

TERTIARY STRATIGRAPHY AND  
THE FRICK COLLECTION OF  
FOSSIL VERTEBRATES FROM  
NORTH-CENTRAL NEBRASKA

MORRIS F. SKINNER AND F. WALKER JOHNSON

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## ABSTRACT

Late Tertiary Valentine and Ash Hollow formations of the Ogallala Group in north-central Nebraska contain two previously unnamed fossiliferous ash-bearing members. These, with four published members, provide a stratigraphic framework for large collections of fossils in the Frick Collection in AMNH and other institutions.

The Cornell Dam Member (New) in the basal Valentine Formation has salient lithic features and geologic relationships not found in other members of the Valentine. Basal channel sand disconformably overlying the Rosebud Formation contains macro- and microvertebrate fossils (Norden Fauna, New) that also show the ecological and faunal distinction of this member. Fission track dates suggest that Valentine sediments spanned one and perhaps three million years.

The Merritt Dam Member (New), of late Clarendonian to late Hemphillian age, disconformably overlies the Cap Rock Member of the referred Ash Hollow Formation. The Merritt Dam Member is less cliff forming than the Cap Rock Member, contains more volcanic ash and local channel and pond sediments. Tectonic readjustment caused deep channel erosion through the Ogallala into

Arikaree rocks on the east flank of the Chadron Arch and eastward into the Cap Rock Member and the Valentine Formation. Sediments filling some of these channels contain vertebrate fossils overlain by vitric tuffs with a fission track date of  $9.5 \pm 0.8$  Ma.

The paleogeomorphology of the Ogallala Group and its depositional framework is the product of overlapping alluvial fans of at least three paleo-drainage systems which filled pre-existing valleys and spread sediments over a vast Great Plains area in Nebraska and South Dakota. In north-central Nebraska widespread aggradation and two short periods of degradation occurred during the Valentinian. Gradual aggradation during the early Clarendonian was followed by intermittent aggradation and degradation during the late Clarendonian and Hemphillian.

The stratigraphic allocation and history of 98 collecting localities and documentation of 90 holotypes of fossil vertebrates and 13 plants provide a firm base for continued research.

The principal aquifer in the Ogallala is the Crookston Bridge Member of the Valentine Formation.

## INTRODUCTION

In the early 1900s Childs Frick envisioned collecting large representative samples from every known late Tertiary vertebrate fossil-bearing area in North America and other parts of the world. By 1927 his field parties had been at work in the Barstow Formation in southern California for 10 years and in the Santa Fe Group in New Mexico for five. By 1928 his collectors were deployed to western Nebraska and northern Arizona. Most of the known late Tertiary areas of the continental United States and some foreign countries (Ecuador, Honduras, and China) were to be explored and worked during the next 38 years.

Childs Frick's introduction to north-central Nebraska was in 1927 when he contributed to the purchase of a collection made by Morris F. Skinner and James H. Quinn of Ainsworth, Nebraska for the American Museum of Natural History. After receiving additional fossils from these men, Frick wrote to Skinner on July 28, 1928:

I am pleased to have yours of July fourth and

wish to thank you for the little packet of fossils safely received. I am more than pleased to learn that you are having the assistance of a University party in working out the stratigraphy of the home section. Of course, I should appreciate a copy of the final report. You state that the deposit is resting on the Pierre Shale and approximates a depth of 400 feet—how much of this seems to represent the equivalent of your fossil horizon?

In the packet I find a single upper molar of a small *Hipparion*, a partial and considerably worn lower series of perhaps the same species, and the mandibular symphysis of a slightly larger horse. In response to your inquiry I am enclosing a rough list of the genera represented in the collection you sent us last fall. The tagging of fragmental material with specific names is always a questionable proceeding and more so when data as to the exact horizon of the find is in question. Modern paleontology must necessarily demand something better than the old. While a collection such as you sent us is of great interest in indicating the occurrence of certain forms at Ainsworth, the present purposes of



study demand large collections where there is some opportunity to determine whether characters are specific or merely those of individual variation. Large collections from a few representative areas, which we might call standard or type areas, are much needed. For some years past we have been in the process of securing such collections from Miocene deposits in the Mohave Desert, California, and Miocene and Pliocene deposits in the vicinity of Santa Fe, New Mexico, the results carefully tagged as to horizon and preserved by most modern methods. The Pliocene deposit at Ainsworth may well be worthy of similar investigation. Should you be interested in undertaking such work for us, we might be able to arrange the same to the benefit of all concerned.

With Frick's support and direction Skinner has continued to follow the original plan for more than 53 years.

The chief purpose of this paper is to present a stratigraphic framework for the late Tertiary rocks in north-central Nebraska. This will provide a geologic base for the study of thousands of specimens in the Frick Collection and those in other institutions. Other objectives are: (1) to place local stratigraphic sections and fossil-bearing sites within that framework; (2) to describe two new stratigraphic fission track dated members in the Valentine and Ash Hollow formations of the Ogallala Group; (3) to document the stratigraphic positions and localities from which holotypes and important faunal assemblages have been collected; and (4) to show on cross sections along the Niobrara River the relationships of the Valentine and Ash Hollow formations to older and younger rocks.

Correlations are based on more than a half-century of field observations of the gross lithology of outcrops showing the pattern of sedimentation of late Tertiary rocks along the Niobrara River and its tributary drainages. These field studies are reinforced by familiarity with the collections of vertebrate fossils found in the sediments and by a limited number of fission track dates. Treatment of faunas is limited, in general, to selected published elements of the fossil assemblages from the stratigraphic units discussed here. Detailed or comprehensive studies of the faunas in the large collections from this area remain a challenge for others to pursue.

Skinner's work has been guided by the col-

lecting procedures and documentation mentioned in Childs Frick's letter. This work has consistently emphasized the need for determination of the lithostratigraphic position of the fossils in the geologic section and the exact geographic location of the collecting sites.

The gross lithology of local geologic sections is shown on a series of cross sections (figs. 30–40) along the Niobrara and Snake rivers from Sheridan County eastward across Cherry, Keya Paha, Brown, and Boyd counties. A section transverse to the Niobrara River trends northwestward from westernmost Cherry County to Porcupine Butte, South Dakota. Others trend northward from tributary creeks south of the river in Brown County and through Keya Paha County into southeastern South Dakota. Several sections show details of the *Aletomeryx* Quarry area in western Cherry and eastern Sheridan counties, the vicinity of the mouth of Bear Creek, and the Xmas-Kat quarries area. The location of the sections and quarries is shown on a series of maps (figs. 2, 16, 18–29).

The sections were measured by hand level, starting at water level on streams and measuring to the top of the nearest hill where possible. Errors are believed to be less than 5 percent within a contour interval. Elevations were extrapolated from USGS topographic sheets as they became available. These and USDA photographs with plots of fossil quarries are in the Department of Vertebrate Paleontology Archives in the American Museum of Natural History. Although this effort has not been completely successful (much of the early collecting was done before adequate maps were available) most sites are located accurately. During the late 1960s and 1970s both of us have re-examined most of the faunal collecting sites.

The location of 98 fossil quarries and significant collecting sites is described, including our interpretation of the stratigraphic position of the sites. Many other locations from which a single specimen or a few fossils were collected are listed in the Frick records as "Prospecting Localities." Fossils from these localities are generally referred to a specific position in the local stratigraphic section within the regional framework presented in this paper.

To enhance the usefulness of the collec-



tions an effort has been made to determine the precise lithostratigraphic and geographic position for holotypes. The lack of documentation by some collectors has made this difficult, particularly for types in older collections. Nevertheless, holotypes of 90 vertebrate fossils and 13 fossil plants are listed for which documentation has been established. This improves the value of existing collections to stratigraphy and paleontology and adds credibility to the use of fossil types and associated specimens as benchmarks in faunal, ecologic, and stratigraphic interpretations.

The geologic units emphasized in this study span about six million years according to isotopic dates thus far known. During this time a blanket of late Tertiary sediments of the Valentine and Ash Hollow formations of the Ogallala Group was deposited across north-central Nebraska and south-central South Dakota (figs. 1, 41).

#### ACKNOWLEDGMENTS

We are deeply indebted to the late Mr. Childs Frick for his patronage and unflagging interest in the fossil beds along the canyons of the Niobrara River. We also acknowledge our great debt to the many field assistants who labored in these canyons to make a great collection.

During the 1970s Dr. Richard H. Tedford visited most of the Frick collecting sites along the river to familiarize himself with the study area. His knowledge of the stratigraphic and paleontological problems has made his advice and assistance particularly helpful in the presentation of this report. Dr. Malcolm C. McKenna, who urged preparation of this paper, read the manuscript, and provided valuable suggestions. Dr. Michael R. Voorhies, University of Nebraska State Museum, and Dr. Robert J. Emry, National Museum of Natural History, Smithsonian Institution, spent many hours critically reading the manuscript, much of which was detailed data documenting geologic and geographic sites of the fossils. Their opinions are highly valued as both are familiar with the geology and faunas of north-central Nebraska.

We gratefully acknowledge the invaluable contributions of Mrs. Shirley M. Skinner who

has been intimately involved with the field investigations during a career of collecting in north-central Nebraska. Her enduring patience, advice, and assistance have been of great value in the preparation of this paper.

Messrs. Mylan Stout and Lloyd Tanner, University of Nebraska State Museum provided pertinent geographic and geologic data concerning specimens. Dr. Robert J. Diffendal, Jr., University of Nebraska Conservation and Survey Division, furnished information on the location of ash beds in the Ash Hollow area. Dr. Robert Evander made helpful suggestions concerning the area in which he worked and The Nature Conservancy kindly furnished maps showing the location of their lands along the Niobrara River.

Special thanks are due to Mr. Raymond J. Gooris for his skillful preparation of the geologic sections, maps, and correlation charts; and to Exxon Corporation for a grant from their Community Services Fund to help defray drafting costs. The presentation of this report depended largely on these illustrations. We are grateful to Miss Barbara Werscheck for expediting department transactions, to Miss Charlotte Holton for library assistance, and to Mrs. Alejandra Lora for typing the manuscript.

Throughout the many years of fieldwork along the Niobrara River and adjacent areas we have received warm hospitality and friendship from the landowners. Many landowners of the 1920s and 1930s are gone, but those who replaced them have continued to extend every courtesy and assistance needed for our study. It would require an extensive compendium to name the former and present landowners who gave access to their property.

#### FIGURES

Since an illustration often conveys more information than a thousand words it is anticipated that the figures will be the most used part of this paper. Figures 1 and 2, pages 222–225, provide the regional geological setting of the area covered and a key to location of detail maps and cross-sections. Figure 3, page 230, provides a guide to the position of fossil quarries in the geologic section. Figure 4, pages 240–246, traces the development of

geologic nomenclature in the Ogallala Group of north-central Nebraska.

Figures 5–8, beginning on page 250, illustrate the lithostratigraphic relationships of the type section and the lithology of several key localities in the Cornell Dam Member of the Valentine Formation. Figures 9–12, beginning on page 272, provide a map and photos of the Valentine quarries area and a geologic section of Railway Quarry “A.” Lithologic symbols used in this paper are on figure 10.

Fission track dates and other relationships between the type sections of the Ogallala and Ash Hollow in the South and North Platte valleys and the geologic section in north-central Nebraska are on figure 13, page 294. Figure 14, page 300, is a contour map on the base of the Ash Hollow in northern Nebraska.

The type section of the Burge, Cap Rock and Merritt Dam Members and the Davis Ash is illustrated on figure 15, page 304. A map and cross-section in the Xmas-Kat quarries area are shown on figures 16–17.

Figures 18–29 are detail maps showing the location of fossil quarries and geologic sections in areas covered by this paper. Numbers in circles provide a key to identity of fossil quarries listed on page facing figure 3. Other numbers identify the exact location of most geologic sections that are plotted on the cross-sections. Detailed maps were prepared from U.S. Geological Survey Topographic Quadrangles.

Figures 30–40 are cross sections extending from Porcupine Butte, South Dakota, south-eastward to the Niobrara River, Cherry County, Nebraska; then eastward to the vicinity of Long Pine, Brown County, Nebraska; and northward to the type locality of *Tri-*

*lophodon giganteus* and Turtle Butte in Tripp County, South Dakota.

Figures 41 and 42 contain a geologic map, show the major structural features of Nebraska and adjacent areas, and the paleo-drainage systems postulated in the Ogallala Group.

ACRONYMS, ABBREVIATIONS AND STRATIGRAPHIC SYMBOLS

- ACM, Amherst College Museum
- AMNH, American Museum of Natural History
- ANSP, Academy of Natural Sciences of Philadelphia
- CM, Carnegie Museum
- CMNH, Colorado Museum of Natural History
- F:AM, Frick Collection, American Museum of Natural History
- FMNH, Field Museum of Natural History
- FMP, Field Museum Paleontology
- MSU, Michigan State University and MSU-VP, Michigan State University, Vertebrate Paleontology
- NMNH, National Museum of Natural History
- SDSM, South Dakota School of Mines
- SDGS, South Dakota Geological Survey
- UCMP, University of California Museum of Paleontology
- UMMP, University of Michigan Museum of Paleontology
- USGS, United States Geological Survey
- UNSM, University of Nebraska State Museum
- USNM, United States National Museum (See also NMNH)
- USDA, United States Department of Agriculture
- YPM, Yale Peabody Museum

OTHER ABBREVIATIONS

- F, Fauna or f, fauna
- Fm., Formation
- L.F. or l.f., Local Fauna or local fauna
- Ma, Mega anni or m.y., million years
- Mbr., Member

STRATIGRAPHIC SYMBOLS

<u>Symbol</u>	<u>Age</u>	<u>Formation</u>	<u>Member</u>
Qp	Pleistocene		
Qpk	Pleistocene	Keim	
Qpl	Pleistocene	Long Pine	
Qpd	Pleistocene	Duffy	
Qpp	Pleistocene	Pettijohn	
Tah	Tertiary	Ash Hollow	
Tahm	Tertiary	Ash Hollow	Merritt Dam
Tahc	Tertiary	Ash Hollow	Cap Rock



<u>Symbol</u>	<u>Age</u>	<u>Formation</u>	<u>Member</u>
Tv	Tertiary	Valentine	
Tvb	Tertiary	Valentine	Burge
Tvdg	Tertiary	Valentine	Devil's Gulch
Tvcb	Tertiary	Valentine	Crookston Bridge
Tvcd	Tertiary	Valentine	Cornell Dam
Tr	Tertiary	Rosebud	
Trw	Tertiary	Runningwater	
Tm	Tertiary	Marsland	
Th	Tertiary	Harrison	
Tmc	Tertiary	Monroe Creek	
Tg	Tertiary	Gering	
Tb	Tertiary	Brule	
Tc	Tertiary	Chadron	

## LOCATION AND EXTENT OF AREA

Physiographically, the study area lies within the Great Plains province in north-central Nebraska and adjacent south-central South Dakota (fig. 1). It extends in an east-west direction about 185 mi. along the Niobrara River and its tributaries, from near Naper (Long. 99°W) in Boyd County, Nebraska, westward to western Sheridan County, Nebraska (Long. 102°45'W) and northward to Porcupine Butte, Shannon County, South Dakota (fig. 2). Dune sand hills stabilized by prairie grasses predominate on both sides of the Niobrara River from the east Sheridan County line eastward to near the town of Valentine, Nebraska, then continue eastward south of the Niobrara River to the mouth of Pine Creek, Brown County, Nebraska, where they shift southeastward. Tableland with only superficial sand and soil cover predominates north of the Niobrara River eastward from Valentine to beyond Naper.

Degradation by the Niobrara River after Blancan time created an east-west slash across the area forming north-south headward eroding canyons more than 200 ft. deep in many places. Skinner and Hibbard (1972, fig. 3) showed a maximum valley depth of 475 ft. south of Springview, Nebraska, on Highway 183. Elevations range from 1677 ft. at the river level south of Naper to 3736 ft. on the river near Paleo Quarry south of Hay Springs, Sheridan County, Nebraska. The average river gradient from south of Naper to near the Paleo Quarry is 11 ft. per mi. Over much of the area it is a gently flowing stream with a

gradient of 9 ft. per mi. that is occasionally interrupted by rapids over erosion resistant rocks. The gradient increases to 18 ft. per mi. on the east flank of the Chadron Arch.

Along the drainages the most prominent topographic features are the canyon rims that are held up by vertical sandstone cliffs 25 ft. or more in height. Below these cliffs are steep talus-covered slopes that generally support a growth of prairie grasses, yucca, and ponderosa pine.

## HISTORY OF COLLECTING

Interest in fossils in northeastern and north-central Nebraska dates back to at least 1796 when James Mackay made a reconnaissance through that area. Mackay (see Diller, 1955, pp. 126–128) found “the middle part of the thigh of an animal the large end of which was 7 inches in diameter and the other 6¾ inches.” This is apparently the “Ossemens de mammoth” shown on the map (between the Keya Paha and Niobrara rivers) attributed to Mackay by Nasatir (1952, map opposite, p. 110). See also Mackay's route on a map in Coues (1893) and discussions in Wheat (1957, pp. 161–164, 246), and Stout (1977, p. 117).

In 1853 Meek and Hayden discovered and collected vertebrate fossils at Bijou Hills (fig. 41), about 40 mi. north of the junction of the Keya Paha and Niobrara rivers. Hayden was again in the area in 1855 and 1856 (Skinner and Taylor, 1967, pp. 1–4).

It was 61 years after Mackay's trip that the

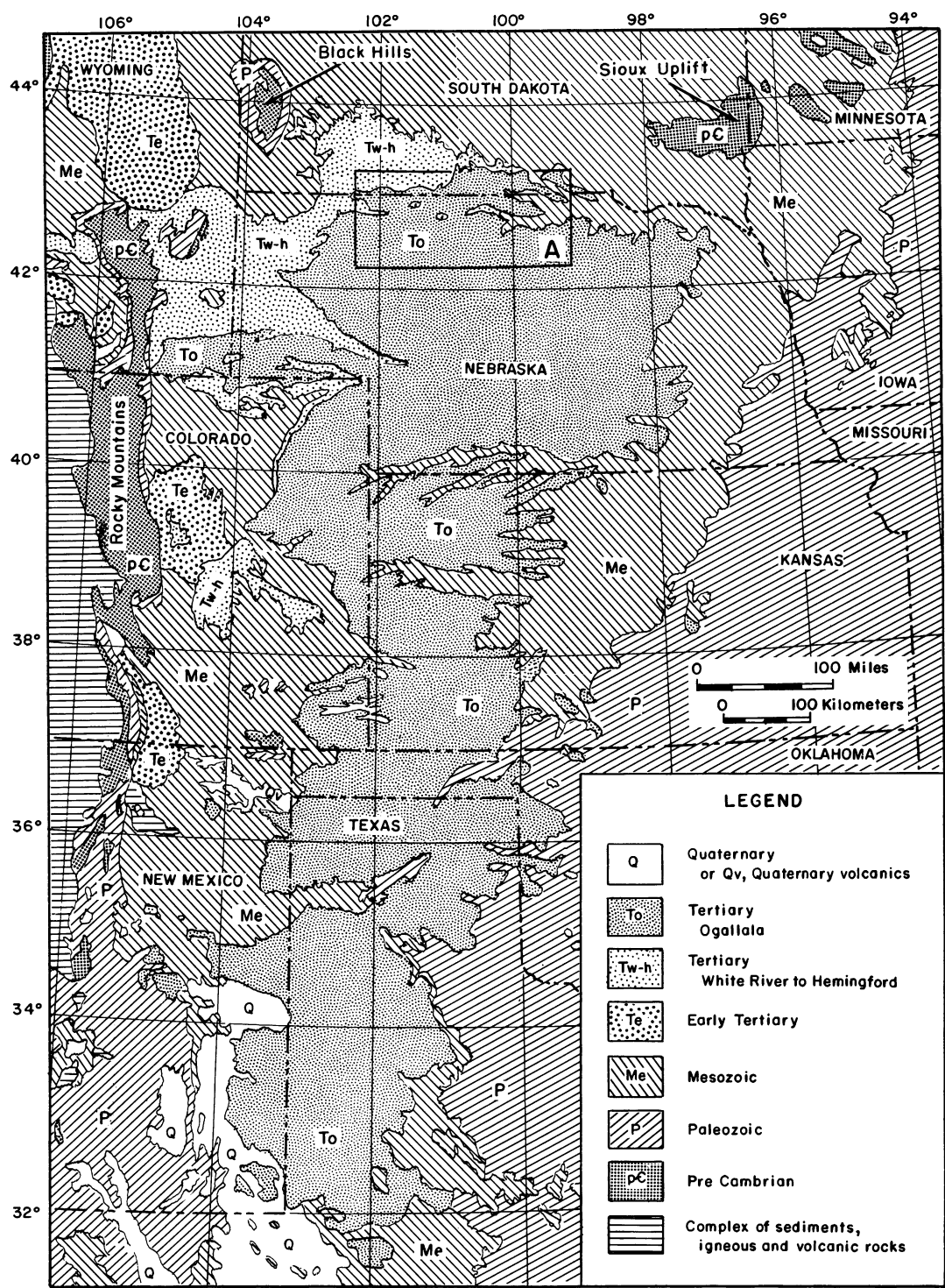


FIG. 1. Geologic map showing study area (A) and extent of Ogallala Group. Modified after Seni (1980) and USGS (1965).



extensive collecting of F. V. Hayden, geologist on the Lt. G. K. Warren Military Expedition of 1857, revealed the presence of a rich fauna of late Tertiary vertebrates along the Niobrara River in north-central Nebraska. Hayden sent his collection to Joseph Leidy (1858b, pp. 20–29), who recognized immediately its great significance in North American paleontology. In 1873 the Marsh Expedition from Yale University (Thorpe, 1922, pp. 423–455; Maghee, 1929, pp. 247–304) collected from near the mouth of Antelope Creek in western Cherry County eastward to the mouth of Minnechaduza Creek northeast of the present town of Valentine, Nebraska. A small collection from near Fort Niobrara, made by Dr. T. E. Wilcox, U.S. Army, was acquired by E. D. Cope in about 1890 and is now in the American Museum of Natural History. Three of Cope's types are from the Wilcox collection: AMNH 8541 *Sthenictis robusta*, AMNH 8543 *Tomarctus compressus* and AMNH 8544 *Brachypsalis pachycephalus*.

The William C. Whitney AMNH Expedition of 1902–1903, led by J. W. Gidley, collected near the headwaters of the Little White River and near Rosebud, South Dakota, but did not get into Nebraska until 1903, when they obtained a small collection in the vicinity of Fort Niobrara. W. D. Matthew and A. C. Whitford of the AMNH visited the Valentine and Springview areas in 1916, but were unsuccessful.

A new era of collecting began in the second decade of the twentieth century when E. H. Barbour of the University of Nebraska State Museum, sent A. C. Whitford, J. B. Burnett, E. F. Schramm, M. G. Richmond, O. E. Hans, C. H. Eaton, C. J. Elmore, and R. W. Ellis, into the Ainsworth and Valentine areas during 1913 to 1917. In 1914 R. S. Lull led a Yale University collecting trip along the Niobrara River following in reverse direction much of the route covered by O. C. Marsh in 1873.

Intensive collecting by M. F. Skinner and J. H. Quinn began in the Ainsworth area in 1926. In 1928 Skinner began 50 years of collecting across north-central Nebraska and many other areas for the Frick Laboratory of AMNH.

During the 1930s Skinner's field party was

made up of young Nebraskans whose interests were exceeded only by their aptitude and endurance. The first were R. L. Mefferd, G. K. Fletcher, A. Potter, J. Potter, H. C. Williamson, F. S. Ballou, H. Dehlin, M. Hestbeck, and F. W. Johnson (co-author of the present paper). In the 1930s, 1940s and 1950s these men left for other work and were replaced by younger local men, some just back from World War II. They were T. Lucas, L. M. Toohey, L. Nelson, H. Potter, R. Lochmiller, W. Lear, J. Beattie and M. F. Skinner, Jr. Again these members left to follow their chosen professions, and in the 1960s were replaced by other younger men: two brothers, Robert J. Emry and Raleigh Emry. Carl Elfren and Kenneth Wiechelman were part-time members.

By 1931 the Frick collectors realized that they were faced with providing field data for hundreds of specimens from isolated prospecting sites as well as quarries, and these data, moreover, must be identifiable by other workers in the field and laboratory. With the able assistance of Floyd Blair, Frick Laboratory Registrar from 1928 to 1955, a system of field cataloguing and geographic and geologic documentation was devised that proved workable and was continued through the years. This work, and that of the University of Nebraska State Museum, the University of California Museum of Paleontology, and the Yale Peabody Museum, has provided much of the data for the present paper.

From 1928 through 1935 the UNSM returned to this area and A. L. Lugin, E. H. Colbert, P. O. McGrew, L. H. Luckert, P. C. Harper, F. W. Johnson, G. E. Meade, C. S. Osborne, D. A. Franzen, K. L. Rathbun, and T. M. Stout worked in Brown County and the Valentine and Snake River areas of Cherry County and in Sheridan County.

R. A. Stirton of UCMP led successful collecting activities in the Fort Niobrara, Snake River, and Big Springs, South Dakota areas between 1932 and 1941. P. O. McGrew and A. Potter also collected for UCMP at Burge and Gordon Creek in 1933 and at Big Spring Canyon, South Dakota, for FMNH in 1939. S. D. Webb collected for UCMP in the Valentine area in 1962. E. S. Riggs of FMNH, H. E. Wood of Rutgers University, and A. E.

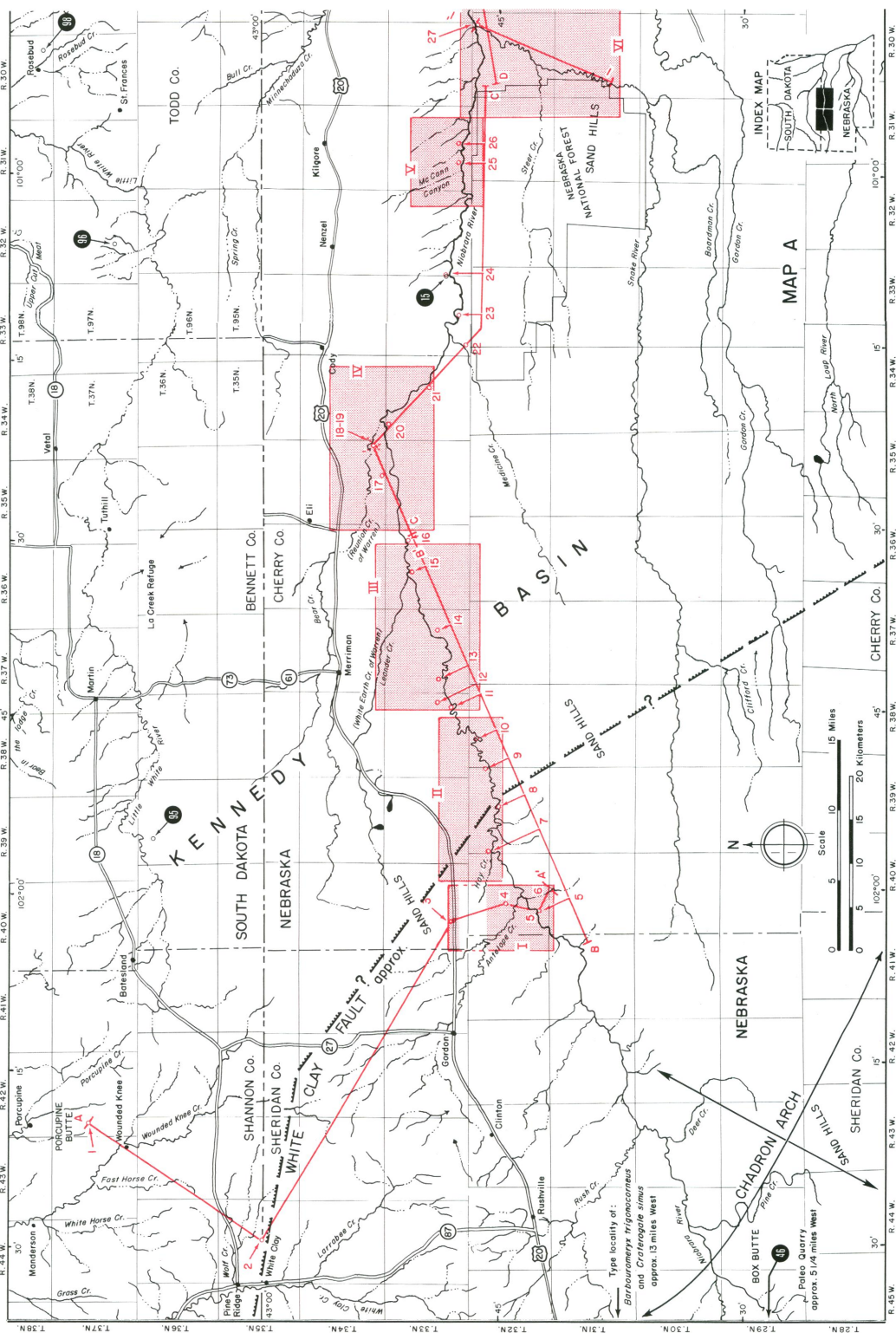


FIG. 2. See caption on page 262.

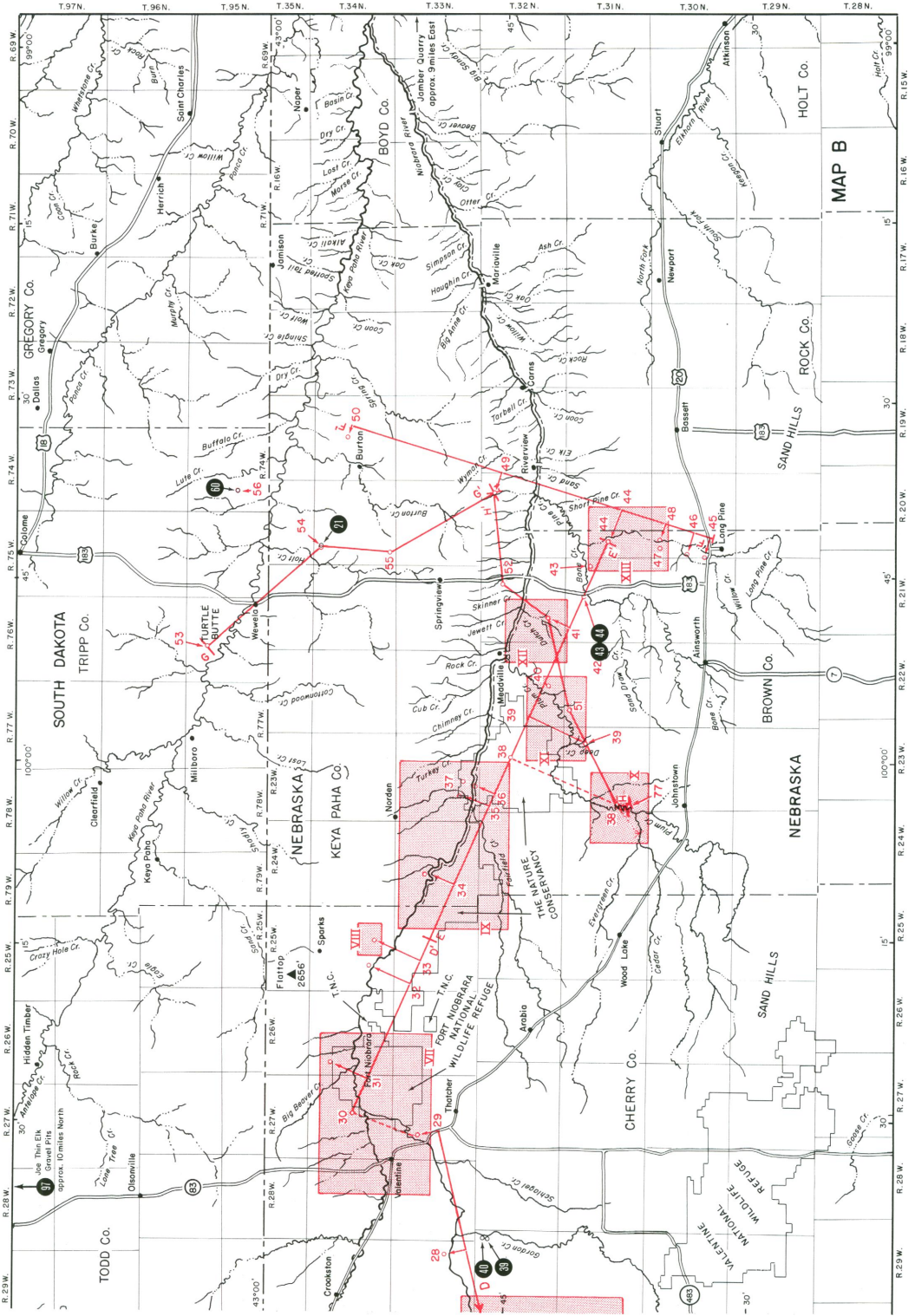


FIG. 2. Continued.



←

FIG. 2. Map in two parts (facing pages), showing western (map A) and eastern (map B) parts of area, index map, key to location of detail maps and cross sections. Numbers inside circle provide key to identity and location of fossil quarries. Other numbers show location of measured sections included in cross sections.<sup>1,2</sup>

See captions on detail maps for identity of quarries and sections not shown below.

Map. A—Identity of quarries: 15, Nenzel; 46, Paleo; 95, Big Spring; 96, Hollow Horn Bear; 98, Rosebud Agency. Identity of sections: 1, Porcupine Butte; 2, White Clay; 16, Below Crane Bridge; 22, Medicine Creek; 23, Hook Bridge; 24, Nenzel.

Map B—Identity of quarries: 21, Schoettger; 39, Gordon Creek; 40, Gordon Creek North; 43, Lucht; 44, South Lucht; 60, *Trilophodon giganteus*. Identity of sections: 28, Moosman Bridge; 32, Copeland Ranch; 45, Long Pine Creek at Hwy. 20; 46, Phalen Ranch; 49, Beeman Creek (Murphy's Gulch); 50, NE of Burton; 52, Niobrara River Hill on Hwy. 183; 53, west end, Turtle Butte; 54, Schoettger; 55, Troxell's Rhino. TNC is property of The Nature Conservancy.

<sup>1</sup> See quarry descriptions for details on the location of quarries shown on figure 2 but which are not in the areas covered by the large scale maps I through XIII.

Location of geologic sections listed on figure 2 but not shown on large scale maps are as follows:

1. Porcupine Butte. SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 17, T. 37 N, R. 42 W, Shannon County, South Dakota. Porcupine Butte Quadrangle, South Dakota Geol. Surv. 1967.

2. White Clay. On the Nebraska-South Dakota line 2.9 mi. east of White Clay.

16. Below Crane Bridge, Near E line SE  $\frac{1}{4}$ , sect. 11, T. 33 N, R. 36 W, Cherry County, Nebraska. Merriman Quadrangle 1951.

22. Medicine Creek. East side of creek in SE  $\frac{1}{4}$ , sect. 31, T. 33 N, R. 33 W, Cherry County, Nebraska. Cody Quadrangle 1950.

23. Hook Bridge. South side of Niobrara River, NW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 34, T. 33 N, R. 33 W, Cherry County, Nebraska. Cody Quadrangle 1950.

24. Nenzel. Composite section on north side of Niobrara River near west line of sect. 30, and east side of Spring Canyon in SW corner sect. 19, T. 33 N, R. 32 W, Cherry County, Nebraska. Cody Quadrangle 1950.

28. Moosman Bridge. North side of Niobrara River in NW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 25, T. 33 N, R. 29 W, Cherry County, Nebraska. Valentine Quadrangle 1950.

32. Copeland Ranch. North side of Niobrara River in N central part of sect. 29, T. 34 N, R. 25 W, Cherry County, Nebraska. Sparks Quadrangle 1950.

45. Long Pine Creek at Hwy. 20. North of hwy. in N  $\frac{1}{2}$ , sect. 30, T. 30 N, R. 20 W, Brown County, Nebraska. Long Pine Quadrangle 1954.

46. Phalen Ranch. NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 18, T. 30 N, R. 20 W, Brown County, Nebraska. Long Pine Quadrangle 1954.

49. Beeman Creek (Murphy's Gulch). E side of creek in NW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 2, T. 32 N, R. 20 W, Keya Paha County, Nebraska. Springview Quadrangle 1964.

50. NE of Burton. SE corner sect. 9, T. 34 N, R. 19 W, Keya Paha County, Nebraska. Burton Quadrangle 1964.

52. Niobrara Hill on Hwy. 183. From top of hill in sect. 36, T. 33 N, R. 21 W, southward to the Niobrara River, Keya Paha County, Nebraska. Springview 1964 and Bassett NW 1950 quadrangles.

53. West End of Turtle Butte. West-central side of NW  $\frac{1}{4}$  sect. 9, T. 95 N, R. 76 W, Tripp County, South Dakota (Skinner, Skinner, and Gooris, 1968, fig. 2).

54. Schoettger. From NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$  to NW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 5, T. 34 N, R. 20 W, Keya Paha County, Nebraska. Springview NW Quadrangle 1964.

<sup>2</sup> Type locality of *Barbouromeryx trigonocorneus* (UNSM 3-27-11-33), which was located erroneously by Barbour and Schultz (1934, p. 4), is in light gray, fine to medium, massive sandstone 25 ft. above the creek bed on the "first exposure on the south side of Antelope Creek east of the west line of E.  $\frac{1}{2}$  sec. 30, T. 31 N, R. 47 W, Dawes Co., Nebr." (Johnson, ms.d, 1934, pp. 84, 152). Chadron 3 NW Quadrangle, 1970.

The holotype of *Craterogale simus* Gazin 1936 (USNM 13801) was collected by Ted Galusha at 4105 ft. on the east side of a branch of Antelope Creek, and only 0.35 mi. S, 35°W of *B. trigonocorneus*, near the east line of the NW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 30, T. 31 N, R. 47 W (Tedford, ms.a, 1975, p. 96). Chadron 3 NW Quadrangle 1970.

Wood are among those who also collected in the area in the 1930s. R. J. Emry has collected in the Ainsworth area for the USNM in recent years.

Emphasis on collecting microvertebrates was initiated in the 1960s by C. W. Hibbard of UMMP and J. Tihen of the University of Notre Dame. This work, which recovered a great variety of little known and new fossil vertebrates, was continued in the 1970s by J. A. Holman of MSU and M. R. Voorhies and R. L. Evander and their associates of UNSM.

In retrospect, perhaps the most spectacular discovery in northern Nebraska since the 1857 discoveries of Hayden and the discovery of Agate Springs Quarries at the turn of the century, has been that of M. R. Voorhies

at the Poison Ivy Quarry in the Ash Hollow Formation. This site contains a unique series of complete skeletons of birds, rhinoceros, horse, camel, and other extinct organisms representing a moment of prehistoric life perfectly preserved in a bed of volcanic ash. Poison Ivy Quarry is near Orchard, Antelope County, Nebraska (Voorhies, 1981, pp. 66–75; Voorhies and Thomasson, 1979, pp. 331–333), which is east of the present study area.

Johnson, after retirement in 1971 from a career in geology and exploration management with Exxon and several of its affiliates, joined Skinner in the preparation of this paper. From 1972 through 1978 Johnson and Skinner reviewed the study area and checked or remeasured many of the sections.

## TERTIARY STRATIGRAPHY ALONG THE NIOBRARA RIVER

Figures 3, 4, 30–40

The setting for deposition of late Tertiary (Neogene) continental sediments in north-central Nebraska was an irregularly eroded to low relief surface on Paleogene continental deposits and marine Pierre Shale of Cretaceous age. Data from well logs in western Nebraska in the files of the Nebraska Conservation and Survey Division show that this surface was interrupted by the large northwest-southeast trending Chadron Arch. Prior to deposition of late Tertiary sediments, a valley more than 1000 ft. deep and about 40 mi. wide was eroded into this arch approximately parallel to its axis, (DeGraw MS, 1969, pp. 1–136). Prior to the deposition of the Oligocene White River Group, rocks as old as Jurassic were exposed in Sheridan County as a result of this erosion (DeGraw, 1971, pp. 13–21).

Major pre-Oligocene uplifting (Moore and Nelson, 1974, pp. 260–268) followed by lesser movement along this arch in the late Tertiary provided a setting for erosion and deep channel cutting followed by widespread aggradation. Results of this cut and fill are observed in outcrops on the east flank of the arch along the Niobrara River between the mouth of Antelope Creek and Rockford

Bridge south of Merriman, where, even today, there is an increase in the gradient and entrenchment of the river. More frequent meanders, however, compensate for the increased gradient so that the gradient of the meandering and incised river is changed very little. The river is locally deflected by, and eroding through, the more resistant rocks on the east flank of the arch, where there is a slightly increased easterly dip.

No attempt has been made to determine the effect of displacement along the White Clay fault near the Nebraska-South Dakota border (fig. 30), on the paleo-drainage system of post early Clarendonian time that existed in that area.

