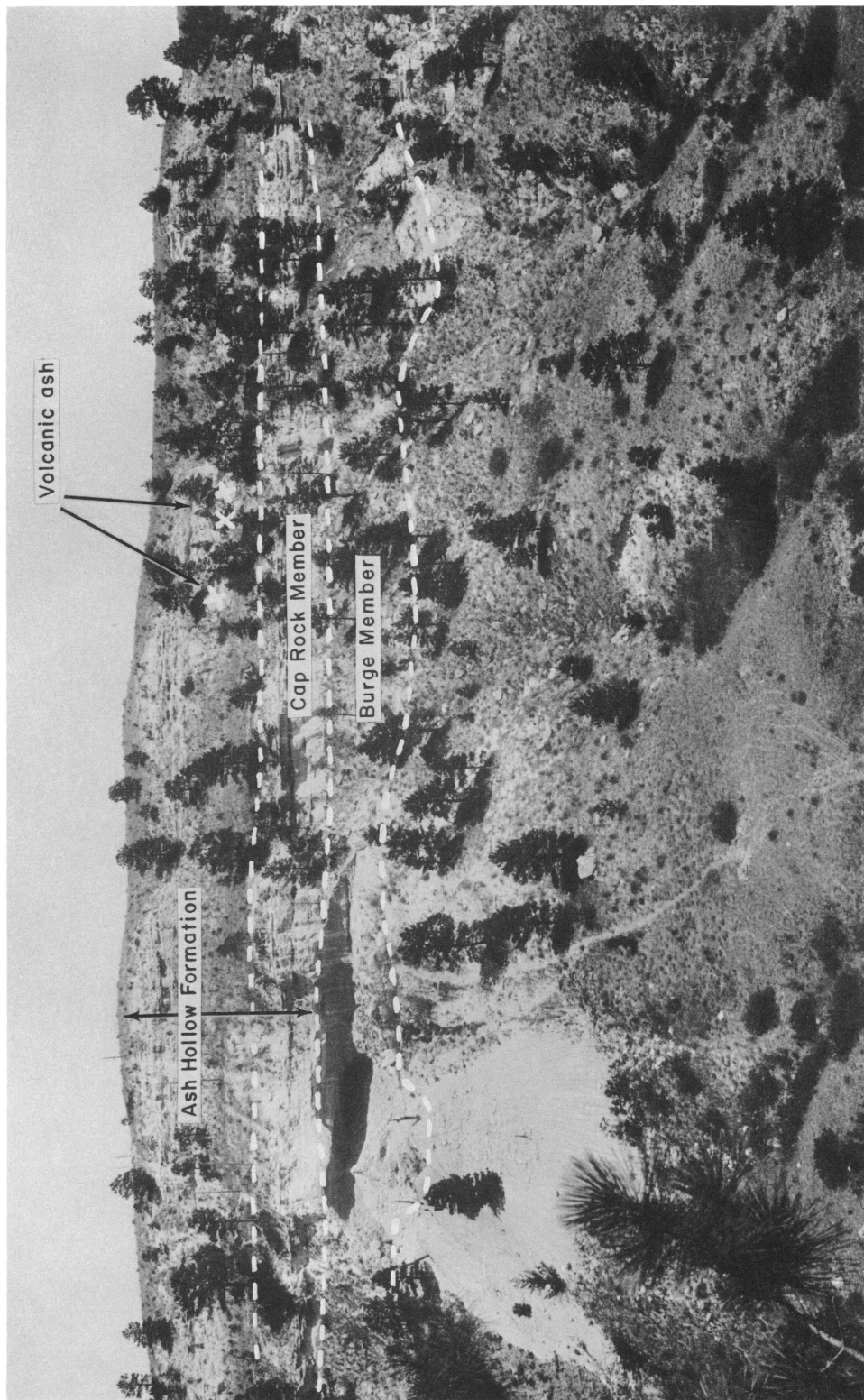
Outcrops at type locality of Crookston Bridge Member of the Valentine Formation taken from the west side of the Niobrara River just below the mouth of the Snake River, looking southeastward



South side of Devil's Gulch taken from the north side, showing superposition of the members of the Valentine Formation overlain by the Cap Rock Member of the Ash Hollow Formation. The channel profile of Devil's Gulch Horse Quarry is indicated. This is the source of the type fauna of Devil's Gulch Member. See plate 24



Devil's Gulch, Brown County, Nebraska, looking eastward and southeastward from the west side of the Gulch, showing superposition of the members of the Valentine Formation and the geographic relationship of various faunal sites as labeled. Note that the left-hand side shows the north side of the canyon from where the photograph shown as plate 23 was taken



East side of the Snake River, Cherry County, Nebraska, looking eastward, showing type locality of the Burge Member of the Valentine Formation. Burge Quarry, source of the type fauna, is on the left. The profile of the Burge Sands is indicated by the lower dashed line. The type locality of the Cap Rock Member of the Ash Hollow Formation is shown in superposition above the Burge Member, which is at the top of the Valentine Formation

camelus, *Blastomeryx*, *Cranioceras*, and *Ramoceros*. The scarcity of merycodont remains in the Devil's Gulch Horse Quarry is noteworthy, since merycodonts are plentiful in collections from the Crookston Bridge and Burge members of the Valentine Formation.

The Verdigre fauna described by Voorhies (MS) is from about 70 miles east of the Devil's Gulch type locality. Examples of the Verdigre fauna, consisting of more than 50 taxa, compare very favorably with forms from the lower part of the Devil's Gulch Member. Voorhies' direct comparisons in 1967 with the Frick Collection from the Devil's Gulch Horse Quarry resulted in one interesting fact. The Devil's Gulch fauna contains very few merycodontines, whereas the Verdigre fauna contains a predominance of merycodont remains.

BURGE MEMBER OF THE VALENTINE FORMATION

Plate 25

The Burge Member of the Valentine Formation is not well developed on Turtle Butte nor is it encountered in south-central South Dakota as in north-central Nebraska. On the west end of Turtle Butte (fig. 2) and at West Gap (fig. 3) thin outcrops of the Burge Member have produced a fauna that compares well with other Burge faunas. The stratigraphic position of the Burge Member above the Devil's Gulch Member and below the Cap Rock Member of the Ash Hollow Formation is duplicated in many places in north-central Nebraska.

TYPE LOCALITY. Johnson (1936, p. 472, fig. 1) defined the upper and lower limits of the Burge Sands, which he regarded as a member of the Ogallala Formation. (The name "Burge" had been in use as a faunal unit.) Johnson selected the Burge Quarry, which is on the east side of the Snake River on the north-central side of the NE. $\frac{1}{4}$, SE. $\frac{1}{4}$, sect. 15, T. 32 N., R. 30 W., in Cherry County, Nebraska, $\frac{3}{4}$ mile northwest of the old Burge post office, now a ranch home, as the type locality. Plate 25 shows Burge Quarry as it was in 1939, after it had been excavated by the Frick field party. The Cap Rock Member (new) of the Ash Hollow Formation overlies the quarry.

LITHOLOGIC CHARACTERS: The Burge Mem-

ber is made up of predominantly unconsolidated, gray, fine- to coarse-grained sand like that of a river deposit. Burge Quarry is a deep channel thickening of the characteristic sand and gravels that are present in nearly all exposures of the member. At Turtle Butte the Burge Sands have a brownish appearance and become more consolidated toward the top of the unit.

HISTORY: The Burge Quarry was discovered by Paul O. McGrew and Albert Potter in 1933. The name "Burge" first appeared in the literature in 1934 when it was applied in a faunal sense by Stirton (*in* Teilhard and Stirton, 1934, table 1). The faunal use was continued by Stirton and McGrew (1935, p. 129, map and sections), clearly indicating where the fauna was obtained geographically and stratigraphically. In 1936 Johnson proposed the Burge Sands as a member of the Ogallala Formation, gave stratigraphic sections, and discussed the sediments and faunas.

The Burge Quarry was worked by the Frick Laboratory in 1934, 1935, and 1939. A mammalian assemblage of some 3000 specimens was collected during these three field seasons.

STRATIGRAPHIC RELATIONSHIPS: The Burge Quarry is 2.6 miles up the Snake River in a southwesterly direction from the type locality of the Crookston Bridge Member. At Burge Quarry the relationship between the Burge and the underlying deposits is not so well exposed as at the Devil's Gulch and the Crookston Bridge type localities. At the type locality of the Burge Member, it is unconformably overlain by about 100 feet of Ash Hollow deposits. This is one of the thickest outcrops of Burge Sands and Ash Hollow deposits in this area. It is also the type locality for the Cap Rock Member of the Ash Hollow (see below, p. 409).

The Burge is the uppermost member of the Valentine Formation and immediately underlies the Cap Rock Member, the lowest unit of the Ash Hollow Formation of northern Nebraska. In an ideal sequence, the Burge overlies the Devil's Gulch Member of the Valentine Formation, but there are numerous places where the Burge is missing and the Cap Rock is in unconformable contact with the Devil's Gulch Member (fig. 4).

FAUNA: McGrew (1935) described a Burge

assemblage of fossil mammals from Gordon Creek and from the Burge Quarry in Cherry County, Nebraska. The components of the Burge fauna known to McGrew at that time were described and identified as *Metechinus* sp., *Cynodesmus euthos*, *Hypohippus affinis*, *Neohipparion coloradense*, *Nannippus* cf. *retrusus*, *Pliohippus* cf. *supremus*, *Procamelus occidentalis*, *Alticamelus* sp., *Merycodus* cf. *furcatus*, and *Eucastor*.

The fauna from the deposits on the east side of West Gap, Turtle Butte (fig. 3; pl. 1, fig. 2), compares well with Burge faunas from other localities. We collected an example of the straight, wedge-shaped, upper tusk of a proboscidean (F:A.M. No. 42969), here referred to *Eubelodon morrilli* Barbour (1913), a partial skull of *Teleoceras major* (F:A.M. No. 42963), examples of equids common in early Pliocene deposits, and fragmentary limb elements of an *Ischyrocyon*-like canid. These taxa occur in other deposits of the Burge Member in Brown and Cherry counties, Nebraska. The entire fauna of the Burge Member has not yet been completely reported. Studies by S. David Webb of the University of California are in press. The Frick Collection is still being studied.

ASH HOLLOW FORMATION

The Turtle Butte is capped by a well-indurated cap rock, as are many of the buttes in south-central South Dakota, particularly in Tripp County. In north-central Nebraska the rims of most of the precipitous canyons along the degrading Niobrara River valley are held up by this cap rock. This unit is the basal member of the Ash Hollow Formation as it is known in northern Nebraska and southern South Dakota.

A brief review of the Ash Hollow Formation is presented, the Cap Rock Member is here formally named, and a type locality is established.

TYPE LOCALITY: The type locality for the Ash Hollow Formation is in the NE. $\frac{1}{4}$, sect. 3, T. 15 N., R. 42 W., southeast of Lewellen, Garden County, in south-central Nebraska. No fauna from the type locality has been published, and none has been collected from it, so far as is known. For all practical purposes the Ash Hollow Formation remains undescribed faunally, although faunas from

correlated Ash Hollow deposits are known along the Platte River, and in northern Nebraska and southern South Dakota.

LITHOLOGIC CHARACTERS: In the type locality the Ash Hollow is composed of about 250 feet of gravel and sand, silt, clay, and some volcanic ash, indurated into caliche beds. It is not known whether all, or which portion, of this sequence is equivalent to the Cap Rock Member. In the type locality the basal conglomerates of the Ash Hollow rest unconformably upon the middle part of the Whitney Member of the Brule Formation.

The Ash Hollow Formation, as applied to deposits in northern Nebraska and adjacent South Dakota, may not correlate temporally or lithologically with the beds at the type locality. In north-central Nebraska and south-central South Dakota the Ash Hollow Formation is a widespread unit of fine-grained sand and silt, and local beds of volcanic ashes, cemented into caliche-like zones. If the lithologic components of the separate areas are not the same, one must still assume that the conditions were similar at the time these deposits were being laid down. The correlated deposits referred to as "Ash Hollow" by numerous authors, and in this paper, were best illustrated in a stratigraphic study by Johnson (1936, pp. 472-473).