The southeast extension of the White Clay fault, postulated by DeGraw (1971, fig. 5; this paper, fig. 2) on the east flank of the Chadron Arch, crosses the Niobrara River east of the Lions Bridge (named for Walter C. Lyon, but spelled Lions on USGS Irwin quadrangle). East of the fault deeply incised valleys are filled with sediments of the Ogallala Group. Such evidence indicates that the fault affected the drainage pattern and deposition of paleo streams that flowed eastward into the Kennedy basin during late Clarendonian and possibly Hemphillian times.

## WHITE RIVER GROUP

### CHADRON FORMATION

A single outcrop referred to the Chadron Formation (basal White River Group) was exposed during construction of U.S. Highway 183, north of the Niobrara River south of Springview, Keya Paha County (fig. 37, sect. 52). The outcrop consists of 77 ft. of siltstone and sandstone ranging in color from buff to greenish and pinkish. The lower 5 ft. consists of buff sandy clay and a basal thin sand containing black concretions and clear quartz sand and some barite crystals at the contact

with the underlying Pierre Shale. This is overlain by about 30 ft. of buff to greenish sandy clay and pinkish silty clay. The upper 30 ft. consists of buff and purplish iron stained clay, sandy clay and channel sand. A few fragments of an unidentifiable mammal limb with fossilization similar to that in the Chadron were found here.

This outcrop and those at Turtle Butte in South Dakota (Skinner, Skinner, and Gooris, 1968, p. 391) appear to be the easternmost remnants of sediments in surface outcrops referable to the Chadron Formation.

## ARIKAREE GROUP

### ROSEBUD FORMATION

The establishment of Rosebud as a formation has been discussed by Skinner, Skinner, and Gooris (1968, pp. 387–401, 412–414, figs. 2, 6) and is not repeated here.

The predominantly pinkish pale orange to brownish siltstone and silty sandstone of the Rosebud Formation are exposed in up to nearly 100-ft. high vertical to nearly vertical cliffs along the Niobrara River from eastern Brown County westward to the Moosman Bridge southwest of Valentine (figs. 33–34). The Rosebud Formation may also occur at or below water level downstream from the abutments of the dismantled Crookston Bridge, or about a quarter-mile below the mouth of the Snake River. Proceeding upriver, tan to pinkish siltstone that may be Rosebud or Monroe Creek equivalent crop out near the Kilgore Floral Locality, from Beaver Bluff to the Thayer Ranch, and at the mouth of Hay Creek (figs. 31, 32).

The Rosebud Formation overlies the Pierre Shale in certain areas in Brown and Keya Paha counties (figs. 35–36; also Skinner, Skinner, and Gooris, 1968, p. 399), and rests on the Chadron Formation along U.S. Highway 183 in Keya Paha County (fig. 37). The Rosebud Formation is disconformably overlain by the Valentine Formation. These stratigraphic relationships are best shown on the sections (figs. 31–37). The top of the Rosebud, although irregularly eroded in some areas, has a regional dip southeastward of about 8 ft. per mi.

The rarity of fossils in the Rosebud Formation outside the type area makes comparisons with fossils from the type area almost impossible. In 1913 E. H. Barbour collected an astragalus, calcaneum, and other skeletal parts of a horse (UNSM 4385) from the Rosebud Formation in Devil's Gulch, Brown County, and submitted these to W. D. Matthew at the American Museum of Natural History. Matthew (letter to Barbour, April 26, 1917, UNSM Archives) stated, "I judge the bones are either *Parahippus*, *Miohippus*, or *Archaeohippus*. They are not *Mesohippus*, therefore the beds are not Middle Oligocene (Oreodon Beds) and not *Merychippus* (Middle Miocene). They might be Upper Oligocene or Lower Miocene, so far as this evidence indicates. At the same time, I must say, that I do not regard the evidence as conclusive, even to this limited extent." Skinner, Skinner, and Gooris (1968, pp. 393–401) reviewed the correlation problems of the Rosebud Formation and estimated its age as ranging from late Oligocene to early Miocene. They placed the Rosebud in the Arikarean North American Land Mammal Age.

Correlation of siltstone along the Niobrara River with siltstones at the type locality at Rosebud and at Turtle Butte, South Dakota, is based on similar lithology and the regional position of outcrops (Skinner, Skinner, and Gooris, 1968, pp. 391–402). The meager faunal evidence is consistent with this interpretation. From the Kilgore Floral Locality westward, the siltstone section may be equiv-



alent, at least in part, to the Monroe Creek Formation<sup>3</sup> of western Nebraska and South Dakota. We have no solid evidence, however, to support this view.

### TURTLE BUTTE FORMATION

Skinner, Skinner, and Gooris (1968, pp. 401–402, figs. 2–4) described the Turtle Butte Formation, which consists of up to 70 ft. of white and light gray siltstone, tuffaceous and calcareous siltstone, and whitish clay. The type section (*ibid.*, p. 387; figs. 2 and 36, present paper) and its fauna, the Wewela Local Fauna, is at the west end of Turtle Butte in the west-central side of the NW  $\frac{1}{4}$ , sect. 9, T. 95 N, R. 76 W, Tripp County, South Dakota. The Turtle Butte Formation is in disconformable contact with the underlying Rosebud Formation and the overlying Valentine Formation.

The Wewela local fauna (Skinner, Skinner, and Gooris, 1968, pp. 402, 415–429) contains fossils similar to those found in the Monroe Creek and Harrison formations of South Dakota and Nebraska. The type of the entelodont, *Archaeotherium trippensis* Skinner, Skinner and Gooris, 1968 (Type F:AM 42937) was collected one foot above the base of the type section of the Turtle Butte Formation.

### HARRISON FORMATION

Hatcher (1902, p. 117) applied the name "The Harrison Beds," now Harrison Formation, to a distinctive unit of gray sandstone that crops out on the Pine Ridge escarpment north of the town of Harrison in northwestern Nebraska. Hatcher (*ibid.*) stated "They are composed of about 200 feet of fine-

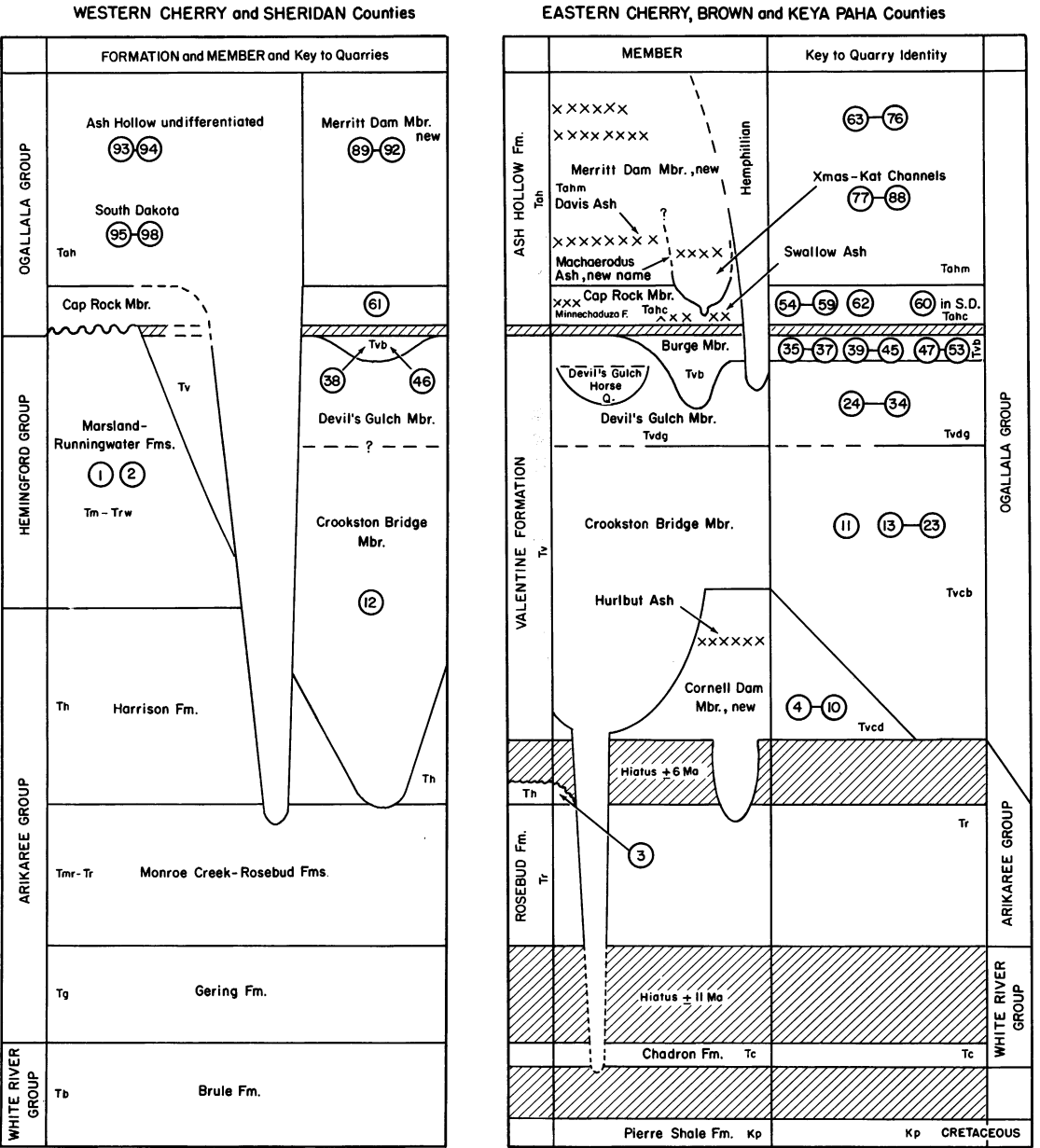
grained, rather incoherent sandstones, permeated by great numbers of siliceous tubes arranged vertically . . . [and] are further characterized by the presence, often in the greatest abundance . . . [of] *Daemonelix*."

Skinner, Skinner, and Gooris (1977, pp. 290–292), however, have shown the widespread occurrence of the Harrison Formation in northwestern Nebraska and eastern Wyoming, and discussed its lithology, distribution, and stratigraphic relations. The most striking characteristics of this formation are its predominantly dull gray "pepper and salt" appearance, the silty to fine-grained texture, resulting from widespread eolian processes during deposition, the presence of channel deposits of fine sand and siltstone clastic pebbles, and the frequent occurrence of pipy concretions, a secondary feature discussed by Schultz (1941, p. 74) and by Shultz and Stout (1961, p. 6). Siliceous root casts, tubules and *Daimonelix* (Barbour, 1892, pp. 301–324) also occur in many localities. At least two beds of volcanic ash are known. One, the Agate Ash (Skinner, Skinner, and Gooris, 1977, p. 291), has a published KA date of 21.3 Ma (Evernden et al., 1964, p. 165).

**HARRISON FOSSIL LOCALITIES AND OUTCROPS SOUTH OF KILGORE:** The easternmost known outcrops referable to the Harrison Formation (figs. 22, 32) occur on the roadside just west of the mouth of McFarland Canyon on the north side of the Niobrara River in the N  $\frac{1}{2}$ , sect. 33, T. 33 N, R. 31 W, and 10 mi. south, about 1 mi. west of Kilgore, Cherry County, Nebraska (Skinner, Skinner, and Gooris, 1977, p. 291). This is about 160 mi. east of the Wyoming line. The McCann Quarry (UNSM Cr-117) is situated at the first outcrop on the north side of the road east of McCann Canyon near the north line of the NE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 32, T. 33 N, R. 31 W, Cherry County, Nebraska, Kilgore Quadrangle. The outcrop at the McCann site consists of 14 ft. of light gray, fine to silty "salt and pepper" appearing friable sandstone. Between 3 and 4 ft. above the road (10–13 ft. above the Niobrara River) are two thin lenses of sandstone pebbles, the upper of which contains most of the microvertebrates characteristic of this locality.

Holman (1981, pp. 49–56) has recognized at least 11 taxa of small amphibians and rep-

<sup>3</sup> Hatcher (1902, pp. 116–117), in his description of the type section, stated: "The Monroe Creek Beds . . . are well shown in the northern face of Pine Ridge, at the mouth of the Monroe Creek canyon, five miles north of Harrison, Nebraska, where they overlie the Gering sandstones, and are composed of some 300 feet of very light colored, fine grained, not very hard but firm and massive sandstones." Hatcher also observed that they were "usually barren" of fossils but that "toward the top they contain *Promerycochoerus*. They decrease in thickness very rapidly to the eastward and increase to the westward."



tiles from the McCann Quarry. Two of the lizards described by Holman, *Harrisonsaurus fossilis* (MSUVP 1029) and *Eumeces antiquus* (MSUVP 1028) are type specimens. The occurrence of *Palaeocaster fossor* in the

Harrison in this area was recognized earlier (Skinner, Skinner, and Gooris, 1977, p. 291) and Stout (personal commun.) has referred F:AM 64614 to *Euhapsis barbouri*. Evander (personal commun.) has identified at least 17

TABLE 1  
Identification of Fossil Quarries Listed in Lithostratigraphic Units on Figure 3

Stratigraphic Position and Quarry		Quarry	Cross		Map	
No.	Name	Description	Figure	Section	Figure	Page
		Page		Page		
PRE-OGALLALA						
1.	<i>Aletomeryx</i>	235	30	336	18	324
2.	Two Miles West of Pole Creek	236	30	336	18	324
3.	McCann	229			22	328
OGALLALA GROUP						
VALENTINE FORMATION						
CORNELL DAM MEMBER						
4.	Achilles	260	34	340	25	331
5.	Carrot Top	260	34	340	25	331
6.	Egelhoff	260	34	340	25	331
7.	Fairfield Creek No. 1	260			25	331
8.	Kuhre	261			25	331
9.	Norden Bridge	261	8, 34	262, 340	25	331
10.	Rockford Site	261			25	331
CROOKSTON BRIDGE MEMBER						
11.	Crookston Bridge	270	33, 38	339, 345	23	329
12.	Devil's Jump Off	270	32	338	21	327
13.	Fairfield Creek IV	270			25	331
14.	Jones Canyon	270			28	334
15.	Nenzel	271	32	338	2A	224
16.	Railway Quarry "A"	271	10, 33	273, 339	9, 11, 24	272, 274, 330
17.	Railway Quarry "B"	276	33	339	11, 24	274, 330
18.	Ripple	277	38	344	23	329
19.	Runlofson	277			29	335
20.	Sawyer	277	38	344	23	329
21.	Schoettger	277	36	342	2B	225
22.	West Valentine	278	33	339	11, 24	274, 330
23.	Yale Quarry D	278			24	330
DEVIL'S GULCH MEMBER						
24.	Deep Creek No. 1	281			27	333
25.	Deep Creek (UNSM)	281			27	333
26.	Devil's Gulch	282	34	340	28	334
27.	Devil's Gulch Horse	282	34	340	28	334
28.	Dutch Creek No. 1	283			28	334
29.	Elliott	283	35	341	29	335
30.	Fairfield Falls	283			25	331
31.	Fairfield Creek No. 2	283			25	331
32.	Horse Thief Canyon No. 3	283			27	333
33.	Mizner	284	38	344	23	329
34.	Rattlesnake Gulch	284			29	335
BURGE MEMBER						
35.	Burge	286	15, 38	304, 345	23	329
36.	Buzzard Feather	287			25	331
37.	<i>Eubelodon morrilli</i>	287	34	340	28	334
38.	Ewert	287			21	327
39.	Gordon Creek	287			2B	225
40.	Gordon Creek North	287			2B	225
41.	June	288	34	340	26	332

TABLE 1—(Continued)

Stratigraphic Position and Quarry		Quarry	Cross		Map	
No.	Name	Description	Figure	Section	Figure	Page
		Page		Page		
42.	West June	288	34	340	26	332
43.	Lucht	288	34	340	2B	225
44.	South Lucht	288	34	340	2B	225
45.	Midway	289	17, 33	313, 339	16	312
46.	Paleo	289			2A	224
47.	Quarry 379	289	38	345	23	329
48.	Quinn Mastodon	289	37, 40	343, 348	27	333
49.	Swallow	290	38	345	23	329
50.	<i>Tetrabelodon</i> Skull	290	38	345	23	329
51.	White Point	291			27	333
52.	Whiteface	291			23	329
53.	Yale Mastodon	291			24	330
ASH HOLLOW FORMATION						
CAP ROCK MEMBER						
54.	Fairfield Creek No. 3	299			25	331
55.	Horse Thief Canyon No. 1	299			27	333
56.	Horse Thief Canyon No. 2	299			27	333
57.	Johnson Rhino	299			24	330
58.	Little Beaver B	301	33	339	24	330
59.	Rock Ledge Mastodon	301			27	333
60.	<i>Trilophodon giganteus</i>	301	36	342	2B	225
61.	Timm Ranch	302	30	336	18	324
62.	Wilson	302			26	332
MERRITT DAM MEMBER						
63.	<i>Alligator mefferdi</i>	308			23	329
64.	Clayton	308	40	348	27	333
65.	East Clayton	308			27	333
66.	Eggers	308	34	340	26	332
67.	Emry	309	34	340	26	332
68.	Horn	309	38	345	23	329
69.	Hurlbut	309	34	340	27	333
70.	Jim Lessig Camel	309			27	333
71.	Jonas Wilson	309			26	332
72.	<i>Platybelodon</i>	309	38	344	23	329
73.	Pratt	310	37	343	26	332
74.	Quinn Rhino Nos. 1 and 2	310	37, 40	343, 348	27	333
75.	RH No. 3	311	37, 40	343, 348	27	333
76.	Wade	311	38	345	23	329
XMAS-KAT QUARRIES						
77.	Balanced Rock	314			16	312
78.	Machaerodus	315	17	313	16	312
79.	Xmas	315	17, 33	313, 339	16	312
80.	Connection Kat	315			16	312
81.	East Kat	315			16	312
82.	Hans Johnson	316			16	312
83.	Kat	316	17	313	16	312
84.	<i>Leptarctus</i>	316	17	313	16	312
85.	Line Kat	316	17	313	16	312
86.	Quarter Line Kat	316			16	312
87.	Trailside Kat	316			16	312
88.	West Line Kat	316			16	312



TABLE 1—(Continued)

Stratigraphic Position and Quarry		Quarry Description Page	Cross Section		Map	
			Figure	Page	Figure	Page
WESTERN CHERRY COUNTY						
89.	Bear Creek	317	32, 39	338, 347	21	327
90.	Eli Ash Pit	317	39	346	21	327
91.	Gallup Gulch	317	31	337	20	326
92.	Mensingers	318	31	337	20	326
93.	Bolling <sup>a</sup>	318	32, 39	338, 346–347	21	327
94.	Garner <sup>a</sup>	318	39	347	21	327
SOUTH DAKOTA						
95.	Big Spring Canyon <sup>a</sup>	319			2A	224
96.	Hollow Horn Bear <sup>a</sup>	319			2A	224
97.	Joe Thin Elk Gravel Pits <sup>a</sup>	319			2B	225
98.	Rosebud Agency Quarry <sup>a</sup>	320			2A	224

<sup>a</sup> Ash Hollow Undifferentiated.

other taxa of mammals in the McCann Quarry Local Fauna.

MOUTH OF BEAR CREEK: Outcrops and a Bureau of Reclamation drill hole reveal at least 220 ft. of pre-Ogallala Tertiary sediments shown on geologic section 20 (figs. 21, 39) measured on the Niobrara River southwest of the mouth of Bear Creek in the SE ¼, sect. 31, T. 34 N, R. 34 W, and NE ¼, sect. 6, T. 33 N, R. 34 W, Cherry County, Nebraska. The drill hole penetrated 87 ft. of buff siltstone referable to the Rosebud Formation or to a Monroe Creek equivalent. This is overlain by 59 ft. of gray, massive fine-grained sandstone containing concretions and capped locally by a limestone that grades laterally into a hard sandstone. The lithology of this bed is typical of the Harrison Formation in the 32 ft. of section seen in the vertical cliff outcrops. A fragmental palate and a partial mandible (F:AM 101930) and a partial maxilla (F:AM 99933) of *Merychys crabilli* were collected at the top of the same bed shown on geologic section 73, figure 39.

The typical Harrison gray sandstone is overlain by pinkish to gray fine-grained sandstone that contains small nodules and weathers in a crumbly manner due to its clay content. It attains a thickness of 75 ft. in section 20 and is also referred to the Harrison. The discovery of skulls of *Promerycochoerus carrickeri* (F:AM 99931 and 99932) at horizons shown on section 20, figure 39 provides faunal evidence that this sandstone may be

equivalent to the upper part of the Harrison as used by Schultz and Falkenbach (1949, p. 94).

A skull and jaw of *Diceratherium* (F:AM 99791) was collected 16 ft. above the base of the pinkish unit (fig. 39, sect. 20). This specimen “compares closely with the small species of this genus which occurs in the John Day of Oregon” (Earl Manning, personal commun.). The John Day Formation in which *Diceratherium* occurs is considered Arikarean in age.

The unconformable relationship between the deeply eroded sediments referred to the Harrison Formation and the overlying fossil-bearing unconsolidated sand and sandstone of the Ogallala Group is shown on several detailed cross sections in the vicinity of the mouth of Bear Creek (fig. 39).

BEAVER BLUFF AND THE LOOP: A prominent outcrop of 92 ft. of sediments referred to the Harrison and Monroe Creek or Rosebud occurs at Beaver Bluff (New Name) near the center of the SE ¼, SW ¼, sect. 25, T. 33 N, R. 38 W, Merriman Quadrangle 1951, on the east flank of the Chadron Arch about 22½ mi. upstream from the mouth of Bear Creek (figs. 20, 31, sect. 11). As at Bear Creek, this appears to be a deeply eroded outlier in unconformable contact with the overlying unconsolidated sand of the Ogallala Group.

The lower 43 ft. of this outcrop is predominantly pink and gray siltstone interbedded with occasional sandstone and may be equiv-

alent to the Monroe Creek or Rosebud formations (fig. 31, sect. 11). This is overlain by 49 ft. of gray fine-grained "pepper and salt" sandstone that resembles Harrison. Its base is marked by springs or seepages at the contact with the underlying siltstone. A fragmental skull, *Desmatochoerus curvidens gregoryi* (F:AM 72394), and listed as occurring in the Harrison Formation by Schultz and Falkenbach (1968, pp. 380–381) was collected 46 ft. above the Niobrara River, or 3 ft. above the contact between the referred Harrison and Monroe Creek.

A section on the river at the Loop, about 3 mi. southwest of Beaver Bluff on the east side of the SE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 4 (using north line of irregular section 4 as base), T. 32 N, R. 38 W, Cherry County, Nebraska, Irwin Quadrangle 1951, consists of a basal 29 ft. of light brown or tan siltstone referred to either the Monroe Creek or the Rosebud (fig. 31, sect. 10). This is overlain by 5½ ft. of gray siltstone or silty sandstone containing concretions that may be remnants of the Harrison Formation. Overlying this is light gray to yellow clay-filled sandstone referred to the Ogallala Group. A ramus (F:AM 95227) collected from near the top of the section is referred to *Pseudoceras*, a camelid that has also been found in the Merritt Dam Member on the Snake River and in the Xmas-Kat quarries, eastern Cherry County.

**MOUTH OF HAY CREEK:** Pinkish siltstone of Rosebud or Monroe Creek crops out at the river level immediately east of the mouth of Hay Creek in the northwest corner of sect. 18, T. 32 N, R. 39 W, Cherry County, Nebraska Irwin Quadrangle 1951 (fig. 31, sect. 7). The top of this unit was irregularly eroded in the eastern part of the outcrop prior to deposition of a thin section of gray fine-grained friable sandstone containing sandstone concretions that resemble Harrison sediments. A radius and ulna comparable to *Michenia* (personal commun., Beryl Taylor) was collected at the base of the latter unit suggesting that the sediments may be Hemingfordian. The gray sandstone and sand is overlain by a channel fill composed of gray-buff granitic sand and gravel containing clay clasts. This predominantly gravel section has a thickness of at least 86 ft. and is tentatively referred to the basal part of the Valentine Formation. The presence of a late Barstovian fauna in similar sand and gravel at Hardin Bridge, about 10½ mi. upriver, in a section that may be stratigraphically equivalent, lends support to this interpretation. Nevertheless, the possibility that the gravel at the mouth of Hay Creek is as old as the Runningwater Formation has not been ruled out.

## HEMINGFORD GROUP

### MARSLAND FORMATION (=UPPER HARRISON OF PETERSON, 1906, 1909) AND THE RUNNINGWATER FORMATION

Lithic and faunal evidence was used for the assignment of several geologic sections (figs. 30, 31) and faunal localities in western Cherry County to the Runningwater Formation. In areas of fine-grained rocks evidence to differentiate the Marsland (=Upper Harrison) as a separate unit was not observed in the area covered by this paper. While pursuing this complex problem is beyond the scope of our paper, a short review of the nomenclature and lithic characteristics of the Runningwater Formation is included.

The type section of the Runningwater For-

mation is in the W  $\frac{1}{2}$  of sect. 5, T. 28 N, R. 52 W, Box Butte County, Nebraska (Cook, 1965, figs. 1–3). Marsland Quadrangle 1951.

The problems of stratigraphic nomenclature of the Marsland and Runningwater formations have been reviewed in various papers, including Schultz (1938, pp. 443–444), Cook (1965, pp. 1–8), McKenna (1965, pp. 2–10), Galusha (1975, pp. 17, 20–22), Skinner, Skinner, and Gooris (1977, pp. 293–295), Hunt (1978, pp. 1–52) and Yatkola (1978, pp. 1–65).

Galusha (1975, p. 22), who considered the Runningwater and Marsland as separate formations, noted a "decided influx of plutonic debris" in these sediments in "sharp contrast to the absence of such debris in the Lower

Marsland Formation = Upper Harrison.” Yatkola (1978, pp. 20–21, 34) divided the Marsland Formation of Schultz (1938) into a lower member, equivalent to the Upper Harrison of Peterson (1906, p. 23; 1909, p. 75) and lowered the rank of Runningwater Formation to Runningwater Member for the upper part of the Marsland Formation. The United States Geological Survey (Swanson et al., 1981, pp. 359, 508) lists Marsland and Runningwater formations as “geologic names in use” while Upper Harrison is not listed.

For the purpose of the present paper the term Runningwater Formation of Cook (1965, the validity of which was reviewed by McKenna, 1965), is retained; and the Marsland Formation (=Upper Harrison) is considered valid where it can be differentiated from the overlying Runningwater Formation.

**DISTRIBUTION:** Skinner, Skinner, and Gooris (1977, fig. 1) postulate a “Runningwater Paleovalley” extending eastward for about 100 mi. from near Agate, Sioux County through Dawes and Sheridan counties into western Cherry County, Nebraska. Only remnants of an earlier pre-Marsland Paleovalley in which are found the predominantly silty sediments of the Marsland Formation, diagrammatically illustrated in Skinner, Skinner, and Gooris (1977, figs. 8–9), occur in the area of Yatkola’s (1978) study. The Marsland, however, becomes difficult to differentiate from the Runningwater in the area covered by our work.

**THICKNESS AND LITHOLOGY:** Yatkola (1978, p. 34) found that Runningwater Formation sediments “unconformably overlie sediments of the Monroe Creek and Harrison formations, and conformably overlie sediments of the lower member of the Marsland Formation. These sediments are composed of a maximum of 300 feet (91 m) of massive, yellowish gray (5Y 7/2) to pale brownish buff (10 YR 6-8/2), silty, very fine to fine, often bimodal . . . loose sandstone; wavy bedded sandstone and crystalline gravel lenses.” In its type section (Cook, 1965, fig. 3) the Runningwater consists of 125 ft. of “massive, loose, channel sands” with a layer of “platy weathering silty clay” 30 ft. above its base, and basal cross-bedded, granitic gravels and conglomerates. A mass of granitic conglomerate

still adheres to a skull of *Merychys elegans* (F:AM 24441), whereas pebbles of clay or fine-grained sediments eroded from Tertiary rocks are in another skull of *M. elegans* (F:AM 99706). Both skulls are from the Runningwater Quarry and the sediments preserved with them illustrate the diversity of material found in the coarser grained rocks of the Runningwater Formation.

Lithology similar to that found in the type section area of the Runningwater Formation was observed in sediments overlying rocks of the Arikaree Group in western Cherry County. Thickness, however, averages about 100 ft. or less (figs. 30–31).

**CORRELATION AND FAUNA:** Correlation between the type section of the Runningwater Formation, including the area covered by Yatkola’s paper, and several localities in western Cherry County is based upon similarities in lithology and the relative lithostratigraphic position of the sediments above the rocks of the Arikaree Group. The common occurrence of *Aletomeryx gracilis* and *Merychys elegans* in the Runningwater Quarry and other localities of the typical Runningwater Formation and the frequent presence of these taxa at sites in Cherry County lend support to the above interpretation.

**FOSSIL LOCALITIES AND OUTCROPS IN THE RUNNINGWATER FORMATION:** At least three localities in western Cherry County, the *Aletomeryx* Quarry and the nearby area west and southwest of the mouth of Antelope Creek, a locality on the north side of the Niobrara Valley 2.2 mi. east of the mouth of Rush Creek, and a prominent outcrop east of the Lions Bridge (fig. 31) contain fossils comparable to those found at the type locality of the Runningwater Formation.

**ALETOMERYX QUARRY** (fig. 18, no. 1): Situated 10 mi. S, 68°E of the center of the town of Gordon, Cherry County, Nebraska, and 1.2 mi. N, 22°W of the mouth of Antelope Creek on the lower slope of a point on the west side of a side canyon in the bluffs north of the Niobrara River. This is near the center of the SW ¼ of the irregularly shaped sect. 16, T. 32 N, R. 40 W, Cherry County, Nebraska. Lat. 42°45’3”N, Long. 102°1’20”W, Gordon SE Nebraska Quadrangle 1969. Scale 1:24,000. Elevation at base of quarry 3460 ft.

SYNONYM: Probably Quarry F of Lull (MS.a, 1914, Aug. 4-9; 1920, p. 84). UNSM Cr-23.

REPOSITORIES OF FOSSILS: YPM, F:AM, UNSM, ACM, and FMNH collections.

HISTORY: This area was visited by members of the O. C. Marsh Yale party in 1873, who on June 27, collected the type of *Blastomeryx marshi* Lull, 1920. In 1914 a Yale party under the leadership of R. S. Lull (1920, p. 84) camped near the mouth of Antelope Creek, and W. S. Benton found "on one side of a small tributary canyon, a talus slope literally strewn with bones . . . it was excavated . . . with still more astonishing results, for no fewer than nineteen skulls were obtained . . . The quarry . . . lay in a 6-foot bed of hard, light gray sandstone . . . 25 feet above the canyon floor . . . other material came from the opposite side of the small canyon and from the same approximate levels." From this collection Lull described the type of *Aletomeryx gracilis*. This site, or a stratigraphically equivalent site, was located in 1934 by Morris F. Skinner and Albert Potter, who named it the *Aletomeryx* Quarry. They collected a large number of slabs containing many skulls, jaws, and skeletal parts of *Aletomeryx* and associated fauna. That same year F. W. Johnson and Keith Rathbun collected 19 slabs of fossils for UNSM. This quarry was also worked in 1934 by F. B. Loomis of Amherst College and by Paul O. McGrew for the Field Museum in 1940.

REMARKS: The lithology of the *Aletomeryx* Quarry varies from light gray, fine to medium-grained, friable thin-bedded sandstone and silt, to very light gray to white calcareous and flaggy sandstone (fig. 30, sect. 4). A section measured by M. R. Thorpe of the Yale expedition (Lull, 1920, p. 84) checks well with our section at the *Aletomeryx* Quarry. The outcrops of these sediments have a distinctly white appearance in the bluffs in which they occur. A distant view of these bluffs inspired T. M. Prudden of the Yale 1873 expedition to record in his diary (Beinecke Library, Yale Univ.) his impression of the view as the Marsh expedition approached the Niobrara River from the south on June 26, 1873, as follows: "Away to the north we see the great white bluffs among which lie fossils for which we are here."

The principal fossil-bearing zone consists

of fine to medium-grained, but friable sandstone. These beds have a dip of  $11^{\circ}$  southeast with a strike of  $140^{\circ}$ . The dip appears to be depositional due to shoreline-deltaic foreset bedding in non-marine sediments (Stanley and Surdam, 1978, pp. 560-563), but a structural dip is not precluded. Directly across the canyon in a bearing  $5^{\circ}$  south of east from the *Aletomeryx* Quarry, layers of diatomaceous marly and slabby limestone and gray sand crops out. These have a dip of  $11^{\circ}$  southeast with a strike of  $100^{\circ}$ .

Well-preserved *Aletomeryx* bones occur in great abundance at this locality, whereas the remains of other animals are much less common. The depositional environment of the *Aletomeryx* Quarry is interpreted as a shoreline of an oxbow pond on a flood plain.

This site, or its local stratigraphic equivalent, is believed to be the type locality of *Aletomeryx gracilis* Lull, 1922 (YPM 10732) and possibly *Blastomeryx marshi* Lull, 1920 (YPM 10756). It is unquestionably the type locality of *Daphaenodon niobrarensis* Loomis, 1936 (ACM 1844) which was "found directly under the layer carrying *Aletomeryx*" (Loomis, 1936, p. 47) and *Alligator mcgrewi* Schmidt, 1940. Loomis (*ibid.*) also reported finding the jaws of *Oxydactylus longipes* in association with the *Daphaenodon*. This may also be the type locality of *Nothocyon latidens multicuspis* Thorpe, 1922 (YPM 12801) that was collected by Marsh.

No comprehensive study has been made of other taxa that occur at this site.

TWO MILES WEST OF POLE CREEK QUARRY (fig. 18, no. 2): Situated at the head of a small canyon in the SE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 32, T. 32 N, R. 40 W, Cherry County, Nebraska. Rushville 4 NE Quadrangle 1969. Scale 1: 24,000 (fig. 30, sect. 76). Elevation between 3452 and 3471 ft.

REPOSITORY OF FOSSILS: F:AM collection has more than 68 specimens from the original 1938 discovery site.

HISTORY: Discovered August 1, 1938, by M. F. Skinner and G. K. Fletcher. Because of other investigations, Skinner left after the quarry was opened. Efforts to relocate the site in 1974 were unsuccessful, but in 1976 F. W. Johnson found a channel sand containing *Aletomeryx* fragments in the same general area described by Skinner. This is believed to be



the site from which Skinner collected *Aletomeryx*, *Merychys*, and *Parahippus* specimens in the late 1930s.

REMARKS: The channel sand at the Two Miles West of Pole Creek site is medium to coarse-grained and lithologically similar to the sand at the type section of the Runningwater Formation. Within the sedimentary sequence of the Two Miles West of Pole Creek site there are interbedded sand and white, marly, diatomaceous clay similar to that in the vicinity of *Aletomeryx* Quarry and in the Antelope Creek section 1 mi. S, 47°W of the *Aletomeryx* Quarry (fig. 30).

*Aletomeryx* from this site is referred to *A. gracilis* and falls within the "range of variation of those collected from the *Aletomeryx* and Runningwater quarries" (*vide* B. Taylor, personal commun.). Several partial rami (F:AM 43306 and 43308) and fragments of a maxilla (F:AM 43307) of *Merychys elegans* were associated with *Aletomeryx* at this quarry. Both are common fossils in the Runningwater Formation at its type section (Cook, 1965).

Additional evidence of sediments that may be temporally equivalent to the Runningwater Formation was found in a section on the east side of the road southeast of the Case Bridge in the NE ¼, SE ¼, sect. 31, T. 32 N, R. 40 W, where a partial ramus (F:AM 112548) of *Merychys elegans* was collected at an elevation of 3398 ft. This fossil was on the talus of a fine to medium and coarse cross-bedded channel sand 10 ft. above its contact with a sandstone that lithologically resembles the Harrison. This is at an elevation 54 ft. below the section containing *Aletomeryx* at the Two Miles West of Pole Creek Quarry, which is only 0.35 mi. E, 22°S of the Case Bridge locality.

Obviously the details of the faunal and stratigraphic succession of Arikarean and Hemingfordian sediments in the vicinity of the *Aletomeryx* Quarry and along the Niobrara River near the western border of Cherry County are not fully understood, but it is expedient to summarize field observations and interpretation of correlations on several cross sections (figs. 30, 31). These cover the local area west of the mouth of Antelope Creek.

Even though the section between the base

of the Valentine (?) and the top of the Harrison on Antelope Creek (fig. 30, sect. 75) is assigned to the Marsland-Runningwater equivalent there may be alternative correlations. On the basis of available evidence, however, these sediments are interpreted as being deposited in the "Runningwater Paleovalley" as postulated by Skinner, Skinner, and Gooris (1977, pp. 316-317, figs. 8-13).

A regional cross section (fig. 30) from the Niobrara River northwestward through the *Aletomeryx* Quarry to the Nebraska-South Dakota boundary, 3 mi. east of White Clay, then northeastward to Purcupine Butte, illustrates the broader stratigraphic framework and structural attitude associated with the Chadron Arch and the Black Hills Uplift as they apply to this area.

EAST OF THE MOUTH OF RUSH CREEK: About 14 mi. west of *Aletomeryx* Quarry and 2.25 mi. N, 87°E of the mouth of Rush Creek near the northeast corner of sect. 33, T. 31 N, R. 42 W, Rushville 4 NW Quadrangle, a ramus of *Aletomeryx gracilis* (F:AM 112549) was found in very light gray to white silty sand. This discovery suggests that sediments in the north part of section 33 are temporally equivalent as well as being lithologically similar to those in the *Aletomeryx* Quarry.

LIONS BRIDGE: A skull and jaw of *Merychys elegans* (F:AM 100000) was collected from a prominent outcrop on the north side of the Niobrara River about 800 ft. N, 12° east of the Lions Bridge near the west line of the NW corner of sect. 15, T. 32 N, R. 39 W, Cherry County, Nebraska, Irwin Quadrangle. This specimen was collected 86 ft. above the river from gray to buff, fine-grained, friable sandstone (fig. 31, sect. 8). The occurrence of *M. elegans* indicates that the sediments in which it was found are approximately equivalent in age to the Runningwater Formation in the type area. These sediments grade downward into lighter gray to buff sandstone containing occasional layers of concretions.

The basal 17 ft. of section at this locality consists of brownish, yellow-gray to pinkish siltstones that may be Marsland, Rosebud or Monroe Creek equivalent. No fossils have been found in the lower unit, however, which precludes the use of fauna in comparing temporal relationships.

From the Lions Bridge downstream for about 8 mi. on the east flank of the Chadron Arch the Niobrara River is incised deeply into the rocks of the Arikaree Group overlain

by sediments as young as Ash Hollow. These are in sharp erosional contact with the underlying section (fig. 31).

## OGALLALA GROUP

Ogallala is a widely recognized group name for extensive alluvial deposits covering the plains east of the Rocky Mountains from southern South Dakota southward into Texas. In the late Neogene this great sheet of sediments probably covered 500,000 square mi. with a north-south extent of 1000 mi. (Frye and Leonard, 1959, p. 27; King and Beikman, 1978, pp. 33–34).

Darton (1898, pp. 734–735) stated: "Extending from Kansas and Colorado far into Nebraska there is a calcareous formation of late Tertiary age to which I wish to apply the distinctive name Ogallala Formation. It is a portion, if not the whole, of the deposit which in Kansas and southward has been called the 'Mortar beds,' 'Tertiary grit,' and other names. It has been regarded as a portion of the Loup Fork Formation. It is extensively developed in the western part of Nebraska . . . It appears to underlie at least a portion of the great sand-hill district." Darton (1898, map, pl. 82) showed the Ogallala sediments extending into adjacent Wyoming and north-eastern Colorado and suggested that they probably occurred along the Niobrara River by use of symbol for "unclassified Tertiary (mainly Arikaree and Ogallala formations or 'Loup Fork')."

Barbour (1903, p. 163) recognized the presence of Ogallala as far east as Rock and Knox counties in northern Nebraska. Darton (1905, pl. 44) mapped the Ogallala and Arikaree formations and the White River Group as occurring over most of the area covered by the present study. Darton (1920, p. 6) finally designated the type locality as "near Ogallala station in western Nebraska" (Wilmarth, 1938, pp. 1530–1532).

Elias (1931, pp. 132–135) in a discussion of "Typical Ogallala Beds," included Hay's (1895, p. 580) "Section of Tertiary grit along the North Platte northwest of Ogallala, Nebr." Elias (1931, p. 133) stated that Hay's section was "at the type locality of the formation." Later, Elias (*in* Stirton, 1936, pp. 177–178)

acted as a first revisor and stated that the type section of the Ogallala Formation was at "the exposures in the canyon 2 miles east and one-half mile north of the town of Ogallala on the Feldt Ranch; SE.  $\frac{1}{4}$  Sect. 33, T. 14 N., R. 38 W. in Keith County, Nebraska."<sup>4</sup> This agreed with Hesse's (1935a, p. 79) reference to "the type locality of the Ogallala formation" as the site from which Elias had collected vertebrate fossils in 1930. Stirton (1936, p. 184) referred to fossils from this locality as the "Feldt Ranch fauna."<sup>5</sup>

Simpson (1933, p. 104) in a discussion on the Ogallala stated: "as a stage name it has been widely used (e.g., in Osborn and Matthew, 1909), where it includes formations now placed in both Miocene and Pliocene in three stages, Barstow, Valentine, and Republican River. In this sense it is nearly the same in usage as the even more commonly used but even less accurately useful 'Loup Fork'."

The lectostratotype of the Ogallala established by Hesse (1935a, pp. 79–80) and later set by Elias (*in* Stirton, 1936) in vertebrate fossil and ash-bearing beds<sup>6</sup> represents an in-

<sup>4</sup> These outcrops extend into the NE  $\frac{1}{4}$ , sect. 33, T. 14 N, R. 38 W, where the fossil-bearing channel sand was observed in 1934.

<sup>5</sup> During a visit to the Feltz Ranch on October 5, 1974 we were informed by Mrs. Theresa Nielson, a niece of Felix J. Feltz who was the owner in the 1930s, that "Feldt" was an incorrect spelling of the name Feltz. Hibbard (1933, p. 273) probably was the first to use Feldt when he cited it as the type locality of *Bassariscus ogallalae*. Subsequently, Hesse (1935a, pp. 80–96) followed Hibbard in the name of the type locality of the Ogallala Formation and the Feldt Ranch Fauna. Feldt Ranch was widely used by Stirton (1936, p. 184) and others as a faunal name. It is proposed that the correct spelling of Feltz replace Feldt and that the fauna be known as the Feltz Ranch Local Fauna.

<sup>6</sup> The lectostratotype section of the Ogallala contains two beds of volcanic ash, the lower having been dated by the fission-track method at  $7.6 \pm 0.7$  Ma (Boellstorff and Skinner, 1977, p. 40) but later revised to  $8.0 \pm 0.7$  Ma (Boellstorff, personal commun.). The lower ash re-

complete section of the formation as widely used by Darton (1905) and others. Hesse (1935a, p. 82) seemed to have recognized this when he stated that the Ogallala "is one of the most extensive North American deposits" and suggested that units such as the Goodnight Formation, the Blanco, the Clarendon Beds, and the Hemphill Beds "be referred to as zones of the Ogallala."

By the mid 1930s usage of the Ogallala Formation was nearly as nondefinitive as that of "Loup Fork," "Loup River," and "Nebraska Beds," none of which represented formation rock units. Lugn (1938, pp. 225–227) recognized that the Ogallala Formation, as used by Darton, was composed of several lithologic units of formational significance and redefined it "as a group consisting of four definite and mappable formations." The Ogallala Group, as defined by Lugn, included raising to formation status the Valentine Beds of Barbour and Cook (1917b, p. 173), as restricted by Johnson (1936, pp. 467–471) and the Ash Hollow Formation of Engelmann (1876, pp. 259–283). Lugn (1938, p. 224) also proposed two new units: "the Sidney Gravel formation" and "the Kimball formation" in the upper part of the Ogallala Group.

This action by Lugn (1938, pp. 224–225) had been agreed to at a meeting of Lugn and Elias with the state geologists of Kansas and Nebraska in March 1936. Lugn (1939, pp. 1258–1264) presented an expanded review of the Ogallala stratigraphy and nomenclature which the Wood Committee (1941, p. 27) accepted. Elias (1942, pp. 132–147) favored the broad usage of Ogallala as a group term, and following Darton's original use, documented the presence of various fossil seed zones in the formations established by Lugn.

Frye, Leonard, and Swineford (1956, pp.

47–67) treated the Ogallala as a formation and accepted its subdivision into several members, with the Valentine as a basal unit deposited on the deeply eroded surface of older formations. In Texas, however, Frye and Leonard (1957a, p. 13) "were unable to recognize and trace rock-stratigraphic units within the Ogallala throughout the region . . . and for that reason treat it . . . as a formation and do not recognize formal members." These authors (1957a, p. 17), nevertheless, were able to recognize floral zones that they used as a basis for assigning a thin section as equivalent to the Valentine, whereas most of the Ogallala in Texas is equivalent to the Ash Hollow or younger. Although Frye and Leonard (1957a, p. 14; 1959, pp. 18–29) did not observe much vertebrate material in their investigations, they found little conflict between correlations based on fossil vertebrates, invertebrates, and seeds.

The problems of identification of rock units in the Ogallala on a north-south profile (Frye and Leonard, 1959, fig. 1, pp. 6–7) appear to be due to variation in the provenance of sediments and the complexity of alluviation in an extensive system of east-west trending valleys, and as aggradation progressed, on great alluvial plains. Whereas their profile (Frye and Leonard, 1959, fig. 1) is roughly perpendicular to the regional system of drainage and alluviation, the area studied in the Niobrara valley of north-central Nebraska is predominantly along an east-west profile. It is more likely, therefore, that sediments in the sections along the Niobrara River and its tributaries are from a relatively restricted westward source in the upstream paleodrainage systems. This results in greater continuity of more readily identifiable rock units and better correlation in east-west profiles.

The nonopaque heavy mineral work of Sato and Denson (1967, pp. C42–C54) and Denson (1969, pp. C25–C32) provide significant data on the source of sand and as an aid in the lithologic diagnosis and correlation in the White River, Arikaree, Hemingford, and Ogallala groups. To use heavy minerals, however, as the sole basis of justification for stratigraphic nomenclature is not consistent with the concept of using all available criteria in the establishment of a lithostratigraphic framework.

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sembles the "polishing powder" of Hay's (1895, p. 580) section, bed 13. This 4- (or more) ft. bed of ash is easily observed on the west side of the canyon near its mouth on the Feltz Ranch. The ash occurs about 57 ft. above the waters of the South Platte River. The second ash layer (about 1 ft. thick) occurs 86 ft. above the river and 2 ft. below a prominent 5-ft. ledge of conglomerate that crosses the bottom of the canyon. The Feltz Ranch Local Fauna occurs in soft sand between 12 and 23 ft. above the top of the hard conglomerate (Skinner MS., vol. 9, pp. 90–91; Johnson, MS.G., 1974, pp. 102–106).

Hayden	Engelmann	Cope	Scott	Matthew	Darton
1858 A, pp. 148, 150 1858 B, pp. 405-408 1869, pp. 13-16	1876, pp. 260-263, 268	1882, pp. 192-193, fig. 7	1894, pp. 594-595	1899, pp. 20-25	1899, pp. 734-735 1905, Pl. 44 Barbour 1903, p. 163, Pl. 10
Loup River beds = Bed F	ASH HOLLOW Formation ? equiv. to Hayden's F3  ?	Loup Fork Beds = Cosoryx beds	Loup Fork Nebraska = Cosoryx beds	Loup Fork Beds equivalent to Hayden's Bed F  Procamelus beds	OGALLALA FORMATION  "Mortar beds" "magnesia"  Tertiary Grit

FIG. 4. Seven consecutive pages showing development of nomenclature of various lithostratigraphic units in the Ogallala Group in north-central Nebraska. The age of 9.7 Ma for the Davis Ash is from Izett. Boellstorff obtained a date of  $10.2 \pm 0.7$  Ma on the same ash (this paper, pp. 246, 297, figs. 13, 15).

Breyer (1975, pp. 5-8) considered the Ogallala of western Nebraska "a single rock-stratigraphic unit" and that "No lithologic criteria were observed which would justify the subdivision of these sediments into two or more formations (members). The term Ash Hollow, as conceived by Engelmann in 1859 and defined in part by Lugn (1939) seems the most appropriate name for these rocks . . .

and includes the rocks formerly assigned to the Sidney gravel and Kimball formations of Lugn."

We accept the Nebraska and Kansas Geological Survey usage of the Ogallala Group as defined by Lugn (1938, 1939). As a group name Ogallala is applicable to widespread alluvial sediments of variable thickness which can be recognized over vast areas in the Great

Gidley 1904, pp. 241-245	Osborn 1909, pp. 79-81	Barbour 1914 a, p. 169 1914 b, pp. 182-183	Barbour and Cook 1917 A, p. 170 1917 B, pp. 173-180	Osborn 1907, pp. 248-250 1918, pp. 23, 27	Matthew 1924 A, pp. 103, 200 1924 B, p. 747 Thorpe 1922, p. 424
<p>?</p> <p>Loup Fork beds</p>	<p>Upper Loup Fork</p> <p>Peraceras Zone</p> <p>Loup Fork</p> <p>Procamelus Zone</p>	<p>(Also see Barbour sketch from 1913 notes in Osborn, 1936, fig. 568)</p> <p>?</p> <p>Devil's Gulch beds</p>	<p>?</p> <p>Devil's Gulch beds upper phase "fauna of Devil's Gulch"</p> <p>Valentine beds lower phase Valentine "fauna of Valentine"</p>	<p>?</p> <p>? Devil's Gulch (upper beds) Peraceras - Pliauchenia zone "Devil's Gulch phase"</p> <p>?</p> <p>Valentine beds Ft. Niobrara Fm., etc. Procamelus-Hipparion zone "Valentine phase"</p>	<p>Devil's Gulch</p> <p>Valentine beds</p> <p>Procamelus-Hipparion</p>

Plains. In north-central Nebraska the Ogallala is divided into two formations, the Valentine and Ash Hollow. The component formations of the Ogallala Group recognized in north-central Nebraska are not necessarily present or recognizable as separate units in all other areas in which Ogallala sediments occur. Hedberg (1976, p. 34), however, has shown that a formation, such as the Valentine, need not be recognizable as a separate unit in all areas in which age equivalent sed-

iments occur to qualify it as a formation in sizeable areas in which it can be recognized.

The Valentine and Ash Hollow formations of the present study area are lithostratigraphic units that carry important biostratigraphic successions of vertebrate fossils. Both formations are divided into several members, some of which contain beds of vitric tuff that have been dated by radiometric methods.

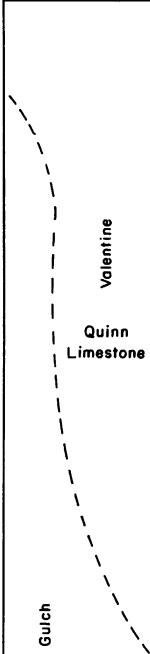
Treatment in detail in this paper of the faunas in the Ogallala of north-central Ne-



Simpson 1933, pp. 94, 113, fig. 6	Stirton 1933, p. 569	Cook and Cook 1933, pp. 43-44	Teilhard de Chardin and Stirton 1934, p. 284	Stirton and McGrew 1935, pp. 125-132 McGrew and Meade 1938, p. 205	Johnson 1936, pp. 467-475, 2 figs. 1938, pp. 215-219	
<div>?</div> <div>Devil's Gulch Formation</div> <div>?</div> <div>Valentine Formation</div> <div>Valentine Fauna</div>	Valentine Fauna (post Clarendon)	upper member "Valentine" beds	<div>?</div> <div>Valentine Fauna</div> <div>?</div> <div>Clarendon Fauna</div>	Valentine Fauna	"cap rock bed" "fragmental layer"	OGALLALA FORMATION
					Burge Sands Member Burge Fauna	
	<div>?</div> <div>Ft. Niobrara Fauna</div>	lower member "Ft. Niobrara"	<div>?</div> <div>Niobrara River Fauna</div>	<div>Burge Fauna</div> <div>Niobrara River Fauna</div>	Upper Valentine beds	
					Valentine Member  Valentine Fauna	
					Lower Valentine beds	

braska is limited to the published taxa from the Cornell Dam Member (New) of the Valentine Formation. Details are not included on the fauna and flora from other members of the Valentine or the Ash Hollow, other than on well-documented types from both formations and discussions on taxa from the type section of the Merritt Member (New). Through checking of field records and revisiting collecting localities, the geographic and lithostratigraphic position was determined for

the types of 80 taxa collected from the Ogallala in north-central Nebraska and south-central South Dakota. Similar information is included on the fossil producing quarries and significant sites worked by Frick field parties during 50 years and most of those worked by the University of Nebraska State Museum. Comprehensive research has not been done on most of the fossils from these quarries. The documentation of geographic and geologic data should serve as a contribution to

Osborn 1936, fig. 679	Stirton 1936, p. 175	Lugn 1938, pp. 221-227	Stirton 1939, pp. 429-433	Lugn 1939, p. 1264	Wood et al. 1941, Pl. I
	Valentine Fauna Pine Creek Fauna Devil's Gulch Fauna Burge Fauna	<div> <div>           Biobia fossil seed zone            ASH HOLLOW FORMATION            "mortar beds"         </div> <div>           Krynitzkia fossil seed zone            "cap rock bed"            "fragmental" .... zone         </div> <div>           Burge channel Member         </div> </div> <div>           VALENTINE FORMATION            Valentine Fauna         </div> <div>           Stipidium fossil seed zone         </div>	Minnechaduzza Fauna Burge Fauna Niobrara River Fauna	ASH HOLLOW FORMATION Biobia seed zone Krynitzkia seed zone "cap rock bed" "fragmental" .... zone Burge channel Member "Burge" fauna VALENTINE FORMATION Stipidium fossil seed zone	Xmas and Kat quarries L.F. Minnechaduzza L.F. Burge Sand Mbr. Burge L.F. Niobrara River L.F.

further studies on the systematics and biostratigraphic relationships of the faunal assemblages from these localities.

Evidence that the Ogallala Group is an important aquifer is provided by the frequent presence of springs emanating from the porous sand in many outcrops along the Niobrara and its tributary streams. The most extensive continuous water-bearing sand is in

the Crookston Bridge Member from which springs flow at its base in various localities.

#### VALENTINE FORMATION

**HISTORICAL REVIEW:** The Valentine Formation, named for the town of Valentine, Nebraska, is widely recognized as the lower unit of the Ogallala Group in north-central Nebraska. Barbour and Cook (1917a, p. 170)

Schultz and Stout, et al. 1941, p. 4	Chaney and Elias 1938, pp. 6-10, 13-16 Elias 1942, fig. 133-143	Condra and Reed 1943, fig. 5	Cronin and Newport 1956, pp. 16-19	Frye, Leonard and Swineford 1956, pp. 51-60
ASH HOLLOW FORMATION	ASH HOLLOW FORMATION  "cap rock bed" Minnechaduza fauna "fragmetary layer"	ASH HOLLOW FORMATION "mortar beds"	ASH HOLLOW FORMATION  cap-rock zone	Ash Hollow Member
Burge Sand Member  VALENTINE FORMATION	VALENTINE FORMATION "Valentine fauna" Niobrara River channel Brown County Bed	VALENTINE FORMATION	Burge Sands Member  VALENTINE FORMATION	Valentine Member

were the first to use the term "Valentine . . . beds." When these authors (1917b, pp. 173, 180) described the type of *Aelurodon platyrhinus* they used the term "a lower phase than . . . the Devil's Gulch," but at the same time referred to "The fauna of the Valentine beds," a substantial part of which came from a site originally known as the Valentine Quarry (present paper, p. 271).

The term Valentine was used by Osborn (1918, p. 23), Thorpe (1922, p. 424), Mat-

thew (1924a, pp. 103, 200), and Simpson (1933, pp. 102, 113) in discussions involving the fauna from the lower part of Hayden's (1858a, p. 149) Bed F. It is not known that Hayden collected fossils in the vicinity of the mouth of Minnechaduza Creek or the present Fort Niobrara,<sup>7</sup> although Gidley (Matthew

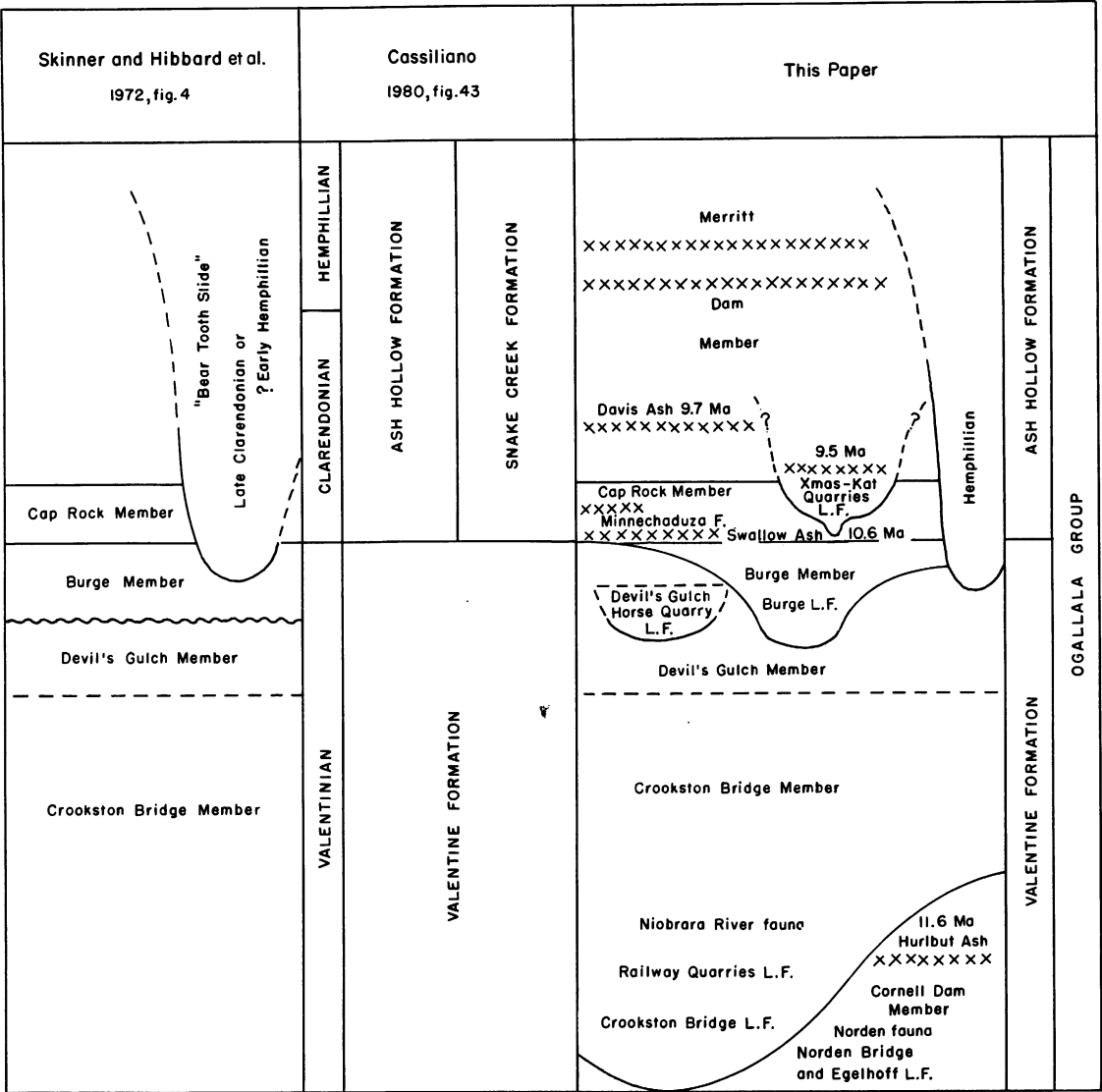
<sup>7</sup> Fort Niobrara (Hamersly, 1881, p. 147; Prucha, 1964, p. 95) was founded on April 22, 1880. Therefore, it was not used as a place name prior to that date. Hayden

Frye and Leonard 1959, fig. 1	Schultz and Stout 1961, fig. 3  Wilson 1960, fig. 5			Skinner, Skinner and Gooris 1968, pp. 402-410, Pl. 23, 25	Webb 1969, fig. 2
ASH HOLLOW FORMATION	HEMPHILLIAN	Feldt Ranch L.F.	Upper Ash Hollow		ASH HOLLOW FORMATION
		Xmas and Kat Quarries L.F.			
	CLARENDONIAN	Minnechaduzu L.F. Complex  Cap Rock Bed	Lower Ash Hollow	Cap Rock Member	
VALENTINE FORMATION	VALENTINIAN	Burge Member Burge L.F.		Burge Member Burge Fauna	"Burge Sands" Burge Fauna
		Devil's Gulch L.F.		Devil's Gulch Member Devil's Gulch Fauna	VALENTINE FORMATION  Niobrara River Fauna
		Ft. Niobrara L.F.		-----  Crookston Bridge Member  "Niobrara River fauna"  "Valentine fauna"	
		Railroad Quarry L.F.  Crookston Bridge L.F.		"Crookston Bridge L.F."	

collected fossils at various sites along the Niobrara River 23 years before the establishment of Fort Niobrara.

Osborn (1912, pp. 232-233, 248) was deeply interested in the establishment of correlations and paleogeographic conclusions through "synthesizing all possible evidence" and realized the great need for "more accurate geologic sections and more concise detail . . ." from the Miocene and Pliocene. Subsequently Matthew (ms.b, 1916, p. 5) told E. H. Barbour that Osborn was interested in visiting Nebraska and suggested that "it might be a good plan to make a joint geological reconnaissance and discuss the stratigraphic problems that come up." Apparently Barbour agreed as he and Osborn visited Devil's

Gulch and Fort Niobrara on September 16, 1916 and observed a "very finely marked unconformity between Oligocene and Pliocene continuous from Devil's Gulch and eastward to Valentine and westward" (Barbour, ms.b, 1916, pp. 72-73 and photos in UNSM). A sketch section near Ft. Niobrara in Barbour's notes shows a "hard ledge" at the top (Cap Rock Member of the Ash Hollow Formation), a thick section of sand (Valentine Formation) overlying the "Brule (Olig.)" (Rosebud Formation). Barbour also recorded "Pliocene like that at Devil's Gulch" in the lower part of the sand section in the Valentine Formation, which is now recognized as the Crookston Bridge Member at both localities.



and Gidley, 1904, p. 241) stated otherwise. Usage of the name Valentine by Osborn and others probably came from Barbour and Cook (1917a).

It appears that Barbour and Osborn observed correctly the general correlation between sections exposed at Ft. Niobrara and Devil's Gulch. Impressions on the correlations formulated on that day are reflected in subsequent publications by Barbour and Cook (1917a and 1917b) and Osborn (1918), shown on the correlation charts of the present paper (fig. 4). Also see p. 276 for Matthew's observations.

Stirton (1933, table on p. 569) applied the name Valentine to a collection from the Cap Rock Member of the Ash Hollow Formation. He interpreted this fauna as being younger than the Clarendon Fauna of Texas. Stirton's usage was followed by Cook and Cook (1933, pp. 43–44). A year later, Chardin and Stirton (1934, p. 278, table 3) applied the name "Niobrara River fauna" to fossils from the Valentine Formation, considered the fauna transitional between the Miocene and Pliocene and stated that "The Valentine fauna,

from an upper-level, however, is distinctly Pliocene." Colbert (1935a, pp. 13–14, fig. 2), however, urged retention of Valentine instead of Niobrara River stating that "Valentine is well established . . . to indicate the formation and the time transitional between the Miocene and the Pliocene . . . abandonment of this usage of the term will lead to some confusion." Stirton and McGrew (1935, pp. 127–131) proposed in ascending order three local faunas: the Niobrara River Local Fauna (actually out of the Valentine Formation), the Burge Local Fauna (from the Burge Member), and the Valentine Local Fauna (actually out of the Ash Hollow Formation).

The term Niobrara River is a generalized locality covering an area more than 400 mi. long with a geologic section that contains several stratigraphic units. It was so used repeatedly by Leidy (1858, pp. 1–29; 1869, pp. 20–30; 1871, pp. 340–367; 1873, p. 247) and Hayden (1858a, pp. 148–150; 1869, pp. 15–17; 1873, pp. 56–60).

Meek and Hayden (1862, pp. 417–424, 433) formally named the Cretaceous Niobrara Formation with its typical locality and fauna near the mouth of the Niobrara River. Hague and Emmons in King (1877, pp. 41–42, 65–68; sect., p. 855), and King (1878, pp. 425–431) introduced confusion by using Niobrara in a stratigraphic sense in both the Cretaceous and Tertiary. Cope (1882, pp. 192–193, fig. 7), noting prior usage of Niobrara in Cretaceous nomenclature, opposed use of the term in the Tertiary.

Stirton and McGrew's (1935, pp. 128–131) Niobrara River faunal list consisted mostly of fossils collected from the talus of a sand slide in the Crookston Bridge Member in the basal 90 ft. of the Valentine Formation on the south side of the Niobrara River,  $5\frac{3}{4}$  mi. N,  $35^\circ\text{E}$  of the Valentine Quarry. This was their UCMP V-3218 locality. They also applied the name Valentine to a fauna from the cap rock in the upper part of the section northeast of Fort Niobrara, most of which came from their Little Beaver B, UCMP V-3326, on the north side of the Niobrara River Valley. This is some  $8\frac{1}{4}$  mi. N,  $39^\circ\text{E}$  of the original Valentine Quarry.

Johnson (1936, pp. 467–473, fig. 2) dis-

cussed the resultant confusion in stratigraphic and biostratigraphic nomenclature, restricted the term Valentine to the lower member of the Ogallala Group, and included the Valentine Quarry in the type section<sup>8</sup> of the Valentine Member. Johnson (1936, p. 472) also named the Burge Sands Member overlying the Valentine Member and informally designated the "cap rock bed" of the Ash Hollow Formation as the unit overlying the Burge Member.

McGrew (1938b, pp. 309, 326), and McGrew and Meade (1938, pp. 198, 203–207) agreed with those who applied the name Valentine to the fauna of the "cap rock bed" and dwelt heavily on their own interpretation of the absence of hipparions in the Niobrara River Fauna.

Matthew (ms.a, 1916, pp. 18–19) identified hipparions from the Valentine Quarry (now Railway Quarry "A") but observed that the "teeth are short crowned for a Hipparion . . . [and that] the milk dentition is much nearer to *Merychippus* than it is to that of *Hipparion occidentale* or *whitneyi*." Past differences of opinion as to the identity of hipparions in the Valentine Formation have been one of the factors that delayed the solution of correlation and nomenclature problems.

Wilmarth (1938) and Keroher (1966) reviewed Johnson's (1936, pp. 467–475, 2 figs.) proposals and listed "Valentine Beds" and "Burge Sands Member" as stratigraphic units. Various names, including "Niobrara River formation," "Loup Fork beds," and "Fort Niobrara fm." were abandoned or rejected

<sup>8</sup> The type section of the Valentine Formation begins at its contact with the underlying Rosebud Formation 11 ft. above the normal water level on the south side of the Niobrara River in the SE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 8, then 1070 ft. S,  $25^\circ\text{E}$  to orthoquartzite ledge on west side of road in NW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 17, then 900 ft. N,  $70^\circ\text{E}$  through the West Valentine and Railway Quarry "B" sites in old excavation made to provide fill for the railroad bridge approach, then 660 ft. S,  $63^\circ\text{E}$  crossing railroad fill to site of Railway Quarry "A" located on south side of drainage 75 to 100 ft. east of railroad culvert marked 1909, then 1800 ft. S,  $73^\circ\text{E}$  to head of canyon in SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 16, all in T. 33 N, R. 27 W, Cherry County, Nebraska (fig. 11, and sect. 29 on fig. 33).



by the USGS (Wilmarth, 1938) and are no longer listed as geologic names (Swanson et al., 1981).

Lugn (1938, pp. 222–223), with the approval of the state geologists of Kansas and Nebraska, raised the Ogallala Formation to group status and included the Valentine and Ash Hollow. At the same time Lugn raised the Valentine to a formation and redefined it to include the Burge Member.

Johnson (1938, pp. 215–219) and Lugn (1939, pp. 1258–1261, 1264, tables 1, 2) reiterated that the term Niobrara in Tertiary stratigraphy and biostratigraphy should be discouraged and that Valentine should be retained for the rocks and faunas of the Valentine Formation. The best example of the Valentine Fauna was from the Valentine Quarry (=Railway Quarry “A”) in the lower part of the Valentine, here considered the Railway Quarry “A” Local Fauna in the Crookston Bridge Member of the Valentine Formation (fig. 10). Johnson (1938, p. 217) included a faunal list from the “Lower Valentine Beds” that is approximately equivalent to the section from which Stirton and McGrew (1935) obtained their Niobrara River Fauna.

Colbert (1938, pp. 212–214) agreed that Valentine had “gained wide favor . . . as a designation for the basal Pliocene, or transitional Miocene” and “came to be applied as a time term,” and that “the name ‘Niobrara River’ . . . has no standing as a stratigraphic unit.” Colbert suggested, however, that Valentine be dropped “as a time designation” to eliminate confusion.

Stirton (1939, pp. 429–433) again urged retention of Niobrara River as a faunal term, but recommended “to avoid confusion, the name ‘Valentine’ as used by Stirton and McGrew in 1935 may be replaced [by] the name ‘Minnechaduza’ taken from Minnechaduza Creek” and designated “The type fauna and locality being on a divide between Little Beaver and Crooked Creeks, SW  $\frac{1}{4}$  of SW  $\frac{1}{4}$  of Sec. 8, T. 34 N., R. 26 W., north pasture Niobrara Game Refuge, U.C. Loc. V3326.” (Present paper, fig. 24, no. 58.)

Wood et al. (1941, pp. 26, 35, pl. 1) accepted the Valentine as a formation “to embrace the two older local faunas . . . (Niobrara River and Burge), but not the Minnechadu-

za.” The Wood Committee, however, did agree to Stirton’s proposal to replace “Valentine local fauna” as used by Stirton and others, with the name Minnechaduza, which they recognized as a local fauna, and thus removed from confusion the application of Valentine to two separate faunas in different formations temporally separated by at least one million years. The view of the Wood Committee received general acceptance in subsequent papers dealing with faunas in north-central Nebraska.

Skinner, Skinner, and Gooris (1968, pp. 402–408) further established the Valentine as a formation when they divided the section below the Burge Member into two new members, the Crookston Bridge and the Devil’s Gulch. The name Burge Sands Member was shortened to Burge Member and the Cap Rock Member was formalized as a unit in the basal Ash Hollow Formation. Webb (1969, pp. 8–15) agreed with Wood et al. (1941) on stratigraphic and biostratigraphic nomenclature and that the Burge Fauna is older than the Clarendon, but nevertheless, placed the Burge Fauna in the “Clarendonian Stage.”

Cassiliano (1980, p. 64) indicated that Valentine is “accepted by most North American paleontologists and stratigraphers” as a valid term in stratigraphic nomenclature. It is listed by the USGS. (Swanson et al., 1981, p. 599) as “VALENTINE, FM (OGALLALA GP),” a geologic name in use in the United States.

Although Valentine Formation has become a frequently used term in late Tertiary nomenclature there is a strong consensus that its use as a faunal term is ambiguous and confusing due to the varied interpretations that have been applied. Furthermore, the name of the original Valentine Quarry has at least 17 synonyms (p. 271), the most commonly used being Railway Quarry “A” which is now the name of the local fauna from that quarry. This differentiates it from Railway Quarry “B” and West Valentine Quarry and their local faunas. These quarries appear, however, to be stratigraphically equivalent and their composite fauna is referred to as the Railway quarries Local Fauna. Railway Quarry “A” is the *Aelurodon platyrhinus* Quarry, UC-V337 that Stirton and McGrew (1935, p. 129) considered the source of “the best representation” of their Niobrara River

Fauna, but it was not included in their faunal list.

Due to the confusion that developed over the use of Valentine as a faunal term, the action of the Wood Committee (1941) and subsequent lack of use of the name, Valentine should be considered obsolete as a faunal term. It seems prudent, however, to continue usage of the term Niobrara River Local Fauna as it applies only to the faunal assemblage described by Stirton and McGrew (1935) from UCMP Loc. V3218. Tedford et al. (ms.), however, use "Niobrara River Fauna" for all assemblages from the Crookston Bridge Member. It is proposed, nevertheless, that local faunal names should continue to be used for faunas from well-defined fossil quarries, such as the Crookston Bridge Local Fauna, Railway Quarry "A" Local Fauna, and Railway quarries Local Fauna. This facilitates a better record of the geographic, lithostratigraphic, and biostratigraphic position and the composition of the local faunas that occur in the Valentine Formation.

**DISTRIBUTION:** The Valentine Formation extends from south-central South Dakota (Skinner and Taylor, 1967, p. 13; Skinner, Skinner, and Gooris, 1968, pp. 402–408) and northeast Nebraska (Simpson, 1960, p. 43) through the type locality area in north-central Nebraska (fig. 33). Its occurrence in northern Nebraska is best observed along the Niobrara River and its tributary streams from Knox through Holt, Brown, and Keya Paha counties; and about 200 mi. westward to the east flank of the Chadron Arch in western Cherry County.

**THICKNESS:** Thickness varies along the Niobrara River from nearly 300 ft. at Rock Rapids, near the mouth of Coleman Creek in western Keya Paha County, to 220 ft. in the type section near Valentine and 225 ft. at the mouth of the Snake River. This unit disappears abruptly on the east flank of the Chadron Arch in western Cherry County where it is cut out by post-Valentine erosion. A thin section, however, of rocks referred to the Valentine Formation occurs at the *Aletomeryx* and Paleo quarries on the Chadron Arch.

The Valentine Formation unconformably overlies Arikaree rocks over much of the outcrop area in Cherry, Brown, and Keya Paha counties. Sandstones tentatively identified as

Valentine overlie the Hemingford Group in western Cherry County. In northeast Nebraska it lies on the Pierre Shale where the Chadron Formation and later sediments were removed by erosion before Valentine deposition; it finally pinches out in Knox County (Simpson, 1960, pl. 1).

**LITHOLOGY:** The Valentine Formation consists of friable, cross-bedded channel sand, semiconsolidated argillaceous sandstone, occasional beds containing silicified casts of fossil roots and *Stipidium commune* (Elias, 1942, p. 138), now *Berriochloa communis* (Elias) Thomasson comb. new (1979, p. 52), and massive sand and gravel.<sup>9</sup> Variations in lithology serve as a basis for dividing the formation into four members: Cornell Dam (New), Crookston Bridge, Devil's Gulch, and Burge. The Cornell Dam Member contains the Hurlbut Ash, whereas the other members have no known ash deposits.

**AGE OF FAUNAS AND CORRELATION:** Schultz and Stout in Wilson (1960, p. 15, chart) and Schultz and Stout (1961, fig. 3) introduced the Valentinian as an age term to encompass the local faunas in the Valentine Formation. Skinner, Skinner, and Gooris (1968, p. 404) concluded that "Faunal evidence provided by the stratigraphically controlled Frick collection supports the recognition of . . . ['Valentinian']" with the qualification that "such a time term cannot be applied until an accurate stratigraphic range of life forms is included." Schultz, Schultz, and Martin (1970, pp. 23–28, fig. 8) provided additional information on their concept of the Valentinian Provincial Age by a list of taxa reported from all then known members of the Valentine

<sup>9</sup> Swineford, Frye, and Leonard (1955, p. 251) reported volcanic ash in the type section of the Valentine Formation at the approximate level of the Railroad quarries and 110 ft. above that horizon. The later occurrence was tentatively correlated with the Calvert Ash of Kansas. Unfortunately, neither the present authors nor Evander (ms, p. 66) have been successful in relocating the lower ash. Evander found, however, "lithic fragments of clastic ash in the terraced Pleistocene alluvium at the same elevation from which the upper ash is reported by Swineford, Frye and Leonard." Sand high in volcanic ash content does occur 10–12 ft. above the base of the type section (fig. 33, sect. 29) in the Cornell Dam Member.

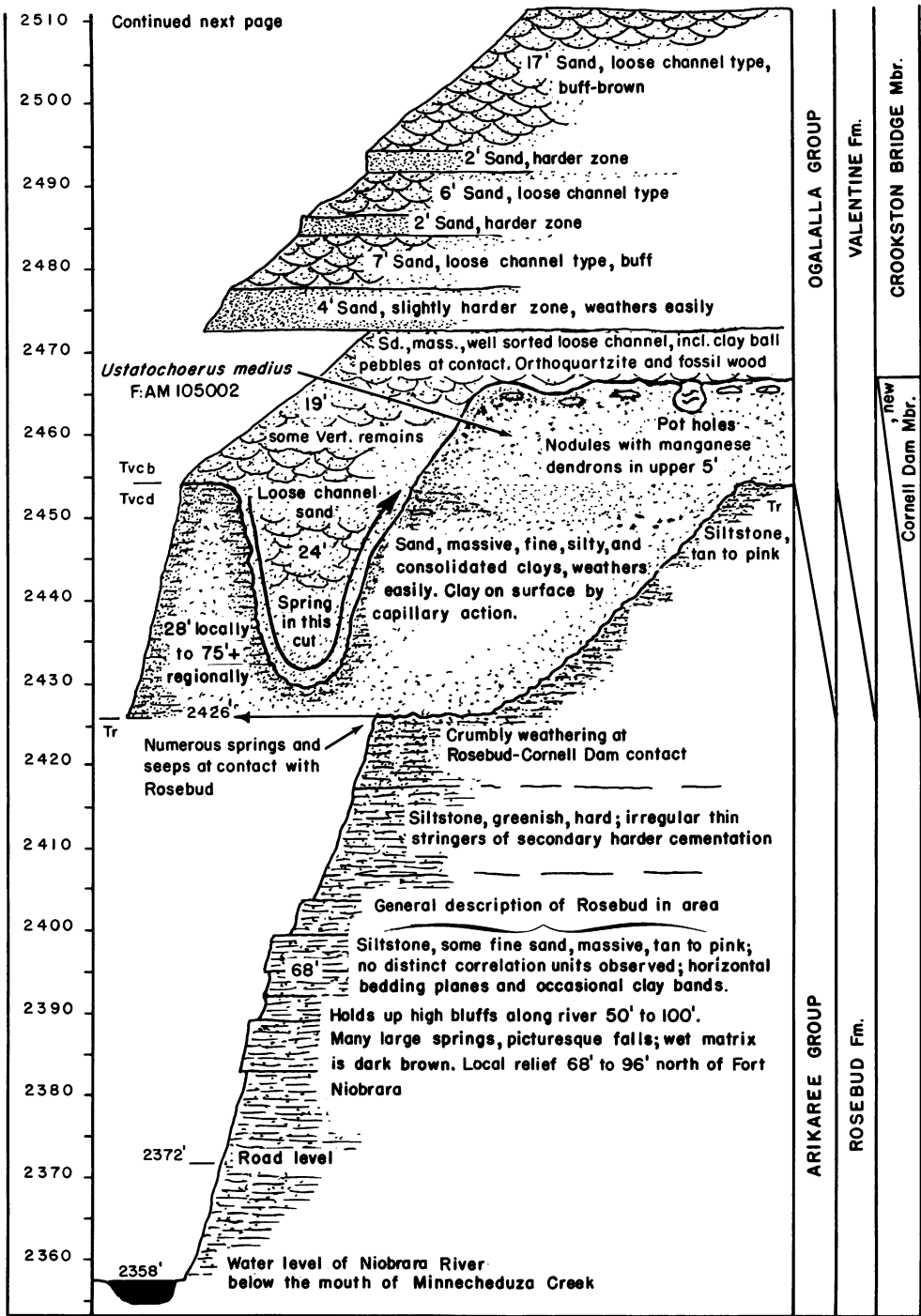
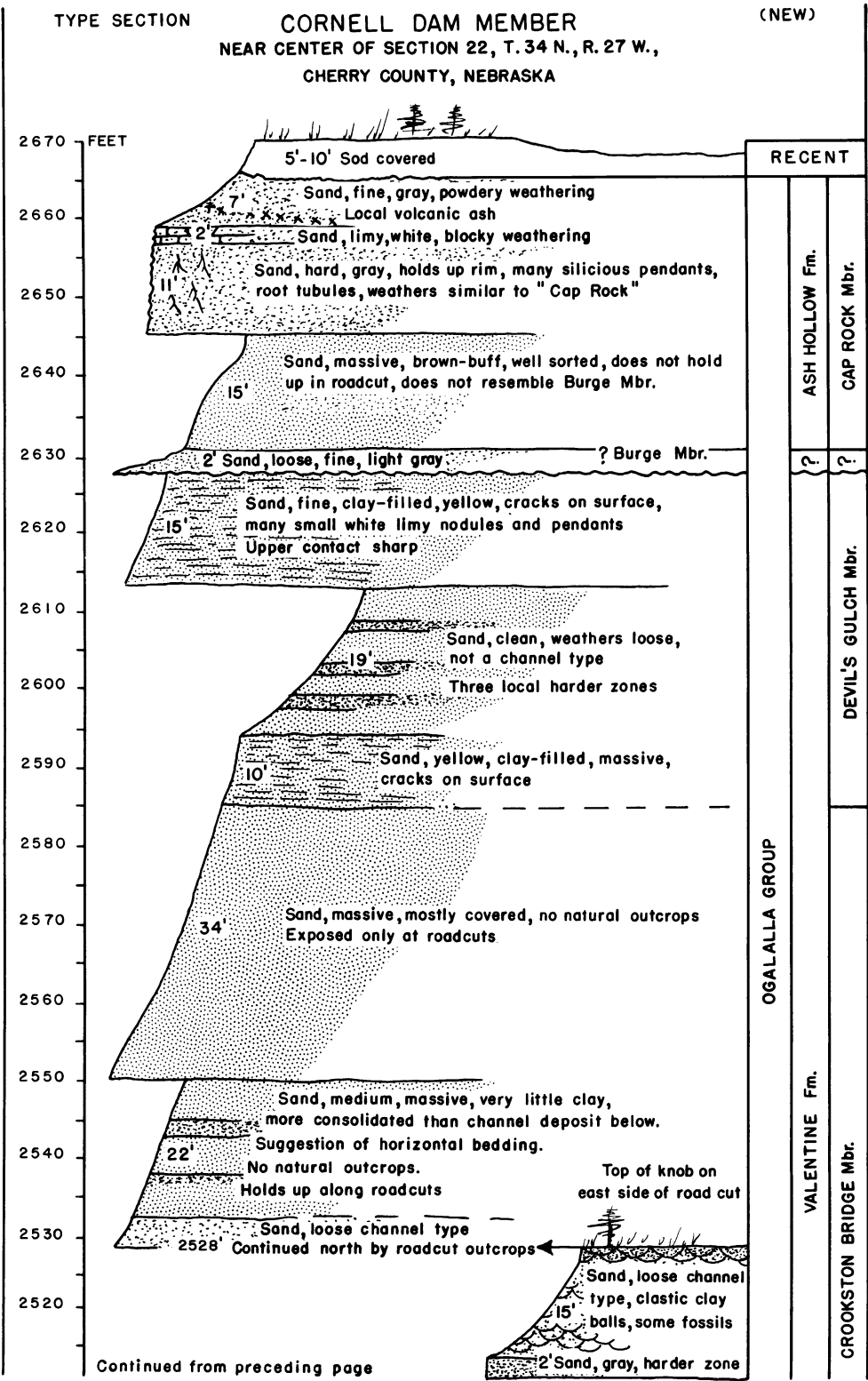


FIG. 5. Two facing pages showing type section of Cornell Dam Member (New) and related litho-stratigraphic units.