HISTORY: Engelmann¹ (1876, pp. 259-263) proposed the Ash Hollow as "probably a Pliocene Tertiary formation" and described rock strata at the mouth of Ash Hollow Canyon that "attain a thickness of over 250 feet." Engelmann (1876, p. 283) also described the underlying stratum (now known as the Whitney Member of the Brule Formation) as part of his Scottsbluff Formation. However, he considered that these beds were similar to the

¹ In 1858-1859 when Engelmann made a geological survey from the Little Blue River in southeastern Nebraska to the eastern foot of the Rocky Mountains near Fort Laramie, Ash Hollow was an important and well-known resting place on the Oregon Trail. At Ash Hollow (named for a growth of ash trees) there was a plentiful supply of wood, water, and grass. Here, westbound wagon trains and eastbound travelers had established a central post office where letters and messages were picked up for delivery. Engelmann's report was not published until 18 years later. He not only discussed the Ash Hollow Formation but also gave stratigraphic descriptions of Court House and Chimney Rocks that may be compared with current stratigraphic sections.

"White River of Hayden" in South Dakota.

Darton (1899, pp. 734-735) proposed the name "Ogallala Formation" for the same beds but included deposits in western Nebraska that are not referable to this formation. Darton defined his Ogallala Formation as: "the deposit which in Kansas and southward has been called the 'Mortar beds,' 'Tertiary grit,' . . . [and] has been regarded as a portion of the Loup Fork formation. It is extensively developed in the western part of Nebraska, in the region about Lodgepole Creek and the area between Platte River and the Kansas line west of the ninety-ninth meridian. It thins out in Banner County and in the central part of Cheyenne County, giving place to the northwest to an underlying member of the Loup Fork series. It crosses North Platte River in the western part of Deuel County, but its limits in the central and northern portions of the State have not been ascertained. It appears to underlie a portion at least of the great sand-hill district."

Lugn (1939, pp. 1258-1261) redefined both names by raising the Ogallala Formation to group rank and repeating in more exact terms the geographic description, lithology, and thickness of the Ash Hollow Formation at its type locality. According to Lugn, the Ogallala Group consists of the Valentine, Ash Hollow, Sidney, and Kimball formations.

Stratigraphic studies made at the type locality of the Ash Hollow Formation by the senior author agree in general with those made by Engelmann (1876) and Lugn (1939). Our section has 16 feet of river bottom, 60 feet of Brule, 277 feet of Ash Hollow, 10 to 20 feet of Sidney gravel, and 100 feet of loess.

CAP ROCK MEMBER OF THE ASH HOLLOW
FORMATION, NEW USAGE FOR
AN OLD NAME

Plate 25

TYPE LOCALITY: The name "Cap Rock" is obviously incongruous for the basal member of the Ash Hollow Formation, but it is retained because of its long tenure and wide usage. "Cap Rock bed" is a descriptive field term that has been used in northern Nebraska and adjacent South Dakota by Frick field parties since 1927. The type locality for the

Cap Rock Member is here designated to be the same as that of the Burge Member of the Valentine Formation, where the Cap Rock rests in unconformable contact upon the Burge. Plate 25 shows the lower and upper limits of the Cap Rock Member. Johnson (1936, fig. 2) gave a section of the Burge Quarry in which the Cap Rock Member (called "Cap Rock bed") was included.

LITHOLOGIC CHARACTERS AND RELATIONSHIPS: In 1939, when the Burge Quarry was opened to expose the maximum extent of channel development, there were 46 feet of Burge sand and gravels in the deepest part of the channel cut. Locally, a 4- to 5-foot bed of white diatomaceous marl separates the Burge from the Cap Rock Member. This marl carries the fragmental bones mentioned by Lugn (1938, p. 223) and Johnson (1936, p. 473). The Cap Rock Member measures 28 feet thick at its type locality above the Burge Quarry (but varies from 25 feet to 50 feet in thickness over the region). In turn, the Cap Rock Member is overlain by 54 feet of undifferentiated, equated Ash Hollow deposits, including one exceptionally pure layer of silvery blue volcanic ash about 5 feet thick (see Johnson, 1936, fig. 2).

Local deposits of silvery gray, pure ash also appear within the Cap Rock Member, but these are at different levels and cannot be correlated from locality to locality. Nearly all of these pure ash deposits have distinct bedding planes, are graded, and show symmetrical ripple marks that indicate pond accumulations.

On the southeast side of Turtle Butte (figs. 1, 4), a silvery gray ash deposit, about 3 feet thick, is significant because it aids in substantiating the proper relationship of the Cap Rock Member to the Valentine Formation at Turtle Butte. In northern Nebraska and southern South Dakota numerous layers of impure volcanic ash and an occasional pure ash deposit (probably windblown, pond, or lake accumulation) are observed. Only one such pure ash deposit is known in the type locality in Ash Hollow canyon. There, the ash is about 100 feet above the base of the section.

FAUNA: The Cap Rock Member at Turtle Butte has yielded a limited but significant fauna. The holotype of *Ustatochoerus skinneri*

(F:A.M. No. 33630), reported by Schultz and Falkenbach (1941, pp. 47-48, figs. 1, 8, 12)¹ was collected about 300 yards east of the Turtle Butte Gap subsection (fig. 3).

The species *Ustatochoerus skinneri* has not been found below the Cap Rock Member and is restricted in stratigraphic occurrence to

¹ Schultz and Falkenbach (1941, p. 47), stated, "The exact stratigraphic position of the remains referred to *U. skinneri* from the Ash Hollow of South Dakota and Nebraska has not been definitely determined." The field data for the type and all but one of the referred specimens were, however, given in Skinner's field lists as "Cap Rock zone," or "base of Ash Hollow." In the case of the referred remains, which were postcranial elements (F:A.M. No. 43081), Skinner's field data stated, "may be equal to, or near base of 'Cap Rock.' "

the base of the Ash Hollow Formation, according to Frick Laboratory usage. Since *U. skinneri* was described, another skeleton tentatively referred to *Ustatochoerus* has been collected from the Cap Rock Member on the west end of Turtle Butte. Unfortunately, this skeleton lacked the skull and mandible.

Hackberry seeds (*Celtis*), common in Cap Rock deposits elsewhere, were found in quantity here. A large individual of the genus *Testudo*, also common in the Cap Rock, was observed. A large, exceptionally fine example of *Testudo* was exposed in the base of the Cap Rock just east of West Gap where the Burge fauna was collected; in 1965 this specimen was destroyed by vandals.

SYSTEMATICS

GIDLEY'S ROSEBUD FAUNA

GIDLEY (1904, p. 246) BELIEVED, and Matthew certainly concurred in his opinion, that there were only two formations in the entire "Rosebud area." As pointed out above (p. 401), the provenance of the actual fossils upon which Gidley's faunal list was based is conjectural, because they were collected from several localities, the geology of which was not clearly understood.

Gidley's (MS) report of the 1903 expedition pointed up the fact that the original Rosebud fauna was derived from several localities, for in it he stated: "The party, consisting of Dr. W. D. Matthew . . . and the writer, left Chadron, Nebraska June 25th. . . ."

"Striking the Little White River near its head, at a point nearly equidistant from the Pine Ridge and Rosebud Agencies, the party began the season's work at this place. The exposures along Little White River at this locality are Lower or Middle Miocene. . . . Most of the country to the south is covered by typical sand-buttles. However, at Big Springs Cañon there is a limited exposure of Loup Fork (Upper Miocene) beds. At this place the party obtained specimens representing several characteristic Loup Fork species. . . ."

"Leaving this locality [Big Springs Cañon] the party went direct to Rosebud Agency. A second camp was established about two miles north of this place. This served as a sort of central camp . . . explorations were made as far east as the Head of Oak Creek, about thirty miles from Rosebud Agency. In the vicinity of Rosebud both the Loup Fork and Middle or Lower Miocene beds are abundantly exposed. The work was confined mostly to the upper beds. While the party was still in this camp at Rosebud, Dr. Matthew returned to New York."

The data from the catalogue of the Department of Vertebrate Paleontology of the

American Museum for Gidley's 1904 faunal list, covering specimens collected by Gidley or Matthew during the 1903 expedition, follow:

"A.M.N.H. No. 10816. ?*Cynodesmus*, Carnivore indet. Fragments of skeleton. No skull. Head of Little White River near Big Spring Canyon, South Dakota. Horizon: Rosebud. [No field number.]

"A.M.N.H. No. 10818. *Steneofiber ?pansus*. Skull and jaws. Little White River, below Lake Cr'k., South Dakota. Horizon: Rosebud. Field number 6. [See Matthew, 1904, pp. 257-259.]

"A.M.N.H. No. 10824. *Meniscomys*. Lower jaw, M₁₋₃, left. Near A.M.N.H. No. 10818. Little White River, below Lake Cr'k., South Dakota. Horizon: Rosebud. [No field number. This specimen was later called *Promyagaulus riggsi* by McGrew, 1941.]

"*Eporeodon*. [No card in the catalogue showed the specimen on which this taxon was based.]

"A.M.N.H. No. 10890. *Merycochoerus* vel *Promerycochoerus*. A symphysis. 5 mi. southeast of Rosebud, South Dakota. Horizon: Loup Fork. [Only one specimen was recorded in the catalogue for this taxon. The area 5 miles southeast of Rosebud exposes mostly Pliocene beds.]

"A.M.N.H. No. 10885. *Merychys* cf. *elegans*. Skull, jaws, and part of skeleton. 2 mi. below Big Spring, Little White River, S. D." Matthew's original field labels differ from the data on the catalogue card. We consider that Matthew's field label has priority over the later entry in the catalogue. The field label states, "Little White River, 3 miles [italics ours] below Big Spring Canyon, S. D., Lower Loup Fork, Field No. 1, W.D. M. 6/28/03." Matthew's location would place the collecting site close to the outcrops near the Flint Hill Quarry discovered many years later by the University of California.

FAUNA FROM THE ROSEBUD TYPE LOCALITY AND ROCKS

ORDER ARTIODACTYLA

FAMILY MERYCOIDODONTIDAE

SUBFAMILY DESMATOCHOERINAE

DESMATOCHOERUS THORPE, 1921

Desmatochoerus (*Paradesmatochoerus*) cf.
wyomingensis or *Desmatochoerus*
(*Paradesmatochoerus*) *sanfordi*

MATERIAL: A partial skull (F:A.M. No. 42986) of an old individual with most of the right side preserved (fig. 10) has only part of the frontals and the tips of the nasal bones. The cheek teeth are worn and broken, but they are in position. Of the incisors, only the right I³ is preserved. Except for the left zygoma, the ventral side is essentially complete. This skull (F:A.M. No. 42986) was collected from the type rocks at the type locality of the Rosebud Formation on the east bank of the Rosebud Creek reservoir just south and east of the Rosebud Agency buildings, Todd County, South Dakota (fig. 6).

An immature, badly crushed skull with most of the basicranium missing, and a right

ramus (J.R.M. No. 1490), were collected by J. R. Macdonald from about 60 feet above the level of the Little White River in the Rosebud Formation, sect. 18, T. 38 N., R. 30 W., Todd County, South Dakota. This specimen is badly crushed and lacks most of the basicranium.

DISCUSSION: The two Rosebud specimens (F:A.M. No. 42986 and J.R.M. No. 1490) are comparable to two specimens referred to *Desmatochoerus* (*Paradesmatochoerus*) *wyomingensis* by Schultz and Falkenbach (1954, p. 202). One of these, a partial skull (F:A.M. No. 49639), was collected from Quiver Hill, Washabaugh County, South Dakota, from 47 feet above the base of the first white layer (or Rockyford Ash Member), in beds that are equal to the lower part of the Sharps Formation. The other, a badly crushed skull (F:A.M. No. 49638), was collected from 1½ miles south of exposures at the mouth of Porcupine Creek canyon, Shannon County, South Dakota, from the upper part of the Sharps Formation. A skull and mandible (F:A.M. No. 42987), from 1 mile west of

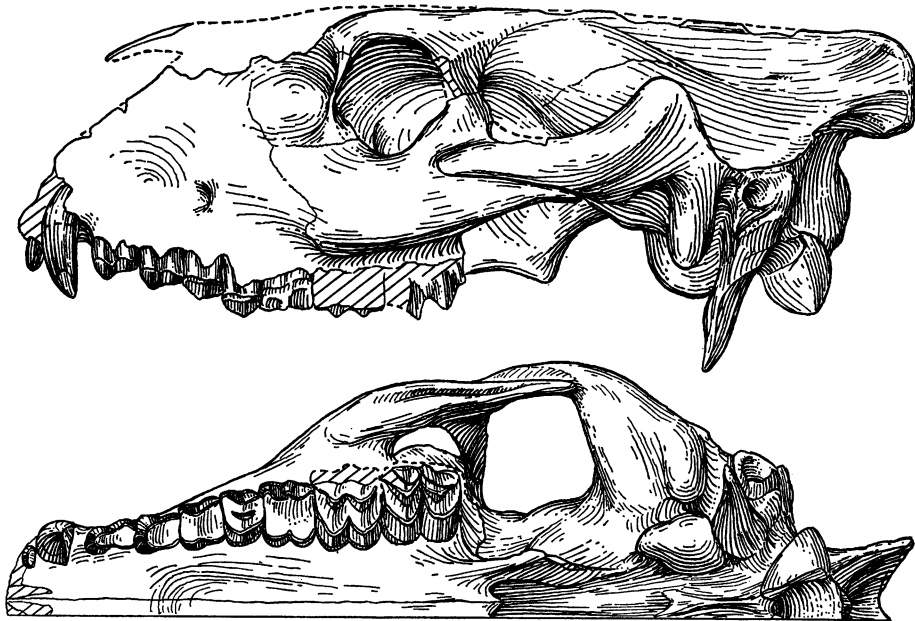


FIG. 10. *Desmatochoerus* (*Paradesmatochoerus*) sp., skull, F:A.M. No. 42986, from the Rosebud Formation at the type locality at 2661 feet on the section (fig. 6); lateral and occlusal views of right side, reversed. $\times \frac{1}{2}$.