Formation. Keroher (1970, p. 793) listed Valentinian in the USGS Lexicon.

Cassiliano (1980, pp. 63–65), in a discussion on the age and usage of the term Valentinian, stated that “Correlation with the European type sections . . . indicates that the Barstovian is still valid, and that the Valentinian is medial Miocene, occurring between the Barstovian and Clarendonian” and “There is . . . a definite group of mammals, widespread on the High Plains, marking a distinct period of medial Miocene time. This group of animals represents the time referred to as the Valentinian, and includes parts of the late Barstovian and early Clarendonian time (Tedford, 1976, personal commun.).”

Woodburne, MacFadden, and Skinner (1981) have accepted the use of Valentinian in their discussions of facial characters of hipparion-like equids. Others, including Wood et al. (1941, p. 16) and Webb (1969, p. 15) place the Burge Local Fauna of the uppermost Valentine Formation in the Clarendonian. Recently, Tedford et al. (ms.) placed the faunas of the Valentine Formation in the late Barstovian and recommend using the term Valentinian in a restricted sense.

The biostratigraphic justification for the term Valentinian, such as the determination of the stratigraphic range of taxa in the Valentine Formation, is beyond the scope of this paper. Valentinian, therefore, is applied as a provincial age term for the faunas that typically occur in the Valentine Formation. That others recognize the presence of fossils of Valentinian age in sediments in other parts of the High Plains is demonstrated by Cassiliano (1980, p. 64, table 12).

Valentinian represents a period of possibly three million years. This is based on fission track dates of  $10.6 \pm 0.2$  Ma (Boellstorff and Skinner, 1977, pp. 39–40) for the Swallow Ash, at the base of the Ash Hollow Formation, and a date of  $13.6 \pm 1.2$  Ma for the Hurlbut Ash, 26 ft. above the base of the Valentine Formation. Boellstorff (1981, personal commun. and ms.), however, has recalculated his glass standards and revised the age of the Hurlbut Ash to  $11.6 \pm 1.1$  Ma. This would reduce to about one million years the time estimated for the deposition of nearly 300 ft. of Valentine sediments in northern Nebraska. Also, the age of  $11.6 \pm 1.1$  Ma on

the Hurlbut Ash suggests a greater temporal separation for the uppermost faunas from the Barstow Formation found in the *Hemicyon* Quarry, which lies just below a tuff with a date of  $13.4 \pm 0.7$  Ma (Tedford et al., ms.).

Correlation of rocks identified as Valentine Formation along the Niobrara River and extending into South Dakota is shown on cross sections (figs. 30–39). Studies by others (see p. 239) have resulted in the correlation of the Valentine with sediments as far south as Texas.

#### CORNELL DAM MEMBER (NEW NAME)

Figures 5, 6, 24

**TYPE LOCALITY AND NAME:** The type section is near the center of the west line of the SE  $\frac{1}{4}$ , sect. 22, T. 34 N, R. 27 W, Lat.  $42^{\circ}53'50''$ N, Long.  $100^{\circ}29'05''$ W, Cherry County, Nebraska, Sparks Quadrangle, 1950, west of the original mouth of Minnechaduz Creek and its junction with the Niobrara River, about 3 mi. east and  $1\frac{1}{4}$  mi. north of the town of Valentine; also  $4\frac{1}{2}$  mi. north and  $1\frac{1}{2}$  mi. east of the type section of the Valentine Formation established by Johnson (1936, p. 467). See Sparks Quadrangle, USGS topographic sheet, 1950, 15 minute series and photograph CAM-15 P-114 flight on 10-17-55 of the U.S. Department of Agriculture.

The member takes its name from the Cornell Dam built in 1914 on the Niobrara River,  $\frac{1}{4}$  mi. above the mouth of Minnechaduz Creek, to generate hydroelectric power. This dam is within sight of the type outcrops that are best exposed north of the river on the west side of a roadcut of Nebraska State Highway 12 (as of 1982). Although the type section does not contain the maximum thickness of the unit, its proximity to the type section of the Valentine Formation and the clear cut lithic sequence were factors in establishing the type section. Thicker and more extensive typical sediments of the Cornell Dam Member are well-exposed downstream in a reference section (hypostratotype) at Rock Rapids and Coleman Creek (fig. 7), but these would be partly covered by the impounded water of the proposed Norden Dam of the O'Neill irrigation project.

**DISTRIBUTION AND THICKNESS:** Outcrops of the Cornell Dam Member occur along the



FIG. 6. Photograph of type section of Cornell Dam Member. R. H. Tedford standing at collecting site of *Ustatochoerus medius* (F:AM 105001) on west side of Hwy. 12.

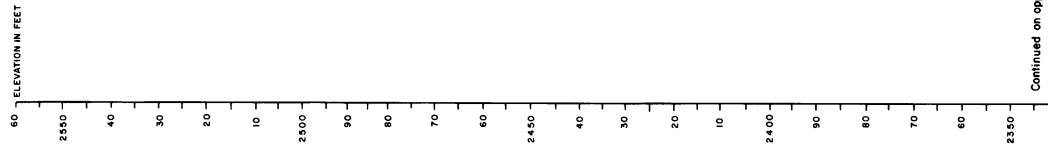
Niobrara River about 35 mi. eastward from the type section in eastern Cherry into southwestern Keya Paha and northern Brown counties (figs. 33–34). West of the type locality Cornell Dam rocks crop out south of the town of Valentine, Nebraska, along the Niobrara River near the Bryan Bridge on U.S. Highway 20 and near the Chicago and Northwestern Railroad Bridge. About  $\frac{1}{2}$  mi. east of the mouth of the Snake River and about  $\frac{1}{4}$  mi. down the Niobrara River from the type section of the Crookston Bridge Member of the Valentine Formation are the “unidentified beds” of Skinner, Skinner, and Gooris (1968, p. 404) that may also belong to the Cornell Dam Member.

The sediments of the Cornell Dam member are 42 ft. thick at the type section (fig. 5), but to the northeast and still within sight of the type outcrops, they have been removed

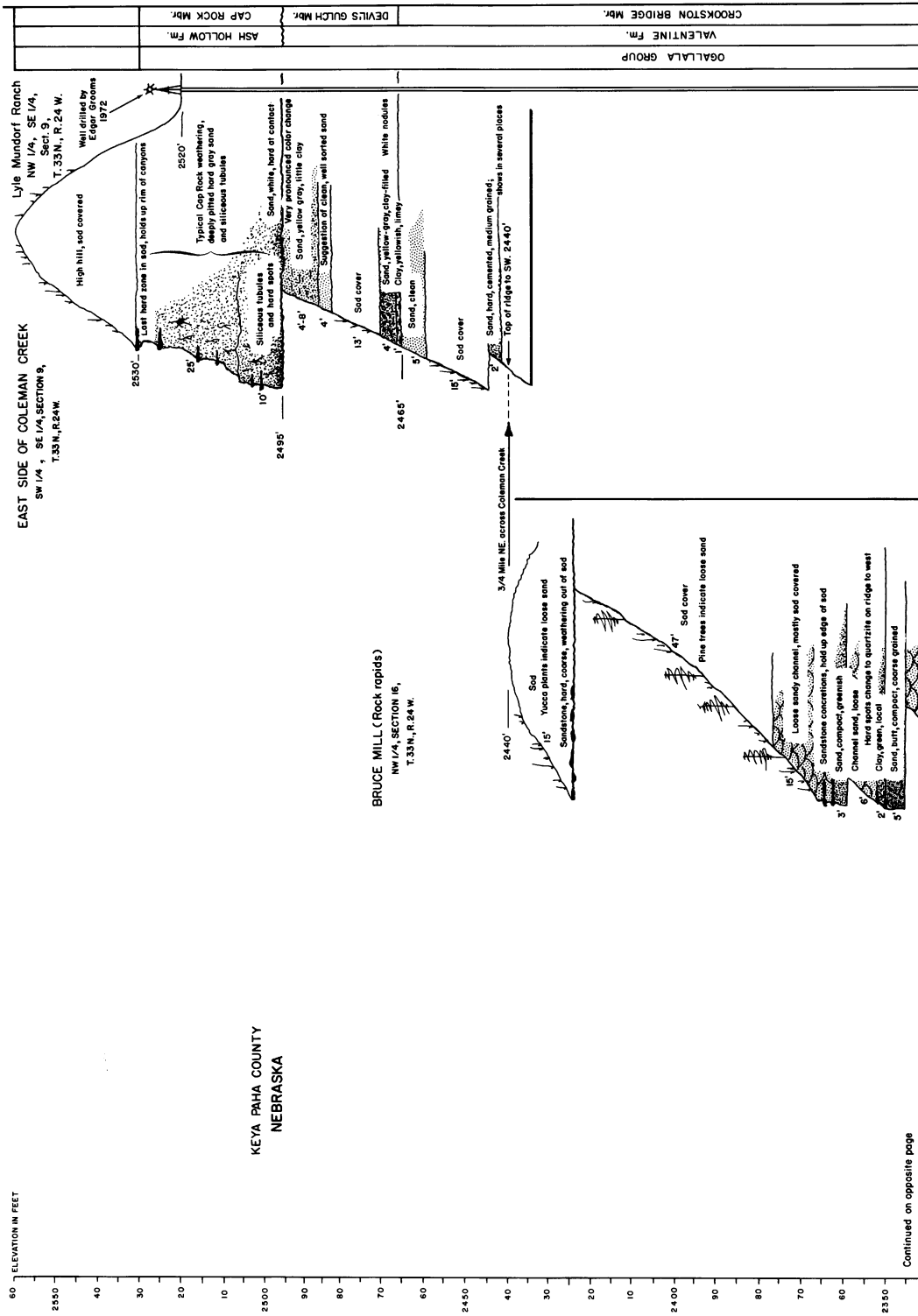
by erosion that occurred during the hiatus between the Cornell Dam and Crookston Bridge members. At this place the Crookston Bridge Member rests on the Rosebud Formation at an elevation of 2455 ft.

Eighteen mi. downstream on the north side of the river at Rock Rapids in sects. 9 and 16, T. 33 N, R. 24 W, Keya Paha County, Nebraska, Norden Quadrangle 1950 (figs. 7, 34, sect. 34), the Cornell Dam Member reaches a maximum thickness of at least 162 ft. in the hypostratotype (Hedberg, 1976, p. 26) section. At Norden Bridge, 7 mi. farther downstream on the south side of the river in the SW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 33, T. 33 N, R. 23 W, Brown County, Nebraska, 47 ft. of sediments of the Cornell Dam member unconformably overlie the Rosebud Formation. Here the Cornell Dam Member was deeply eroded prior to deposition of the over-





KEYA PAHA COUNTY  
NEBRASKA



Continued on opposite page

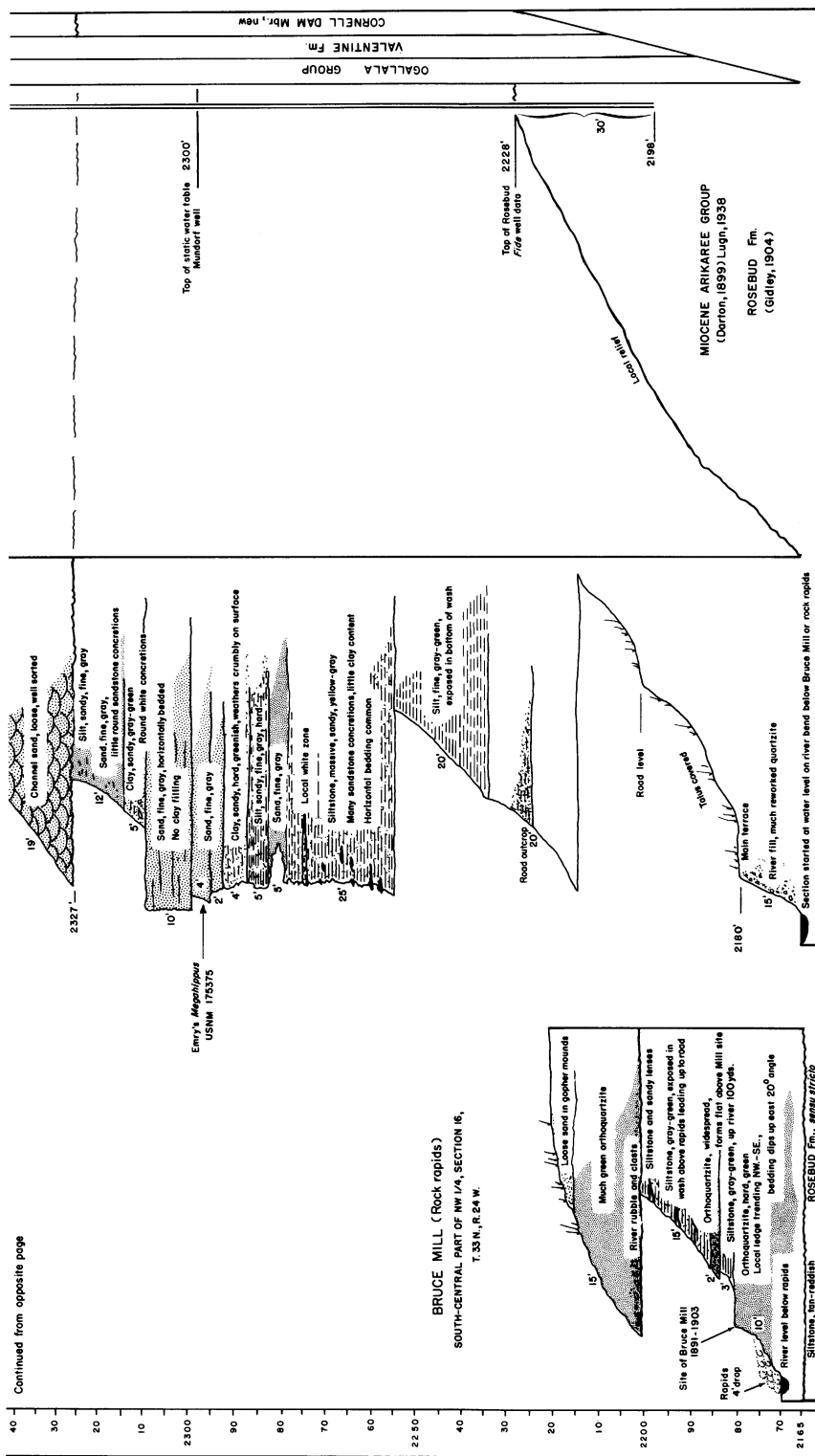


FIG. 7. Hypostatotype section of Cornell Dam Member at Rock Rapids and Coleman Creek, Keya Paha County, Nebraska.

lying Pleistocene-Holocene river terrace deposits.

**LITHOLOGY:** The type section near the mouth of Minnechadua Creek consists of gray, massive, firm silty sandstone and clay that weather whitish. Nodules containing manganese dendrons occur in the upper 5 ft. and glass shards are common in these rocks as well as at other localities in this member.

The lower part of the Cornell Dam Member in some localities consists of unconsolidated channel deposits of cross-bedded, well to poorly sorted, fine to medium and coarse-grained fossil-bearing sand that often contains clay clasts, siliceous rootlike tubules, but rarely contains pebbles of igneous quartz and feldspar. Such pebbles do occur at the Norden Bridge, Egelhoff, Kuhre, and Carrot Top fossil quarries.

These fluvial deposits are overlain by later sediments of the Cornell Dam Member that consist mostly of gray to light buff and yellow-gray, fine to medium-grained bluff forming siltstone and sandstone. Beds with high clay content often contain light cream to white nodules that have black manganese dendritic patterns similar to those found at the type locality. These later beds were sometimes called the "barren beds" by Frick collecting parties because of the paucity of fossils.

Deposits at Rock Rapids 17 mi. downstream from the holotype section bear a marked lithic similarity to those that directly overlie the Norden Bridge, Egelhoff, Kuhre, and Carrot Top quarries. The Rock Rapids are formed by an exceptionally hard lens of orthoquartzite, a channel deposit that has been solidly cemented with secondary silica. This quartzite represents a basal channel sand of the Cornell Dam Member at this site.

Another ledge of quartzite occurs at a slightly higher level about 100 yards upstream where a dense grayish green siltstone grades into an orthoquartzite that is overlain by an additional 15 ft. of grayish green siltstone and sandy lenses.

One of the most distinctive aspects of the Cornell Dam Member is the glass shards that lend a tuffaceous character to the fine-grained layers of sandstone and siltstone observed in many outcrops. This contrasts sharply with the overlying clean, well-sorted, unconsolidated fluvial sand of the Crookston Bridge

Member that contains little or no tuffaceous material and none of the white nodule-bearing, manganese stained rocks characteristic of the Cornell Dam Member.

James Swinehart (personal commun.), Conservation and Survey Division, University of Nebraska, Lincoln, made a petrographic examination of a sample of fine-grained sediments in the type section of the Cornell Dam Member as well as a sample from sandy clay 3 ft. below the top of a referred section south of the Norden Bridge and found that both had a glass shard content of 33 percent. A sample 12 ft. above the base of the Cornell Dam Member in the type section of the Valentine Formation was 65 percent volcanic ash (fig. 33, sect. 29). No ash was noted in the clean channel sand of the Norden Bridge Quarry at the base of the outcrop.

Two samples from the fluvial deposits of the Crookston Bridge Member overlying the type section of the Cornell Dam have a glass shard content of 0 and 2 percent. Samples of fine-grained sediments, however, from the Crookston Bridge have not been checked for ash content. Beds of volcanic ash<sup>9</sup> in the Crookston Bridge were not found during the fieldwork for the present paper. A sample from the Burge Member of the Valentine Formation contained no glass. The Rosebud Formation is relatively high in glass shard content, ranging from 26.0 to 66.5 percent in four samples.

The best example of a known volcanic ash in the Cornell Dam Member is a 0–2 ft. layer of bluish gray ash on the east side of Hurlbut Canyon in the northwest corner of the SW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 27, T. 32 N, R. 22 W, Brown County, Nebraska, Ainsworth NW Quadrangle. At its type locality the Hurlbut Ash is 26 ft. above the Rosebud-Cornell Dam contact, 37 ft. below the Cornell Dam-Crookston Bridge contact, and 146 ft. below the local Valentine Formation-Ash Hollow Formation contact at the head of Hurlbut Canyon (fig. 34, sect. 40). A revised estimate has reduced its age from  $13.6 \pm 1.3$  Ma to  $11.6 \pm 1.1$  Ma (see above).

The Hurlbut Ash is further evidence of volcanic activity that prevailed in the west during the late Hemingfordian and Barstovian into the early Valentinian. Several of these

ash falls are represented by beds of vitric tuff in the Sheep Creek and Olcott formations in Sioux County, Nebraska (Skinner, Skinner, and Gooris, 1977, pp. 297–303, fig. 4A–B). Most of these ashes and those of the Pawnee Creek area of Colorado, which were collected in conjunction with faunal studies, have not been dated.

The Crookston Bridge, Devil's Gulch, and Burge members of the Valentine Formation are characteristically lacking in beds of volcanic ash, suggesting a period of volcanic quiescence during their deposition.

**STRATIGRAPHIC RELATIONS:** The irregular paleo-surface of the Rosebud (upon which the Cornell Dam Member rests) indicates extensive regional erosion and channel cutting prior to deposition of the Cornell Dam member (figs. 33, 34). Locally, this degradation resulted in a hiatus of possibly about 10 million years.

Prior to deposition of the Crookston Bridge Member another period of degradation resulted in the erosion of significant amounts of the Cornell Dam Member. The Hurlbut Canyon section (fig. 34, sect. 40) shows that at least 37 ft. of Cornell Dam Member was deposited above the Hurlbut Ash before pre-Crookston Bridge erosion occurred.

Skinner, Skinner, and Gooris (1968, p. 405) thought the cross-bedded channel sand that yielded the Norden Bridge Local Fauna was a Crookston Bridge channel that had cut through the adjacent bluff forming sandstone of the Cornell Dam Member. Subsequent erosion, road work, and test holes showed that the channel sand of the quarry unconformably overlies the Rosebud Formation and is overlain by the typical bluff forming sediments of the Cornell Dam Member that contain the white manganese stained nodules. The Norden Bridge Local Fauna is interpreted as being in a stratigraphic position below the Crookston Bridge Member (fig. 4), and somewhat older than the faunas from the Crookston Bridge Member.

At Egelhoff Quarry  $1\frac{1}{4}$  mi. northwest of the Norden Bridge Quarry on the north side of the Niobrara River 115 ft. of rocks of the Cornell Dam Member are exposed. USC & GS benchmark B-229, which is directly opposite the Egelhoff Quarry and the benchmark at the south end of the Norden Bridge,

provide a check on elevations for the base of the Norden Bridge Quarry (2170–2175 ft.) and for the base of the Egelhoff Quarry (2194–2199 ft.).

Although the two quarries appear to be near equivalents in the stratigraphic section (fig. 34), comprehensive studies on the characteristics of the sediments, fossilization, and faunal relationships are needed to determine if this is correct.<sup>10</sup>

**AGE, FAUNAS, AND CORRELATIONS:** The Cornell Dam Member is early Valentinian. The date of  $11.6 \pm 1.1$  Ma of the Hurlbut Ash in the Cornell Dam Member provided a temporal assignment for this member indicating that deposition of sediments of the Valentine Formation may have required at least one million years.

Vertebrate fossils are best represented by the Norden Bridge and Egelhoff local faunas. Otherwise, fossil occurrences have been listed to smaller quarries and isolated finds.

*Geochelone orthopygia* (UMMP 31192) from the Norden Bridge Quarry indicates moderate temperatures during late Cenozoic time (Hibbard, 1960, p. 13, fig. 2). Smith (1962, p. 506) recognized four taxa of class Osteichthyes (present paper, pp. 263–264) that were recovered from matrix contained within the tortoise shell and on this evidence stated that the Norden Bridge Quarry deposits "are equivalent in age to the Laverne Formation [Oklahoma]." Some of these bony fishes are comparable to Recent genera that have a fossil record as far back as Eocene, however, which would limit their usefulness in correlating late Tertiary rocks.

Meszoely (1966, p. 495) concluded that "All North American cryptobranchid fossils [that he examined] are . . . considered conspecific," meaning *Andrias matthewi*. Meszoely's (1966, p. 499) conclusion was based on a study of the type of *Plicagnathus matthewi* Cook, 1917, from the early Barstovian Olcott Formation (Skinner, Skinner, and Gooris, 1977, p. 345), the type of *Cryptobranchus mccalli* Tihen and Chantell, 1966, from the Norden Bridge Quarry, two specimens from

<sup>10</sup> A recent paper (Wellstead, 1981, pp. 67–85) provides substantial information on the sedimentology of these quarries but does not resolve this problem.

the Marsland Formation of western Nebraska, and others collected in northeastern Colorado by the University of Kansas. A lack of morphological change suggests that cryptobranchiids and the amiids have ecological significance, but have little value in correlating late Tertiary faunas.

Estes and Tihen (1964, p. 470) concluded that the Valentine herpetofauna, most of which occurred in the Norden Bridge Local Fauna, "bears a much closer relationship to the Pliocene-Recent herpetofauna of the continental interior than it does to the Oligocene and earlier faunas . . . ."

Holman (1970, pp. 1317-1325) compared the Barstovian Kleinfelder Farm herpetofauna from the Wood Mountain Formation in Saskatchewan with additional material from the Norden Bridge Local Fauna, and concluded that the Kleinfelder site might be slightly older. Upon further study and observation of new occurrences, however, Holman (1976a, p. 268) concluded that "The Lower Valentine fauna has archaic elements (salamander: *Andrias*; lizards: *Nordenosaurus*; *Peltosaurus*, *Amphisbaenidae* sp.; snakes: *Neonatrix*, *Nebraskophis*) that so far have not been found in any Pliocene deposits; thus an upper Miocene rather than a lower Pliocene age is suggested for the lower Valentine sites in north-central Nebraska."

Many of the mammalian fossils from the Cornell Dam Member are similar to those from the Crookston Bridge Member. T. M. Stout (personal commun.) stated that a skull of *Eucastor* sp. (F:AM 65293) from Egelhoff Quarry "falls within the size range of those from the Railway and Crookston Bridge quarries but is larger than the beavers found in the lower Snake Creek Fauna, whereas a partial skull of *Mylagaulus* (F:AM 65014) from the Norden Bridge Quarry is slightly smaller than comparable material from the Crookston Bridge Quarry."

According to Rich and Rasmussen (1973, pp. 50-51) the presence of *Parvericius montanus* in the Norden Bridge and Egelhoff local faunas showed that this hedgehog, which is present in Arikarean deposits, is "more closely related to known Oligocene species of Europe and Asia than to any other North American erinaceines . . . . *Parvericius* survived until late Barstovian."

Other taxa in the Cornell Dam Member represent forms that ranged from early Barstovian to the late Barstovian. Klingener (1966, p. 2-3) identified a sicistine rodent in the Norden Bridge Local Fauna in the UCMP Fort Niobrara Locality, V-3218, a faunal site in the Crookston Bridge Member. This rodent, *Plesiosminthus*, is known from the early Miocene elsewhere in North America. Klingener (1968, p. 78) also reported several other rodent taxa in common between Norden Bridge Quarry and UCMP Loc. 3218.

Storer (1975, p. 127) determined that rodents of the "uppermost Barstovian" Wood Mountain Fauna of Saskatchewan closely resembled those of the Norden Bridge local fauna. Storer (1975, p. 126) also observed that various carnivores, ungulates, and some rodents in the Wood Mountain Fauna were similar to species from the Lower Snake Creek of Nebraska, whereas "Certain large mammals, present in the Wood Mountain Fauna, are missing from the Lower Snake Fauna . . . . Thus, although the Wood Mountain Fauna bears similarity to the Lower Snake Creek Fauna, it is significantly younger."

Storer (1975, p. 127) erroneously cited the source of the type of *Cranioceras* (*Procranioceras*) *skinneri* as the basal Valentine rocks of Nebraska. This data was from a misspoken personal communication inadvertently given by M. F. Skinner in 1969. The type (F:AM 31250) was collected by Skinner from the Devil's Gulch Horse Quarry in the type section of the Devil's Gulch Member in the upper part of the Valentine Formation. *Bouromeryx*, which has dentition similar to, but smaller, than *Cranioceras* (*sensu lato*), does occur in the Norden Bridge Local Fauna.

Proboscidean partial tusks, tooth fragments, a partial ramus, and fragments of postcranial elements from the Norden Bridge Local Fauna are further evidence that it is younger than the Olcott and Fort Randall formations, neither of which have yielded proboscideans (Skinner and Taylor, 1967, p. 13; Skinner, Skinner, and Gooris, 1977, pp. 300-306). The type of *Tatabelodon gregorii* Frick (F:AM 25740) was collected northwest of Rockford Bridge in eastern Cherry County, Nebraska, from the lower part of the Valentine Formation in sediments overlying the Rosebud Formation. These sediments are be-

lieved to be equivalent to the Cornell Dam Member.

Skinner and Voorhies (1977, pp. 43–44) cited the occurrence of *Protohippus*, *Calippus*, and *Merychippus* in the Norden Bridge Local Fauna. *Calippus* is not known from sediments older than late Barstovian.

A skull, mandible, and postcranial elements of *Megahippus* sp. (USNM 175375) were collected by Robert J. Emry of the Smithsonian Institution, 0.4 mi. northeast of Rock Rapids from 30 ft. below the contact of the Cornell Dam and Crookston Bridge members, at an elevation of 2297 ft. This specimen is smaller than *Megahippus matthewi* from the Burge Member (latest Valentinian) and somewhat larger than *Megahippus mckennai* Tedford and Alf (1962, p. 114) from “near the base of the upper member of the Barstow formation . . .” The specimen from the Cornell Dam Member (USNM 175375) is larger than *Megahippus* from the Lower Snake Creek Fauna of the Olcott Formation and specimens (i.e., F:AM 60720 to 60730 inclusive) from the Horse and Mastodon Quarry in the Pawnee Creek Formation, Colorado.

A skull, mandible, and postcranial elements of *Ustatochoerus medius* (F:AM 105002) were collected from the west side of the roadcut on Nebraska State Highway 12 at the type section of the Cornell Dam Member. The specimen is from a gray sandy siltstone 5 ft. below the contact of the Crookston Bridge and Cornell Dam members (fig. 5). The discovery of *U. medius*, which has been found mainly in the Valentine Formation, documents the sediments in the type section of the Cornell Dam as being significantly younger than the underlying Rosebud Formation. Also, *U. medius* has not been recognized in the Olcott Formation of Sioux County (Skinner, Skinner, and Gooris, 1977, p. 358), nor in the Barstow Formation in California.<sup>11</sup>

<sup>11</sup> Schultz and Falkenbach (1941, p. 32, fig. 10) allocated an oreodont from the “*Hemicyon Stratum*, Barstow area, San Bernardino County California . . .” to their variety *Ustatochoerus medius mohavensis* (F:AM 34464), and stated: “No examples of *Ustatochoerus* have been reported from the Miocene deposits underlying the ‘*Hemicyon Stratum*’ which contain the remains of *Bra-*

CONCLUSIONS: The Cornell Dam, the lowermost member of the Valentine Formation, is a lithostratigraphic unit that can be distinguished from the disconformably underlying Rosebud Formation as well as the overlying Crookston Bridge Member of the Valentine Formation. This unit is observed eastward along the Niobrara River for at least 40 mi. from south of Valentine in Cherry County to Hurlbut Canyon in Brown County, Nebraska.

The Cornell Dam Member has a varied fauna of microvertebrates, and larger mammals are also present. Three genera of reptiles, *Nordenosaurus*, *Paleoheterodon*, and *Nebraskophis*, as well as the rodent, *Megasminthus*, first appear in these deposits.

Although some of the lower vertebrates (i.e., *Andrias*, ?*Peltosaurus*, and *Neonatrix*) suggest that the fauna was archaic in character, the record shows that they evolved too slowly to be of more than limited use in late Tertiary correlation. The fish, amphibians, and reptiles, however, attest to a mild climate during deposition of the Cornell Dam Member. Estes and Tihen (1964, p. 471) and Wellstead (1977, pp. 45–46) agree with MacGinitie’s (1962) view that the Kilgore Flora from the lower part of the Valentine also bespeaks a warm, temperate climate, as well as open savannas and a forested river bottom.

Mammalian fossils in the Cornell Dam Member are similar, in many respects, to those in the Crookston Bridge Member. Some forms (i.e., *Bouromeryx*, *Eucastor*, and *My-lagaulus*) appear to be closely related to forms from the Crookston Bridge and Valentine Railway quarries. The genus *Megasminthus* occurs in the Fort Randall Formation, South

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*chycrus* and *Merychys*.” Further preparation of the type of *Ustatochoerus medius mohavensis* (F:AM 34464) shows that it is referable to *Mediochoerus* cf. *blicki*, which occurs principally in the Early Barstovian Lower Snake Creek Fauna in the Olcott Formation, Sioux County, Nebraska. The type of *Mediochoerus blicki* (F:AM 43172) came from New Surface Quarry, East Sinclair Draw (Skinner, Skinner, and Gooris, 1977, p. 348). The position of the infraorbital foramen and the retraction of the nasals in “*U. medius mohavensis*” removes it from *Ustatochoerus* and allies it with *Mediochoerus*, thus eliminating the only known occurrence of *Ustatochoerus* from the Barstow Formation.



Dakota (Green, 1977, p. 1008) and is represented in the Cornell Dam Member by a large sample from Egelhoff Quarry. The presence of *Protohippus*, *Calippus*, and *Tatabelodon* further distinguishes the fauna, since these genera are unknown in sediments older than the Cornell Dam. The occurrence in the Cornell Dam Member of *Ustatochoerus medius*, an oreodont found mainly in the Valentine Formation, is not known from the underlying Rosebud Formation.

The Norden Fauna of the Cornell Dam Member represents late Barstovian (or earliest Valentinian) slightly younger than the late Barstovian Wood Mountain Fauna of Saskatchewan, Canada (Storer, 1975, p. 127) and distinctly younger than the Lower Snake Creek Fauna of the Olcott Formation in Sioux County, Nebraska.

#### QUARRIES IN THE CORNELL DAM MEMBER OF THE VALENTINE FORMATION

**ACHILLES QUARRY** UNSM Bw 110 (fig. 25, no. 4): North side of Fairfield Creek near the east line of the SW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 31, T. 33 N, R. 23 W, Brown County, Nebraska. Norden Quadrangle 1950. Air photo CAL-1-34 dated 8-23-39. Elevation of base of quarry about 2217 ft.

**HISTORY:** Discovered by M. R. Voorhies, University of Nebraska.

**REPOSITORY OF FOSSILS:** UNSM has about 110 specimens.

**REMARKS:** Achilles Quarry is in a thin channel sand 40 ft. above the Rosebud Formation and 33 ft. stratigraphically higher than the base of the nearby Carrot Top Quarry, in the lower part of the Cornell Dam Member (Johnson, ms.h, 1978, pp. 55-56).

**CARROT TOP QUARRY** UNSM Bw 107 (fig. 25, no. 5): North side of Fairfield Creek near the east line of the SW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 31, T. 33 N, R. 23 W, Brown County, Nebraska. Norden Quadrangle 1950. Air photo CAL-1-34 dated 8-23-39. Elevation at base of quarry 2184 ft.

**REPOSITORY OF FOSSILS:** UNSM has about 750 specimens.

**HISTORY:** Discovered by J. Westgate of M. R. Voorhies field party, University of Nebraska in 1976 and worked by UNSM.

**REMARKS:** The quarry is in the lower part

of the Cornell Dam Member about 7 ft. above the Rosebud Formation (Johnson, ms.h, 1978, pp. 55-56). It appears to be stratigraphically equivalent to the Norden Bridge Quarry but is different lithologically. The fossils occur in a fine sand and sandy siltstone.

**EGELHOFF QUARRY** (fig. 25, no. 6): East side of Middle Creek, 0.9 mi. north of the Niobrara River on the east side of a roadcut opposite USC & GS benchmark (elevation 2188 ft.) in the SE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 29, T. 33 N, R. 23 W, Keya Paha County, Nebraska. Norden Quadrangle 1950. Air photo CAL-1-34 dated 8-23-39. Elevation at base of quarry 2193 ft.

**SYNONYM:** UNSM Kp 101.

**REPOSITORY OF FOSSILS:** Frick Collection has 297 specimens. Collections also in the University of Michigan and Michigan State University museums. Several hundred specimens, mostly microvertebrates, have been collected by UNSM and USNM.

**HISTORY:** Discovered by Skinner in 1964 and worked by C. W. Hibbard of the University of Michigan. Michigan State University field party under the direction of J. A. Holman worked the site in 1971 and several later years.

**REMARKS:** Egelhoff Quarry is in a 5 ft. layer of gray, fine-grained, cross-bedded sand with clay ball clasts at its base (Skinner, ms., vol. 9, pp. 18, 54-55). This is the type locality of *Peltosaurus minimus* Holman, *Neonatrix elongata* Holman, *Nebraskophis skinneri* Holman, *Salvadora paleolineata* Holman, and *Arctonasua gracilis* Baskin.

**FAIRFIELD CREEK NO. 1** (fig. 25, no. 7): South side of Fairfield Creek in NW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 2, T. 32 N, R. 24 W, Brown County, Nebraska. Norden Quadrangle 1950.

**SYNONYM:** F-I.

**REPOSITORY OF FOSSILS:** F:AM Collection.

**HISTORY:** Discovered by Skinner and J. H. Quinn in 1928.

**REMARKS:** Fossils were collected at two levels at this site. At the upper level, 160 ft. (elevation 2348 ft.) above the creek a small *Aphelops*-like skull and mandible was collected. It is stratigraphically allocated to the Crookston Bridge on the basis of its elevation in relation to known sections in this area.

A partial jaw of proboscidean was collected

at the same site, but only 40 ft. (elevation 2228 ft.) above the creek. Stratigraphically, it is probably near the middle of the Cornell Dam Member (Skinner, MS.a, 1928).

KUHRE QUARRY (fig. 25, no. 8): "In a cliff along a tributary of Fairfield Creek directly south of the Loring Kuhre home in the SE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , sect. 31, T. 33 N, R. 23 W, Brown County, Nebraska . . . at an elevation of 670 meters" (Holman, 1977a, p. 459). Norden Quadrangle 1950.

SYNONYM: UNSM Bw-120.

REPOSITORY OF FOSSILS: Michigan State University.

Discovered July 20, 1971, by a Michigan State University field party under the direction of J. A. Holman. Worked in 1971 and 1975.

REMARKS: Vertebrate fossils were "weathering from the surface of crossbedded lower Valentine Formation sands lying directly above the pinkish beds of the Rosebud Formation near the Niobrara River . . ." Holman (1977, p. 459). This is interpreted as being stratigraphically equivalent to the Norden Bridge Quarry.

NORDEN BRIDGE QUARRY (fig. 25, no. 9): East side of the road south of the Norden Bridge near the south line of the NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 33, T. 33 N, R. 23 W, Brown County, Nebraska. Elevation at base of quarry 2170 ft. It is on land recently acquired by The Nature Conservancy. Lat. 42°47'04"N, Long. 100°02'07"W. Norden Quadrangle 1950.

SYNONYM: UNSM Bw 106.

REPOSITORY OF FOSSILS: The Frick collection in the AMNH contains more than 200 specimens. Additional collections are in the UNSM, UMMP, and the USNM.

HISTORY: Discovered by J. H. Quinn and Skinner on July 9, 1929. Frick field parties worked the quarry intermittently from 1929 through 1978. The University of Michigan, under the leadership of C. W. Hibbard, and Notre Dame University, under J. H. Tihen, collected here in the 1960s. Michigan State under J. Alan Holman and the University of Nebraska under M. R. Voorhies and R. L. Evander worked in the 1970s. These collectors have processed more than 50 tons of channel sand to recover lower vertebrates and small mammals at the Norden Bridge and

Egelhoff quarries. Voorhies from the UNSM and R. J. Emry from the USNM made extensive excavations at the Norden Bridge Quarry in 1981.

REMARKS: The Norden Bridge Quarry is in 15 ft. of unconsolidated highly porous and permeable quartz sand in a channel deposit containing clay ball clasts ranging from pebbles to boulders in size. The channel deposit is in disconformable contact with the underlying Rosebud Formation (figs. 8, 34). Wellstead (1981, pp. 74–83) has discussed in some detail the variations in stream channel sedimentation at this quarry.

Norden Bridge Quarry is a prolific producer of previously little known fossils of small vertebrates, and "one of the most productive late Tertiary herpetological sites in North America" (Holman, 1982a, p. 31). The lower vertebrates from this quarry have been studied and reported upon in a series of papers by Hibbard (1960), Smith (1962), Tihen and Chantell (1963), Estes and Tihen (1964), Chantell (1964), Meszoely (1966, 1970), Holman (1964, 1973, 1976, 1982), Holman and Sullivan (1981), and Lundberg (1975). Rodents were reported by Klingener (1966, 1968) and Storer (1975), and comments on hedgehogs were published by Rich and Rasmussen (1973) and Rich (1981). Thirteen genera from the Norden Bridge Quarry were listed by Skinner and Voorhies (1977). Additional taxa are in a preliminary faunal list from the Norden Bridge and Egelhoff quarries which was prepared by M. R. Voorhies and published in Wellstead (1981, pp. 68–70).

Norden Bridge Quarry is the type locality of *Cryptobranchus mccalli* Tihen and Chantell, *Ambystoma minshalli* Tihen and Chantell, *Scaphiopus* (*Scaphiopus*) *wardorum* (Estes and Tihen), *Bufo kuhrei* Holman, *Pseudacris nordensis* Chantell, *Geochelone nordensis* Holman, *Trionyx quinni* Holman, *Nordenosaurus magnus* Holman, *Neonatrix magna* Holman, *Paleoheterodon tiheni* Holman, *Lampropeltis similis* Holman, *Elaphe nebraskensis* Holman, *Allomys stirtoni* Klingener and *Megasmithus tiheni* Klingener.

ROCKFORD SITE (fig. 25, no. 10): In a sand blowout about 550 yards due north of the Rockford School in SW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , SE

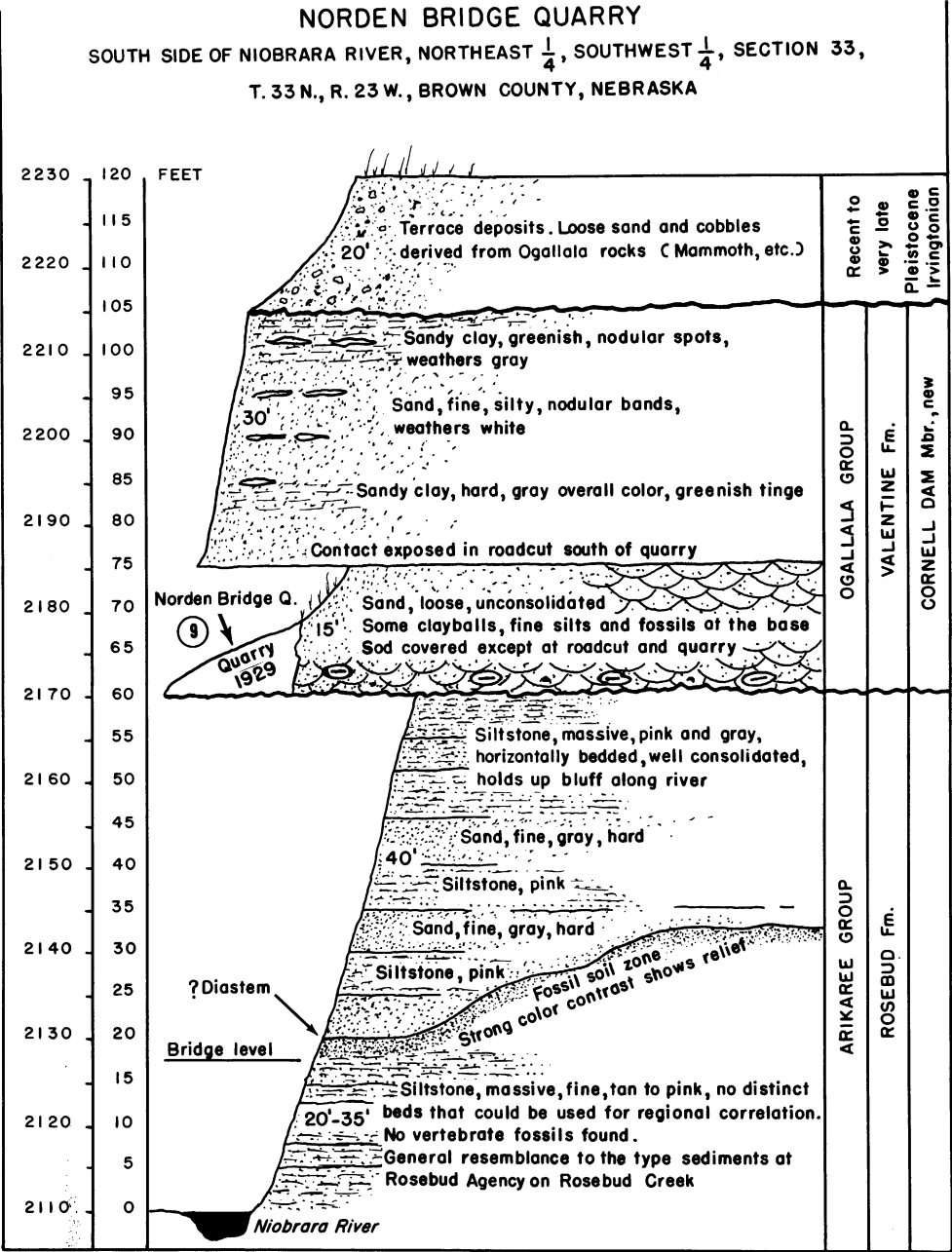


FIG. 8. Geologic section at Norden Bridge Quarry, Brown County, Nebraska.

$\frac{1}{4}$ , sect. 1, T. 33 N, R. 25 W, Cherry County, Nebraska. Norden Quadrangle 1950. Air photo CAM-14P-120 dated 10-13-55. Elevation about 2350 ft.

SYNONYMS: UNSM Cr 120. Tunnel Rock Locality. Rocky Ford Quarry.  
REPOSITORY: F:AM Collection consists of type of *Tatabelodon gregorii*. UNSM has eight

associated fragmental specimens suggesting at least four taxa.

**HISTORY:** Discovered by Skinner December 1932. The palate and partial mandible of the type of *T. gregorii* were found semi-articulated in the sand. The blowout was well-known locally on account of the bones exposed in it.

**REMARKS:** The quarry is in an unconsolidated channel sand in the lower part of the Valentine Formation. Skinner (ms.i, 1932, December 2 and 12) estimated that "this material is . . . not over 25 ft. above the base of the section at this place" and Frick (1933, p. 590) reported "the Rocky Ford *Tatabelodon* at the bottom of the section." Due to the vegetative cover of the nearby area correlation is not definite, but the sand in which the specimen was found is tentatively assigned to the Cornell Dam Member. An alternative interpretation places it in the basal part of the Crookston Bridge Member in a channel sand cut into the Cornell Dam Member. The presence of the top of the Rosebud Formation is indicated by a green meadow fed by springs at the base of the Valentine Formation south of this site. Southeast of the quarry the Rosebud is exposed at water level below the Rockford Bridge. The nearby river valley land is subirrigated, and about 1/8 mi. north of the bridge a large spring flows at the rate of 300 to 400 gallons per minute from sand at the base of the Valentine Formation.

*Tatabelodon gregorii* may be one of the geologically earliest proboscideans described from North America. Prospects are good that additional material will be found if this interesting site is excavated or exposed again as it was in the drought years of the 1930s.

#### THE NORDEN FAUNA

(Earliest Valentinian or late Barstovian)

The Norden Fauna represents a compilation of taxa from the Cornell Dam Member that have appeared in various publications or have been obtained through personal communication. The Norden Bridge and Egelhoff local faunas contain most of the taxa represented in the Norden Fauna.

Many taxa are small lower vertebrates and reflect the intensive collecting done under the direction of Claude W. Hibbard of the Uni-

versity of Michigan and J. Alan Holman of Michigan State University. The fossil mammals have been less intensively studied. Wellstead (1981) published a list of fossils identified by M. R. Voorhies from the Norden Bridge and Egelhoff quarries.

#### CLASS OSTEICHTHYES

##### ORDER AMIIFORMES

##### FAMILY AMIIDAE

*Amia calva* Linnaeus. Norden Bridge Quarry. Smith (1962, p. 506) identified one right nasal, one fragmentary right coronomeckelian, one incomplete right scalebone, one skull fragment?, and one fragmentary right dentary, that were recovered from the matrix in a shell of *Geochelone orthopygia*, UMMP 31192.

##### ORDER SEMIONOTIFORMES

##### FAMILY LEPISOSTEIDAE

*Lepisosteus* sp. Smith (1962, p. 506) identified one scale, recovered from the matrix in a shell of *Geochelone orthopygia*, UMMP 31192, from the Norden Bridge Quarry. Holman (1977a, pp. 460-461) identified one ganoid scale from the Kuhre Quarry.

##### ORDER SKLURIFORMES

##### FAMILY ICTALURIDAE

*Ictalurus* cf. *punctatus* (Rafinesque). Norden Bridge Quarry. Smith (1962, p. 507) identified one fragment of left cleithrum, one nearly complete supraethmoid, UMMP 37117, recovered from the matrix in a shell of *Geochelone orthopygia*, UMMP 31192. Lundberg (1975, p. 23) listed UMMP V57356, V57361, V56258 from Egelhoff Quarry.

*Ictalurus lambda*. Norden Bridge Quarry (Wellstead, 1981, p. 68).

*Ictalurus echinatus* Lundberg. Norden Bridge Quarry (Lundberg, 1975, p. 25) one right articular, three left pectoral spines, two right pectoral spines and four worn pectoral spine fragments, UMMP 42186.

*Ictalurus* sp. indet. Holman (1977a, pp. 460-462) identified the posterior part of a left cleithrum and the centrum of a vertebra from Kuhre Quarry and Wellstead (1981, p. 69) lists from the Egelhoff Quarry.

*Pylodius olivarius* (Rafinesque). Egelhoff Quarry. Lundberg (1975, p. 46) UMMP V56528, pectoral spines; UMMP V57361 pectoral spine, hyomandibular, dentary.

ORDER PERCIFORMES  
FAMILY CENTRARCHIDAE

*Lepomis cf. microlophus* (Gunther). Norden Bridge Quarry. Smith (1962, pp. 507–508) identified a left partial dentary.

CLASS AMPHIBIA  
ORDER CAUDATA  
FAMILY AMBYSTOMATIDAE

*Ambystoma minshalli* Tihen and Chantell (1963, pp. 509–510). Norden Bridge Quarry. Type UNSM 61002, a trunk vertebra. Holman (1976, p. 264) identified six specimens from Egelhoff Quarry and (1982, p. 31, fig. 1) six vertebrae and a right humerus from the Norden Bridge Quarry.

FAMILY CRYPTOBRANCHIDAE

*Andrias matthewi* (Cook). Norden Bridge Quarry. Tihen and Chantell (1963, pp. 507–508, fig. 3) a maxilla (UNSM 61000) the type of *Cryptobranchus mccalli*. Estes and Tihen (1964, p. 456) referred the type and a maxillary fragment to *Andrias matthewi*.

ORDER ANURA  
FAMILY PELOBATIDAE

*Scaphiopus (Scaphiopus) wardorum* Estes and Tihen (1964, pp. 457–460, fig. 2). Norden Bridge Quarry. Type UNSM 61014, partial left ilium. Holman (1976a, p. 264, table 1) referred one specimen from the Norden Bridge Quarry and four from Egelhoff Quarry.

*Scaphiopus (Spea) cf. bombifrons* (Cope). Holman (1976a, p. 264, table 1) referred one from Norden Bridge Quarry and four from Egelhoff Quarry.

*S. sp. cf. S. holbrooki* from Egelhoff Quarry (Wellstead, 1981, p. 69).

FAMILY BUFONIDAE

*Bufo hibbardi* Taylor. Holman (1976a, p. 264, table 1) referred four specimens from Egelhoff Quarry and three from Norden Bridge Quarry and Wellstead (1981) lists it from the Egelhoff Quarry.

*Bufo valentinensis* Estes and Tihen (1964, pp. 462–463, fig. 2E). Norden Bridge Quarry. Type UNSM 61019, right frontoparietal. Holman (1976a, p. 264, table 1) referred five specimens from Egelhoff Quarry and three from Norden Bridge Quarry.

*Bufo kuhrei* Holman (1973d, pp. 153–154, fig. 1). Norden Bridge Quarry. Type MSU VP719, left ilium and (1982, p. 32) a right tibiofibula.

FAMILY HYLIDAE

*Acris cf. crepitans* Baird. Holman (1976a, p. 264, table 1) referred five specimens from Egelhoff Quarry and nine from Norden Bridge Quarry.

*Pseudacris cf. clarki* (Baird). Holman (1976a, p. 264, table 1) referred seven specimens from Egelhoff Quarry and one from Norden Bridge Quarry.

*Pseudacris nordensis* Chantell (1964, pp. 217–219, fig. 3). Norden Bridge Quarry. Type UNSM 61007, left partial ilium.

*Hyla cf. gratiosa* Le Conte. Holman (1976a, p. 264, table 1) referred two specimens from Norden Bridge Quarry.

*Hyla cf. squirella* Sonnini and Latreille. Holman (1976a, p. 264, table 1) referred one specimen from Norden Bridge Quarry.

*Hyla cf. versicolor* Le Conte. Holman (1976a, p. 264, table 1) referred.

*Hyla cf. cinerea* (Schneider). Holman (1976a, p. 264, table 1) referred four specimens from Egelhoff Quarry and one from Norden Bridge Quarry.

*Hyla cf. crucifer* Wied. Holman (1976a, p. 264, table 1) referred three specimens from Egelhoff Quarry.

FAMILY RANIDAE

*Rana cf. pipiens* Schreber. Holman (1976a, p. 264, table 1) referred 22 specimens from Egelhoff Quarry and 31 from Norden Bridge Quarry.

CLASS REPTILIA  
ORDER CHELONIA  
FAMILY EMYDIDAE

*Chrysemys cf. picta* (Schneider). Norden Bridge Quarry. Holman (1976a, p. 264, table 1) referred one specimen.

FAMILY TESTUDINIDAE

*Geochelone orthopygia* (Cope). Holman (1976a, p. 264, table 1) referred one specimen from Egelhoff Quarry and three from Norden Bridge Quarry.

*Geochelone nordensis* Holman (1973d, pp. 154–159, fig. 2A–C). Norden Bridge Quarry. Type MSU-VP 714 nearly complete plastron, anterior portion of carapace and four carapace pieces.

FAMILY TRIONYCHIDAE

*Trionyx sp.* Holman (1976a, p. 264, table 1) referred one specimen from Egelhoff Quarry and two from Norden Bridge Quarry.

*Trionyx quinni* Holman (1982a, pp. 32–34, figs. 2–5). Norden Bridge Quarry. Type MSUV 952 (fig. 2A and B), left hypoplastron.

ORDER SQUAMATA  
FAMILY XENOSAURIDAE

*Nordenosaurus magnus* Holman (1973a, pp. 107–112, fig. 1). Norden Bridge Quarry. Type MSU-VP-715, dorsal part of skull, consisting of fused frontals.

FAMILY IGUANIDAE

*Sceloporus* sp. Norden Bridge Quarry (Wellstead, 1981, p. 68).

*Leiocephalus* sp. Norden Bridge Quarry (Wellstead, 1982, p. 365) UNSM 61025.

FAMILY ANGUIDAE

*Ophisaurus ventralis* (Linnaeus). Egelhoff Quarry. Holman (1976a, p. 264, table 1) referred one specimen.

*Gerrhonotus* cf. *mungerorum* Wilson. Holman (1976a, p. 264, table 1) referred one specimen from Egelhoff Quarry and one from Norden Bridge Quarry.

*Peltosaurus minimus* Holman (1976b, pp. 42–44, fig. 1). Egelhoff Quarry. Type MSU-VP 790, frontal bone. Holman (personal commun.) stated: "This is probably another genus. Bob Sullivan of MSU is studying this form now."

FAMILY SCINCIDAE

*Eumeces* sp. Holman (1976a, p. 264, table 1) identified nine specimens from Egelhoff Quarry and Wellstead (1982, p. 371) referred UNSM 56063, a fragmentary dentary, from Norden Bridge Quarry.

FAMILY AMPHISBAENIDAE

Amphisbaenid indet. Norden Bridge Quarry. Holman (1976a, p. 264, table 1) identified one specimen.

FAMILY BOIDAE

*Charina prebottae* Brattstrom. Holman (1976a, p. 264, table 1) identified one specimen from the Norden Bridge Quarry and one from Egelhoff Quarry.

*Geringophis depressus* Holman. Norden Bridge Quarry. Holman (1982a, p. 34) one vertebra.

FAMILY COLUBRIDAE

cf. *Thamnophis* sp. Norden Bridge Quarry. Holman (1976a, p. 264, table 1) identified one specimen.

*Neonatrix elongata* Holman (1973c, pp. 130–131, fig. 3). Egelhoff Quarry. Genotype MSU-VP 710, one lumbar vertebra, and referred specimens MSU-VP 711, two lumbar vertebrae from Egelhoff Quarry. Also in Norden Bridge Quarry (Wellstead, 1981, p. 68; Holman, 1982, p. 35).

*Neonatrix magna* Holman (1982a, p. 35, fig. 6). Norden Bridge Quarry. Type MSVP 943, trunk vertebra.

*Paleoheterodon tiheni* Holman (1964, pp. 633–634, fig. 1). Norden Bridge Quarry. Genotype UNSM 61031, precaudal vertebra, and referred specimens UNSM 61032 two precaudal vertebrae. Also in the Egelhoff Quarry (Wellstead, 1981, p. 70).

*Nebraskophis skinneri* Holman (1973c, pp. 131–132, fig. 4). Egelhoff Quarry. Genotype MSU-VP 708, lumbar vertebra and a referred fragmentary lumbar vertebra MSU-VP 709 from Egelhoff Quarry. Wellstead (1981, p. 68) from Norden Bridge Quarry.

*Ameiseophis* cf. *Ameiseophis robinsoni* Holman. Norden Bridge Quarry. Holman (1982a, p. 34) trunk vertebra.

*Salvadora paleolineata* Holman (1973c, p. 132, fig. 5). Egelhoff Quarry. Type UMMP V56292 lumbar vertebra, and referred specimens UMMP V56293 five lumbar vertebrae, and MSU-VP 706 11 lumbar vertebrae, all from Egelhoff Quarry. Also in the Norden Bridge Quarry (Wellstead, 1981, p. 68).

*Lampropeltis similis* Holman (1964, pp. 635–636, fig. 3). Norden Bridge Quarry. Type UNSM 61035, precaudal vertebra and referred specimen UNSM 61036, precaudal vertebra.

*Elaphe nebraskensis* Holman (1964, pp. 634–635, fig. 2). Norden Bridge Quarry. Type UNSM 61033, precaudal vertebra, and referred specimen UNSM 61034, precaudal vertebra. Holman (1976, p. 264, table 1) referred one specimen to *E. nebraskensis* from Egelhoff Quarry.

FAMILY VIPERIDAE

Viperid indet. Norden Bridge Quarry. Holman (1982a, p. 36) referred a trunk vertebra.

CLASS MAMMALIA

ORDER INSECTIVORA  
FAMILY ERINACEIDAE

*Untermannex copiosus* Rich (1981, p. 17) referred isolated teeth, F:AM 76735, 76737, 76738 and several UMMP specimens from the Egel-



hoff Quarry and F:AM 76740 and several specimens collected by UMMP from the Norden Bridge Quarry.

*Parvericius montanus* Koerner. Rich and Rasmussen (1973, pp. 33–45, fig. 7) identified a complete left mandible (F:AM 76704) with P<sub>4</sub> only, a left mandible (UMMP V57331), three isolated lower teeth and three isolated upper teeth in the University of Michigan collection, all from the Egelhoff Quarry. Also in Norden Bridge Quarry (Wellstead, 1981, p. 68).

*Metechinus amplior* Rich (1981, p. 53) identified a partial skull UMMP V57329, three lower molars in the Frick Collection from Egelhoff Quarry, and an isolated upper molar (F:AM 76741) from Norden Bridge Quarry. Wellstead (1981, pp. 68–70) listed *M. amplior* and *Untermannex copiosus* from both quarries.

#### FAMILY SORICIDAE

*Alluvisorex* sp. Norden Bridge Quarry (Wellstead, 1981, p. 68).

#### FAMILY TALPIDAE

*Mystipterus* sp. Norden Bridge Quarry (Wellstead, 1981, p. 68).

*Scalopoides* sp. Norden Bridge Quarry (Skinner and Voorhies, 1977, pp. 43–44).

*Domnoides valentinensis* Reed. Norden Bridge and Egelhoff quarries (Wellstead, pp. 68, 70).

#### ORDER LAGOMORPHA

##### FAMILY OCHOTONIDAE

*Hesperolagomys fluviatilis* Storer. Norden Bridge Quarry (Voorhies, personal commun.) and Wellstead (1981, p. 70) reports its occurrence in Egelhoff Quarry.

#### FAMILY LEPORIDAE

*Hypolagus* sp. Norden Bridge Quarry (Skinner and Voorhies, 1977, p. 44) and Egelhoff Quarry (Wellstead, 1981, p. 70).

#### ORDER RODENTIA

##### FAMILY APLODONTIDAE

*Allomys stirtoni* Klingener (1968, pp. 66–67, fig. 1A) Norden Bridge Quarry. Type UMMP 53022, M<sub>1</sub> or M<sub>2</sub>, and a referred partial P<sup>4</sup> (UMMP 53020).

#### FAMILY MYLAGAULIDAE

*Mylagaulid* indet. Klingener (1968, p. 67, fig. 1B) made no generic allocation for this material from

the Norden Bridge Quarry, which was a partial M<sup>1</sup> or M<sup>2</sup>, whereas Wellstead (1981, p. 69) allocated material to *Mylagaulus* sp.

#### FAMILY EOMYIDAE

*Paradjidaumo stirtoni*. Norden Bridge Quarry. Klingener (1968, p. 70, fig. 3E) tentatively assigned a fragmentary mandible with dP<sub>4</sub>, M<sub>1</sub> (UMMP 53003) to ?*Leptodontomys*. Lindsay (1972, p. 34) referred Klingener's ?*Leptodontomys* to *P. stirtoni*.

#### FAMILY SCIURIDAE

?*Tamias* sp. Klingener (1968, p. 67) tentatively referred a mandibular fragment (UMMP 53014) and seven upper and lower teeth from the Norden Bridge Quarry and Wellstead (1981, p. 70) listed it from the Egelhoff Quarry.

#### FAMILY GEOMYIDAE

*Lignimus* sp. Storer (1973, p. 79, figs. 15–18) compared two teeth (UMMP V60702 and UMMP V60703) with *L. montis* and *L. hibbardi*, but could make no specific assignment. Storer (1973, p. 79) concluded that two separate lineages, "one with and one without dentine tracts, were present contemporaneously" at Norden Bridge Quarry.

#### FAMILY HETEROMYIDAE

*Perognathus trojectionastrum* Korth, Norden Bridge Quarry. Korth (1979b, pp. 290–293) assigned a mandibular fragment (UMMP 53019) and a maxillary fragment (UMMP 53025) to this taxon.

*Perognathus* sp., cf. *P. furlongi*. Norden Bridge Quarry (Wellstead, 1981, p. 69).

*Perognathoides* cf. *P. cuyamensis*. Norden Bridge Quarry. Klingener (1968, pp. 68–69, fig. 2F) compared two partial mandibles (UMMP 53023 and 53024) and seven isolated P<sub>4</sub>s (UMMP 53026 and 53039) with *P. cuyamensis*, with which they agree fairly well in size and morphology.

*Cupidinimus nebraskensis* Wood. Klingener (1968, p. 69, fig. 2B) referred a right mandibular fragment with P<sub>4</sub> (UMMP 53018), three P<sub>4</sub>s and a right maxillary fragment with M<sup>2</sup> (UMMP 53017) to *C. nebraskensis*. From the Norden Bridge Quarry and was listed (Wellstead, 1981, p. 70) from Egelhoff Quarry.

*Cupidinimus* sp. made up "62% of the fauna" from the Achilles Quarry (Korth, 1979, p. 276).

*Diprionomys agrarius* Wood. Klingener (1968, p. 69, fig. 2D) referred three isolated teeth from

the Norden Bridge Quarry (UMMP Collection) to this species.

?*Diprionomys* sp. Klingener (1968, p. 70) placed two teeth (UMMP 53012 and UMMP 53035) in this genus pending more material from the Norden Bridge Quarry, stating: "Unless a larger series of premolars . . . show that tooth size in *D. agrarius* is highly variable, they represent a second species of heteromyine in the fauna."

#### FAMILY CASTORIDAE

*Eucastor tortus* Leidy. Stout (personal commun.). Norden Bridge Quarry.

*Monosaulax* sp. Klingener (1968, p. 68) referred six upper and lower teeth in the University of Michigan collection from the Norden Bridge L. F. to this genus, stating that these are not referable to *Eucastor*. Wellstead lists *Monosaulax* from the Egelhoff Quarry. Stout (1967, p. 49), however, maintains that *Monosaulax* is "invalid and a synonym of *Eucastor*," so these may be the same taxon.

#### FAMILY MURIDAE

*Copemys kelloggae* (Hoffmeister). Klingener (1968, pp. 71–72, fig. 3B, D) referred "a total of 21 tooth-bearing fragments or isolated teeth" to specimens from the Norden Bridge Quarry. Also in Egelhoff Quarry (Wellstead, 1981, p. 70).

*Copemys niobrarensis* (Hoffmeister). Norden Bridge Quarry (Wellstead, 1981, p. 69).

*Tregomys* sp. Norden Bridge Quarry (Wellstead, 1981, p. 69).

#### FAMILY DIPODIDAE

?*Plesiosminthus* sp. Norden Bridge Quarry. Klingener (1966, p. 2) tentatively assigns a mandible, I, M<sub>1-3</sub> (UMMP 52872) and 2 M<sub>1s</sub> (UMMP 52873) to *Plesiosminthus sensu* Wilson (1960) "in view of the extensive variability of fossil populations of *Plesiosminthus* . . ." Egelhoff Quarry (Wellstead, 1981, p. 70).

*Megasmnthus tihen* Klingener (1966, pp. 3–8, figs. 1, 2). Norden Bridge Quarry. Genotype (UMMP 52874) consists of a fragmentary palate with partial left and right tooth rows and fragmentary mandibles and maxillas and isolated upper and lower molars in the UMMP collection. *Megasmnthus* "makes up 14% of the total mammalian fauna" (Korth, 1979, p. 276) from Achilles Quarry. By 1979 more than 200 specimens of *Megasmnthus* were collected from the Egelhoff Quarry by J. Alan Holman, Michigan State University, and deposited in the Frick Collection at the AMNH.

#### ORDER CARNIVORA

##### FAMILY CANIDAE

*Tomarctus* sp. Norden Bridge Quarry (Skinner and Voorhies, 1977, p. 44), Kuhre Quarry (Holman, 1977, p. 461).

*Aelurodon* sp. Norden Bridge Quarry (Skinner and Voorhies, 1977, p. 44).

*Leptocyon vafer* (Leidy). Norden Bridge Quarry (Wellstead, 1981, p. 69).

*Cynarctus* sp. Norden Bridge Quarry (Wellstead, 1981, p. 69).

##### FAMILY PROCYONIDAE

*Bassariscus* cf. *parvus* Hall. Norden Bridge Quarry and the Egelhoff Quarry (Wellstead, 1981, p. 69).

*Arctonasua gracilis* Baskin (1982, pp. 75–77, fig. 3) Egelhoff Quarry. Type F:AM 105248, right mandible with P<sub>2</sub>–M<sub>2</sub>, premaxilla-maxilla fragment with left and right P<sub>3</sub>–M<sub>2</sub>, P<sup>1</sup> and RC<sup>1</sup>, and detached P<sub>2</sub>–M<sub>2</sub>.

##### FAMILY MUSTELIDAE

*Leptarctus primus* Leidy. Norden Bridge Quarry. R. H. Tedford (personal commun.) identified a partial skull (F:AM 103337) that is smaller than *Leptarctus primus* from the Devil's Gulch Member.

#### ORDER PROBOSCIDEA

##### FAMILY GOMPHOTHERIIDAE

*Tatabelodon gregoryi* Frick (1933, pp. 597–598, figs. 13, 27A). Rockford Site. Type (F:AM 25740) palate with M<sup>2-3</sup>, tusks, partial mandible with M<sub>3</sub> and incisor. A left ulna (F:AM 68175) was associated. Collected by M. F. Skinner 560 yards north of Rockford school in the SE ¼, sect. 1, T. 33 N, R. 25 W, eastern Cherry County, Nebraska from sediments that may be equivalent to the lower part of the Cornell Dam Member.

cf. *Serridentinus*. Holman (1977, p. 461, fig. 1) assigned a vertebra from the Kuhre Quarry to this genus.

*Gomphotherium* sp. Norden Bridge Quarry (Wellstead, 1981, p. 69).

#### ORDER PERISSODACTYLA

##### FAMILY EQUIDAE

*Merychippus* sp. Skinner and Voorhies (1977, p. 44) reported this equid from the Norden Bridge Quarry and Holman (1977, p. 461) noted its occurrence from Kuhre Quarry. The predominant horse in the Norden Bridge Local Fauna is

*Merychippus* and it compares best with *M. insignis* (*sensu* Skinner and Taylor, 1967, pp. 18–35). “*Merychippus*” *republicanus* is represented by at least a P<sup>4</sup> in the Norden Bridge Quarry. A left M<sup>3</sup> and a right M<sup>1</sup> or M<sup>2</sup> compared well with the type of *M. severus* (AMNH 8180) from the Mascall Formation, Grant County, Oregon.

*Protohippus* sp. Norden Bridge Quarry (Skinner and Voorhies, 1977, p. 44). Deposited in the University of Nebraska State Museum collection. Wellstead (1981, p. 69) listed *P. perditus* from the same quarry.

*Cormohipparion sphenodus* ref. Norden Bridge Quarry. F:AM specimens 108219 RM<sup>1</sup> and LP<sup>3</sup>; F:AM 108220 RM<sup>3</sup>; and 108221 LM<sup>3</sup> (Woodburne, MacFadden, and Skinner, 1981, pp. 493–524).

*Calippus* sp. Boellstorff and Skinner (1977, p. 40) recognized two upper molars of *Calippus* sp. (F:AM 105105) collected from “20 feet above the Hurlbut Ash.” They were found in direct superposition, the locality for which is in the SW ¼, SW ¼, NW ¼, sect. 27, T. 32 N, R. 22 W, Brown County, Nebraska, near the mouth of Hurlbut Canyon. Skinner and Voorhies (1977, p. 44) also assigned material from the Norden Bridge Quarry to this genus. A mandible compares well with specimens from the Devil’s Gulch Horse Quarry.

*Hypohippus* sp. Norden Bridge Quarry (Wellstead, 1981, p. 69).

*Archaeohippus* sp. Norden Bridge Quarry (Wellstead, 1981, p. 69).

*Megahippus* cf. *mckennai* Tedford and Alf. First prominent outcrop NE of Rock Rapids, N side Niobrara River in SE ¼, NE ¼, NW ¼, sect. 16, T. 33 N, R. 24 W, Keya Paha County. Elevation 2295 ft. Skull, mandible, partial skeleton (USNM 175375; AMNH 104951, cast); on figure 34, sect. 34.

#### FAMILY RHINOCEROTIDAE

*Teleoceras* cf. *minor* Olcott. Norden Bridge Quarry. An immature skull (F:AM 109518) and a small mature left ramus (F:AM 109520) are compared with *T. minor* primarily on the basis of their small size.

*Aphelops* sp. Norden Bridge Quarry (Wellstead, 1981, p. 69).

#### FAMILY TAPIRIDAE

*Tapirus* sp. Norden Bridge Quarry. Skinner and Voorhies (1977, p. 44) recognized material in this group that had not been generically allocated, and Voorhies later (Wellstead, 1981, p. 65) identified the presence of *Tapirus*.

#### ORDER ARTIODACTYLA

##### FAMILY TAYASSUIDAE

?*Dyseohyus*. Norden Bridge Quarry. Skinner and Voorhies (1977, p. 44) question the generic assignment. Material in the Frick Collection consists of a maxilla, a lower jaw, and two isolated teeth.

cf. *Prosthennops*. Norden Bridge Quarry (Wellstead, 1981, p. 69).

##### FAMILY MERYCOIDODONTIDAE

*Ustatochoerus medius* (Leidy, 1858). Type (USNM 118) partial left ramus with M<sub>1-3</sub> was collected by F. V. Hayden in 1857 from the “sands of the Niobrara River.” A possible site for the type specimens of *Ustatochoerus medius* and *Meryceros warreni* is the Crookston Bridge Quarry, which is in channel sands on the Niobrara River about ¼ mi. below the mouth of the Snake River. Wellstead (1981, p. 69) listed cf. *Ustatochoerus* from the Norden Bridge Quarry.

A skull, mandible, and postcranial elements (F:AM 105002) referred to *U. medius* were collected 5 ft. below the top of the type section of the Cornell Dam Member (fig. 5).

#### SUBORDER RUMINANTIA

##### FAMILY MOSCHIDAE

*Blastomeryx* sp. Skinner and Voorhies (1977, p. 44) included *Blastomeryx* sp. in the fauna from Norden Bridge Quarry and Wellstead (1981, p. 70) listed it from Egelhoff.

##### FAMILY DROMOMERYCIDAE

*Bouromeryx* sp. Skinner and Voorhies (1977, p. 44). Occurrence of *Cranioceras* cannot be substantiated in the Norden Bridge Quarry. B. Taylor (personal commun.) assigned a left dental series dP<sup>3</sup>–M<sup>2</sup> (F:AM 97224) from Norden Bridge Quarry to *Bouromeryx*. Taylor stated that it is “morphologically close but smaller and lower crowned than F:AM 52657, a series of dP<sup>2</sup>–M<sup>3</sup> of *Procranioceras* sp. from Valentine Railway Quarry ‘A’.”

##### FAMILY ANTILOCAPRIDAE

*Merycodus* sp. Norden Bridge and Egelhoff quarries (Wellstead, 1981, p. 69).

*Ramoceras* sp. Skinner and Voorhies (1977, p. 44). A horn-core from the Norden Bridge Quarry compares well with *Ramoceras howardae*.

##### FAMILY CAMELIDAE

*Procamelus* sp. and *Protolabis* sp. Norden Bridge Quarry (Wellstead, 1981, p. 69).

CROOKSTON BRIDGE MEMBER  
Figures 31–38

Skinner, Skinner, and Gooris (1968, pp. 404–405, pl. 22) applied the name Crookston Bridge Member to the “150 to 175 feet of unconsolidated sand” in the lower to middle part of the Valentine Formation. Its type locality is on the south side of the Niobrara River about  $\frac{1}{4}$  mi. downstream from the mouth of the Snake River, Cherry County, Nebraska. The type section contains the Crookston Bridge Quarry (Johnson, 1936, fig. 2; present paper, fig. 33, sect. 27).

The Crookston Bridge Member has been recognized in the valley of the Niobrara River and its tributaries of northern Nebraska from Knox County (Korth, 1979b, p. 287) to near the mouth of Bear Creek in Cherry County. It is difficult to differentiate the Crookston Bridge Member from the overlying Devil's Gulch Member near the east flank of the Chadron Arch where the Valentine Formation pinches out against the underlying Arikaree Group, or has been cut out by pre-Ash Hollow erosion.

The thickness varies from 170 ft. at the type locality to about 150 ft. in the Olson Ranch section (fig. 32). Thickness becomes indeterminate to the westward due to the increased variation in the transitional nature of the sediments at the contact between the Crookston Bridge and Devil's Gulch members. Eastward from the type locality the section varies little as far as the vicinity of Valentine where it thins over an erosional high at the contact with the underlying Cornell Dam Member. At Devil's Gulch it has a thickness of 96 ft. and gradually thins to the east and northeast (figs. 33–36).

The lithology of the buff to gray, fine to medium-grained, friable, cross-bedded channel sand, and the occasional layers of white siliceous root cast-bearing sandstone, and greenish gray clay has been described by Skinner, Skinner, and Gooris (1968, p. 404). The widespread occurrence of channel sand in the lower part of the section indicates that an extensive fluvial environment must have occupied a valley many miles wide. In the upper part of the Crookston Bridge Member the irregular occurrence of sandstone layers

consisting of poorly sorted sand and sandstone clasts that often contain seeds and roots of fossil plants suggests a combination of overbank or flood plain and aggrading channel conditions of deposition.

Widespread pre-Crookston Bridge erosion caused by a slight increase in regional eastward tilting, and possibly an increase in precipitation, produced a somewhat dissected topography with broad valleys and some hills. This erosion exposed rocks as old as Cretaceous (Pierre Shale) in southeastern South Dakota and north-central Nebraska. The extensive channel sand typical of the lower part of the Crookston Bridge Member was deposited upon this eroded surface in a disconformable relationship through valley alluviation (Frye and Leonard, 1959, p. 7). This covered a wide area during deposition of the lower part of the Valentine Formation.

The contact between the Crookston Bridge Member and the overlying Devil's Gulch Member is difficult to place precisely in some localities. In general, however, the Crookston Bridge Member is a predominantly cross-bedded to massive sand with occasional root filled sandstones, whereas the Devil's Gulch Member is a yellow-gray, argillaceous massive sandstone.

The Crookston Bridge Local Fauna (Schultz and Stout, 1961, fig. 3) occurs in a quarry of the same name (Skinner, Skinner, and Gooris, 1968, pl. 22) situated 13–18 ft. above the Niobrara River in the type section of the member (Johnson, 1936, fig. 2; this paper, fig. 33). The predominant taxon in this fauna is *Meryceros warreni johnsoni*, represented by a “superb series of skulls and other remains” from which Frick (1937, p. 362) selected the type. Other taxa from this quarry have not been studied in detail, but numerous specimens from the Railway Quarries “A” and “B,” which are referred to *M. warreni johnsoni* (Frick, 1937, pp. 366, 426–427), provide evidence that the local faunas from the Crookston Bridge and Railway quarries are very similar.

A skull and jaw (immature) referred to *Protohippus perditus* (F:AM 107665) was found in the first prominent sandstone ledge 80 ft. above the base of the Crookston Bridge Quarry in the type section. A partial right ramus

(UNSM 32009) identified by R. H. Tedford (personal commun.) as *Leptocyon vafer* was collected 40 ft. above the quarry.

Although the local faunas from the quarries in the Crookston Bridge Member remain little studied or unpublished their position in the stratigraphic section suggests they may contain many of the taxa listed by Stirton and McGrew (1935, pp. 128–129) as the “Niobrara River Fauna.” Holotypes documented from sediments referred to the Crookston Bridge Member are listed on pages 278–280.

#### QUARRIES IN THE CROOKSTON BRIDGE MEMBER

**CROOKSTON BRIDGE QUARRY** UNSM Cr-15 (fig. 23, no. 11): On the south side of the Niobrara River about ¼ mi. below the mouth of the Snake River near the west end of a huge sand slide in the south part of NW ¼, sect. 1, T. 32 N, R. 30 W, Cherry County, Nebraska. Elevation of floor about 2522 ft. Lat. 42°46'45"N, Long. 100°47'22"W, Valentine Quadrangle 1950. Air photo CAM 12P-170 dated 10-7-55.

**SYNONYMS:** *Merycodus* Quarry (Johnson, ms.b, 1932, pp. 11–13).

**REPOSITORY OF FOSSILS:** UNSM.

**HISTORY:** Discovered by Charles S. Osborne, June 13, 1932 (Johnson, ms.b, 1932, p. 11). Worked by UNSM field party led by Johnson and C. Osborne in 1932, and Johnson and K. L. Rathbun in 1934 (Johnson, ms.d, 1934, p. 63; sect., pp. 160–171; ms.f, 1972, p. 44; ms.g, 1973, pp. 37–40); Skinner, ms., vol. 1, pp. 78–79; vol. 9, p. 41). Skinner and Frick party, using excavation equipment, opened up a large area for Johnson, Rathbun, and T. M. Stout in 1935 (Johnson, ms.e, 1935, pp. 37, 44–51, 54–111).

**REMARKS:** Quarry was in lower 5 ft. of cross-bedded sand immediately overlying a thin clay lens which, in 1935, was 13 ft. above the normal level of the Niobrara River, or 27 ft. below a prominent bed of argillaceous sand in the type section of the Crookston Bridge Member. A varied fauna of more than 700 specimens was collected, including the best series of *Meryceros* skulls, jaws, and skeletal material on record (Frick, 1937, pp. 362–365).

The Crookston Bridge Local Fauna remains unpublished for the most part.

This quarry was a prolific producer until a cave-in of the soft overburden stopped work on September 6, 1935 (Johnson, 1936, fig. 2; Skinner, Skinner, and Gooris, 1968, pl. 22; this paper, fig. 33, sect. 27, quarry 11).

**DEVIL'S JUMP OFF QUARRY** (fig. 21, no. 12): On the east side of a south branch of a south-west trending box canyon on the south side of the Niobrara River in the SE ¼, SW ¼, NW ¼, sect. 23, T. 33 N, R. 34 W, Cherry County, Nebraska. Elevation of floor about 2895 ft. Eli Quadrangle 1952. Air photo CAM-13P-162 (Johnson, ms.f, 1972, pp. 70–71; Skinner, ms., vol. 1, pp. 122–123).

**SYNONYM:** East Devil's Jump Off Quarry.

**HISTORY:** Discovered by Skinner and party October 31, 1949. Intermittent collecting in 1949, 1950, 1955, 1961.

**REPOSITORY OF FOSSILS:** F:AM Collection has 78 specimens.

**REMARKS:** Base of quarry 70 ft. below base of Ash Hollow in 17 ft. of cross-bedded medium to coarse sand containing clay ball clasts. Considered to be near the top of the Crookston Bridge Member (fig. 32, sect. 21, quarry 12).

**FAIRFIELD CREEK IV** (fig. 25, no. 13): On the south side of Fairfield Creek in NW ¼, NW ¼, sect. 10, T. 32 N, R. 24 W, Brown County, Nebraska. Norden Quadrangle 1950. Site is 160 ft. above creek level at an elevation of about 2408 ft.