Quiver Hill, Washabaugh County, South Dakota, and 168 feet above the Rockyford Ash Member, are also comparable to the two Rosebud specimens. This specimen (F:A.M. No. 42987) was collected in 1950 but was not included in the study of the *Desmatochoerinae* by Schultz and Falkenbach (1954).

The type of *Desmatochoerus (Paradesmatochoerus) wyomingensis*, a skull (F:A.M. No. 33312), was collected in 1932 by C. H. Falkenbach and his associates and was reported by Schultz and Falkenbach (1954, p. 200) as having been derived from the "Gering formation, Willow Creek, Niobrara County, Wyoming." The original field data for this specimen, however, gave no indication of the age of the formation: "Willow Cr. (top of beds)." The two Rosebud specimens (F:A.M. No. 42986 and J.R.M. No. 1490) and the specimens from the Sharps Formation (F:A.M. Nos. 49638, 49639, and 42987) are more brachycephalic and have lower, shorter, broader sagittal crests and less development of the exoccipital vacuities than the type of *D. (P.) wyomingensis* (F:A.M. No. 33312).

Desmatochoerus (Paradesmatochoerus) sanfordi is represented by four partial skulls, none of which has sufficient basicranial characters preserved for comparison. The type skull (F:A.M. No. 45443), a very old individual, was collected from the Sanford ranch north of Mitchell in sect. 36, T. 25 N., R. 56 W., Sioux County, Nebraska, from 5 feet above the Whitney-Gering contact out of the lowermost Gering Formation. It should be noted that this specimen came from about 1½ miles southwest of the Tunnel Hill locality on the Ledingham ranch and about 100 feet below the Monroe Creek-Harrison undifferentiated deposits that yielded the remains of *Megoreodon hollandi*.

Even though morphologic comparisons are limited, the type of *D. (Paradesmatochoerus) sanfordi* (F:A.M. No. 45443) and the Rosebud specimens (F:A.M. No. 42986 and J.R.M. No. 1490) bear a close resemblance to one another.

The type of *Desmatochoerus curvidens gregoryi* (A.M.N.H. No. 12964) was collected by Albert Thomson (MS) from the "Divide E. of Porcupine Cr'k 7 m. below [Porcupine] p.1. . . lower Rosebud." This is the area in Shannon County, South Dakota, to which

Matthew (1907) transferred the concept of the Rosebud Formation. Schultz and Falkenbach (1954, p. 184) interpreted the age of the type locality for *D. curvidens gregoryi* as the Harrison Formation, an assignment in which Macdonald (1963, p. 155) concurred. A comparison between the Rosebud specimens (F:A.M. No. 42986 and J.R.M. No. 1490) and the Sharps specimens (F:A.M. Nos. 42987, 49638, and 49639) and the type of *D. curvidens gregoryi* (A.M.N.H. No. 12964) shows that they may be congeneric, but are different subgenerically, if the subgeneric allocations of Schultz and Falkenbach (1954) are followed. *Desmatochoerus curvidens gregoryi* is one-third larger than *D. (Paradesmatochoerus) wyomingensis* or *sanfordi* and has more hypsodont teeth, a higher, more compressed sagittal crest, and pointed paroccipital processes. The auditory bullae of *D. (Paradesmatochoerus)* are inflated and bulbous, whereas those of *D. curvidens gregoryi* are laterally compressed.

SUMMARY: Comparisons of the stratigraphically controlled oreodonts indicate that there is a specific population of desmatochoerids in the early Miocene lower Sharps and Rosebud deposits. These specimens fall easily into the *Desmatochoerus (Paradesmatochoerus) wyomingensis* and *sanfordi* groups. These groups appear to be antecedent to *Desmatochoerus curvidens gregoryi* from the younger formation that directly overlies the Sharps Formation in the Porcupine Butte and Wounded Knee area.

The most likely ancestor of the desmatochoerids from the Rosebud and Sharps beds is the taxon *Desmatochoerus (Subdesmatochoerus) socialis* from the Poleslide Member of the Brule or its temporal equivalent, which is stratigraphically below the Rockyford Ash Member of the Sharps Formation. Three skulls of *D. (S.) socialis* (F:A.M. Nos. 45460, 45327, and 49640) bear an over-all resemblance to the Rosebud specimens (F:A.M. No. 42986 and J.R.M. No. 1490) but are smaller and have less bulbous auditory bullae and distinct hyoidal grooves, which the Rosebud specimens lack.

Desmatochoerus sp. indet.

MATERIAL: The anterior portion of a skull (J.C.H.V.P. No. 65) was collected by J. C.

Harksen (personal communication) from the Rosebud Formation "on the new road on the east side, Little White [River] between Ghost Hawk Park and Spring Creek Day School," Todd County, South Dakota, about 40 feet

above the level of the Little White River. On the basis of size, this specimen could be allocated to *D. (Paradesmatochoerus) wyomingensis* (near the type, F:A.M. No. 33312) or to *D. hatcheri geringensis*.

TABLE 1
FAUNAL LIST AND STRATIGRAPHIC DISTRIBUTION OF FAUNAS FROM TURTLE BUTTE

	Wewela Fauna Turtle Butte Formation	Valentine Formation Burge Member	Ash Hollow Formation Cap Rock Member
Osteichthyes			
Amiiformes			
<i>Amia</i> sp.	x	—	—
Reptilia			
Squamata			
Anguidae			
<i>Glyptosaurus</i> sp.	x	—	—
Chelonia			
Testudinidae			
Gen. et sp. indet.	—	—	x
<i>Geochelone</i> sp.	x	—	—
<i>Chrysemys</i> sp.	x	—	—
Mammalia			
Carnivora			
Canidae			
? <i>Leptocyon</i> sp.	x	—	—
<i>Enhydrocyon crassidens</i>	x	—	—
<i>Ischyrocyon</i> sp.	—	x	—
Family indet.	x	—	—
Gomphotheriidae			
<i>Eubelodon morrilli</i>	—	x	—
Perissodactyla			
Equidae			
<i>Archaeohippus equinanus</i>	x	—	—
<i>Pseudhipparion retrusum</i>	—	x	—
<i>Pliohippus pernix</i>	—	x	—
<i>Hipparion occidentale</i>	—	x	—
Rhinocerotidae			
<i>Teleoceras</i> sp.	—	x	—
Gen. et sp. indet., large	x	—	—
Gen. et sp. indet., small	x	—	—
Artiodactyla			
Entelodontidae			
<i>Archaeotherium trippensis</i> , new species	x	—	—
Merycoidodontidae			
Cf. <i>Merychys siouxiensis</i>	x	—	—
<i>Ustatochoerus skinneri</i>	—	—	x
Camelidae			
Gen. et sp. indet.	x	—	—
<i>Aepycamelus</i> sp.	—	x	—

SUBFAMILY LEPTAUCHENINAE

LEPTAUCHENIA LEIDY, 1856

Leptauchenia cf. *major* or*Leptauchenia* cf. *decora*

A partial skull of a leptauchenid (S.D.G.S. No. 1403) was collected by J. C. Harksen in 1965 from the Rosebud Formation along the Little White River in sect. 10, T. 37 N., R. 31 W., Todd County, South Dakota, at an elevation between 2430 feet and 2470 feet. This specimen is smaller than the lectotype of *Leptauchenia major* (A.N.S.P. No. 10941) and larger than the lectotype of *Leptauchenia decora* (A.N.S.P. No. 10878). Comparable dental measurements are close to the mean between the lectotype of *L. decora* and that of *L. major*.

A cast of the Rosebud specimen (S.D.G.S. No. 1403) was sent to C. B. Schultz, who

stated (personal communication) that it was comparable chiefly to other Frick specimens from Hay Creek, tributary of Bear Creek, Washabaugh County, South Dakota. In this area there are deposits that equate with the lower part of the Sharps Formation.

The occurrence of *Leptauchenia* in the Rosebud Formation is of biostratigraphic significance. Specimens referable to *Leptauchenia* are plentiful in the lower part of the Sharps Formation and other equivalent rock units, but they become progressively rare with time. Examples of *Leptauchenia* are exceedingly rare in the Monroe Creek Formation and are not known to occur at all in Harrison deposits. This observation is based on data associated with the collection of more than 500 leptauchenid skulls made by the senior author over the past 40 years.

WEWELA FAUNA OF THE TURTLE BUTTE FORMATION

CLASS OSTEICHTHYES

ORDER AMIIFORMES

FAMILY AMIIDAE

AMIA

Two vertebrae of the bowfin (F:A.M. No. 42947) were collected from the east end of Turtle Butte near the 2390-foot level (fig. 4) of the Turtle Butte Formation. The bowfin (*Amia*) still survives in fresh-water lakes and sluggish parts of large streams in eastern North America (Smith, 1962, p. 506). Fragmentary remains such as these two vertebrae would ordinarily be identified only as to order or family, but vertebrae of *Amia* are easily recognized.

CLASS REPTILIA

ORDER SQUAMATA

FAMILY ANGUIDAE

Glyptosaurus sp.

The ramus (F:A.M. No. 42948) of a lizard of this genus was found on the east end of Turtle Butte near the 2390-foot level of the Turtle Butte Formation (fig. 4). *Glyptosaurus* is rare in almost all faunas, but its remains are found more frequently in late Chadronian time when its appearance was first noted.

ORDER CHELONIA

FAMILY TESTUDINIDAE

Geochelone sp. and *Chrysemys* sp.

Two kinds of turtle occur in the Wewela fauna: the larger, a species of *Geochelone*, and the smaller, a species of *Chrysemys* (painted turtle). Examples of both were found at the east end of Turtle Butte at about the 2380-foot level in the Turtle Butte Formation (fig. 4).

CLASS MAMMALIA

ORDER CARNIVORA

FAMILY CANIDAE

SUBFAMILY CANINAE

Gen. and Sp. Indet.

MATERIAL: A fragment of a right ramus, with the alveoli of P₂-P₄ (F:A.M. No. 42939), was collected from the talus of the exposures on the east end of Turtle Butte (fig. 4). Even though the ramus was not in place, its position in the deposits leaves no doubt that it was derived from the Turtle Butte Formation.

DESCRIPTION: The ramus (F:A.M. No. 42939), although toothless, has well-preserved

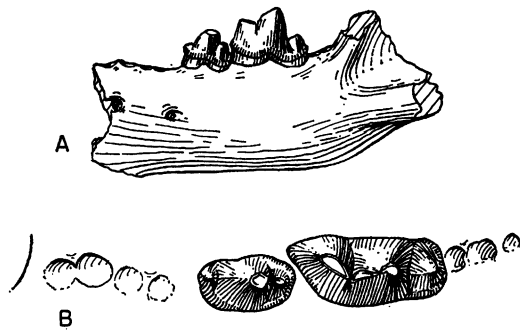


FIG. 11. *Enhydrocyon crassidens*, left ramus, P_4-M_1 , F:A.M. No. 42965; from 1 foot above the base of the Turtle Butte Formation at the type locality (fig. 2). A. Lateral buccal view. $\times \frac{1}{2}$. B. Occlusal view. $\times 1$.

measurable alveoli. The following measurements (in millimeters) were made from these unbroken alveoli: length of P_2-P_4 , 19.0; length of alveolus of P_2 , 5.5; length of the alveolus of P_3 , 6.4; and length of the alveolus of P_4 , 6.3; depth of horizontal ramus below the center of P_4 , 10.3; depth of ramus below P_2 , 8.8. The major mental foramen or anterior foramen is below the posterior part of P_1 . A smaller secondary mental foramen is below the center of P_3 . The internal junction of the posterior symphysis is opposite the center of P_2 .

DISCUSSION: This specimen (F:A.M. No. 42939) is closely comparable to *Leptocyon* examples from Harrison deposits in western Nebraska in the Frick Collection. Although *Leptocyon* has not been recorded over a long geologic period, specimens in the Frick Collection show that the *Leptocyon* group became distinct from other genera of the Caninae in the early Miocene and persisted to early Pleistocene time.

SUBFAMILY SIMOCYONINAE

ENHYDROCYON COPE, 1879

Enhydrocyon crassidens Matthew, 1907

TYPE: A skull, mandible, and partial skeleton (A.M.N.H. No. 12886).

TYPE LOCALITY: The field data of Albert Thomson (1906), the collector, reads, "Porcupine Cr'k 3 m. below p.o. Lower Rosebud. Pine Ridge Reservation, South Dakota." Macdonald (1963, p. 155) stated: "The geo-

logic section in Matthew's field notes indicates that this locality is in the Monroe Creek formation. As outcrops in the area are present in both formations [Monroe Creek and Harrison formations], it must be presumed that the field notes are correct." Macdonald (1963, p. 217) assigned the species to "Monroe Creek formation or Harrison formation, early Miocene."

REFERRED SPECIMEN: A partial left ramus (F:A.M. No. 42965; fig. 11), which has P_4-M_1 and alveoli for P_2-P_3 and M_2-M_3 , was collected from the type locality of the Turtle Butte Formation 1 foot above its contact with the Rosebud Formation.

DISCUSSION: This specimen (F:A.M. No. 42965) probably represents a smaller individual of the *Enhydrocyon crassidens* population, but in other respects is similar to the type of *E. crassidens* from Porcupine Creek and a referred example (A.M.N.H. No. 13799) from 6 miles west of American Horse Creek, South Dakota. The last specimen was collected by Albert Thomson in 1907 and assigned in the field data to the "Lower Rosebud Formation."

The specimen from Turtle Butte (F:A.M. No. 42965) is very closely comparable to mandibles in the Frick Collection (F:A.M. Nos. 25424 and 25425) from the upper part of the Monroe Creek Formation or the lower part of the Harrison Formation at the Tunnel Hill locality on the Ledingham Ranch in southern Sioux County, Nebraska, where a suite of specimens referable to *Megoreodon hollandi* was also collected (see p. 426). Interestingly enough, the ramus (F:A.M. No. 42965) from Turtle Butte was found in close association with a maxilla (F:A.M. No. 42966) and a partial skull (F:A.M. No. 42950) of *Megoreodon hollandi*. Moreover, the ramus was collected from the same horizon and within 1 foot of the mandible and less than 1 inch from the premaxilla of the holotype of *Archaeotherium trippensis*, new species (F:A.M. No. 42937).

UNALLOCATED CARNIVORA

Figures 12 and 13

MATERIAL: A left second metacarpal (F:A.M. No. 42946) and three unarticulated left phalanges of an otherwise unknown large

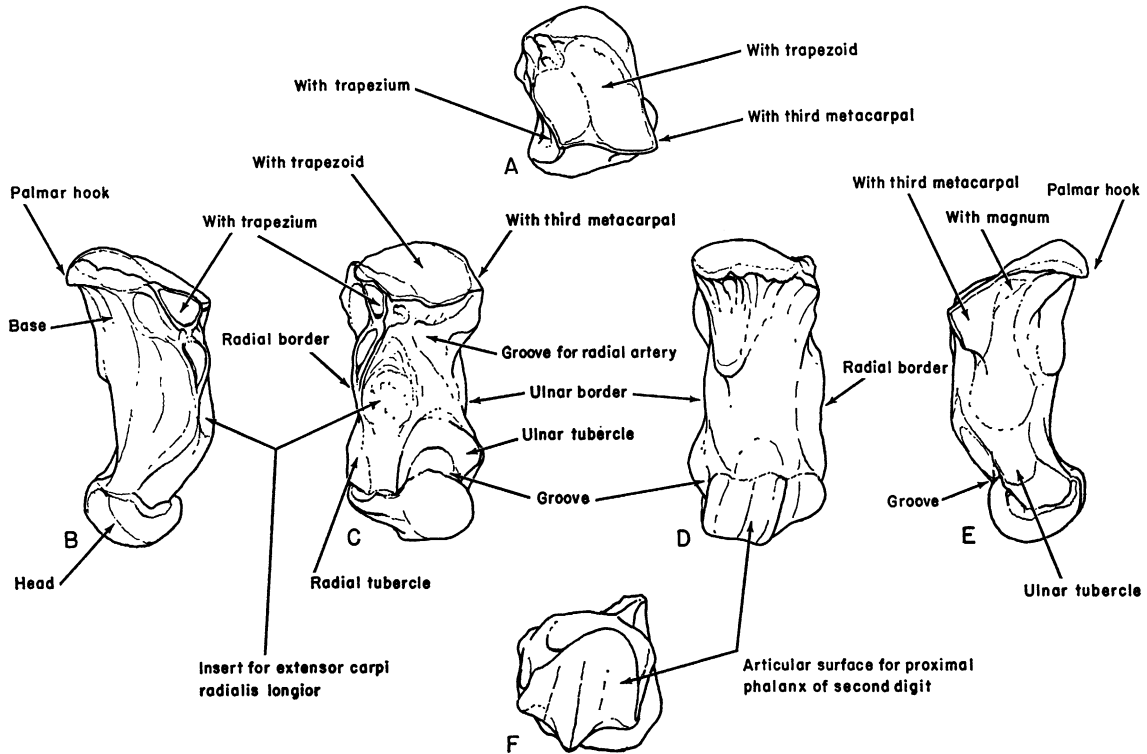


FIG. 12. Unallocated Carnivora, metacarpal 2, F:A.M. No. 42946, from the type locality of the Turtle Butte Formation (fig. 2). A. Proximal view. B. Radial view. C. Dorsal view. D. Palmar view. E. Ulnar view. F. Distal view. $\times 1$.

carnivore were collected from the type locality of Turtle Butte Formation, in association with the proximal end of an oreodont metatarsal. Two of the phalanges articulate reasonably well and are tentatively considered the proximal (F:A.M., No. 42959A) and median (F:A.M. No. 32959B) phalanges of a second metacarpal. The third, a larger proximal phalanx (F:A.M. 42960), may represent a phalanx of a third or fourth metacarpal of an animal similar in size (table 2).

DESCRIPTION: The characters of the proximal and distal ends of the second metacarpal (F:A.M. No. 42946) seem to place the specimen in the Carnivora, but the shaft possesses a radial breadth and massiveness that, in conjunction with its shortness, give its surface a twisted, uneven, lumpy appearance, unlike the metacarpal of any carnivore we have seen. Shafts of some sloth metacarpals show this twisted, uneven, lumpy condition,

but these have very different proximal and distal ends.

There are no carnivore phalanges of such large size known to us from the North American early Miocene. F:A.M. Nos. 42959A, 42959B, and 42960 compare in size only with phalanges of *Amphicyon*. But, unlike those of *Amphicyon*, the proximal phalanges F:A.M. Nos. 42959A and 42960 have two deep, triangular-shaped depressions above the head on the palmar side (fig. 13). These palmar depressions, one above each side of the head, give the phalanx an appearance of having a median longitudinal rounded ridge. Such marked depressions have not been observed thus far in any other carnivore phalanx, although many examples show faint scars and rugose surfaces on the palmar side near the head.

In comparison with the phalanges, the small size of the second metacarpal (F:A.M. No. 42946) seems to preclude the possibility

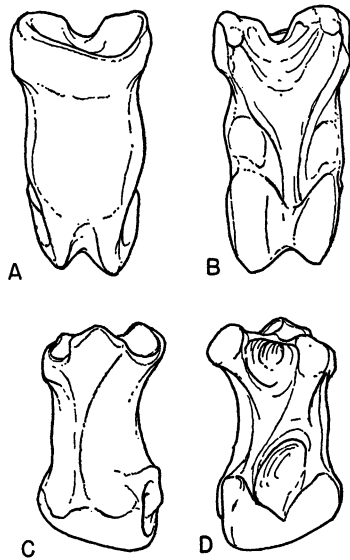


FIG. 13. Unallocated Carnivora, from the type locality of the Turtle Butte Formation (fig. 2). A, B. Proximal phalanx, F:A.M. No. 42959A. A. Dorsal view. B. Ventral view. C, D. Second phalanx, F:A.M. No. 42959B. C. Dorsal view. D. Ventral view. $\times 1$.

that it was part of the same individual. The proportions of the animal to which the metacarpal belonged cannot, of course, be estimated, but we know of no carnivore forefeet that have proximal phalanges larger and more massive than the metacarpal. Even if the metacarpal (F:A.M. No. 42946) were derived from the overlying younger beds, we know of no allocation for it. Because it was

found in close association with a fragment of a metatarsal of an oreodont the size of that of *Megoreodon* or *Promerycochoerus*, and with three unknown carnivore phalanges, we are fairly certain that this is an early Miocene occurrence.

ORDER PERISSODACTYLA

FAMILY EQUIDAE

SUBFAMILY ANCHITHERIINAE

ARCHAEOHIPPIUS GIDLEY, 1906

Archaeohippus equinanus (Osborn, 1918)

TYPE: Two maxillae with dP^1 , P^2 - P^3 on the right side and dP^1 , P^2 - M^3 on the left (A.M.N.-H. No. 12912).

TYPE LOCALITY: Collected by Albert Thomson in 1906. In his field notes for June 23, opposite entry No. 6, Thomson wrote, "*?Archaeohippus* upper jaw, Rosebud beds 5 miles above Manderson." Osborn (1918, p. 65) stated that the horizon and locality for the specimen were "Lower Rosebud formation, *Promerycochoerus* zone, Porcupine Creek, Pine Ridge, South Dakota." After checking Thomson's field data, Macdonald (1963, p. 154) noted that Thomson's locality was south of Manderson and that the Rosebud beds there were "Probably Harrison formation, possible Monroe Creek formation."

REFERRED SPECIMENS: A right ramus (F:A.M. No. 42943), with dP^1 , P^2 alveolus, and P^3 - M^3 , was collected from the Turtle Butte Formation on the east side of West Gap at an elevation of 2365 feet, 40 feet be-

TABLE 2

COMPARATIVE MEASUREMENTS (IN MILLIMETERS) OF METACARPAL 2 AND PHALANGES OF CARNIVORA INDETERMINATE

	Metacarpal 2 F:A.M. No. 42946	Proximal Phalanx F:A.M. No. 42960	Proximal Phalanx F:A.M. No. 42959A	Median Phalanx F:A.M. No. 42959B
Maximum length	39.4	40.3	34.8	20.0
Shaft, transverse width	16.3	18.6	16.2	12.4
Proximal end				
Transverse width	16.0	22.3	19.2	17.1
Anteroposterior width	21.0	15.9	15.3	16.5
Distal end				
Transverse width	15.5	16.3	14.9	16.9
Anteroposterior width	16.0	12.2	11.9	10.9

low the Turtle Butte-Valentine contact (fig. 3). This ramus (F:A.M. No. 42943) was collected within 5 feet of a skull referred to *Megoreodon hollandi* (F:A.M. No. 42927) and an upper molar (F:A.M., No. 42945) referred to the Merychyinae. Two other examples of *Archaeohippus equinanus*, right rami with M_1 - M_2 (F:A.M. Nos. 42940 and 42941), were collected from the Turtle Butte Formation at 2390 feet (fig. 4), at the east end of Turtle Butte on the west side of the gap.

The type of *Archaeohippus equinanus* (A.M.N.H. No. 12912) has a length from the alveolus of dP_1 to M_3 of 71.0 mm. inclusive. The length of F:A.M. No. 42943 from the alveolus of dP_1 to M_3 is 71.5 mm. inclusive.