**SYNONYM:** F-IV. Fairfield Cr. Quarry No. 4.

**REPOSITORY OF FOSSILS:** F:AM Collection.

**HISTORY:** Discovered by Skinner and J. H. Quinn in 1928.

**REMARKS:** Collection consists of a partial skull and jaw of a proboscidean from a channel sand correlated with the upper part of the Crookston Bridge Member in this area (Skinner, ms.a, 1928).

**JONES CANYON SITE** (fig. 28, no. 14): On a branch of Dutch Creek in the S ½, SW ¼, sect. 30, T. 32 N, R. 21 W, Brown County, Nebraska. Dutch Creek Quadrangle 1950. Elevation of floor about 2307 ft. (Skinner, ms., vol. 1, pp. 108–109; Skinner, 1968, fig. 2).

**HISTORY:** Discovered by Skinner and worked intermittently from 1949–1952.

REMARKS: Skinner (1968, pp. 1–24) reported a chalicothere and an associated fauna from this site, and placed the channel sand in which it occurred in the upper part of the Crookston Bridge Member. Further study of Skinner's (1968, fig. 3) section, and comparison with the type section of the Devil's Gulch Member, suggests that this quarry may be in the basal Devil's Gulch Member near the contact between the two members.

MIZNER QUARRY (fig. 23, no. 33, see p. 284).

NENZEL QUARRY (fig. 2, no. 15): On a south facing sand slide on the north side of the Niobrara River near the NW corner, NW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 30, T. 33 N, R. 32 W, Cherry County, Nebraska. Cody Quadrangle 1950. Elevation of quarry 2710–2730 ft. (Skinner, ms., vol. 1, pp. 114–115).

REPOSITORY OF FOSSILS: F:AM Collection has 448 specimens; UCMP has two specimens, including a rodent skeleton.

HISTORY: Discovered on May 7, 1934, by Skinner who worked it intermittently between 1934 and 1975. Stirton of UCMP collected here in 1941.

REMARKS: Fossils occur in loose sand filling a channel cut to within 15 to 30 ft. of the river level in the lower part of the Crookston Bridge Member (fig. 32, sect. 24, quarry 15). Frick (1937, pp. 359–360), who described the holotypes of *Meryceros nenzelensis*, referred to specimens from this quarry as being of "heavier proportions" than the *M. warreni* material from the Crookston Bridge Quarry.

It is speculated that F. V. Hayden may have visited this site when the Warren-Hayden Expedition camped  $\frac{1}{4}$  mi. northwest on the night of October 19, 1857.

RAILWAY QUARRY "A" UNSM Cr-12. (figs. 9–12; fig. 24, no. 16): On the south side of a ravine between the old and new railroad grades, 25 to 75 yards southeast of a railroad culvert (dated 1909), near center of W  $\frac{1}{2}$ , NE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 17, T. 33 N, R. 27 W, or about 3 mi. S, 31°E of Valentine, Cherry County, Nebraska. Lat. 42°50'14"N, Long. 100°31'10"W, Valentine Quadrangle 1950. Air photo CAM-13P-200 dated 10-12-55. Elevation of quarry in interval 2495–2505 ft.

SYNONYMS: Burnett (ms.a, 1915, p. 92): "W & B Fossil Quarry," and "Valentine Fossil

Quarry" on topographic map (present paper, fig. 9). Richmond (ms.a, 1916, July 11): "Valentine Quarry." McGrew (ms.b, 1930, p. 40): "Railroad Quarry." Johnson (ms.a, 1931, p. 27): "Valentine, Railroad Q. 'A'" and "= Cr 12" [entry by unknown]. Stirton (ms.a, 1933), June 4: "Railway Locality 'A'," June 5: "Railway Quarry 'A'," and June 11: "Railway 'A'." Johnson (ms.c, 1933, pp. 3–12): "Railway Locality 'A'." Stirton and McGrew (1935), p. 127: "UCMP V-337" and p. 129: "*Aelurodon platyrhinus* Quarry." Skinner (ms.b, 1935, September 30): "Railroad Quarry 'A'." Johnson (1936, p. 467): "Railway Locality Quarry 'A'." Frick (1937, p. 241): "Quarry A, Valentine." Skinner, Skinner, and Gooris (1968, p. 405): "Valentine Railroad Quarry." Skinner ms., vol. 1, p. 82: "Railway Quarry." Estes and Tihen (1964, p. 456): "V-337-ND."

Cr-12 is a Cherry County locality number that was inserted into the field records by UNSM curators several years after the collections were made. Also see descriptions of Railway Quarry "B" (Cr-13) and West Valentine Quarry (Cr-114), which are separate sites southwest of the Chicago and Northwestern Railroad tracks.

In order to avoid further confusion of the term Valentine, it is proposed that the frequently used Railway Quarry "A" be adopted as the name for the original Valentine Quarry. Its fauna should be identified as from the Railway Quarry "A" site of the Railway quarries Local Fauna that also includes the Railway Quarry "B" and West Valentine Quarry sites.

REPOSITORY OF FOSSILS: UNSM has more than 2130 specimens, 245 are in the F:AM Collection, and 55 are at UCMP.

HISTORY: Railway Quarry "A" was discovered by J. B. Burnett and F. Miller August 11, 1915. Burnett also named it the "Valentine Fossil Quarry" on his topographic map of August 16, 1915 (present paper, fig. 9). The quarry was worked by Burnett and A. C. Whitford in 1915 and was reopened July 12, 1930 by P. O. McGrew and George Bunnell (who knew of the 1915 work). McGrew first named it "Railroad Quarry" and later (McGrew, ms.b, 1930, pp. 93–94, geologic section) the "Valentine Quarry." It was

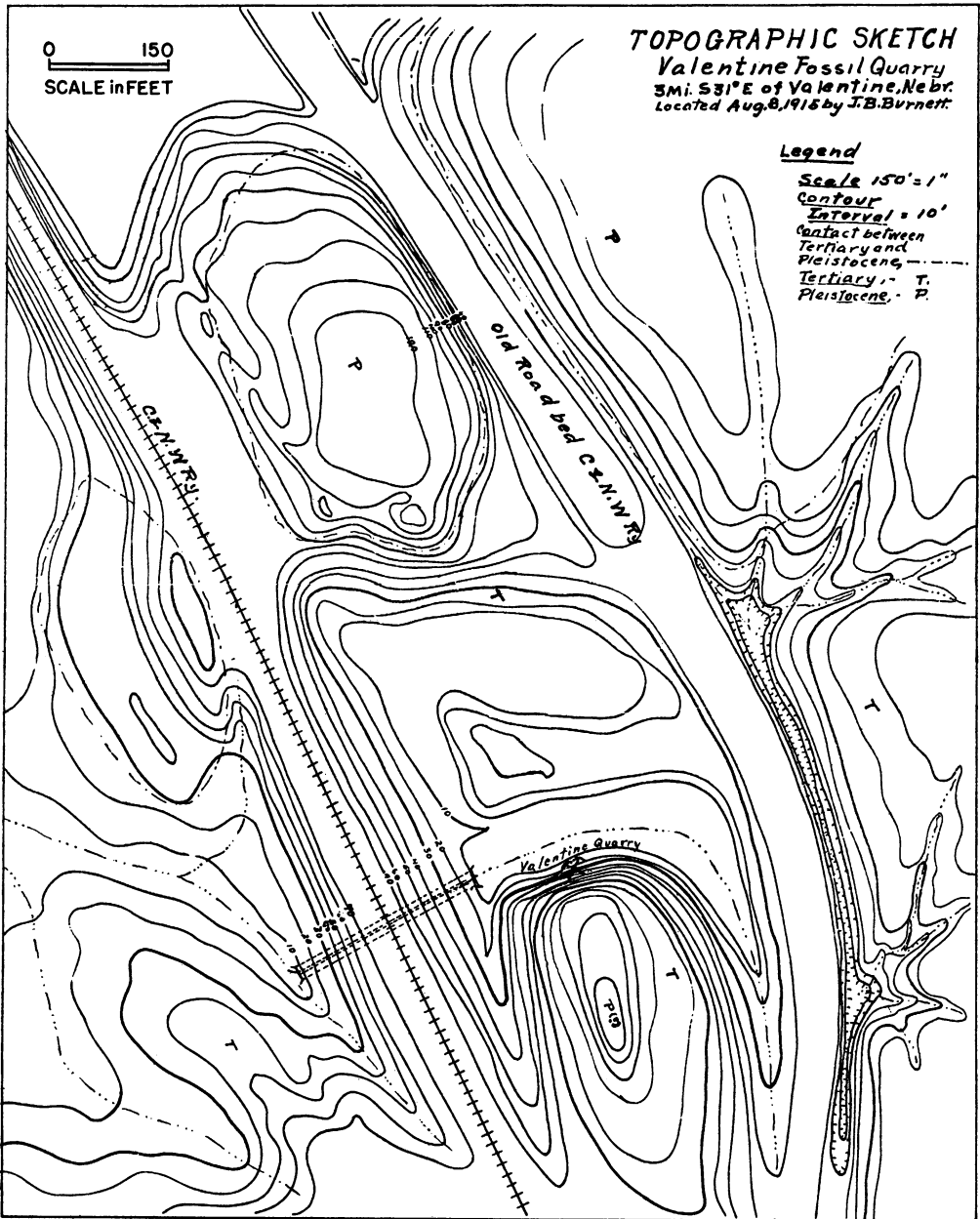


FIG. 9. Topographic sketch showing location of Valentine Fossil Quarry, now known as Railway Quarry "A" or UNSM Cr-12. Discovery of this map at the University of Nebraska a few years ago established the precise location of the original Valentine Quarry. This sketch by J. B. Burnett (ms.b, 1915, p. 90) on August 15, 1915, is in UNSM archives.

worked by UNSM in 1930 and 1931, and jointly with R. A. Stirton of UCMP in 1933. At that time the name was changed to Rail-

way Quarry "A," as Stirton (ms.a, 1933, June 7) thought (mistakenly) that the AMNH had a Valentine Quarry, and that Valentine "can-

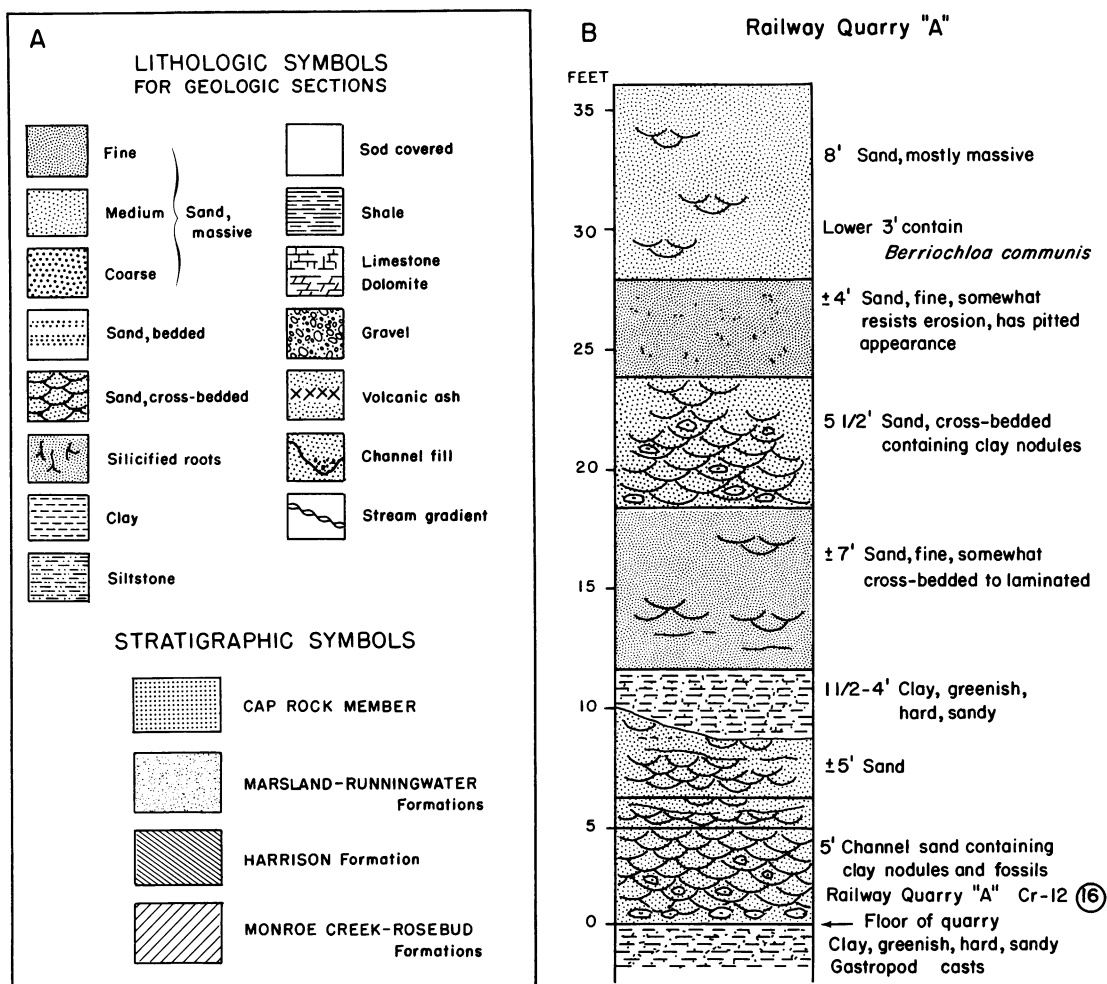


FIG. 10. A. Lithologic symbols used in this paper. B. Detailed geologic section at Railway Quarry "A" measured by F. W. Johnson on June 11, 1933, while site was being excavated on a cooperative basis by the UNSM and UCMP.

not be used since American Museum parties referred the name Valentine to the Pliocene fauna north of the river." The UNSM field party (Johnson, ms.c, 1933, pp. 3-11; McGrew, ms.e, 1933, June 6) accepted Stirton's opinion and changed the name of the quarry in their field notes. Subsequent checking of records in AMNH, however, revealed no evidence of a Valentine Quarry worked by that museum prior to 1933. Railway Quarry "A" was reopened by M. F. Skinner in 1935 in a cooperative project between the Frick Laboratory and UNSM.

REMARKS: Fossils occur in soft cross-bedded sand associated with clay ball clasts overlying a thin layer of hard sandy clay containing casts of gastropod shells (present paper, fig. 10). (Johnson, ms.c, 1933, pp. 10-11; ms.d, 1934, pp. 142-149; ms.f, 1972, p. 28; ms.g, 1973, pp. 31-33.) Elias (1942, p. 137) designated the deposits in which these fossils occur "the Niobrara River channel," an informal term that has not come into general use. The elevation of the base of the quarry is 13 ft. higher than the top of the east end of the railroad culvert some 75 yards north-



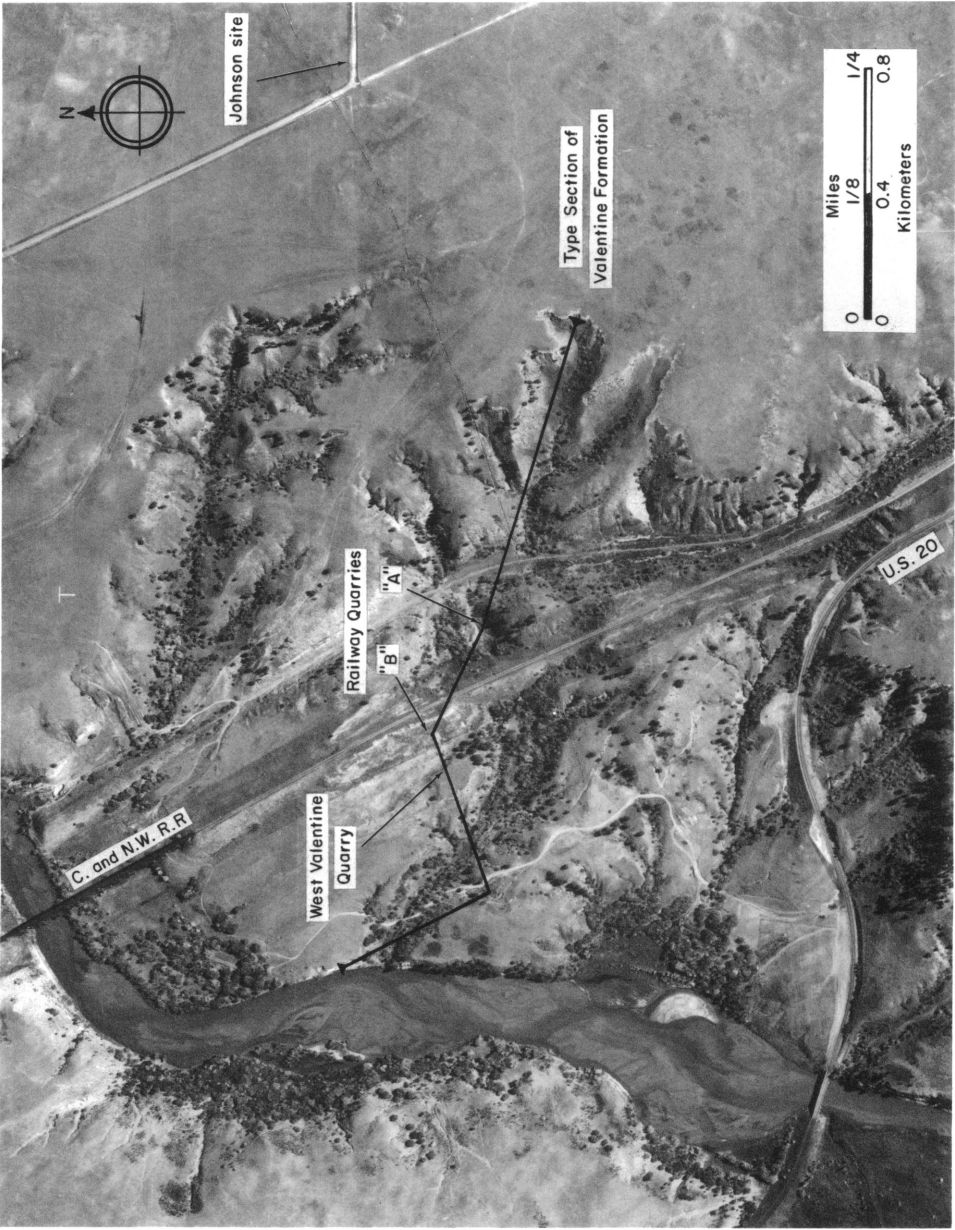


FIG. 11. Location of Valentine quarries and the type section of Valentine Formation. From U.S. Department of Agriculture air photo CAM-13P-200 dated 10-12-55.

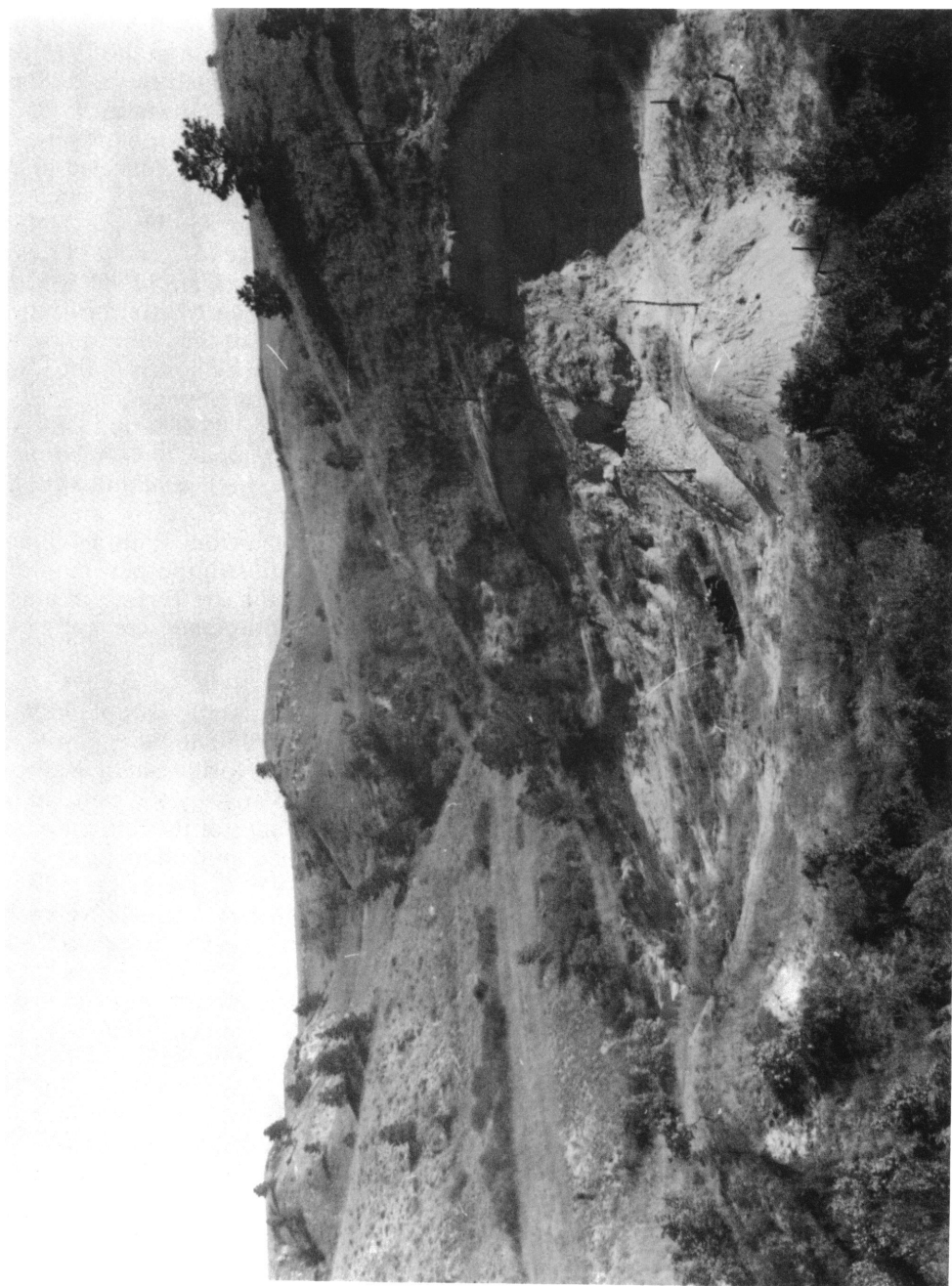


FIG. 12. Railway Quarry "A" during 1935 excavations. Vehicle is model A Ford in which Skinner installed double transmission and used as power for special dragline to remove soft sand overburden.

west of the quarry site (fig. 33, sect. 29, quarry no. 16).

More than half of the Valentine Fauna of Barbour and Cook (1917b, p. 180) appears to have been collected in Railway Quarry "A" according to a memo labeled "Matthew's notes." Matthew (ms.a, 1916, p. 19) referred to this quarry as "the older horizon (Valentine Quarry—typical Leidy fauna)." Stirton and McGrew (1935, p. 129) in their discussion of the Niobrara River Fauna, stated: "The best representation of the fauna is from the old *Aelurodon platyrhinus* quarry (UC. Loc. V337)." They did not include, however, a list of taxa collected here.

Railway Quarry "A" is the type locality of *Dissouroides milleri* Short, *Aelurodon platyrhinus* Barbour and Cook, *Prosthennops xiphodonticus* Barbour and Cook, and *Blasioteryx gemmifer valentinensis* Frick.

At least eight generic groups of horses are represented in Railway Quarry "A" but this is true of most of the localities in the Valentine Formation when a large enough collection has been made. Known from Railway Quarry "A" are: *Calippus*, *Protohippus*, *Cormohipparion*, *Pseudhipparion*, *Merychippus sensu lato*, a complete articulated skeleton of *Pliohippus* cf. *mirabilis* (F:AM 60801), *Megahippus*, and *Hypohippus*.

Matthew's (ms.a, 1916, pp. 16–19) recognition of the hipparion group (p. 247, this paper) of horses and probably *Procamelus* in Railway Quarry "A" (then known as the Valentine Quarry) may have been the basis of Osborn's (1918, pp. 23, 27) application of the term "*Procamelus-Hipparion* Zone" to beds in the lower part of the geologic section in the Valentine area. This was followed by Matthew (1924b, p. 747) placing the Valentine in the lower portion of the *Hipparion* Zone but younger than the Barstow Formation. Matthew's views must have been influenced by his examination of specimens (at least eight, possibly 10 taxa) in the UNSM, collected in 1915 from Railway Quarry "A" and other localities in north-central Nebraska. In his notes on an equid skeleton Matthew (ms.a, 1916, p. 19) stated "This is from the later horizon (Devil's Gulch-Snake Creek) not from the older horizon (Valentine quarry—typical Leidy fauna) . . . ."

The 1915 collection seen by Matthew has been studied recently by Skinner and M. R. Voorhies. Voorhies (in letter dated Jan. 12, 1982) states "There are some definite '*Hipparion*' upper molars (free protocones in mid-wear) among the loose teeth in the 1915 collection. These are numbered in the 208-11-8-15 B & W series. I think Matthew would definitely have regarded them as *Hipparion* teeth." Skulls in the UNSM collected in the 1930s from Railway Quarry "A" which are placed in the hipparion group are UNSM 2672, 41441, 42446, 42452, and 1352 *Cormohipparion* cf. *sphenodus* (AMNH 105299, cast). Although not seen by Matthew, these skulls further document the common occurrence of the hipparionine horses in the lower portion of the Valentine Formation.

Holman and Sullivan (1981, pp. 138–144) have identified *Scaphiopus*, *Bufo valentinensis*, *Chelydra*, *Chrysemys picta* and *Geochelone orthopygia* from this site.

Although the fauna from Railway Quarry "A" is one of the most important mammalian assemblages in the late Tertiary of northern Nebraska, no comprehensive study of it has been published.

RAILWAY QUARRY "B" UNSM Cr-13 (figs. 11, 24, no. 17): About 250 yards N, 55°W of Railway Quarry "A" and on the right-of-way of the Chicago and Northwestern Railroad on a flat area excavated by the railroad between a west line fence of the railroad property and the railroad embankment near the middle of NE ¼, NW ¼, NE ¼, sect. 17, T. 33 N, R. 27 W, Cherry County, Nebraska. Valentine Quadrangle 1950. Air photo CAM-13P-200 dated 10-12-55. White area to left of base of bluff in Richmond photograph dated 4-15-8-16 in UNSM Archives.

SYNONYMS: Heteromyid Locality, Wood (1935, map, p. 119), Railway Locality "B" (McGrew, ms.e, 1933, specimen lists for 1-6-7-33 and 1-8-7-33); Johnson (ms.a, 1931, pp. 33–34; ms.c, 1933, pp. 4–5); Railway Locality "B," site 1 in Stirton (ms.a, 1933, June 4–7, 13–15).

REPOSITORY OF FOSSILS: UNSM, UCMP, F:AM, and CM.

HISTORY: Large numbers of fossils must have been destroyed here in 1909 during excavation for a fill on the railroad bridge ap-

proach, and some specimens were probably collected as early as 1916 by the University of Nebraska. The locality was known by Johnson (ms.a, 1931, pp. 33–34) who showed it to H. E. and A. E. Wood as a prospective site where they did some collecting for the Carnegie Museum. Stirton (ms.a, 1933, June 7) stated that “George Bunnell first called Paul O. McGrew’s attention to the occurrence of bones at Railway Locality B in 1930.” Stirton collected 23 specimens here for UCMP. McGrew (ms.e, 1933, June 19) records that UNSM began collecting here and F:AM parties prospected it in later years. UNSM collected 53 specimens in 1933 and R. Evander (personal commun.) excavated about 300 specimens for UNSM in 1977.

REMARKS: Fossils occur in soft sand stratigraphically equivalent to the channel sand at Railway Quarry “A” and the West Valentine Quarry. Wood collected the type of *Cupidinimus nebraskensis* here in 1931.

Holman and Sullivan (1981, pp. 138–144) reported the presence of *Geochelone orthopygia*, *Leiocephalus*, *Salvadora paleolineata* and *Neonatrix elongata* from Cr-13.

RIPPLE QUARRY (fig. 23, no. 18): On a south-facing outcrop on west side of the Snake River, 6 to 8 ft. above river level near the middle of west line of NE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , sect. 5, T. 31 N, R. 30 W, Cherry County, Nebraska; about 350 ft. downriver from Sawyer Quarry, and 220 yards straight south of *Alligator mefferdi* locality. Kennedy Quadrangle 1950. Air photo CAM-11P-193 dated 10-7-55. Elevation 2682 ft. (Skinner, ms., vol. 1, pp. 134–135).

REPOSITORY OF FOSSILS: F:AM Collection contains 85 specimens.

HISTORY: Discovered by Skinner and Loren Toohey on August 21, 1954. Worked intermittently from 1954–1964.

REMARKS: Fossils were concentrated in the bottom of a massive channel deposit consisting of cross-bedded sand and gravel. This may be the same channel as Sawyer Quarry. Stratigraphically, Ripple Quarry is near the top of the Crookston Bridge Member.

RUNLOFSON QUARRY (fig. 29, no. 19): On the east side of Long Pine Creek in the central part of the N  $\frac{1}{2}$  of the NE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 29, T. 31 N, R. 20 W, Brown County, Nebraska.

Bassett NW Quadrangle 1950. Elevation 2145–2147 ft. (Skinner ms., vol. 1, p. 14).

REPOSITORY OF FOSSILS: F:AM Collection.

HISTORY: Discovered by Skinner, November 18, 1939.

REMARKS: Fossils occur in a channel sand 12 ft. thick that is 70–82 ft. above Pine Creek, and overlain by a sandy clay.

About 700 ft. northwest of the Runlofson Quarry a block of four associated skulls of *Ustatochoerus medius* F:AM 43030 A, B, C, D (Schultz and Falkenbach, 1941, p. 25) was collected from the basal part of the Crookston Bridge Member, 18 ft. above the creek level, on the east side of Long Pine Creek in the first ravine north of the south line of SE  $\frac{1}{4}$ , sect. 20, T. 31 N, R. 20 W.

SAWYER QUARRY (fig. 23, no. 20): Situated 15–18 ft. above the river on an east-facing outcrop on the west side of the westernmost bend in the Snake River in the NW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , sect. 5, T. 31 N, R. 30 W, Cherry County, Nebraska. Kennedy Quadrangle 1950. Air photo CAM-11P-193 dated 10-7-55. Elevation of fossiliferous zone about 2695 ft. (Skinner, ms., vol. 1, p. 134).

REPOSITORY OF FOSSILS: F:AM Collection has 115 specimens.

HISTORY: Discovered by Skinner and Mefferd, October 1941.

REMARKS: Appears to be in the same channel sand as Ripple Quarry, stratigraphically near the top of the Crookston Bridge Member (fig. 38, sect. 60, quarry 20) Sawyer Quarry was worked in 1941 and 1954. An exceptionally large rhinoceros skull is in the unpublished fauna.

SCHOETTGER QUARRY (fig. 2, no. 21): On the west side of a local drainage into Holt Creek, near the NE corner of SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 5, T. 34 N, R. 20 W, about 2 mi. east and  $8\frac{3}{4}$  mi. north of Springview, Keya Paha County, Nebraska. Springview NW, Nebraska-South Dakota Quadrangle 1964. Elevation at base of quarry 2215 ft. (Skinner, ms., vol. 3, pp. 8–10).

REPOSITORY OF FOSSILS: F:AM Collection has 139 specimens.

HISTORY: Discovered by Skinner and party in December 1947 and worked intermittently through 1952.

REMARKS: Fossils occur in massive loose

channel sand containing pebbles and nodules of greenish clay which immediately overlies the Pierre Shale. The contact with the impervious Pierre Shale is marked by water seeps and a spring. Schoettger Quarry is in the lower part of the Crookston Bridge Member. When discovered, the outcrop was a blowout containing fossil wood and scattered fossil vertebrates. One fossil log was 30 ft. long.

WEST VALENTINE QUARRY UNSM Cr-114 (fig. 24, no. 22): About 125 ft. southwest of the Chicago and Northwestern Railroad right-of-way fence west of Railway Quarry "B," and on the east face of the original terrain left by excavation of material for the railroad bridge approach, in the SW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 17, T. 33 N, R. 27 W, Cherry County, Nebraska. Valentine Quadrangle 1950, air photo CAM-13P-200 dated 10-15-55, figure 11, this paper. Richmond photographs in UNSM Archives labeled 4-15-8-16 and 3-30-8-16.

SYNONYMS: Railway Locality "B," site 2 in Stirton (MS.a, 1933).

REPOSITORY OF FOSSILS: UNSM and UCMP.

HISTORY: Discovered by M. G. Richmond, O. E. Hans and George Bunnell on July 22, 1916 (Richmond, MS.a, 1916; Hans MS.a, 1916, July 22, sketch map and geologic section). Richmond (MS.a, pp. 6-8) listed a "collection from West Valentine Quarry about 300 yards west of the Valentine Quarry described by J. B. Burnett in 1915." Richmond's photographs of the site (in Hans scrapbook, UNSM Archives) checked against air photo CAM-13P-200 places the most probable site at 270 yards N, 72°W of Burnett's Valentine Quarry (Railway Quarry "A"). This documentation and field observations at the site serve as the basis for a description of its location.

George Bunnell, who lived about  $\frac{1}{8}$  mi. west of the railroad bridge in the 1930s (Valentine Quad. 1950 shows house) was teamster for the UNSM field parties 1914-1916 and also served as guide and provided information on localities. Bunnell recalled to Johnson (about 1931) that he had seen large numbers of bones (but did not know they were fossils) during the 1909 excavations for material used in the railroad grade construction. The cut resulting from the excavation,

clearly shown on a Richmond photograph (4-15-8-16 in UNSM archives), provided the sites for Valentine Railway Quarry "B" and the West Valentine Quarry.

REMARKS: West Valentine Quarry is stratigraphically equivalent to Railway quarries "A" and "B." UNSM collected 32 specimens from this site in 1916 and Stirton's work for the UCMP in 1933 listed 12 specimens from Railway Locality "B," site 2, which is synonymous with West Valentine Quarry. A skull of *Neohipparion affine* ref. (UNSM 42447) (F:AM 107756 cast) is among the fossils collected here on August 5, 1916 by Richmond and Hans. The UNSM catalog lists this specimen as "*Hipparion*-identified by W. D. Matthew."

YALE QUARRY D (fig. 24, no. 23): On the south side of the Niobrara River and located by Lull (MS.a, 1914, July 17) as "camp to Quarry D  $1\frac{1}{4}$  miles by pedometer. Probably in Sect. 24, R. 27 W, T. 34 N. Cherry Co., Nebraska." Lull was measuring from his camp near the old Fort Niobrara buildings. Quarry D appears to be at, or near, UCMP Locality V-3218 of Stirton and McGrew (1935, p. 127) and Webb (1969, fig. 46a). See also discussion under Yale Mastodon Quarry in the Burge Member. Sparks Quadrangle 1950.

SYNONYMS: Probably same as UCMP V-3218 or Fort Niobrara Locality (Stirton, MS.a, 1933, April 17-20, including sketch map).

REPOSITORY OF FOSSILS: YPM and UCMP.

HISTORY: Discovered on July 16, 1914 by YPM party under R. S. Lull (present paper, p. 292). Also worked by UCMP in 1933.

REMARKS: Lull (MS.a, 1914, July 17) measured a section that compares closely with a section shown in Stirton (MS.a, 1933, April 20). Fossils occur in loose channel sand that is correlated with the Crookston Bridge Member.

TYPE SPECIMENS FROM THE  
CROOKSTON BRIDGE MEMBER

CLASS AVES  
ORDER CICONIIFORMES  
FAMILY CICONIIDAE

*Dissouroides milleri* Short, 1966. (Type UNSM 5780.) Found by P. O. McGrew and P. Harper

July 18, 1930, in Railway Quarry "A" from the type locality of the Valentine Formation.

CLASS REPTILIA  
ORDER SQUAMATA  
FAMILY IGUANIDAE

*Leiocephalus septentrionalis* Wellstead, 1982. (Type UNSM 56085.) From UNSM Kx-110 or Annie's Geese Cross Quarry in NW ¼, sect. 23, T. 33 N, R. 3 W, Knox Co., Nebr.

CLASS MAMMALIA  
ORDER INSECTIVORA  
FAMILY TALPIDAE

*Domninoidea valentinensis* Reed, 1962. (Type UCMP 33152.) From UCMP V-3218 locality, south side Niobrara R., about 1½ mi. NE of Wildlife Refuge Headquarters in SE ¼, SW ¼, NW ¼, sect. 24, T. 34 N, R. 27 W, Cherry Co., Nebr. USGS Sparks Quad. 1950, scale 1:62,500, Air photo CAM-15-P-116 dated 10-17-55. From unconsolidated sand overlying Rosebud Formation.

FAMILY SORICIDAE

*Limnoecus niobrarensis* Macdonald, 1947. (Type UCMP 36171.) From UCMP V-3218 locality (?Yale Quarry D). From "cross-bedded, unconsolidated gray sand between thin members of green clay and well indurated sandstone, exposed along sand bank on S. side Niobrara R. Formation about 87 feet thick; shrew came from middle of section" (Macdonald, 1947, p. 124).

ORDER RODENTIA  
FAMILY HETEROMYIDAE

*Cupidinimus nebraskensis* Wood, 1935. (Type CM 10193.) Found by A. E. Wood in Railway Quarry "B."

*Perognathus trojectionis* Korth, 1979. (Type UNSM 56311.) From UNSM Kx-110 or Annie's Geese Cross Locality in NW ¼, sect. 23, T. 33 N, R. 3 W, Knox Co., Nebraska. From unconsolidated sand. (Referred specimens collected at Norden Bridge Quarry.)

FAMILY MURIDAE

*Miochomys niobrarensis* Hoffmeister, 1959. (Type UCMP 36103.) Collected by UCMP field party in 1936 from UCMP Locality V-3218 "on quarter section line between NW and SW quarters of Sec. 24, T 34 N, R. 26 W, Cherry County, Nebraska . . . in a gray formation with green clay and sandstone members, but mostly loose sand" (Hoffmeister, 1959, p. 698).

*Peromyscus kelloggae* Hoffmeister, 1959. (Type UCMP 36105.) Collected by UCMP party, 1936, from same locality and lithic unit as *Miochomys niobrarensis* (Type UCMP 36103).

ORDER CARNIVORA  
FAMILY CANIDAE

*Aelurodon platyrhinus* Barbour and Cook, 1917b. (Type UNSM 78-11-8-15.) Found by J. B. Burnett and A.C. Whitford, 1915, in Railway Quarry "A."

ORDER PROBOSCIDEA  
FAMILY GOMPHOTHERIDAE

*Tetrabelodon willistoni* Barbour, 1914b. (Type UNSM 2-16-5-13.) Found by E. H. Barbour, A. C. Whitford, and H. Eaton in Devil's Gulch, Brown Co., Nebr. in "Quarry No. 2, about 115 feet below the general level, 75 feet below and about 300 feet distant from Quarry No. 1" (Barbour, 1914b, p. 184) and Barbour's sketch map and section in Osborn (1936, p. 601, fig. 568). In upper Crookston Bridge or at transition into basal Devil's Gulch Member. (See also locality description for *Eubelodon morrilli* (Quarry No. 1) in Burge Member.)

*Tetrabelodon osborni* Barbour, 1916b. Type UNSM 30-6-15.) Found by "Z. T. Long, 7 miles north and 2 miles east of Bristow, Boyd County, Nebraska . . . The skeleton was exposed on a sloping hillside in channel gravels composed of three to four feet of very coarse, lime pebbles underlain by five or six feet of fine sand. The deposit is of Pliocene age equivalent to the Snake River of Cherry County, and the Lower Devil's Gulch beds of Brown County. For convenience we shall call these the Bristow beds" (Barbour, 1916b, pp. 522-529; 1917, pp. 499-542, 12 figs.). Associated material included "teeth of horse (*Protohippus* and *Hipparion*), rhinoceros, camel and rodent (*Dipoides tortus*)."

Osborn (1936, p. 298), who identified *T. osborni* as *Trilophodon* (*Genomastodon*) *osborni*, was "inclined to regard this as one of the most primitive Hyperlongerostrines found in America and nearest to the typical *T. angustidens* stage of evolution." Tobien (1973, p. 231), however, lists *T. (Genomastodon) willistoni*, *T. abeli*, and several other taxa as synonyms of *Gomphotherium productum*. Souders (1976, illus. 10) mapped the presence of a thin section of the Ogallala Group overlying the Pierre Shale in the area from which the type of *Tetrabelodon osborni*

was collected. On the basis of Barbour's (1916b, p. 522) correlating the collecting site with the lower part of the section in Devil's Gulch, which would place it stratigraphically nearly equivalent to the section from which the type of *T. willistoni* was collected, the locality is tentatively placed in the middle to lower part of the Valentine Formation, probably equivalent to the Crookston Bridge Member of early Valentinian age. This interpretation is compatible with Osborn's views on *T. osborni* being an early longirostrine in America. In view of the significance of the specimen and the presence of an associated fauna more detailed work on the geology and fauna at the type locality of *T. osborni* is encouraged.