DISCUSSION: Osborn's allocation (1918, pp. 65, 66) of *equinanus* to *Miohippus* is untenable, because he ignored the characters of the types species, *M. annectens*, and, moreover, used the generic concept for early Miocene equids of dissimilar morphology. Even the present reference of *equinanus* to *Archaeohippus* may be subject to revision. Isolated examples of dentitions such as those in the Wewela fauna may be misleading because of the scarcity of *Archaeohippus*. *Archaeohippus* was also a relatively conservative group; that is, the structural changes of the dentition that occurred during early Miocene to late Miocene time were very slight. The morphology of the preorbital region of the skull evidently showed greater change, but the rarity of examples of *Archaeohippus* with preserved skull parts makes it difficult to document the degree of change.

SUBORDER CERATOMORPHA

FAMILY RHINOCEROTIDAE

Gen. and Sp. Indet.

Two forms of rhinoceros are represented by limb elements only in the type locality of the Turtle Butte Formation. Beyond the family category, no allocation is attempted here. The two forms are identified by the obvious size difference.

LARGE FORM: A right radius (F:A.M. No. 42954) and the proximal end of a left metacarpal (F:A.M. No. 42955) indicate the occurrence of a very large and very long-limbed rhinoceros. A particularly good match for the radius is in a Wyoming collection

made by C. H. Falkenbach, but there are very few geographic and geologic data with it. A label states "Horse Creek, 5 feet below the white layer," and a single word, "Gering," was added later to the Horse Creek locality card in the collector's handwriting. We assume that the Wyoming specimen came from early Miocene deposits because of its resemblance to the Turtle Butte form.

MEASUREMENTS: The total length of the radius is 425 mm; the greatest proximal width (transverse) is 97.5 mm.; the distal width (transverse) is 89.0 mm.

SMALL FORM: The proximal end of a right radius (F:A.M. No. 42956) is matched by examples of *Menoceras*, a Miocene rhinoceros with transversely paired horns. The transverse proximal width of the radius is 63.0 mm. The fragment is, however, not considered generically diagnostic.

ORDER ARTIODACTYLA

FAMILY ENTELODONTIDAE

ARCHAEOTHERIUM LEIDY, 1850

Archaeotherium trippensis,¹ new species

Figures 14 and 15

TYPE: F:A.M. No. 42937, a nearly complete skull and mandible,² lacking only parts of the premaxilla, of an immature individual. The right premaxillary fragment contains the germ of a large I^3 . A fragment of the left premaxilla has the alveolus for dI^1 and remnants of the alveoli for dI^2 - dI^3 , which show that the deciduous incisors were moderately large and increased in size from dI^1 to dI^3 progressively. However, in this left premaxillary fragment, the germ of I^2 is preserved and is greatly reduced in comparison with the germ of I^3 which is preserved in the right premaxillary fragment. Upper deciduous canines and germs of mature canines are present, as are dP^1 - dP^4 and M^1 - M^2 ; M^3 had not formed

¹ Named for Tripp County, South Dakota.

² In 1949 Skinner and party collected the skull of *Archaeotherium trippensis* (F:A.M. No. 42937), new species, and several specimens of *Megoreodon hollandi*. Nineteen years later, while re-examining the site, the same collector discovered the mandible, which had been separated from the skull by less than 1 foot. The condyle of the mandible had been exposed by less than 1 inch of weathering from the surface of the pit where the skull had been blocked out.

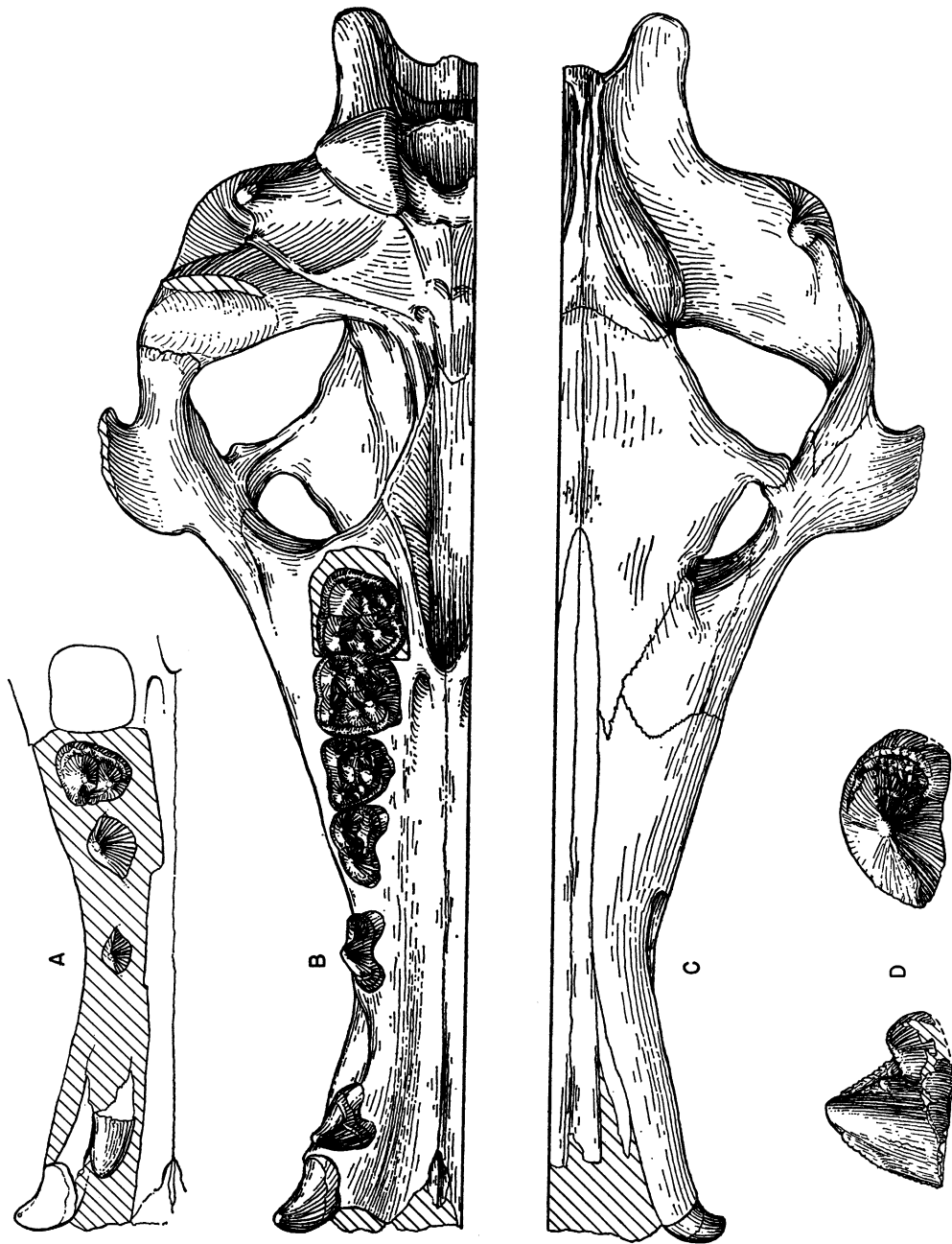


FIG. 14. *Archaeotherium trippensis*, new species, type, skull and mandible, F.A.M. No. 42937, from 1 foot above the base of the Turtle Butte Formation, at the type locality. A. Occlusal view of left dC/, and C/-P³ germs. $\times \frac{1}{4}$. B. Occlusal view of left side, M² germ from right side, exposed and reversed. $\times \frac{1}{4}$. C. Dorsal view of left side. $\times \frac{1}{4}$. D. Lateral and occlusal views of P₄ germ. $\times \frac{1}{4}$.

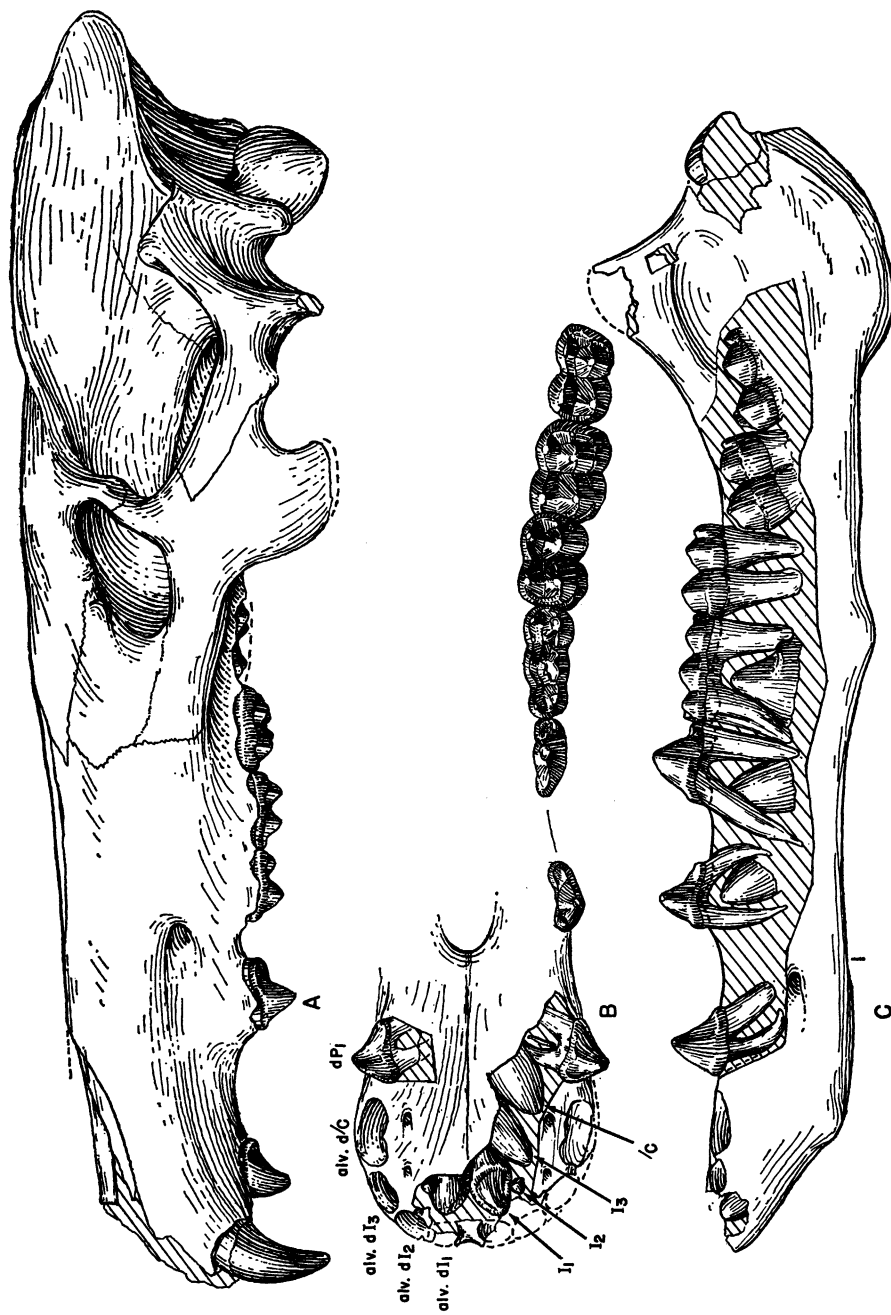


FIG. 15. *Archaeotherium trippensis*, new species, type, skull and mandible, F.A.M. No. 42937, from 1 foot above the base of the Turtle Butte Formation, at the type locality. A. Lateral view. B. Occlusal view of symphysis and left ramus. C. Lateral buccal view of right ramus, reversed. All $\times \frac{1}{4}$.

TABLE 3
MEASUREMENTS (IN MILLIMETERS) OF THE SKULL AND UPPER DENTITION OF *Archaeotherium trippensis*, NEW SPECIES (F:A.M. No. 42937)

	Length	Width
Median, occiput to anterior incisive border	(747) ^a	—
Median, foramen magnum to incisive border	(640) ^a	—
Postorbital process to tip of premaxilla (facial length)	(493) ^a	—
Postorbital process to occiput (cranial length)	256.0	—
Median, foramen magnum to postpalatine border	265.0	—
Median, foramen magnum to anterior dP ⁴	296.0	—
Median, foramen magnum to anterior dP ³	383.0	—
Median, foramen magnum to anterior dP ²	446.5	—
Median, foramen magnum to postpalatine fissure	529.0	—
Muzzle across canines (on outside)	—	145.0
Narrowest part of palatal side (mid diastema of dP ¹ -dP ²)	—	85.0
Widest part of palatal side (between jugals and condyles)	—	336.0
Diastema between dC and dP ¹	10.0	—
Diastema between dP ¹ and dP ²	53.0	—
Diastema between dP ² and dP ³	17.5	—
DC	32.0	19.3
DP ¹	32.8	19.4
DP ²	38.8	15.7
DP ³	44.1	30.8
DP ⁴	39.0	38.8
M ¹	47.8	49.0
M ²	49.2	49.3

^a The basilar and over-all skull measurements are approximate because they are based on the articulation of the mandible with the upper dentition. The fragmentary premaxilla was not measurable. The posterior edge of the lower canine occludes with the anterior edge of the upper canine. From the posterior edge of the deciduous canine to the anterior border of the symphysis the length is 80 mm., which is added to the observable measurement from the foramen magnum to the anterior border of the canine.

in the maxilla. A section removed from the maxilla shows that there was no replacement for dP¹, but germs of P²-P⁴ are present.

The symphysis was opened to show germs of an unreduced I₁, a greatly reduced I₂, and a large I₃ (fig. 15B). Three deciduous incisors were found close to the mandible, detached, but their identity is uncertain. A deciduous lower right canine was also detached. Germs of mature canines dP₁-dP₄, and germs of P₃-P₄, an erupted M₁, and germs of M₂-M₃ are present.

TYPE LOCALITY AND LITHIC UNIT: From the west end of Turtle Butte, Tripp County, South Dakota, about 1 foot above the base of the Turtle Butte Formation (fig. 2).

HYPODIGM: Type only.

DIAGNOSIS: *Archaeotherium trippensis*, new species, is the largest species of the genus. The type specimen (F:A.M. No. 42937) differs from other species of *Archaeotherium*

in having greatly reduced or vestigial second incisors in the mature dentition, above and below. In this character, *Archaeotherium trippensis* also differs from *Dinohyus hollandi* Peterson (1905), another early Miocene entelodont. The canines are relatively small, much smaller than those of *Dinohyus* which are greatly enlarged, and the enamel of the immature premolars and the mature molars is much more crenulate than in *Dinohyus hollandi* or in *Ammodon leidymanum* Marsh (1893), also from early Miocene deposits, insofar as comparisons with *Ammodon leidymanum* can be made. The type of *Ammodon leidymanum* (Y.P.M. No. 12041) consists of a detached P₄. A detached M₂ paratype was found close to the type but could not be positively identified as belonging to the type. *Ammodon leidymanum* is larger than *Archaeotherium trippensis*: in the type of *Archaeotherium trippensis*, the P₄ is 49.0 mm. in

length and 28.5 mm. in width, and, in the type of *Ammodon leidyanum*, the P_4 is 53.8 mm. in length and 33.5 mm. in width. In *Archaeotherium trippensis*, P_4 has a prominent anterior serrate ridge (fig. 14D) not present on the type of *Ammodon leidyanum*, and the crown of the heel of P_4 is recessed below the elevated rim of the cingulum. In *Ammodon leidyanum*, the heel is elevated above the cingulum.

DESCRIPTION: On the basis of size alone, *Archaeotherium trippensis* can be separated from all other species allocated to *Archaeotherium*, even if the immaturity of the type specimen (F:A.M. No. 42937) is considered. Undoubtedly, the total size of the type would have increased and some of the proportions might have changed with maturity. The

stage of dental development reached in the type specimen is ideal for morphologic study, for it is seldom possible to observe the immature and mature dental characters in one type object.

In the type of *Archaeotherium trippensis*, new species (F:A.M. No. 42937), the skull and mandible are long and shallow in comparison with their width (fig. 15A, C); the rostrum and horizontal ramus are long and slender, not greatly expanded in the area of the incisors and canines as in *Dinohyus hollandi*; and the jugal is neither extended downward nor expanded outward as in certain other entelodonts (i.e., *Megachoerus*), possibly owing to immaturity. On the inferior part of the horizontal ramus are two small bosses, one below the canine and the second

TABLE 4
MEASUREMENTS (IN MILLIMETERS) OF THE MANDIBLE AND LOWER DENTITION OF
Archaeotherium trippensis, NEW SPECIES (F:A.M. No. 42937)

	Length	Width	Depth
Posterior border of dC to anterior border of dI ₁ alveolus ^a	80.0	—	—
Diastema of dC to dP ₁	8.0	—	—
Diastema of dP ₁ to dP ₂	45.0	—	—
Diastema of dP ₂ to dP ₃	36.0	—	—
Posterior of dC to posterior of dP ₄	259.0	—	—
Center of condyle to tip of symphysis	585.0	—	—
Mandible at middle of dP ₁ to dP ₂ diastema ^b	—	—	68.8
Mandible at middle of dP ₂ to dP ₃ diastema ^b	—	—	72.5
Mandible at posterior of dP ₄ to ventralmost part of posterior boss ^b	—	—	96.0
Mandible at posterior of M ₁ ^b	—	—	77.0
Coronoid process to ventralmost extent of angle of horizontal ramus	—	—	(165.0) ^c
DI ₁ alveolus	13.5	15.5	—
DI ₂ alveolus	20.0	15.0	—
DI ₃ alveolus	24.0	16.0	—
DC alveolus	37.2	18.8	—
DP ₁	33.0	16.8	—
DP ₂	35.2	12.7	—
DP ₃	40.0	16.0	—
DP ₄	59.6	24.7	—
M ₁	47.5	35.6	—
M ₂ germ	52.2	37.7	—
M ₃ germ	51.7	32.5	—

^a The length of this part of the symphysis (80 mm.) was added to the over-all, basilar, and facial lengths of the skull (table 3).

^b The mandible, detached from the skull but embedded in the same horizontal position in the matrix, was dorsoventrally compressed. When the P_4 was removed, there was an indication that dorsoventral compression had subtracted about 10 mm. from the depth of the mandible. The measurements in this table, however, are as observed, for the compression was not uniform.

^c Parentheses around a measurement show that it was approximate.

TABLE 5

MEASUREMENTS (IN MILLIMETERS) OF *Archaeotherium trippensis*, NEW SPECIES (F:A.M. No. 42937), AND *Dinohyus hollandi* (A.M.N.H. No. 22730)

	<i>A. trippensis</i> F:A.M. No. 42937		<i>D. hollandi</i> A.M.N.H. No. 22730 ^a	
	Diameter		Diameter	
	Minimum	Maximum	Minimum	Maximum
DI ₁ alveolus ^b	13.5	15.5	10.0	12.8
DI ₂ alveolus ^b	15.0	20.0	15.0	18.5
DI ₃ alveolus	16.0	24.0	25.5	20.0
D/C alveolus	18.8	37.2	28.7	43.0
I ₁ germ	18.3	22.5	—	—
I ₂ germ	6.0	9.5	—	—
I ₃ germ	(15.0) ^c	(30.0)	—	—

^a A.M.N.H. No. 22730 is an immature specimen referred to *Dinohyus hollandi*. This specimen was collected from the Agate Springs Quarry, Harrison Formation, in southern Sioux County, Nebraska. The type of *Dinohyus hollandi* was also collected in this quarry.

^b The deciduous incisors were not in place in the symphysis, but the diameters of the alveoli show that they increased from DI₁ to DI₃ as in *Dinohyus hollandi*.

^c Parentheses indicate that the measurement is approximate.

below dP₄, which no doubt would have enlarged with age. A single mental foramen lies below dP₁.

INCISORS: The lower incisors are procumbent as in *Dinohyus hollandi*, but they differ from those of *D. hollandi* and other species of *Archaeotherium* in having greatly reduced permanent second incisors above and below. The deciduous second incisors do not reflect the vestigial condition of the permanent second incisors, which apparently were also non-functional. The deciduous canines of the type of *Archaeotherium trippensis* (F:A.M. No. 32937) are not enlarged and rounded as in *D. hollandi*, but are comparatively slender and transversely compressed.

DIASTEMATA: In both the upper and lower dentitions, immature and mature, the diastemata of *Archaeotherium trippensis*, new species, are similar to those of *Archaeotherium* species. There is one short diastema between the canine and first premolar and a long one between the first and second premolar. This condition is different from that in *Dinohyus*, in which there is a short diastema between the first and second premolars and no diastema thereafter.

UPPER DENTITION: In the type of *Archaeotherium trippensis*, new species (F:A.M. No. 42937), the molars are larger than the premolars and the enamel surface of the im-

mature premolars is noticeably crenulate, much more so than in *D. hollandi*.

Apparently dP¹ was not replaced although it is double-rooted; dP² is also double-rooted, with a prominent posterior heel; dP³ is triple-rooted, semi-molariform, with an expanded posterior heel; and dP⁴ is molariform and is the largest of the deciduous premolars. Germs of the permanent premolars show that P² and P³ are conical in shape, with serrate posterior crests, that P⁴ is transversely bilobed, each lobe having anteroposterior serrate crests, and that there is a cingulum extending around the base of the tooth from the posterior side to about midway on the lingual side. In the upper dentition, development of the premolar germs apparently proceeded from P⁴ forward, because P⁴ is most developed and would have been the first to emerge.

M¹ is molariform, with a more pronounced heel than P⁴ and with a girdling cingulum interrupted only on the lingual side. M² is also molariform, with a girdling cingulum, but has more pronounced cones than M¹. M³ had not formed in the maxilla.

LOWER DENTITION: As in the upper dentition, the molars are larger than the premolars, and there is no replacement for dP₁. A slender rootlet (fig. 15B) is situated between the two roots of the left dP₁, a struc-

ture occasionally observed in the milk dentitions of other forms. The second and third lower deciduous premolars are blade-shaped, with anteroposterior serrate edges; dP_2 has a small, sloping posterior heel and dP_3 a more prominent heel; dP_4 is trilobed, has no cingulum, and has a roughened crown surface.

P_2 and P_3 are simple cones and not fully formed but the anteroposterior borders of P_2 and the posterior border of P_3 are serrate. P_4 has a prominent anterior serrate ridge (fig. 14D), and the crown of the heel is recessed below the elevated rim of the cingulum.

The anterior and posterior crests of M_1 are not so high as in *Dinohyus hollandi* or *Ammodon leidymanum*, and the enamel surface of M_1 - M_3 is much more crenulate than in either of these. Weak anterior cingula are present on M_1 - M_2 .

The primary cones of M_1 - M_3 (paraconid, metaconid, protoconid, and hypoconid) are not so high or so pointed as in *D. hollandi* and *Ammodon leidymanum*. There are distinct postcingula on M_1 - M_3 which extend across the posterior part of each molar. These postcingula are low, broad crests and not the cone-shaped structures (or hypostylids) present in *Ammodon leidymanum* and *Dinohyus hollandi*.

MEASUREMENTS: See tables 3-5. All measurements are orthogonal projections.

INFRAORDER OREODONTA

FAMILY MERYCOIDODONTIDAE

SUBFAMILY DESMATOCHOERINAE

MEGOREODON SCHULTZ AND FALKENBACH, 1954

Megoreodon hollandi (Douglass, 1907)

TYPE: A partial skull, mandible, and postcranial elements of one individual (C.M. No. 1194) were collected by Earl Douglass in 1902 from the Canyon Ferry beds at Canyon Ferry on the Missouri River about 20 miles east of Helena, Lewis and Clark County, Montana.

DISTRIBUTION: Canyon Ferry beds at Canyon Ferry on the Missouri River, early Miocene; Monroe Creek-Harrison formations (undifferentiated) from the Tunnel Hill locality on the Ledingham ranch, Sioux County, Nebraska; Turtle Butte Formation, Turtle Butte, Tripp County, South Dakota; beds equivalent to the Monroe Creek Formation

on the east side of Porcupine Creek on the Pine Ridge Indian Reservation in Shannon County, South Dakota.