ORDER PERISSODACTYLA  
FAMILY RHINOCEROTIDAE

*Diceratherium jamberi* Tanner, 1977. (Type UNSM 62048.) Collected by UNSM "on farm of Joseph Jamber. W of C of the S line of the SE ¼, NW ¼, section 7, T. 33 N., R. 12 W., on the west side of a tributary drainage leading SSE to the Niobrara River . . . at about 1730 or 1720 contour . . ." (letter from L. G. Tanner and T. M. Stout dated Jan. 14, 1982). The sediments of the Jamber Quarry (UNSM BD-6) "could be as young as the Burge Member or at the level of the Devil's Gulch Horse Quarry in the Valentine Formation . . . Perhaps the most unusual find so far made at the quarry is of the very rare beaver, *Anchitheriomys* (T. M. Stout, 1978 . . . figs. 6-8 . . . found previously only at the Myers Farm Quarry (Wt. 15) near Red Cloud, Webster County, Nebraska (Corner, R. G., Ms. of 1976, Master's thesis, Univ. Nebraska) but it was found last summer in the basal Valentine . . . in the . . . Norden Bridge Quarry (BW-106) . . . (personal commun. from M. R. Voorhies)."

Voorhies (personal commun., June 1982) provided a second opinion on the age of the fauna stating "it is clearly not as young as the Burge fauna. It is closer to the Railway or Crookston Bridge faunas in age." The Voorhies interpretation concurs with earlier views that the Jamber Quarry carnivores and associated fauna appear to be early Valentinian in age (Messenger and Messenger, 1976, p. 47; 1977, p. 95).

On the basis of available evidence *D. jamberi* is tentatively placed in the lower part of the Valentine Formation, possibly in the

Crookston Bridge Member. There is no solid evidence that precludes the sediments in which the Jamber Quarry occurs being as old as the Cornell Dam Member. Future stratigraphic and faunal work may more clearly define the details of biostratigraphic relationships in this area.

ORDER ARTIODACTYLA  
FAMILY TAYASSUIDAE

*Prosthennops xiphodonticus* Barbour, 1925a. (Type UNSM 85-11-8-15 B & W.) Found by J. B. Burnett and A. C. Whitford in 1915 in Railway Quarry "A."

FAMILY MOSCHIDAE

*Blastomeryx gemmifer valentinensis* Frick, 1937. (Type UNSM 10-6-9-31.) Found by UNSM party of 1931 in Railway Quarry "A."

FAMILY ANTILOCAPRIDAE

*Meryceros warreni johnsoni* Frick, 1937. (Type UNSM 2-3-8-34.) Found by Johnson and K. L. Rathbun in 1934 in the Crookston Bridge Quarry.

DEVIL'S GULCH MEMBER

Barbour (1914a, p. 169; 1914b, pp. 182-183) applied the term "Devil's Gulch beds" to "225 feet of sandy beds belonging to the 'Loup Fork'" which, in present nomenclature, includes all of the Ogallala Group and possibly a thin section of Pleistocene at Devil's Gulch in Brown County, Nebraska. Barbour and Cook (1917a, p. 170; 1917b, p. 173) followed this designation by an ambiguous restriction of Devil's Gulch sediments to an "upper phase" and the Valentine to a "lower phase."

For more than 50 years Devil's Gulch sediments remained an obscure entity, whereas Valentine sediments had been defined, accepted, and frequently used since 1938 as a formation in a specific sequence of sedimentary rocks in the lower part of the Ogallala Group in north-central Nebraska. In the 1930s it became obvious to Skinner that lithic units recognized in the Valentine and Snake River areas of Cherry County were represented by stratigraphically and temporally equivalent rocks in Brown County.

Skinner, Skinner, and Gooris (1968, p. 406, pls. 23, 24) recognized the need for more precise lithostratigraphic allocation of fossil collections in northern Nebraska and restricted the term "Devil's Gulch Member" to a specific part of the Valentine Formation. Fortuitously at the type section these rocks encompass "one of the rare stream-channel deposits in this part of the Valentine Formation" from which a remarkable assemblage of fossils was collected at the Devil's Gulch Horse Quarry (see below).

The Devil's Gulch Member is distributed over an area at least 100 mi. long in the Niobrara River drainage, from the vicinity of the type locality westward to at least the Crane Bridge near the east flank of the Chadron Arch (sects. 32–37). Its thickness is about 60 ft. in the type section and varies from less than 50 to about 60 ft. over much of the outcrop area.

The predominance of beds of massive yellow-gray argillaceous sandstone that occasionally contains limy nodules and tubules distinguishes this unit from the underlying and overlying strata. In many localities it cracks and peels on exposed vertical surfaces, suggestive of the type of weathering that occurs in loess deposits. Its relative uniform thickness indicates deposition over an area of low relief near the end of a cycle of slow aggradation. The possible influence of dry climate and eolian processes in its deposition on a broad flood plain should be considered in a postulation of its origin.

Whereas the contact between the clay-filled sand of the Devil's Gulch Member and the underlying massive to cross-bedded sand of the Crookston Bridge Member is frequently sharp, it is more likely to be gradational as the contact zone is approached with an increased frequency of clay and argillaceous sand interbedded with soft sand in the upper part of the Crookston Bridge Member. The zone of interfingering of these facies is usually thin relative to the thickness of the members themselves so that a "contact" can be recognized over much of the area.

The age of the fauna in the Devil's Gulch Member is late Barstovian (Tedford et al., MS.) or late Valentinian depending upon the terminology applied. An important local fauna is that of the Devil's Gulch Horse Quarry

(see below). Fossils in the massive sandstone of this member generally occur locally as single species or clusters of several taxa, some with articulated skeletal parts.

Correlation of the Devil's Gulch over the study area is shown on the cross sections. This member is equivalent to the Upper Valentine Beds (Johnson, 1936, p. 469), a term that is obsolete, since Lugin (1938, p. 223) included the overlying Burge Member in the Valentine when it was elevated to the status of a formation in the Ogallala Group.

#### QUARRIES IN THE DEVIL'S GULCH MEMBER

DEEP CREEK QUARRY NO. 1 (fig. 27, no. 24): At the head of the second side canyon above the mouth on the east side of Deep Creek in the E  $\frac{1}{2}$ , sect. 2, T. 31 N, R. 23 W, Brown County, Nebraska. Ainsworth NW Quadrangle 1954. Not to be confused with UNSM Deep Creek Quarry of 1929.

REPOSITORY OF FOSSILS: FAM Collection has three horse skulls and specimens of several other taxa.

HISTORY: Discovered by Skinner and J. H. Quinn on June 28, 1929.

REMARKS: Fossils were collected in a large block of argillaceous sand at an elevation of about 2323 ft., or 117 ft. above the water level at the confluence of Deep and Plum creeks. This places the quarry near the base of the Devil's Gulch Member or 45–50 ft. below the base of the Burge (Skinner, MS.c, 1929, July 4; MS., vol. 1, p. 50; vol. 10, p. 26).

DEEP CREEK QUARRY OF UNSM (fig. 27, no. 25): On the east side of the west branch of Deep Creek near the center of west line of SE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 11, T. 31 N, R. 23 W, Brown County, Nebraska. Ainsworth NW Quadrangle 1954. Elevation about 2354 ft. Not to be confused with Deep Creek Quarry No. 1 above. UNSM Bw-10.

REPOSITORY OF FOSSILS: More than 100 specimens in UNSM Collection.

HISTORY: Discovered by E. H. Colbert (MS.a, June 24, 1929) for UNSM and worked that summer.

REMARKS: Skinner visited the Nebraska collecting site and found that the UNSM Quarry was in the massive argillaceous sand



of the Devil's Gulch Member, probably about 5–7 ft. below the top. This is the type locality of *Prosthennops niobrarensis* Colbert (Skinner, MS., vol. 1, pp. 48–49).

**DEVIL'S GULCH QUARRY** (fig. 28, no. 26): On a westerly facing outcrop at the head of Devil's Gulch in the W  $\frac{1}{2}$ , NW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 28, T. 32 N, R. 21 W, Brown County, Nebraska. Dutch Creek Quadrangle 1950. The quarry is shown in Skinner, Skinner, and Gooris (1968, pl. 24). Elevation about 2290 ft. Not to be confused with Devil's Gulch Horse Quarry.

**HISTORY:** Discovered and worked by Skinner (MS.h) during September 1931. This quarry consisted of a small pocket of closely packed bones that were collected in three large blocks and one small one.

**REPOSITORY OF FOSSILS:** About 60 specimens are in the F:AM Collection.

**REMARKS:** This quarry is in the basal part of the massive argillaceous sandstone characteristic of the upper part of the Devil's Gulch Member that directly overlies a lateral facies of the channel sand in which the Devil's Gulch Horse Quarry occurs.

Six associated skulls, partial skulls and mandibles, and associated bones (F:AM 33591–33596) from this site were referred to *Ustatochoerus medius* by Schultz and Falkenbach (1941, pp. 23–25). These specimens, however, were not from the lower Valentine as reported by Schultz and Falkenbach, but from the Devil's Gulch Member in the upper part of the Valentine.

The collection from this quarry includes a skull of *Cormohipparion* (F:AM 108231) and a skull and mandible of *Cranioceras* (*Procranioceras*) *skinneri* (F:AM 31251). McGrew (1938, pp. 323, 329–331, fig. 89) referred a palate (FMP 25537) to *Cynarctus crucidens*. Skinner is of the opinion that the specimen was collected at this site. Other taxa have not been studied.

**DEVIL'S GULCH HORSE QUARRY** (fig. 28, no. 27): On the south side of Devil's Gulch, tributary of Dutch Creek, near the center of the north line of SW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 28, T. 32 N, R. 21 W, Brown County, Nebraska. (See Skinner, Skinner, and Gooris, 1968, pls. 23–24 for photograph of the area and quarry.) Lat. 42°42'46"N, Long. 99°47'35"W, Dutch

Creek Quadrangle 1950. Elevation of base 2260 ft.

**HISTORY:** Discovered by Skinner and R. L. Mefferd May 15, 1933. Worked intermittently until 1953 (Skinner, MS., vol. 1, p. 45).

**REPOSITORY OF FOSSILS:** F:AM Collection has 283 specimens.

**REMARKS:** This quarry is in a local cross-bedded sand containing greenish clay pebbles and nodules, filling a 28 ft. channel cut into the lower part of the Devil's Gulch Member at its type section (fig. 34, sect. 41, quarry 27). This channel sand is overlain and underlain by yellow-gray, massive, firm, but friable sandstone typical of the member. The fauna from this quarry is the type fauna for the Devil's Gulch Member of the Valentine Formation.

The local fossiliferous channel deposit crops out on the south side of Devil's Gulch and trends southeasterly (Skinner, Skinner, and Gooris, pp. 406–407). When first discovered during the drought of the 1930s there was a small 4 or 5 ft. interval of highly fossiliferous sand exposed in the bottom of a small gully on the south side of Devil's Gulch. Skinner and Mefferd dug closely spaced "prospect holes" through masses of tree roots on the south side of the pine covered gulch. The dry sand below the tree roots in the prospect holes ran out like salt because of the extreme drought. After a week's work they had expanded the quarry laterally a good distance, tracing the contact of the channel sand above a more consolidated argillaceous sand floor. On returning after the weekend they found the entire surface of the tree covered slope had broken loose and slumped to the bottom of the gulch, exposing the true profile and nature of the channel and revealing a very fossiliferous deposit to work.

No fossils from this quarry were collected by Barbour and his associates of UNSM in 1913, who worked on the opposite side of the Gulch. The Devil's Gulch Horse Quarry was completely covered by sod and trees when discovered 20 years later.

The Devil's Gulch Horse Quarry fauna consists of at least 24 genera (Skinner, Skinner, and Gooris, 1968, pp. 406–407). Many of the rodents, lagomorphs, and other small forms have not been identified or studied.

Frick (1937) described the holotypes of *Cranioceras* (*Procranioceras*) *skinneri* and *Blasioteryx* *mefferdi* from this site. Other taxa identified are *Leptarctus*, *Aelurodon*, *Ischyrocyon*, *Tomarctus*, *Plionictis*, *Prosthennops*, *Trilophodon*, *Teleoceras*, *Hypohippus*, *Megahippus*, *Pseudhipparion*, *Calippus*, *Protohippus*, *Pliohippus*, *Cormohipparion*, *Neohipparion*, *Ustatochoerus*, *Procamelus*, *Protolabis*, *Homocamelus*, *Aepycamelus*, and *Ramoceros*. This is the type locality of the Devil's Gulch Local Fauna but a comprehensive study of this significant fauna has not been published.

DUTCH CREEK QUARRY NO. 1 (fig. 28, no. 28): On the east side of the main south trending draw of Dutch Creek near the center of SW  $\frac{1}{4}$ , sect. 29, T. 32 N, R. 21 W, Brown County, Nebraska. Dutch Creek Quadrangle 1950.

REPOSITORY OF FOSSILS: F:AM Collection has about 25 specimens.

HISTORY: Discovered by Skinner on July 4, 1929.

REMARKS: Fossils were concentrated in a small pocket in the lower part of the massive argillaceous sand of the Devil's Gulch 114 ft. above the Valentine-Rosebud contact. This is the type locality of *Ramoceros* (*Pararamoceros*) *howardae* Frick. The associated fauna remains to be studied (Skinner, MS.c, 1929, July 4 and MS., vol. 1, p. 39).

ELLIOTT QUARRY (fig. 29, no. 29): About 300 yards east of Long Pine Creek in the first northeast branch of an east-west trending side canyon off the creek. In the SW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 5, T. 30 N, R. 20 W, Brown County, Nebraska. Long Pine Quadrangle 1954. Elevation of quarry about 2200 ft. or 50 ft. above Long Pine Creek.

SYNONYM: Elliott place.

REPOSITORY OF FOSSILS: F:AM Collection has 45 specimens.

HISTORY: Discovered by Rastus Elliott on the property of his father, George Elliott. Worked by Skinner and Mefferd starting April 3, 1933. Skinner collected again in 1938 and 1948.

REMARKS: Fossils occurred in about 5 ft. of white marly clay overlain by greenish sandy clay and underlain by loose channel sand, clay pebbles, and clasts. This pond and chan-

nel complex has a thickness of at least 13 ft., wedges out laterally to the south, and is encompassed above and below by typical yellow-gray argillaceous sand of the Devil's Gulch Member (Skinner, MS., vol. 3, pp. 22-33).

Rocks exposed at this quarry appear to be lithostratigraphically equivalent to those in nearby Rattlesnake Gulch Quarry. The timber covered area made it difficult to get a good section.

Baskin (1982, p. 82, fig. 5E) identified F:AM 25248 from this quarry as *Arctonasua* sp. A.

FAIRFIELD FALLS QUARRY (fig. 25, no. 30): On north side of Fairfield Creek and uphill above a small set of falls slightly upstream from intersection of west end of high terrace and canyon in the NE  $\frac{1}{4}$ , sect. 3, T. 32 N, R. 24 W, Brown County, Nebraska. Norden Quadrangle 1950.

SYNONYM: FFQ. Not to be confused with Fairfield No. 1 site, nor with the falls on the west fork of the creek in Cherry County.

REPOSITORY OF FOSSILS: F:AM Collection contains 53 specimens.

HISTORY: Discovered by Skinner (MS.d, 1934) and A. Potter, May 4, 1934. Collections were made in 1934 and 1937.

REMARKS: Fairfield Falls Quarry is situated on a talus covered slope, and no section was measured because of the covered topography. It is probably in the Devil's Gulch Member.

FAIRFIELD CREEK QUARRY NO. 2 (fig. 25, no. 31): On south side of Fairfield Creek in the NE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 9, T. 32 N, R. 24 W, Brown County, Nebraska. Norden Quadrangle 1950. Quarry is 174 ft. above the creek and 20 ft. below the contact between Tertiary rocks and Sand Hills. Elevation about 2430 ft.

SYNONYM: F-II.

REPOSITORY OF FOSSILS: F:AM Collection.

HISTORY: Discovered by Skinner and J. H. Quinn in 1928 (Skinner, MS.e, 1928, August 12).

REMARKS: Collection here consisted of a gomphothere jaw and a set of horse teeth. Stratigraphically the site is in the Devil's Gulch Member.

HORSE THIEF CANYON NO. 3 (fig. 27, no. 32): On north side of Plum Creek in the SE

¼, sect. 35, T. 32 N, R. 23 W, Brown County, Nebraska. Ainsworth NW Quadrangle. Elevation not determined. Could be confused with Horse Thief Canyon No. 2, but is stratigraphically lower.

SYNONYM: Also known as Prospecting Locality No. 71 (Skinner, ms.g, 1937).

REPOSITORY OF FOSSILS: F:AM Collection contains the major part of a horse skeleton.

HISTORY: Discovered in the spring of 1937 by Skinner and assistants.

REMARKS: The stratigraphic position is in the upper part of the Valentine Formation, probably in the Devil's Gulch Member.

MIZNER QUARRY (fig. 23, no. 33): A large sand slide on east side of Snake River 500 ft. south of north line of the NE ¼, sect. 5, T. 31 N, R. 30 W, Cherry County, Nebraska. Kennedy Quadrangle 1950. Air photo CAM-11P-193 dated 10-7-55. Elevation at base of fossil-bearing channel sand 2690 ft.

SYNONYM: Misner Locality, Meisner Quarry. UNSM Cr-18.

REPOSITORY OF FOSSILS: UNSM has at least 16 specimens, F:AM Collection has 135.

HISTORY: Discovered by F. W. Johnson, K. Rathbun, G. Meade, and D. Franzen of UNSM, June 27, 1934. Originally described as "In channel sands about 30' above water level." (Johnson, ms.d, 1934, p. 29.) A visit in 1976 verifies that the sand slide resulting from this channel has been active for at least 50 years.

REMARKS: UNSM Collection is from near the base of the channel sand, and Skinner's collection for Frick came from scattered intervals throughout the slide.

A section (fig. 38, sect. 62) at this locality shows a sand filled channel cut at least 35 ft. and possibly as much as 54 ft. in depth. This channel fill appears to be contemporaneous with the lower part of the Devil's Gulch or uppermost Crookston Bridge, or in the transition between the two members. Present interpretation favors placing it in the basal Devil's Gulch Member (Johnson, ms.d, 1934, pp. 29-34; Skinner, ms. vol. 1. pp. 74-75; vol. 9, p. 44).

RATTLESNAKE GULCH QUARRY (fig. 29, no. 34): In SE ¼, sect. 6, T. 30 N, R. 20 W, Brown County, Nebraska. Long Pine Quadrangle 1954. Elevation about 2200 ft.

SYNONYM: Rattlesnake Canyon Quarry.

REPOSITORY OF FOSSILS: F:AM Collection.

HISTORY: Discovered by Skinner and R. L. Mefferd, August 16, 1931. Worked in 1931, 1932, and 1933.

REMARKS: Fossils occurred in the basal part of a 6-ft. white marly clay and the underlying 10 ft. of channel sand. This pond and channel complex is correlated with similar rocks at the Elliott Quarry at the same elevation. It is overlain and underlain by typical argillaceous sandstone of the Devil's Gulch. The interval in which the fossils occur is 43-55 ft. below the base of a hard gray sandstone referred to the Ash Hollow Formation (Skinner, ms., vol. 3, pp. 36-37).

#### TYPE SPECIMENS FROM THE DEVIL'S GULCH MEMBER

#### CLASS MAMMALIA ORDER ARTIODACTYLA FAMILY TAYASSUIDAE

*Prosthennops niobrarensis* Colbert, 1935b. (Type UNSM 20-6-7-29 CM.) Collected by E. H. Colbert and P. O. McGrew, 1929. Several other taxa were found associated with the type skull. From Deep Creek Quarry.

#### FAMILY MOSCHIDAE

*Blastomeryx mefferdi* Frick, 1937. (Type F:AM 31375.) Collected by M. F. Skinner in 1933 from Devil's Gulch Horse Quarry.

#### FAMILY DROMOMERCIDAE

*Cranioceras (Procranioceras) skinneri* Frick, 1937. (Type F:AM 31250.) Collected by M. F. Skinner in 1933 from Devil's Gulch Horse Quarry.

#### ANTILOCAPRIDAE

*Ramoceros (Pararamoceros) howardae* Frick, 1937. (Type F:AM 31271.) Collected by M. F. Skinner from Dutch Creek Quarry No. 1.

#### BURGE MEMBER Figures 15, 32-38

Stirton (in Chardin and Stirton, 1934, table 1) used the name Burge in a faunal sense. Stirton and McGrew (1935, pp. 129-131) used the name "Burge fauna" and provided a faunal list from localities on the Snake River and Gordon Creek, Cherry County, Nebraska. Johnson (1936, pp. 471-472) named the Burge Sands as a member of the Ogallala Formation, published a section and desig-

nated the Burge Quarry on the Snake River as the type locality of the member and of the Burge Fauna.

Lugn (1938, pp. 220–227) raised Ogallala from formation to group status, and the Valentine from a member to a formation in the Ogallala Group. Concurrently Lugn designated the Burge as the uppermost member of the Valentine Formation; he apparently considered the gross lithology of the Burge more closely related to the thick sections of soft sand in the Valentine than to the overlying section he referred to the Ash Hollow Formation. This designation was later used by Schultz and Stout in collaboration with Lugn, Elias, Johnson, and Skinner (1941, p. 4).

Skinner, Skinner, and Gooris (1968, pp. 407–408, pls. 23, 25) dropped the term Sands and firmly established the use of Burge as a member of the Valentine Formation, provided more information on the Burge Quarry, which had been extensively excavated in the 1930s by Frick fossil collecting operations, and published a photograph of the quarry as it appeared in 1939 showing the superposition of the Cap Rock Member of the Ash Hollow Formation. Webb (1969, pp. 9–10) agreed that the Burge is easily recognized as a lithic unit, and accepted, with some reservations, the use of the name, Burge, as a stratigraphic unit as well as a faunal name.

The Burge Member is recognized westward at least 30 mi. up the Niobrara River to the Ewert Quarry located in Deer Canyon 1 mi. northwest of the Devil's Jump Off section (fig. 32, sect. 21). Seventy-six miles upriver from the Ewert Quarry the sand in which the Paleo Quarry occurs near the crest of the Chadron Arch is tentatively referred to the Burge. The Burge Member extends eastward downriver from its type locality for more than 60 mi. into Brown and Keya Paha counties (fig. 34). Skinner and Gooris (1968, p. 408, figs. 2–3) found that the faunal content of a channel sand between the Cap Rock and Devil's Gulch Members at Turtle Butte in south-central South Dakota indicate a Burge equivalent. These rocks vary in thickness from 50 ft. in a few localities to zero in some sections.

Johnson (1936, 1938), Skinner, Skinner, and Gooris (1968), and Webb (1969, pp. 9–10) discussed the gross lithology and min-

eralogy of the Burge, which is characteristically cross-bedded loose quartz sand and greenish gray to olive-green quartz pebbles. Frequently, it contains greenish clay ball clasts, particularly in its basal part where vertebrate fossils are found. Lenses of greenish clay occur at various levels in the unit.

The abrupt change from the underlying massive yellow-gray argillaceous sandstone of the Devil's Gulch Member to the channel sands of the Burge may be due to a minor increase in the regional tilt associated with uplift in the Black Hills and Rocky Mountains providing a new source of sediments as discussed by Webb (1969, p. 11), or a dramatic change in the climate that produced a cycle of widespread flooding, channel cutting, and subsequent channel fill. The upper part of the Burge Member tends to be less cross-bedded, finer grained, better sorted to thin bedded, and contains occasional layers of greenish to light gray clay as the channels filled prior to the deposition of the overlying Ash Hollow Formation.

The stratigraphic relationships between the Burge and the underlying and overlying rock units can usually be identified by the break in lithic sequence. Unconsolidated channel deposits of the Burge generally weather into gently sloping outcrops and lie disconformably on the underlying cliff-forming friable argillaceous sandstone of the Devil's Gulch Member. The contact of the Burge with the base of the overlying Ash Hollow Formation is frequently represented by an undercut of sand slides in the Burge Member below the vertical outcrops of the Cap Rock Member. The contact between the two units is often marked by a change from soft to firm massive sand at the top of the Burge Member to a weathered zone at the base of the Ash Hollow Formation containing sandstone clasts and bone fragments (the "fragmental layer" of Johnson, 1936), or layers of diatomaceous, freshwater, marly limestone or clays of the type found in pond deposits on a low relief flood plain.

Webb (1969, pp. 15–16) followed Wood et al. (1941) in placing the Burge Fauna in the Clarendonian, but recognized that the Burge "is distinctly older than the Clarendon Fauna from the type Clarendonian." Recent studies (Tedford et al., *MS.*), however, place the Burge

in the latest Barstovian, which is temporally equivalent to the late Valentinian of Schultz and Stout (1961, fig. 3) and Schultz, Schultz, and Martin (1970, fig. 8).

Stirton and McGrew (1935) and Johnson (1936) provided preliminary lists of the Burge Fauna. McGrew (1938b) followed with a detailed study of a local fauna from the Burge Member on Gordon Creek, 8 mi. E, 11°N of Burge Quarry. Webb (1969) studied the fauna in the UCMP collections from Burge Quarry (UCMP V-3312) and several other localities. The results were incorporated into a detailed compilation of the Burge Fauna. No comprehensive work, however, has been done on the much larger assemblages of more than 6500 fossils from quarries in the Burge Member in the Frick and University of Nebraska collections. A list of holotypes known to have been collected from the Burge Member, details on collecting localities, and quarries in sediments referred to the Burge, are included.

Correlation of the Burge over the area in which it has been recognized has been facilitated by its lithologic character, position in relation to underlying and overlying lithostratigraphic units, and its fauna. Lugin (1938, p. 222) and Skinner, Skinner, and Gooris (1968, pls. 23, 24) recognized Burge sediments at Devil's Gulch, and documented its position in sections at that locality.

#### QUARRIES IN THE BURGE MEMBER

**BURGE QUARRY** UNSM Cr-17 (fig. 23, no. 35): On east side of Snake River about 60 yards south of middle of north line of NE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , sect. 15, T. 32 N, R. 30 W, or 0.6 mi. N, 29°W of Burge Post Office (no longer extant), Cherry County, Nebraska (Johnson, ms.d, 1934, pp. 9–11, 55–56, map and sections; ms.g, 1973, pp. 43–44; Skinner, ms., vol. 1, pp. 130–131; vol. 9, p. 43). Lat. 42°44'59"N, Long. 100°48'51"W, Kennedy Quadrangle 1950. Air photo CAM-12P-105 dated 10-7-55 and photograph in Skinner, Skinner, and Gooris (1968, pl. 25). Elevation at base of quarry about 2711 ft.

**SYNONYMS:** UCMP Loc. V-3312.

**REPOSITORY OF FOSSILS:** F:AM Collection has about 3000 specimens, 23 are at UNSM, and R. A. Stirton collected 52 specimens in addition to those collected for UCMP by P. O. McGrew.

**HISTORY:** Grayson Meade has confirmed (personal commun.) the Burge Quarry was discovered by P. O. McGrew and Meade of the UNSM on June 10, 1932 (McGrew, ms.d, 1932), not in 1933 as stated by Skinner, Skinner, and Gooris (1968, p. 407). It was worked by P. O. McGrew and A. Potter in the fall of 1933 for the UCMP. The Stirton (ms.b, 1934, May 10–22) UCMP field party collected here from May 10–22. UNSM collected during June 1934 (Johnson, ms.d, pp. 9–11; Meade, ms.a, 1934, pp. 7–9). A Frick party led by Skinner worked the quarry in the fall of 1934. In 1935 and 1939 Skinner and his party used a mechanical scraper to remove overburden exposing extensive fossil bearing matrix from which a large collection was made. From the early 1940s through 1947, they collected additional fossils during short visits. The quarry was abandoned because of the high risk of a major cave-in.

**REMARKS:** This highly productive fossil quarry is in 40 ft. of cross-bedded sand and gravel that contains clay balls and occasional clay lenses. The quarry is in one of the thickest sections of the Burge Member known, in a channel deeply eroded into the Devil's Gulch Member. This is the type locality of the Burge Member and Fauna, and it is overlain by the type section of the Cap Rock Member of the Ash Hollow Formation (figs. 15, 38; Johnson, 1936, fig. 2; Skinner, Skinner, and Gooris, 1968, pl. 25).

Stirton and McGrew (1935, pp. 129–131) cited this locality as the principal source of 18 taxa listed in their Burge Fauna. Webb (1969, pp. 30–172) made the most complete study of this fauna, based on the collection at UCMP. UNSM and F:AM collections from Burge have not been studied in detail. Stirton and McGrew (1935, p. 130), Johnson (1936, fig. 2), and figures 15 and 38, present paper, show sections at this locality.

The Burge Fauna is noteworthy for its quantity, quality, and variety. Of the 2000 specimens from the quarry at least 14 were articulated skeletons. Among these are at least one large turtle (F:AM 12720), a skull of *Ictalurus punctatus* (F:AM 10619), an articulated skeleton of *Sthenictus* (F:AM 25235), two partial peccary skeletons (F:AM 42886 and 42887), a partial gomphothere skeleton, and three horse skeletons, one of which is a

complete, articulated skeleton of *Protohippus simus* (F:AM 60353). This skeleton lacked only the right upper and lower canines, and contained an unborn foal in the pelvis. At least five camel skeletons and the type of *Paracosoryx burgensis* Frick are from the Burge Quarry. No comprehensive study has been made of the large F:AM collection from the Burge Quarry.

**BUZZARD FEATHER QUARRY** UNSM Kp 108 (fig. 25, no. 36): About 325 ft. east of the west end of Cap Rock escarpment in NW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 29, T. 33 N, R. 23 W, Keya Paha County, Nebraska. Norden Quadrangle 1950.

**REPOSITORY OF FOSSILS:** UNSM has 70 specimens.

**HISTORY:** Discovered in 1979 by Kevin Seevers of UNSM Field party.

**REMARKS:** Up to about 5 ft. of Burge sand in an undercut at the base of a Cap Rock escarpment. At least six taxa of fossils have been collected here.

**EUBELODON MORRILLI QUARRY** UNSM Bw-11 (fig. 28, no. 37): On north side of Devil's Gulch near center of S  $\frac{1}{2}$ , NW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 28, T. 32 N, R. 21 W, Brown County, Nebraska. Dutch Creek Quadrangle 1950. Elevation at base of Burge 2294 ft.

**SYNONYM:** UNSM Quarry No. 1 in Devil's Gulch and Devil's Gulch Quarry (of UNSM).

**REPOSITORY OF FOSSILS:** UNSM.

**HISTORY:** Discovered by A. C. Whitford of UNSM in 1913, and reported by E. H. Barbour (1914b, pp. 186–189, pls. 1, 9–13; MS.a, 1913, pp. 54–62). The exact level from which the type of *Eubelodon morrilli* Barbour was collected is near the Burge-Ash Hollow contact shown at "a" on Barbour's plate 1. This is about 16 ft. above the base of the Burge Member (Johnson, MS.f, 1972, p. 24) at an elevation of approximately 2310 ft. Skinner, Skinner, and Gooris (1968, pl. 24) showed a photograph of the site labeled "Nebraska State Museum 1913."

The type of *Hypohippus matthewi* Barbour (1914a, p. 171) was collected "6 feet below the level of the mastodon skull" (type of *Eubelodon morrilli*).

**EWERT QUARRY** (fig. 21, no. 38): On east side of a small northwest trending canyon off headward end of Deer Canyon on the middle of the south line of NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , SE

$\frac{1}{4}$ , sect. 15, T. 33 N, R. 34 W, on the south side of the Niobrara River,  $3\frac{3}{4}$  mi. below mouth of Bear Creek, Cherry County, Nebraska. Eli Quadrangle 1952. Air photo CAM-13P-162 dated 10-12-55. Elevation at base of quarry about 2922 ft.

**SYNONYM:** Prospecting Locality 400.

**REPOSITORY OF FOSSILS:** F:AM Collection has 49 specimens.

**HISTORY:** Discovered by R. L. Mefferd in November 1939. About 18 ft. referred to the Burge Member, the lower part of which consists of sand. Underlain by yellow-gray argillaceous sandstone referred to the Devil's Gulch Member (Skinner, MS., vol. 1, p. 136).

**GORDON CREEK QUARRY** UNSM Cr-14 (fig. 2, no. 39): On west side of Gordon Creek, 220 yards downstream from the trail crossing shown on the air photo CAM-12P-163, dated 10-7-55. Near the center of NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , sect. 1, T. 32 N, R. 29 W, Cherry County, Nebraska. Valentine Quadrangle 1950. Elevation at base of quarry about 2666 ft.

**REPOSITORY OF FOSSILS:** UNSM, UCMP, and 184 specimens in F:AM Collection.

**HISTORY:** Discovered in 1928 by Lugen (MS.a, 1928, p. 33) and Colbert for UNSM. Worked intermittently by UNSM until 1930 (McGrew, MS.a, 1929, pp. 33–59, map, p. 89; MS.b, 1930, p. 31). McGrew (1935, pp. 305–312; 1938b, pp. 309–323) and Albert Potter collected during the fall of 1933 for UCMP a Burge equivalent fauna, including the type of *Cynodesmus euthos* McGrew, from the Burge Member on the east side of Gordon Creek at a site also named the Gordon Creek Quarry (UCMP Locality V3313). This was probably opposite or near the UNSM and F:AM Gordon Creek Quarry and part of the same channel sand deposit. Skinner removed the accumulated talus with a mechanical scraper at the UNSM Quarry in 1934 and obtained additional fossils for the F:AM Collection.

Fossils occur in typical Burge sand and gravel overlain by the Cap Rock Member of the Ash Hollow Formation and underlain by the Devil's Gulch Member (Johnson, 1936, fig. 2; Skinner, MS., vol. 1, p. 69).

**GORDON CREEK NORTH QUARRY** (fig. 2, no. 40): On a southeast facing outcrop on west side of Gordon Creek 330 yards downstream from Gordon Creek Quarry and 50 yards

downstream from a bend in stream-course from NNW to NNE. Valentine Quadrangle 1950. Air photo CAM-12P-163 dated 10-7-55.

REPOSITORY OF FOSSILS: F:AM Collection contains 28 specimens. Among these are the only complete mandible of *Megahippus* in the F:AM Collection (F:AM 60701) and an articulated skull and mandible with partial postcranial elements of *Cosoryx* (F:AM 54763).

HISTORY: Discovered by Skinner, Sr., and Skinner, Jr., November 6, 1949.

REMARKS: Occurrence same as in Gordon Creek Quarry in a local thickening of the Burge Member (Skinner, MS., vol. 1, p. 68).

JUNE QUARRY (fig. 26, no. 41): On a south facing outcrop on a sharp bend on east side of Plum Creek in the middle of the N $\frac{1}{2}$ , NE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , SW $\frac{1}{4}$ , sect. 19, T. 31 N, R. 23 W, 5 mi. north and  $\frac{1}{4}$  mi. west of railroad crossing at Johnstown, Brown Co., Nebraska. Elevation at base of quarry 2384 ft. Wood Lake Quadrangle 1950. Air photo CAL-3-104 dated 9-17-39.

REPOSITORY OF FOSSILS: F:AM Collection contains 793 specimens. Small collections in USNM and UNSM.

HISTORY: Discovered by R. Mefferd and L. Nelson for F:AM in June 1941. Worked by Skinner's F:AM party intermittently to 1976. Johnson, J. Behm, and L. Vadnais added 11 specimens to the F:AM Collection in 1976. R. J. Emry's field party from USNM collected a canid skeleton in 1976. Voorhies obtained a small collection in 1976 for UNSM.

REMARKS: The Burge Member is 36 ft. thick at this site. The lower 12 ft. consist of cross-bedded typical Burge channel sand. This is overlain by a local 1 $\frac{1}{2}$  to 2 ft. layer to clay, which is overlain by cross-bedded sand that becomes finer and more massive toward the top of the unit. Fossils collected in 1976 by the Johnson party (MS.h, 1976, pp. 6-8) were from the section immediately overlying the clay layer, whereas the canid skeleton obtained by Emry came from the basal sand. There is no record as to which part of the unit the earlier collections were made, but most of them probably came from the lower 15-20 ft. of the member (fig. 34, sect. 38, quarry 41).

The Burge Member is underlain by typical Devil's Gulch argillaceous sandstone and overlain by the Cap Rock (Skinner, MS., vol. 1, p. 144).

WEST JUNE QUARRY (fig. 26, no. 42): Main fossil deposit in June Quarry is east of where stream cuts into hill. West June Quarry is a westward extension of the fossil-bearing deposit of June Quarry.

REPOSITORY OF FOSSILS: F:AM Collection has 74 specimens.

HISTORY: Discovered November 20, 1946, by Skinner and Thomas Lucas.

REMARKS: The fossils in West June Quarry occur at the base of a sand above a clay deposit well up in the channel. This may be the same clay layer above which Johnson and party collected fossils in 1976 and added to the F:AM Collection from June Quarry proper. The Burge channel is extensive in this vicinity both up and downstream from June Quarry.

LUCHT QUARRY (fig. 2B, no. 43): On north side of Bone Creek near center of the E  $\frac{1}{2}$ , NE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 10, T. 31 N, R. 21 W, Brown County, Nebraska. Dutch Creek Quadrangle. Elevation of base 2280 ft.

REPOSITORY OF FOSSILS: F:AM Collection has 736 specimens.

HISTORY: Discovered by Skinner April 21, 1948, and named after Elmer Lucht, owner of the land at time of discovery. Worked intermittently by Skinner and assistants from 1948-1968. Eighty-one additional specimens have been collected in a lateral extension in the road cut since U.S. Highway 183 was built directly over the site in 1955.

REMARKS: Most of the fossils were collected from near the middle of typical Burge sediments deposited in a channel cut 22 ft. into the upper part of the Devil's Gulch Member (Skinner, MS., vol. 3, pp. 52-53).

SOUTH LUCHT QUARRY (fig. 2B, no. 44): About 200 yards southwest of Lucht Quarry in the NE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 10, T. 31 N, R. 21 W, Brown County, Nebraska. Dutch Creek Quadrangle 1950.

REPOSITORY OF FOSSILS: F:AM Collection has 67 specimens.

HISTORY: Discovered by Skinner August 31, 1950, and worked the same year.

REMARKS: Stratigraphically equivalent to

Burge and June quarries (Skinner, MS., vol. 3, pp. 52–53).

**MIDWAY QUARRY** (fig. 16, no. 45): Situated on a west facing outcrop below a cliff formed by the Cap Rock Member of the Ash Hollow Formation near the south line of the SW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , sect. 27, T. 34 N, R. 25 W, Cherry County, Nebraska. Norden Quadrangle 1950. Air photo CAM-14P-127 dated 10-15-55. Elevation of base 2522 ft.

**REPOSITORY OF FOSSILS:** F:AM Collection has 737 specimens.

**HISTORY:** Discovered by Skinner, Haakon Dehlin, and Gordon Fletcher July 26, 1934. Worked in 1934, 1936, and 1965.

**REMARKS:** A rich concentration of fossils associated with cross-bedded sand and gravel was found near the base of the Burge Member, which is 15 ft. thick, at this quarry. The Burge Member is overlain by typical Ash Hollow sediments with the “fragmental layer” consisting of a sandy marl in the basal 3 ft. of the 33-ft.-thick Cap Rock Member of the Ash Hollow Formation. The upper 3 ft. of the Cap Rock Member contains the borage herb, *Cryptantha coroniformis* (Elias) (1942, p. 138) and a fossil seed, *Biorbia*, occurs in the basal 10 ft. of the overlying Merritt Dam Member of the Ash Hollow Formation (Johnson, MS.g, 1974, p. 97; Skinner, vol. 1, pp. 86–87).

**PALEO QUARRY** (fig. 2A, no. 46): In the bottom of a small canyon on the south side of Niobrara River on east side of the NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 22, T. 29 N, R. 46 W, Sheridan County, Nebraska. Skunk Lake Quadrangle 1950. Elevation at base of quarry about 3755 ft.

**REPOSITORY OF FOSSILS:** F:AM Collection has 453 specimens.

**HISTORY:** Discovered by Ted Galusha in early July 1938 and worked until the overburden became excessive in the fall of 1938.

**REMARKS:** In a very fossiliferous unconsolidated 10-ft.-thick local channel sand. The base of the channel is 26–29 ft. below an ash bed in the overlying Ash Hollow Formation. Galusha (MS.a, August 13, 1938), in a “Composite section in the vicinity of the Paleo-channel Quarry” shows the channel cutting into or, in part, laterally equivalent to a sandstone from which was collected a skull (F:

AM 37225) referred to *Ustatochoerus medius* by Schultz and Falkenbach (1941, p. 29). *Ustatochoerus medius* is common in the Valentine Formation. Overlying this sandstone are lighter gray sandstones, an ash layer, and ash bearing sandstones typical of the Ash Hollow Formation (Johnson, MS.g, 1974, p. 86; Skinner, MS., vol. 1, p. 111). No comprehensive study has been published on the fauna from this quarry.