REFERRED SPECIMENS: From the Turtle Butte Formation, Turtle Butte, Tripp County, South Dakota: F:A.M. No. 42927, a partial skull with canines and P^1 - M^3 , was collected from the west end, just east of West Gap at an elevation of 2360 feet (fig. 3). The following specimens were collected from the west end of the butte (fig. 2): F:A.M. No. 42950, the right dorsal portion of a skull with M^3 , occipital region, a detached symphysis with canines, a partial pelvis, and other fragments, at an elevation of 2338 feet; F:A.M. No. 42951, the right portion of a skull with a fragmentary, undetermined molar, at an elevation of 2338 feet; F:A.M. No. 42929, a left maxilla and ramus, at an elevation of 2347 feet; F:A.M. No. 42952, a partial skull with M^1 - M^3 , a maxilla, F:A.M. No. 42934, and four rami, F:A.M. Nos. 42930, 42931, 42932, and 42933, at 2360 feet. At the gap on the west side of the east end of the butte (fig. 4), we collected a partial, dorsoventrally crushed skull with incisors, canines, and P^1 - M^3 (F:A.M. No. 42928), at an elevation of 2390 feet. The skull (F:A.M. No. 37582) described by Schultz and Falkenbach (1949, p. 131) was also collected from this same locality and elevation. (See the present paper, p. 391, footnote 1.)

From beds equivalent to the Monroe Creek Formation on the east side of Porcupine Creek on the Pine Ridge Indian Reservation in Shannon County, South Dakota: F:A.M. No. 42981, a skull and mandible, articulated, with incisors, canines, and P^1 - M^3 .¹

¹ In 1951 an oreodont skull and mandible (F:A.M. No. 42981) and other fragmentary oreodont specimens referable to *Megoreodon hollandi* were collected from the north end of the bluffs on the east side of Porcupine Creek. The skull and mandible (F:A.M. No. 42981) were collected about 80 feet below the first hard concretionary zone in a massive pink siltstone that is considered equivalent to the Monroe Creek Formation. This siltstone is well below the Harrison-like sediments and just above outcrops considered to be the upper part of the Sharps Formation. Osborn (1918, fig. 7, p. 13) published a photograph of this locality, on which he indicated the "lower Rosebud" at the base of a high bluff in the background. The skull and mandible (F:A.M. No. 42981) were collected from the base of this bluff from beds considered by Macdonald (1963, p. 154) and the present writers equivalent to Monroe Creek.

DISCUSSION: The nearly complete and uncrushed skull (F:A.M. No. 42927) from the Wewela fauna at the type locality of the Turtle Butte Formation (fig. 2) is very similar to skulls in a suite of specimens from the upper part of the Monroe Creek Formation in southern Sioux County, Nebraska. These specimens came from the Tunnel Hill locality on the Ledingham ranch near the center of sect. 29, T. 25 N., R. 55 W., Sioux County, Nebraska. The exact stratigraphic zone was difficult to determine, because, at this place, the specimens were collected from a zone in the middle of the Monroe Creek-Harrison sequence. Schultz and Falkenbach (1954, pp. 173-177) referred this suite of specimens, which included six skulls, five with mandibles, to *Megoreodon grandis loomisi*, a "geologic variety" of a smaller form of *M. grandis* from the Monroe Creek Formation.

In the same paper Schultz and Falkenbach (1954, p. 169) placed *Promerycochoerus hollandi* in synonymy with *Megoreodon grandis* on the basis that sexual variation would account for the difference between them. However, the 17 specimens from the Wewela fauna fall more easily into *M. hollandi* than *M. grandis* group. The wide skull and heavy jugal of *M. hollandi* are characters shown in all *Megoreodon* specimens from Turtle Butte and in the suite of specimens from the Ledingham ranch in Sioux County, Nebraska. We therefore propose to retain *M. hollandi* as a taxon distinct from *M. grandis*.

The exact age of the beds from which the types of *M. grandis* and *M. hollandi* were collected is not known. Schultz and Falkenbach (1954, pp. 170, 172) considered the lower Miocene beds in the Canyon Ferry area of Montana about equal to the Gering, whereas Thorpe (1937, p. 124) considered these beds equal to the Harrison. The Wewela fauna closely resembles the fauna of the Tunnel Hill locality on the Ledingham ranch where the lithic sequence can be shown to be upper Monroe Creek or the lower part of the Harrison. *Megoreodon hollandi* is the most frequently occurring group in the Wewela fauna, and *Megoreodon* is relatively common in Monroe Creek faunas as well. So far *Megoreodon* has never been recorded from the Brule Formation nor from the deposits above the Harrison Formation.

MEASUREMENTS: Measurements of the types of *M. grandis* and *M. hollandi* and referred examples of *M. hollandi* from the Turtle Butte and the Ledingham ranch are given in table 6.

SUBFAMILY MERYCHYINAE

Cf. *Merychys siouxensis*

REFERRED SPECIMEN: A left M^2 (F:A.M. No. 42945) was collected from the type locality of the Turtle Butte Formation, 40 feet below the contact of the Turtle Butte Formation with the Valentine Formation (fig. 3).

REMARKS: The single molar (F:A.M. No. 42945) is very close to the size of specimens referred to *Merychys siouxensis* Schultz and Falkenbach (1947, p. 223-227, fig. 17).

In 1941 a block containing four associated skulls and mandibles (F:A.M. Nos. 44606A-D) was collected from the vicinity of the Tunnel Hill locality on the Ledingham ranch from massive gray consolidated sand and assigned at the time of the collection to the Harrison Formation.

The oreodonts represented in the Wewela fauna, *Megoreodon hollandi* and cf. *Merychys siouxensis* are also those represented in the Tunnel Hill locality on the Ledingham ranch.

SUBORDER TYLOPODA

FAMILY CAMELIDAE

Subfamily Indet.

MATERIAL: A partial left M_3 (F:A.M. No. 42938), with the second lobe and talonid preserved, is the tenuous evidence on which the presence of a small camelid (about the size of a large poebrothere) is based. The specimen (F:A.M. No. 42938) was collected from the type locality of the Turtle Butte Formation, 30 feet below the contact of the Turtle Butte and Valentine formations (fig. 2).

REMARKS: The partial M_3 (F:A.M. No. 42938), so far as any comparisons can be made, compares in size with the small form "*Protomeryx*" *leonardi*¹ Loomis (1911) and two rami (F:A.M. Nos. 36796 and 41949)

¹ We use the generic allocation "*Protomeryx*" with reservation. As McKenna (1966, pp. 2-3) pointed out, the type species, *Protomeryx halli*, rests upon inconclusive evidence.

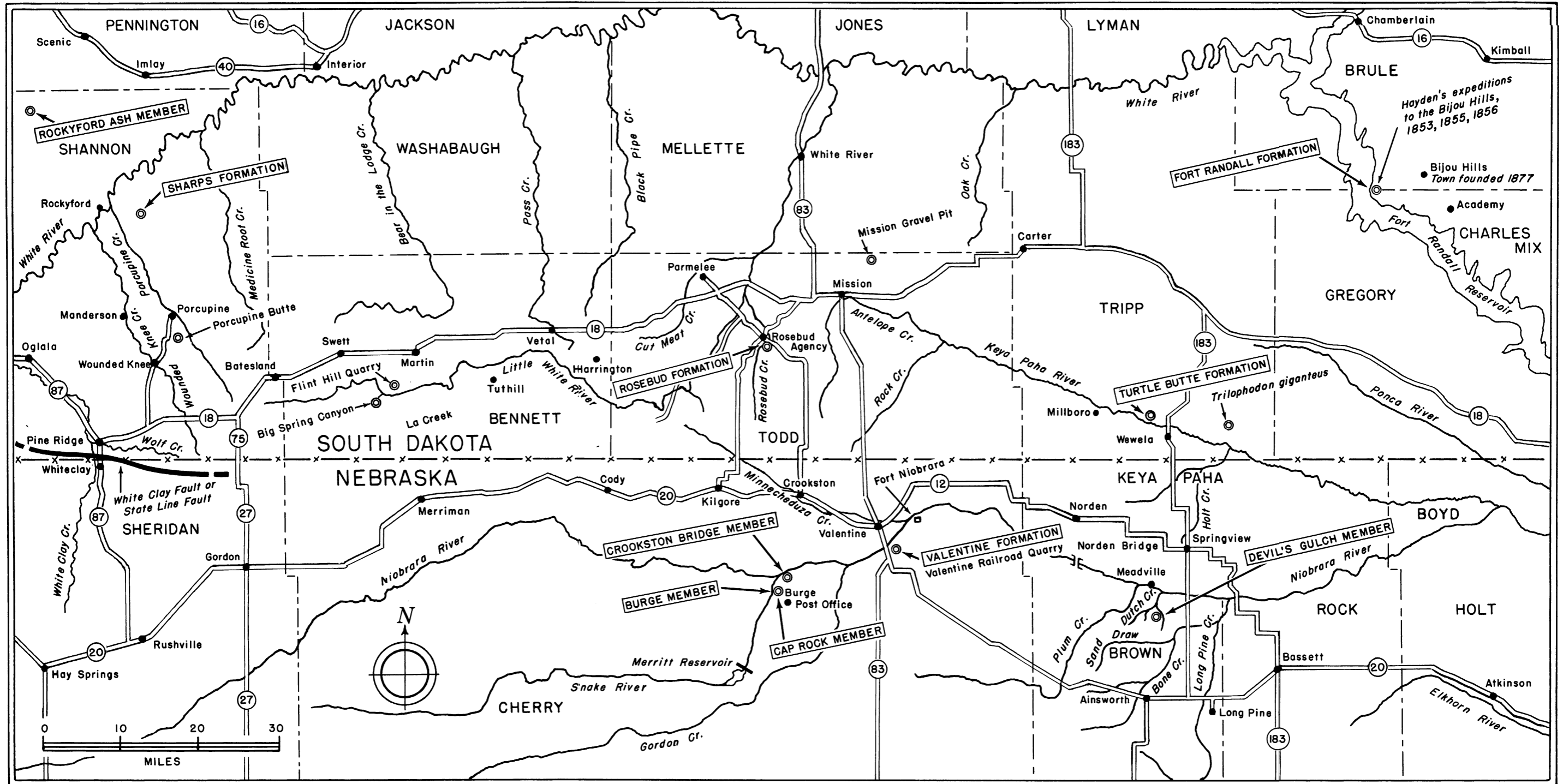


FIG. 16. General index map of south-central South Dakota and north-central Nebraska. The boxed names signify geological type localities.

referable to it from Monroe Creek deposits. However, the M₃ (F:A.M. No. 42938) from the Turtle Butte Formation could be assigned to *Dyseotylopus* or a small species of *Miotylopus* as well.

Specimens referable to "*Protomeryx*" *leopardi* have been collected from the Monroe Creek-Harrison sequence in the vicinity of the Tunnel Hill locality at the Ledingham ranch in southern Sioux County, Nebraska.

THE PALEOECOLOGY OF THE WEWELA FAUNA

The fauna of the Turtle Butte Formation, like that of the Monroe Creek Formation, is very scanty (table 1). Nothing has been

interpreted from the deposits themselves that would give an insight into the climate of the area in Turtle Butte time, so the few generalizations that can be made are based on the fossils.

That the climate was mild, probably warm temperate, can be hypothesized by the presence of large chelonians and the large lizard, *Glyptosaurus*. As a broad generalization, it seems safe to assume that during the time of deposition of the Turtle Butte Formation, the environment was warm, perhaps quite humid, with streams and lakes, and enough foliage to support sufficiently large numbers of herbivores to support, in turn, several kinds of carnivores.

TABLE 6
COMPARATIVE MEASUREMENTS^a (IN MILLIMETERS) OF SKULLS OF *Megoreodon grandis*
AND *Megoreodon hollandi*

	C.M. No. 990	C.M. No. 1194	F:A.M. No. 42927 ^b	F:A.M. No. 45437 ^c	F:A.M. No. 45436 ^c
Stage of wear of teeth	(w+) ^d	(w±)	—	—	—
Length (including supraoccipital crest and incisors)	391.0	—	395.7	(382.0) ^e	—
Basal length (from anterior notch of foramen magnum to posterior base of I ¹)	327.0	327.0	336.4	307.0	—
Width (maximum)	189.0	243.0	244.0	(244.0)	—
Width of brain case (maximum)	73.0	92.0	82.0	87.0	—
Width, interorbital (minimum)	83.0	99.0	92.7	91.0	—
Distance from anterior rim of orbit to supraoccipital crest	207.0	—	223.5	—	—
Length of nasals	—	—	164.0	160.5	—
Width of muzzle at infraorbital foramina	89.0	96.0	88.0	(90.0)	—
Width across canines	71.0	97.0	82.4	89.2	—
Length, C/-M ³ inclusive	199.0	191.5	187.0	193.6	208.0
Length, P ¹ -M ³ inclusive	176.0	162.5	156.0	162.4	178.2
Length, P ¹ -P ⁴ inclusive	83.0	78.0	76.0	83.3	86.4
Length, M ¹ -M ³ inclusive	96.0	88.5	84.5	82.3	94.8
Width of M ³ (maximum)	34.0	31.0	30.4	30.0	30.6
Depth of malar below orbit	—	—	43.0	44.2	—

^a The points of measurements and the measurements for the type of *M. grandis* (C.M. No. 990) and the type of *M. hollandi* (C.M. No. 1194) were taken from Schultz and Falkenbach (1954, table 1, p. 166). These two specimens were not available at the time of this study.

^b F:A.M. No. 42927 was collected from the Turtle Butte Formation, Tripp County, South Dakota.

^c F:A.M. Nos. 45437 and 45436 were collected from the upper part of the Monroe Creek Formation on the Ledingham ranch in southern Sioux County, Nebraska.

^d The stage of wear is after Schultz and Falkenbach (1941, 1947, 1949, 1954), given by them as "(t), immature; (m), mature; (w), worn." No explanation was made of the plus (+) signs.

^e Parentheses around a measurement indicate that it is approximate.

FAUNA OF THE BURGE MEMBER OF THE VALENTINE FORMATION
OF TURTLE BUTTE

The fauna from deposits here considered equivalent to the Burge Member of the Valentine Formation is easily duplicated in collections from the Burge Quarry (type locality of the Burge Member and fauna) or from deposits recognizable as the Burge Sands in Brown and Cherry counties, Nebraska.

CLASS MAMMALIA

ORDER CARNIVORA

FAMILY CANIDAE

?SIMOCYONINAE INCERTAE SEDIS

ISCHYROCYON MATTHEW, 1904

MATERIAL: A partial left humerus (F:A.M. No. 42967) and a calcaneum (F:A.M. No. 42968) were collected from the east side of West Gap, Turtle Butte, from beds equal to the Burge Member of the Valentine Formation.

REMARKS: The middle part of a left humerus (F:A.M. No. 42967), with an entepicondylar foramen and part of the deltoid ridge preserved, indicates the presence of a heavy-limbed carnivore. The diameter of the shaft at the distal end of the deltoid ridge is 41.0 mm. This specimen is quite comparable to *Ischyrocyon* examples (F:A.M. Nos. 68158 and 68158A) from the Burge Quarry in Cherry County, Nebraska.

The calcaneum (F:A.M. No. 42968) is closely comparable to calcanea of *Ischyrocyon* from the Burge Quarry but is also comparable in size with that of a medium-sized individual of *Amphicyon*. The tuber calcis of F:A.M. No. 42968 is eroded, and the length can only be estimated: greatest length, about 90.0 mm.; greatest width, 44.0 mm.; greatest depth, 40.0 mm.

ORDER PROBOSCIDEA

FAMILY GOMPHOTHERIIDAE

Eubelodon morrilli Barbour, 1913

TYPE: U.N.S.M. No. 1-16-5-13 is a skull, mandible, and pelvis, collected from the Burge Member of the Valentine Formation at Devil's Gulch in Brown County, Nebraska.

REFERRED SPECIMEN: An upper tusk (F:A.M. No. 42969) was collected from the cor-

related Burge Member at Turtle Butte on the first exposure east of West Gap.

REMARKS: The upper tusk (F:A.M. No. 42969), with a wedge-shaped tip, compares favorably with *E. morrilli* Barbour, 1913. *Eubelodon morrilli* had upper tusks, but the long, straight, and massive mandible was tuskless. The upper tusk (F:A.M. No. 42969) from Turtle Butte is long, straight, and measures 1670 mm.

Frick (1933, fig. 15) figured two tusks of *Eubelodon morrilli* (F:A.M. Nos. 25707 and 25708) from the Burge Member in the vicinity of Ainsworth, Nebraska. Osborn (1936, pp. 606-607) also figured one of these tusks (F:A.M. No. 25708).

An isolated dentition, one tooth (F:A.M. No. 42973), a calcaneum (F:A.M. No. 42970) and a metacarpal (F:A.M. No. 42972), collected from West Gap of Turtle Butte from the Burge Member, are here referred only to the Proboscidea.

ORDER PERISSODACTYLA

FAMILY EQUIDAE

Three groups of horses are recognized from detached teeth and fragmentary material in the Burge fauna at Turtle Butte. *Pseudhipparion retrusum*¹ occurs more frequently than any other equid taxon, although all are rare. A left P² and a lower molar (F:A.M. No. 42974) are referable to *P. retrusum*. Three other detached molars (F:A.M. No. 42975), one of which bears a resemblance to a molar of *Calippus*, were collected, but, as evidence

¹ In 1904 Ameghino (p. 262) established the genus *Pseudhipparion* on Cope's species *retrusum*, which was based on two upper molars exhibiting protocones free from protoloph and united to the hypocones. One of the dominant species in the Burge fauna is *P. retrusum*; it is easily recognized, and the generic name applied to it is *Pseudhipparion*. Ameghino undoubtedly was applying generic names in an irresponsible manner when he established a new genus on specimens he knew only from figures, but he did cite a species and not an object.

In 1955 Quinn proposed the name *Griphippus* for the smaller "*Hipparion*" *gratum*, which is one of the dominant and later-occurring equids in lower Ash Hollow time. *Griphippus gratus* is seldom, if ever, found in the Burge zone or earlier in the Valentine. However, there is no question that these two taxa are very closely related.

is inconclusive, we are maintaining these under *P. retrusum* also. *Pliohippus pernix* is represented by an upper molar (F:A.M. No. 42976). A lower molar and an M¹ (F:A.M. No. 42977) are consonant with these teeth in "*Hipparion*" *occidentale*.

FAMILY RHINOCEROTIDAE

SUBFAMILY TELEOCERATINAE

Teleoceras sp.

MATERIAL: A partial skull (F:A.M. No. 42963), with P³-M³ on the right side and P⁴-M³ on the left, lacking the premaxilla and the anterior part of the nasals, was collected on the east side of West Gap from the Burge Member, immediately below its contact with the Cap Rock Member (fig. 3).

DESCRIPTION: The skull of the Turtle Butte specimen (F:A.M. No. 42963) has a widely rounded occipital region and a nearly horizontal dorsal outline with no cranial flexing. In these respects, it is similar to *Teleoceras major*, but has less hypsodont cheek teeth, and is in general smaller than *T. major* (see measurements).

DISCUSSION: A generic and specific review of all the Teleoceratinae is long overdue, but, until such a study is forthcoming, we shall not introduce a new specific (or subspecific) name for the specimen from the Turtle Butte Burge.

The genus *Teleoceras* is based on *Teleoceras major* Hatcher (1894a), the type of which is a partial skull and lower jaw of an old individual, which were collected by Hatcher (1894a, p. 149) during the Princeton Expedition of 1893. Hatcher (1894a, p. 149) stated that the type specimen came from the "Loup Fork Beds of Sheridan County, Nebraska." In a second notice Hatcher (1894b, fig. 2, p. 247) described the type locality, which was later relocated and proved to be what is known to the Frick Laboratory as "Turtle Canyon." Turtle Canyon is on the south side of the Niobrara River in the SW. $\frac{1}{4}$, sect. 23, T. 29 N., R. 54 W., Sheridan County, Nebraska. Deposits from which the type of *Teleoceras major* was derived are here considered as equivalent to the Cap Rock Member of the Ash Hollow Formation.

Osborn (1898) began the vogue for com-

binning Hatcher's genus *Teleoceras* with Cope's species *fossiger* and applied that combination to the short-limbed rhinoceroses from middle Pliocene deposits in Kansas.

Osborn did not, however, prove that *Teleoceras major* was a synonym of Cope's species, which was a syntypic series of four skulls originally described under the name *Aphelops fossiger*. The series of rhinoceros skulls and postcranial elements that Osborn considered to be *Teleoceras fossiger* was collected by the American Museum expedition in 1894 and came from the Phillips County Quarry near Long Island, Kansas. The material was derived from beds that we believe are Hemphillian. The type of *Pliohippus nobilis* Osborn (1918, pp. 160-161, fig. 128) also was collected on the same expedition from Long Island, Phillips County, Kansas. Although Osborn gave no quarry data in his type description, we assume that the type of *P. nobilis* came from the same quarry as the composite skeleton on which Osborn based his concept of *Teleoceras fossiger*.

The type of *Philohippus nobilis* (A.M.-N.H. No. 2668) is closely comparable to specimens in the Frick Collection from beds that are middle Hemphillian. We contend that the rhinoceros that Cope called *Aphelops fossiger* occurred later in time than, and is specifically different from, *Teleoceras major*.

The specimen from Turtle Butte (F:A.M. No. 42963) is comparable in size and in characters to a complete skull from the Burge Quarry (F:A.M. No. 42978) which has the nasal horn preserved (lacking in the specimen from Turtle Butte). Both specimens have a widely rounded occipital region, a horizontal dorsal outline with no cranial flexing, and subhypsodont cheek teeth. Both specimens are smaller and have less hypsodont cheek teeth than the type of *Teleoceras fossiger* (table 7).

Rhinoceros remains are rare in the Burge Member of the Valentine Formation. From the Burge Quarry, which is rich in most large mammalian remains, only one mature skull of rhinoceros, *Teleoceras* sp. (F:A.M. No. 42978), is in the Frick Collection. In northern Nebraska, in late Valentine and early Ash Hollow time, *Teleoceras* was contemporaneous with *Aphelops*, a hornless rhinoceros with low-crowned cheek teeth.

TABLE 7
MEASUREMENTS (IN MILLIMETERS) OF THE SKULL AND DENTITION OF THE TYPE OF
Teleoceras major AND OF *Teleoceras* SP.

	Type of <i>T. major</i> ^a	F:A.M. No. 42963	F:A.M. No. 42978
Length, tip of nasal horn to behind posttympanic process	585.0	—	535.0
Width, in front of zygoma	210.0	(183.0) ^b	187.0
Length of horn beyond end of nasals	28.0	—	—
Diameter of horn	41.0	—	39.0
Length of molar dentition	158.0	157.0	159.0
Diameter of M ²	69.0	71.0	74.0
Anteroposterior length of M ²	55.0	57.0	57.0

^a The points of measurements and the measurements for the type of *Teleoceras major* are those given by Hatcher (1894b, pp. 243, 244).

^b An approximate measurement is shown in parentheses.

ORDER ARTIODACTYLA

FAMILY CAMELIDAE

SUBFAMILY CAMELINAE

Procamelus sp.

MATERIAL: A partial left ramus (F:A.M. No. 42964), which has an alveolus for dP₂ and roots and partial crowns for dP₃–dP₄, was collected at the east side of West Gap, Turtle Butte, from the Burge Member.

REMARKS: This ramus matches referred specimens of *Procamelus* from the Burge Quarry, Cherry County, Nebraska, and is particularly comparable to the immature mandible (F:A.M. No. 40614) from the latter site. Numerous examples of *Procamelus* from the Burge Quarry make this allocation possible.

Because of the small size of the ramus (F:A.M. No. 42964), no comparison can be made with *Aepycamelus*. Also, the ramus cannot be referred to rami of *Protolabis*, because the premolars of immature rami of *Protolabis* are more reduced than those of *Procamelus*. The three most common taxa of the Camelidae in the Burge fauna are

Aepycamelus, *Protolabis*, and *Procamelus*. Two of these, *Aepycamelus* and *Procamelus*, are present in the Burge Member at Turtle Butte.

MEASUREMENTS: In F:A.M. No. 42964 from Turtle Butte, the length from dP₂ to dP₄ (alveoli) measures 55.3 mm.; in F:A.M. No. 40614 from Burge Quarry it is 50.6 mm.

SUBFAMILY AEPYCAMELINAE

AEPYCAMELUS MACDONALD, 1956

MATERIAL: F:A.M. No. 42962 represents the proximal end of a very large fused radius and ulna collected at the east side of West Gap, Turtle Butte, from the Burge Member.

REMARKS: Examples of *Aepycamelus* have been reported from Pliocene beds in north-eastern Colorado (Matthew, 1901), Upper Snake Creek beds in Sioux County, Nebraska (Matthew and Cook, 1909), and from the Truckee Formation of western Nevada (Macdonald, 1956).

MEASUREMENTS: The greatest transverse width of the proximal end of the radius and ulna is 85 mm.

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