On the basis of the stratigraphic position of the channel cut in relation to the overlying Ash Hollow Formation and the Valentine Formation, it is tentatively placed in the Burge Member.

**QUARRY 379** (fig. 23, no. 47): Slightly farther up the side canyon and about 50 yards southwest of Wade Quarry on west side of Snake River, and 990 yards downstream from mouth of Steer Creek near middle of north line of the SW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 28, T. 32 N, R. 30 W, Cherry County, Nebraska. Kennedy Quadrangle 1950. Air photo CAM-1P-65 dated 8-22-55. Elevation at base of quarry about 2735 ft.

**SYNONYM:** Formerly Prospecting Locality No. 379.

**REPOSITORY OF FOSSILS:** F:AM Collection has 67 specimens.

**HISTORY:** Discovered by Skinner and party September 1939. Additional material collected in 1941 and 1942.

**REMARKS:** Fossils were in a local thickening of the channel sand (fig. 38, sect. 65, quarry 47) in the Burge Member. A gomphothere skull (F:AM 99071) and a *Cosoryx* skeleton were among the specimens collected (Skinner, MS., vol. 1, pp. 132–133).

**QUINN MASTODON QUARRY** (fig. 27, no. 48): On north side of a small west trending side canyon 0.1 mi. west from Quinn Canyon on the middle of the south line of the SE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 5, T. 31 N, R. 22 W, and 9.2 mi. north and 3 mi. W of the Ainsworth Courthouse, Brown County, Nebraska. Lat. 42°41'01"N, Long. 99°55'22"W, Ainsworth NW Quadrangle 1954. Elevation at base 2358 ft.

**SYNONYMS:** Quinn Quarry. Ainsworth Quarry (Osborn, 1936, fig. 270). Quinn Canyon was known as Williams Canyon by A. C. Whitford, collector for UNSM in 1913.



Barbour and Cook (1914a, p. 225) used Williams Canyon. After its discovery the name "Graveyard Gulch" was given the canyon where the quarry was found, but this was a local name. Skinner and Quinn used the name Quinn Canyon, however, as the source of their specimens. The canyon was erroneously shown as Byron Baker Canyon on the soil survey map of Brown County (Nieschmidt, Hayes, and Bacon, 1938). This was corrected when the U.S. Geological Survey accepted the name Quinn Canyon for publication on the Ainsworth NW Quadrangle Topographic map.

REPOSITORY OF FOSSILS: CMNH. F:AM Collection has at least 50 specimens.

HISTORY: Discovered in the fall of 1926 by J. H. Quinn and Skinner. They collected two partial gomphothere skeletons and other fossils in the summer of 1927. After a failure of negotiations for acquisition of the specimens by UNSM, H. J. Cook and later, J. D. Figgins of CMNH, visited the site and bought the collection, including fossils from Rhino Quarry No. 1, and other localities. Barnum Brown and Carl Sorensen from AMNH and Nelson Vaughan from CMNH packed the fossils for shipment. The more complete proboscidean skeleton (CMNH 1261) was shipped to Denver and is on exhibit in the CMNH, now the Denver Museum of Natural History. It was described by Cook (1928, pp. 37-45, 3 pls.) as the holotype of *Trilophodon phippsi*. Through a joint arrangement with Childs Frick and AMNH, the remainder of specimens from Quinn Quarry was shipped to New York, including the "cranium and jaws of a finely preserved individual" (F:AM 22411) that Osborn (1936, pp. 316-318, fig. 271) referred to *Trilophodon phippsi*.

REMARKS: This quarry occurs in 10 ft. of cross-bedded channel sand and gravel typical of the Burge Member (Skinner, ms., vol. 1, p. 44; vol. 10, pp. 12-13; ms.i, 1932; this paper fig. 37, sect. 51, quarry 48).

SWALLOW QUARRY UNSM Cr-16 (fig. 23, no. 49): On a west facing cliff on the east side of the Snake River about 100 yards southwest of UNSM *Tetrabelodon* Skull Quarry in the NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 22, T. 32 N, R. 30 W, or 1.1 mi. S, 51°W of the former Burge Post Office, Cherry County, Nebraska. Kennedy Quadrangle 1950. Air photo CAM-

12P-105 dated 10-7-55. Elevation at base about 2741 ft.

REPOSITORY OF FOSSILS: There are 91 specimens in UNSM and 50 in the F:AM Collection.

HISTORY: Discovered by G. Meade and D. Franzen June 16, 1934 (Meade, ms.a, pp. 10, 15-27) and worked by UNSM that summer. Skinner's party reopened the quarry in 1939.

REMARKS: Swallow Quarry is in the basal part of 11 ft. of typical Burge sediments consisting of cross-bedded channel sand and gravel (Johnson, ms.d, 1934, pp. 17-31, map and geologic section). The top of the Burge Member is separated by 2½ ft. of calcareous sandstone and 1 ft. of marl in the basal Ash Hollow from a 2-ft. layer of Swallow Ash (Skinner, ms., vol. 1, pp. 72-73 and vol. 5, p. 65; present paper, p. 296). A fission track date of  $10.6 \pm 0.2$  Ma for the Swallow Ash establishes that the underlying Burge Member of the Valentine Formation was deposited more than 10 m.y. ago. The fauna from Swallow Quarry includes (B. Taylor, personal commun.) a well-preserved skull and jaw of *Strobodon stirtoni* (UNSM 25789 and AMNH cast 97286). Two nearly complete skulls from Swallow Quarry were referred by Frick (1937, p. 342) to *Cosoryx furcatus* (UNSM 25-22-6-34 and 3-27-6-34).

TETRABELODON SKULL QUARRY UNSM 16A (fig. 23, no. 50): On a high narrow ledge on a south facing outcrop on the east side of the Snake River near center of west line of the SW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 22, T. 32 N, R. 30 W, Cherry County, Nebraska. Kennedy Quadrangle 1950. Air photo CAM-12P-105 dated 10-5-55. Elevation of quarry about 2747 ft. (also see Swallow Quarry).

SYNONYM: *Tetrabelodon* Skull Locality (Johnson, ms.c, 1933, p. 46).

REPOSITORY OF FOSSILS: UNSM has about 53 specimens.

HISTORY: Discovered by F. W. Johnson on June 14, 1933, and worked by UNSM that summer.

REMARKS: This quarry is in soft sand at the top of the Burge Member. With the exception of the upper 2 or 3 ft. the sand in the Burge is sufficiently consolidated to resist erosion and form a vertical ledge in the underlying 5 ft. The fauna from this quarry in the Burge is only 3 to 5 ft. below a 3 or 4 inch thick

volcanic ash layer that is correlated with the Swallow Ash in the basal Ash Hollow Formation. *Tetrabelodon* Skull Quarry is faunally and stratigraphically equivalent to Swallow Quarry and others in the Burge Member (Johnson, MS.c, 1933, pp. 14, 29–48, map, section, and quarry sketch).

Proboscidean skull and ramus, and 17 skeletal parts and examples of several other taxa were collected here.

**WHITE POINT QUARRY** (fig. 27, no. 51): In the bottom of a north trending draw on east fork of Deep Creek in the center of the NW  $\frac{1}{4}$ , sect. 12, T. 31 N, R. 23 W, Brown County, Nebraska. Ainsworth NW Quadrangle 1954. Elevation at base 2353 ft.

**REPOSITORY OF FOSSILS:** F:AM Collection has 74 specimens.

**HISTORY:** Discovered by Skinner in 1928 or earlier. Name was first applied August 18, 1949. Fossils collected intermittently from 1928 to 1969.

**REMARKS:** Fossils occur in typical Burge loose channel sand (Skinner, MS., vol. 3, p. 20).

**WHITEFACE QUARRY** (fig. 23, no. 52): On east side of Snake River just west of middle of east line of the SE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 27, T. 32 N, R. 30 W; Cherry County, Nebraska. Kennedy Quadrangle 1950. Air photo CAM-1P-65 dated 8-22-55. Elevation at base of quarry about 2730 ft.

**REPOSITORY OF FOSSILS:** F:AM Collection has 186 specimens.

**HISTORY:** Discovered on August 4, 1937 by Skinner and party. Intermittent collecting from 1937 through 1972.

**REMARKS:** Fossils are in typical Burge channel sand and gravel ranging from 10 to 20 ft. in thickness depending upon relief on the base of the channel cut into the top of the Devil's Gulch Member (Skinner, MS., vol. 1, pp. 128–129).

**OTHER QUARRIES OR PROSPECTING LOCALITIES:** F:AM and UNSM collections contain fossils from many places not listed here. In most localities Skinner gave quarry status to any fossil site that yielded more than 30 specimens. Frick parties under Skinner gave the geographic and stratigraphic position in local lithostratigraphic sequence for each fossil from a numbered Prospecting Locality. Skinner (Skinner and Hibbard, 1972, p. 30) ex-

plained his usage of Prospecting Locality numbers in detail.

Webb (1969, pp. 178–179) described in detail 11 UCMP localities or quarries that yielded Burge faunas; only one of these, UCMP V-3329, requires some clarification and is discussed here.

**YALE MASTODON QUARRY** (fig. 24, no. 53): Discovered and named by R. S. Lull in 1914. Lull (MS.a, July 9, 1914) indicates that the quarry was situated on the west side of Coon Creek drainage in "Section 23, T. 34 N, R. 27 W," Cherry County, Nebraska. Lull found a skull, ramus, and partial skeleton of a proboscidean at this site shortly after he went "over the divide" east of Short Creek, which would place him in the upper part of the stratigraphic section on the west side of Coon Creek. Since the Lull party made an excavation 35 by 13 feet in five days while collecting the proboscidean they were probably working in the soft sand and gravel of the Burge Member that Lull (MS.a, July 8, 1914) called the "Mastodon level."

Yale's Mastodon Quarry appears to have been worked later by UCMP and given Locality Number UCMP V-3329. Stirton (MS.a, 1933) shows the site on a map dated 5/5/33 as "Lull's . . . Locality Valentine Quarry V-3329." There is no evidence in Lull's records, however, that he ever used the term "Valentine" as a quarry name, or as the name of any collecting site. The name "Valentine Quarry" must have been applied by Stirton only.

Stirton's (MS., June 20, 1933) application of Valentine appears to have been influenced by Skinner's advising him of an old quarry "across the river North of the Game Preserve Headquarters. This quarry is directly under the mortar beds according to Skinner." At that time Skinner did not know who had worked the quarry. The evidence presented above indicates it was Lull's Mastodon Quarry.

Webb (1969, p. 178) identified UCMP V-3329 as "Lull Locality. (Quarry D of Yale Party.) . . . SE  $\frac{1}{4}$  of SW  $\frac{1}{4}$ , Sec. 14, T. 34 N, R. 27 W.; nearly on middle of south section line; near the top of an east facing slope just east of north-south stretch of dirt road. Bones in loosely consolidated medium to coarse sands . . ." Although Webb plots this local-

ity in section 14 this is not a serious discrepancy, since Lull was probably using general land maps and the locality is near the line between sections 14 and 23. No U.S. Geological Survey topographic sheets of that area were available in 1914 nor in the 1930s during UCMP collecting.

Furthermore, Lull's Locality D, as designated by Webb, is not the same site as Quarry D recorded in Lull's 1914 Journal. Yale's Quarry D was on the south side of the Niobrara River (this paper, p. 278). UCMP V-3218 is in the Crookston Bridge Member at the same site.

Again, Lull's field record is explicit. Quarry D, where the Yale party collected "whole bones, teeth and jaws" was discovered on July 16 and located as follows: "camp to quarry D 1 1/4 mile by pedometer probably in Sect. 24, R. 27 W. T. 34 N. Cherry Co., Nebraska" (Lull, ms.a, July 17, 1914). This is about the correct distance from the old Fort Niobrara buildings near which Lull was camped (fig. 24, no. 23).

It must be concluded that Lull did not use the term "Valentine" as Stirton's records suggest, and that Lull's Quarry D was not UCMP V-3329 in the Burge Member, but was most likely at or near the same site as UCMP V-3218 in the Crookston Bridge Member.

#### TYPE SPECIMENS FROM THE BURGE MEMBER

##### CLASS MAMMALIA ORDER CARNIVORA FAMILY CANIDAE

*Cynodesmus euthos* McGrew, 1935. (Type UCMP 29283.) Collected by P. O. McGrew and A. Potter from UCMP-V 3313 Gordon Creek Quarry. *Strobodon stirtoni* Webb, 1969. (Type UCMP 33474.) Collected by P. O. McGrew and A. Potter from UCMP-V3331. Webb (1969, p. 178) stated: "Fence Line Locality, NE 1/4, SW 1/4, SW 1/4, sect. 16, T. 34 N, R. 26 W, 1/2 mile north of the Niobrara River and a few yards east of the Game Refuge fence. In loosely consolidated yellowish conglomeratic sands at top of breaks below cap rock."

##### ORDER PROBOSCIDEA FAMILY GOMPHOTHERIIDAE

*Tetrabelodon lulli* Barbour, 1914c. (Type UNSM 10-8-14.) Figure 38, section 64. Collected by E.

F. Schramm and J. B. Burnett, 1914. Barbour (1914d, p. 214) stated that the type was from "section 33, range 30 west and township 32 north." Burnett (ms.a, 1914, p. 22) recorded the site at 148 ft. above the river on a geologic section "taken on east side of Snake River 1/4 mile south of Steer Creek."

In 1935 K. L. Rathbun and F. W. Johnson (ms.e, pp. 27, 73, 154-155, section and map) found additional material, including a tuskless symphysis (Osborn, 1936, pp. 707-709) at 144 ft. above the river and relocated the site from which the type of *T. lulli* was collected. Burnett's (ms.a, 1914) and Johnson's (1936, fig. 1, *Megabelodon* Quarry) measured sections here agree within the limits of error on the location of the specimens in the local lithostratigraphic section. Data from both sections place the type of *T. lulli* in the upper part of the Burge Member.

After discussing the find with George Bunnell, who was teamster for Schramm and Burnett, Johnson and T. M. Stout accompanied Bunnell to the Snake River. Bunnell directed them without hesitation to the locality where Schramm and Burnett had collected. Descending into the canyon he confirmed that the type of *T. lulli* was collected "within 50 or 75 feet, or possibly at the same spot, where specimens UNSM 1-25-6-35 NP and 2-25-6-35 NP were collected in 1935." Recently, it came to our attention that E. H. Barbour and E. F. Schramm visited the site on July 17, 1919. Barbour's (ms.c) field notes confirm its location.

The site is now described as being on the north side of an old trail on the east side of the Snake River in the E 1/2, NE 1/4, SE 1/4, SW 1/4, sec. 28, T. 32 N, R. 30 W, Cherry County, Nebraska. Air photo CAM-1P-65 dated 8-22-55, Kennedy Quad. 1950. Barbour's placing the site in adjacent section 33 is not a serious discrepancy because topographic maps and air photos of the area were nonexistent in 1919.

The anterior part of the symphysis was missing on the mandible of the type of *T. lulli*. Barbour (1914d, pls. 3-6) included small tusks in his restoration of the symphysis, but in 1934 (pp. 303-309) after discovery by P. O. McGrew (ms.c, 1931, p. 39 and quarry map) of a partial skeleton (UNSM 2-29-7-31), including essentially a perfect mandible

with a tuskless symphysis, Barbour concluded that the new evidence indicated that the type of *T. lulli* lacked tusks. He designated *T. lulli* (UNSM 10-8-14) the type species of the genus *Megabelodon*, referring the newly discovered partial skeleton to *M. lulli*. The fortuitous discovery in 1935 of a tuskless symphysis at or near the type locality of *M. lulli*, adds strength to Barbour's interpretation. Barbour (1934, p. 306) also stated "There is one fine example of this type of mastodon, a complete skeleton, *Trilophodon phippsi* in the Colorado Museum of Natural History."

The mounted skeleton of *Megabelodon lulli* in the UNSM consists of skeletal parts and mandible of UNSM 2-29-7-31. It was collected (Johnson, ms.a, 1931, p. 40) "about 150 feet west of the east fence of the Forest Reservation, on the N. side of the canyon of Steer Creek" on land of the Nebraska National Forest. This site is about 150 ft. west of the east line of the NE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , sect. 30, T. 32 N, R. 30 W, Cherry County, Nebraska. No geologic section was made at this site, but Johnson's recollection is that it was collected from the Burge Member. The type of *M. lulli* was from the upper part of the Burge Member.

*Trilophodon phippsi* Cook, 1928. (Type CMNH 1261.) Collected by M. F. Skinner and J. H. Quinn in 1927 from the Quinn Mastodon Quarry. A skull and jaw of *T. phippsi* (F:AM 22411) from the same locality is in the AMNH (Osborn, 1936, p. 316, fig. 271).

*Eubelodon morrilli* Barbour, 1914b. (Type UNSM 1-16-5-13.) Collected by E. H. Barbour, A. C. Whitford, and H. Eaton in 1913 (Barbour, 1914b, pp. 186-189, pls. 9-13) from UNSM Devil's Gulch Quarry No. 1 which is named *Eubelodon morrilli* Quarry in the present paper to avoid confusion with other quarries in Devil's Gulch (fig. 37, sect. 41, quarry 37).

The appearance in the Burge Member of three gomphotheres, *Eubelodon morrilli*, *Megabelodon lulli* and *Trilophodon phippsi*, lacking mandibular tusks, suggests a sudden influx of a unique population not previously living in northern Nebraska. *Eubelodon morrilli* and *M. lulli* were collected from the upper few feet and *T. phippsi* from the basal part of the Burge Member.

Detailed morphologic studies are needed

to determine if these taxa represent a single genus and species. Should they prove to be the same taxon, its frequent occurrence in a restricted part of the stratigraphic section indicates that the tuskless mandibles are not the result of sexual dimorphism.

#### ORDER PERISSODACTYLA

##### FAMILY EQUIDAE

*Hypohippus matthewi* Barbour, 1914a. (Type UNSM 10-16-5-13.) Collected by A. C. Whitford in 1913 from the *Eubelodon morrilli* Quarry at a level 6 ft. below the type of *E. morrilli*.

#### FAMILY RHINOCEROTIDAE

*Peraceras troxelli* Matthew, 1918. (Type AMNH 14434.) Collected by E. L. Troxell in 1916 in a pasture a short distance west of road near the east line of SE part of NE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 31, T. 34 N, R. 20 W, Keya Paha County, Nebraska, Springview NW Quadrangle 1964. Elevation 2310-2312 ft. This locality appears to occur at the top of channel sand of the Valentine Formation underlying the Cap Rock Member of the Ash Hollow Formation and probably is from the Burge Member of the Valentine. Additional fauna collected in 1972 and 1974 by M. F. Skinner and F. W. Johnson. This locality was made known to Skinner in 1929 or 1930 by residents living in the area when Troxell collected here. Bone fragments and a depression marking the collecting site were observed in 1972 (fig. 36, sect. 55).

#### ORDER ARTIODACTYLA

##### FAMILY DROMOMERYCIDAE

*Cranioceras mefferdi* Frick, 1937. (Type F:AM 32243.) Collected by M. F. Skinner and R. L. Mefferd from  $\frac{1}{2}$  mi. north of Nenzel Quarry in a small side canyon on E. Branch of Spring Canyon in SW corner, sect. 19, T. 33 N, R. 32 W, Cherry County, Nebraska, Cody Quadrangle 1950, scale 1:62,500, in unconsolidated sand "presumably equal to the Midway Quarry" (Frick, 1937, p. 89), present paper, figure 32, section 24. Interpretation indicates that this site is in the Burge Member.

#### FAMILY ANTILOCAPRIDAE

*Paracosoryx burgensis* Frick, 1937. (Type F:AM 32900.) Collected by M. F. Skinner from the Burge Quarry.

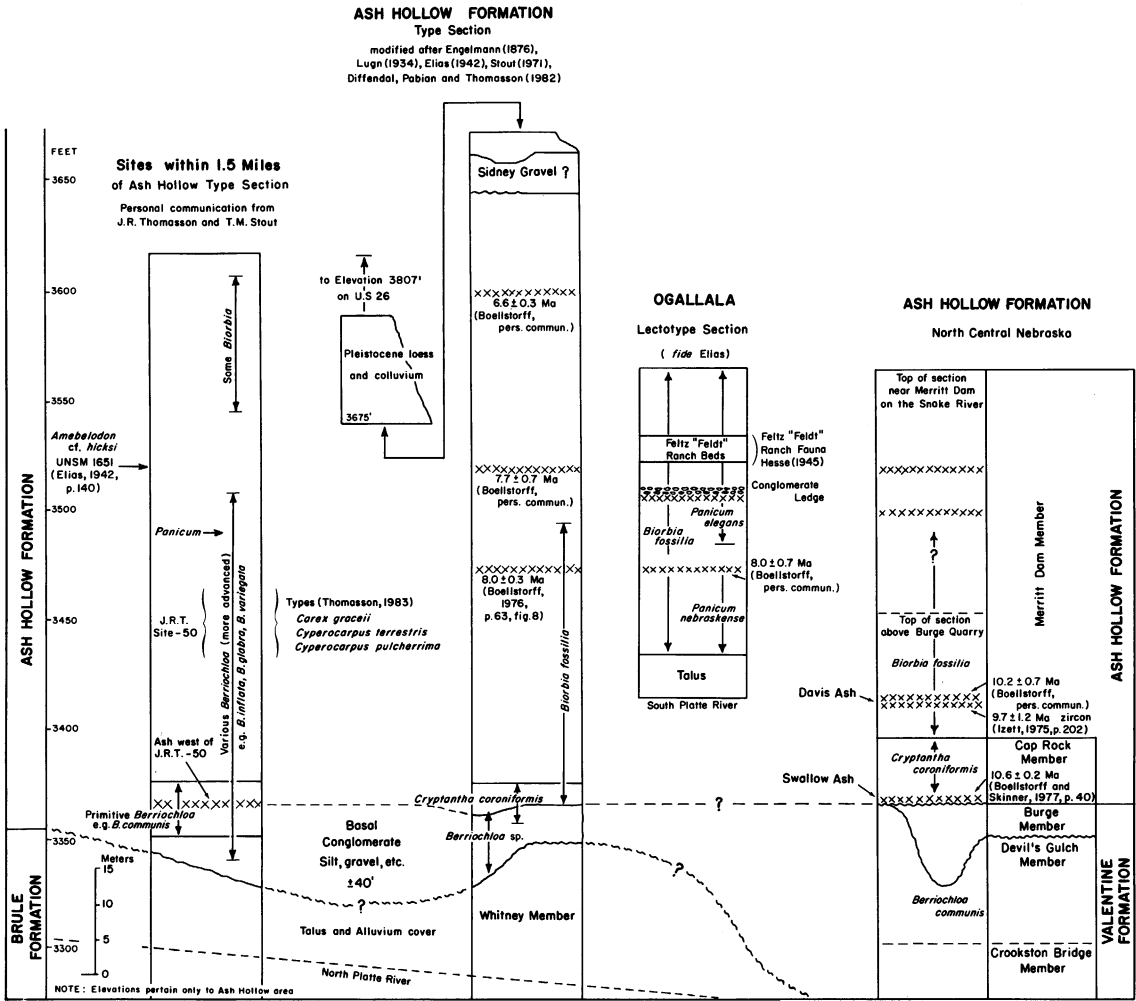


FIG. 13. Fission track dates and other relationships between type sections of Ogallala and Ash Hollow in South and North Platte valleys, and Ash Hollow section on Snake River in north-central Nebraska. In the Ash Hollow area, the ash at 3600 ft. is in W ½, SE ¼, SW ¼, SW ¼ sect. 22, T. 15 N, R. 42 W. Ash at 3520 ft. is in W ½, SW ¼, SW ¼ sect. 22, T. 15 N, R. 42 W. Ash at 3475 ft. is on W side of Hwy. US 26 near N line SE ¼, NW ¼, NW ¼ sect. 23, T. 15 N, R. 42 W. *Amebelodon* cf. *hicksi* mandible collected by Oren V. Clary from sand and gravel at ca. 3520 ft. elevation, east side of short drainage in SW ¼, NE ¼, NW ¼, sect. 11, T. 15 N, R. 42 W, Garden Co., Nebraska.

ASH HOLLOW FORMATION  
Figures 13, 15

**HISTORICAL REVIEW:** The upper unit of the Ogallala Group in north-central Nebraska is referred to the Ash Hollow Formation. Engelmann (1876, pp. 260–262, 283) applied the name “Ash Hollow series” and “Ash Hol-

low formation” to rocks that crop out in Ash Hollow canyon southeast of Lewellen, Garden County, Nebraska. Lugn (1938, pp. 223–224; 1939, pp. 1260–1261) formalized Engelmann’s site as the type locality of the Ash Hollow Formation in the Ogallala Group. Among others who have reviewed the history

and definition of the Ash Hollow, or who have accepted it as a stratigraphic unit in the Ogallala Group, are Wood et al. (1941, pp. 14, 27), Elias (1942, pp. 139–145), Skinner, Skinner, and Gooris (1968, pp. 408–409), Webb (1964, pp. 10–12, 19), Stout (1971, pp. 5, 36–40), USGS (Swanson et al., 1981, p. 33), and Breyer (1975, p. 12).

**DISTRIBUTION:** The Ash Hollow Formation is widely distributed and consists of coalescing sheets of continental sediments in the Great Plains from South Dakota to Texas (fig. 1). Lugn (1938, p. 223) recognized its occurrence in the Niobrara River valley in north-central Nebraska. Sediments referred to the Ash Hollow Formation have been found across northern Nebraska from western Sheridan County (see pp. 336–348, figs. 30–40) and for more than 200 mi. eastward into Antelope County in northeastern Nebraska (Voorhies, 1974, p. 493; Voorhies and Thomasson, 1979, pp. 331–333).

In southern South Dakota the Ash Hollow Formation has been mapped by the South Dakota Geological Survey in several quadrangles from Porcupine Butte (Harksen, 1967) and White Clay (present paper, fig. 30) eastward for about 180 mi. to Gregory County (Stevenson, 1958) and at the top of the Turtle Butte section by Skinner, Skinner, and Gooris (1968, fig. 2) and present paper (fig. 36). Skinner and Taylor (1967, p. 13, fig. 1) recognized the occurrence of Valentine and Ash Hollow sediments on the Bijou Hills on the east side of the Missouri River in Brule and Charles Mix counties, South Dakota.

West of the type section Ash Hollow sediments have been described by Stout (1971, pp. 30–32) at Greenwood Canyon, Morrill County, Nebraska. Breyer (1975, p. 8) placed “all of the Ogallala Rocks exposed in western Nebraska” in the Ash Hollow Formation. We infer that sediments mapped as “Pliocene” by J. H. Buffington (in Stout et al., 1971, pl. 1) in adjacent areas in southeastern Wyoming and northeastern Colorado are also Ash Hollow. McGrew (1953, pp. 62–64) and Cassiliano (1980, p. 63, fig. 35, and chart) reported the presence of the Ash Hollow Formation east of the Laramie Range in Wyoming and included it on a correlation chart of north-eastern Colorado. Frye, Leonard, and Swineford (1956, pp. 59–60) and Frye and Leonard

(1959, fig. 1) recognized the widespread occurrence of the Ash Hollow southward from its type locality in Nebraska across Kansas and Oklahoma into the Texas High Plains.

**THICKNESS:** Pleistocene and Recent erosion precludes the determination of the original thickness of the Ash Hollow in many areas. Sevon (1960) recorded up to 180 ft. of Ash Hollow near the Bennett-Todd County line in south-central South Dakota. A maximum of 215 ft. (figs. 13, 15, 38) crops out along the Snake River in north-central Nebraska, but it is much thinner in many areas along the Niobrara River (figs. 30–38). In the type section Engelmann (1876, pp. 260–262) measured “over 250 feet” of Ash Hollow Formation overlying “30 feet . . . of buff-colored, finely arenaceous material, with no visible cement” of the Whitney Member of the Brule Formation. Skinner (ms., vol. 3, pp. 64–67) measured 277 ft. excluding the Sidney Formation and Diffendal, Pabian, and Thomasson (1982; this paper, fig. 13) measured 294 ft. in composite sections. Stout (1971, pp. 36–39, B-B'-B", fig. 10) published a somewhat thinner section. Westward from the type section 240 ft. of Ash Hollow rocks, plus 80 ft. of Sidney and Kimball formations crop out in Greenwood Canyon, Morrill County (Stout, 1971, pp. 30–33, fig. 10). Breyer (1975, pl. 1) assigned to the Ash Hollow Formation 500 ft. of subsurface section in a paleovalley in Kimball County. Southward from the type locality Frye and Leonard (1959, fig. 1) found up to 130 ft. of Ash Hollow in sections across Kansas and Oklahoma into the High Plains of Texas.

**LITHOLOGY:** The calcareous sandstones described by Engelmann (1876, pp. 260–261),<sup>12</sup>

<sup>12</sup> In 1859 Henry Engelmann, geologist and mining engineer, was attached to an exploration expedition of the Great Basin of Utah commanded by Captain J. H. Simpson, Corps of Topographical Engineers, U.S. Army. The expedition's route followed the Oregon Trail down Ash Hollow Canyon into the North Platte valley (see Ruthon, Nebraska and Big Springs NE, Nebraska, 1971, 1:24,000 scale topographic maps). It was here that Engelmann (1876, pp. 260–261) described the type section of the Ash Hollow Formation. He observed that rocks “cropping out at intervals at one or other side of the river . . . were found most developed in Ash Hollow where they attain a thickness of over 250 feet. This series is composed of an alternation of loose, finely sandy, and

Lugn (1938, pp. 223–224, 1939, p. 1261), Elias (1942, pp. 139–141), Stout (1971, pp. 39–40, section B-B'-B" on fig. 10), Diffendal, Pabian, and Thomasson (1982, pp. 9–12, 30–32, illus. 8) are the prominent ledge and cliff forming rocks sometimes referred to as "Mortar beds" and "Tertiary grit" by Darton (1899, p. 734) that crop out across several states in the High Plains. The interbedded, less consolidated sediments weather readily and are often covered by talus and vegetation. Several beds of volcanic ash occur in the type section and many other areas.

In north-central Nebraska the basal Ash Hollow (Cap Rock Member) consists of gray ledges and cliffs of calcareous sandstones similar to the rocks in the Ash Hollow area. The overlying remainder of the Ash Hollow Formation, the Merritt Dam Member (New), in the Niobrara River valley, has less prominent ledges and is mostly composed of mas-

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of harder rocky strata, the latter consisting of fine to coarse drift-sand, generally cemented by carbonate of lime, forming more or less calcareous, and gritty, very impure limestones. Partly they are coarse sandy, partly finely earthy or even on the fracture, and a few are sub-crystalline. Their age is, probably, the Pliocene-Tertiary . . . . Moreover, they appear to answer the description by Dr. Hayden . . . of the Pliocene strata, F 3 . . ." [this paper, fig. 4, in north-central Nebraska]. "In Ash Hollow these strata vary much in appearance; some are white, nearly subcrystalline, and somewhat chalky, irregularly intermixed with loose, sandy portions; in the purer pieces the sand is fine, and can only be recognized by dissolving the rock in acid. Others are buff-colored, of a fine grit, coarse grit, compact, or loosely cemented; a few are even conglomeratic."

At the mouth of Ash Hollow Canyon, underlying the lowermost layer of cliff-forming sandstone, approximately 15 to 40 ft. of conglomerate disconformably overlies the Whitney Member of the Brule Formation. This conglomerate represents the initial stage of aggradation following a widespread period of degradation in the general area of the North Platte Valley. Lugn (1939, p. 1261) and Stout (1971, pp. 39–40) considered this conglomerate, in which Elias (1942, p. 140) found fragments of seeds comparable with *Berriochloa communis*, to be a possible equivalent of the Valentine Formation in north-central Nebraska. More evidence is needed to confirm or refute that interpretation. This conglomerate consists primarily of sedimentary clasts and contains few igneous rock components. The lithic character of the clasts suggests that they were derived from local sources of Brule and post-Brule sediments.

sive, friable sandstone and silty sandstone. Friable channel sands are intercalated and these are finer grained than in the Platte valley where coarse sand, gravel, and conglomerate is common. Paleochannels incised into earlier Ash Hollow and older sediments in north-central Nebraska often contain vertebrate fossils.

AGE, FAUNAS, AND CORRELATION: Radiometric dating of volcanic ash samples from the type section of the Ash Hollow Formation in southwest Nebraska and the Snake and Niobrara rivers in north-central Nebraska provide data for correlation between those areas. Boellstorff (1976a, p. 63a, fig. 8), using the fission track method, dated an "Ash about 120 feet above base of Ash Hollow Fm at its type locality" at  $8.0 \pm 0.3$  Ma and a second ash "very near top of Ash Hollow Fm. at its type locality" at  $6.6 \pm 0.3$  Ma (Boellstorff, 1981, personal commun.). Assuming that Boellstorff's placement of the ash is approximately correct, the sediments in the basal part of the type section may be substantially older than 8 m.y.

Boellstorff and Skinner (1977, pp. 39–40) stated that "Ash from the lower part of the type Ogallala Formation of Elias (1936) is dated at  $7.6 \pm 0.7$  m.y.B.P. This date is bracketed by ashes in the type Ash Hollow Formation that range from  $8.0 \pm 0.3$  to  $6.8 \pm 0.3$  m.y. B.P." Boellstorff (1981, personal commun.) revised the  $7.6 \pm 0.7$  to  $8.0 \pm 0.7$  Ma and the  $6.8 \pm 0.3$  to  $6.6 \pm 0.3$  Ma (present paper, fig. 13). An undated ash occurs 29 ft. above the dated Ogallala and 2 ft. below a prominent hard ledge of conglomerate in the bottom of the canyon and 13 ft. below the base of a soft channel sand from which the Feldt (*viz.* Feltz) Ranch Local Fauna was collected. If this ash can be dated it should furnish additional evidence for correlation between the two sections.

On the Snake River, in north-central Nebraska, the Swallow Ash (fig. 38, sect. 66) which has a fission track date of  $10.6 \pm 0.2$  Ma (Boellstorff and Skinner, 1977, p. 40) occurs 3 ft. above the base of the section referred to the Ash Hollow Formation. The source of this ash is unknown, but it may be contemporaneous with volcanic activity in the Black Hills reported by Kirchner (1977, p. 977).

The Davis Ash (New), also on the Snake River lies 50 ft. above the base of sediments referred to the Ash Hollow Formation (figs. 3, 15, 38; Skinner, Skinner, and Gooris, 1968, pl. 25), overlying the Burge Quarry. The Davis Ash is named for the pioneer rancher, H. A. Davis, who lived at the Burge Post Office in the 1930s and owned the land on which the ash occurs. The Davis Ash consists of 8 ft. of silvery bluish gray vitric tuff that grades from exceptionally pure and coarse at its base to fine and sandy at the top.

Skinner submitted a split of an identical sample of the Davis Ash to G. Izett and J. Boellstorff for fission track dating. Izett (1975, p. 202) determined an age of  $9.7 \pm 1.2$  Ma on zircon and  $7.5 \pm 2.2$  Ma on glass shards. Boellstorff (1981, personal commun.) obtained a date of  $10.2 \pm 0.7$  Ma on glass shards from the same ash.

Undated ash beds occur northeast of the Merritt Dam in a cut for an irrigation ditch at 76 and 99 ft. above the Snake River or 112 and 135 ft. above the projected base of the Ash Hollow Formation (figs. 13, 15, 38). Dating of these ashes is needed to determine their age in relation to the ash falls in the type sections at Ash Hollow Canyon and the Feltz Ranch.

Thomasson (1979, pp. 13–17) showed that the overlap in the range of floras represented by “seeds” in his “*Prolithospermum johnstonii*-*Nassella pohlii* Assemblage Zone illustrates that past interpretations of the seeds in the Ash Hollow or Kimball floral zones are no longer tenable” and stated that the “Ash Hollow and Kimball floral zones as previously described must be abandoned.” Thomasson, however, stated “I am convinced, as others before me, that fossil anthoecia, nutlets, endocarps, and achenes from the Tertiary sediments of the High Plains are one of the most important biostratigraphic tools available.”

Additional studies are needed on seeds from carefully documented geographic locations and lithostratigraphic horizons in the type sections of the Ash Hollow Formation in southwest Nebraska and the Valentine Formation of north-central Nebraska. For the purpose of this paper the range of taxa recorded by Elias (1942, pp. 134–147) in southwestern and north-central Nebraska and the

relative position of taxa identified by Thomasson (1983, personal commun.) in the vicinity of Ash Hollow are shown on figure 13.

The lower 10 ft. of the “mortar beds” (fig. 13) in Ash Hollow Canyon contain the “*Krynitzkia coroniformis* seed zone” (Lugn, 1939, pp. 1260–1261; Elias, 1942, p. 140) which is also found in the Cap Rock Member in north-central Nebraska (*Cryptantha* has priority over *Krynitzkia* according to Segal, 1964, p. 203; 1966, p. 207). This was referred to by Elias (1942, p. 142) as the “20 feet thick rim-rock above the Valentine sands at Valentine.” Both Lugn and Elias used the presence of *Cryptantha* in the Cap Rock as evidence to support their view that the Cap Rock represents the basal part of the Ash Hollow Formation in northern Nebraska.

Elias (1942, p. 140) reported that another seed, *Biorbia fossilia*, occurs in 110 ft. of section above *Krynitzkia* (now *Cryptantha*) in Ash Hollow Canyon. Recently (Thomasson, personal commun.) found additional *Biorbia* between 3560 and 3625 ft. *Biorbia fossilia* was also found in a 130-ft. section at Hesse’s (1935) Ogallala locality and is in the section above the Cap Rock Member in north-central Nebraska (Elias, 1942, pp. 140–142). Following the premise that grasses are closely related to environmental conditions (Thomasson, 1979, pp. 16–17), the relative position of *Biorbia* and *Cryptantha* in the Ash Hollow in both areas suggests that similar environments existed over large areas during deposition of the Ash Hollow.

On the basis of radiometric dating, floral zones, and general lithologic similarity, it is reasonable to assume that the type section of the Ogallala as used by Hesse (1935a), Stirtton, Lugn, and Elias is equivalent to a part of Engelmann’s Ash Hollow section (present paper, fig. 13). The term Ogallala, however, with its long history of usage throughout the High Plains, should be retained in its expanded usage as a group name as defined by Lugn (1938, 1939).

Although Hesse’s (1935a, pp. 83–99) Feldt [viz. Feltz] Ranch Fauna of Hemphillian age (Wood et al., 1941) contains some components, *fide* Hesse’s identification, found in the Ash Hollow rocks of north-central Nebraska, it is older than the late Hemphillian at the Bear Tooth Slide (field term in Skinner, Hib-



bard et al., 1972, fig. 4) and younger than faunas found in other areas covered by the present paper.

The several hundred feet of sediments containing ledge and cliff-forming sandstone, datable volcanic ashes (some have been dated) and fossil "seed" zones provide evidence supporting the regional correlations set up by Lugn (1939), Elias (1942), Frye and Leonard (1959), and Skinner, Skinner, and Gooris (1968). The presence of undated ashes in many areas, the potential of geochemical studies of the ashes, the promise of significant new data from scanning electron microscope work on fossil seeds, the further search for fossils in Ash Hollow Canyon, the presence of little studied vertebrate faunas and abundant seeds (Thomasson, 1980a, 1980b, 1980c) from nearby temporally equivalent deposits in the North Platte Valley combined with studies of the large collections of vertebrate fossils from the Ash Hollow Formation in north-central Nebraska provide a rich field for future investigation. The results of such studies and pattern correlation of carefully measured elevation-controlled lithostratigraphic sections in the valleys of the Platte River should provide clarification of details of correlation between southwestern and north-central Nebraska.

#### CAP ROCK MEMBER

Figures 15, 32–38

Johnson (1936, pp. 472–473) applied an informal name, "cap rock bed," to 25–50 ft. of cliff-forming calcareous sandstone that forms the rims of most of the canyons along the Niobrara River and its tributaries in north-central Nebraska. Johnson (1938, p. 216) also showed these sandstones as the "Cap Rock Bed Member" overlying the "Burge Sands Member" of the Ogallala Formation, but the informal usages continued for the next 30 years. Lugn (1938, p. 223) recognized the "cap rock bed" as the "lowest part of the mortar beds division of the Ogallala group" and as the lowest unit in the Ash Hollow Formation in northern Nebraska. Skinner, Skinner, and Gooris (1968, pp. 409–410) formalized the name, Cap Rock Member of the Ash Hollow Formation, and confirmed that its 28 ft. of type section lie immediately above

the type section of the Burge Member of the Valentine Formation at the Burge Quarry locality on the Snake River in Cherry County, Nebraska.

The contact between the Ash Hollow and Valentine formations in north-central Nebraska is often marked by the "fragmental layer" (Johnson, 1936, p. 473). The fragmental layer consists of poorly sorted, friable to hard caliche or calcareous sandstone and sandstone clasts, and contains local occurrences of scattered fragments of fossil bone, and a high percentage of marly or calcareous and diatomaceous material that often occurs as a thin layer of pond sediments overlying the Burge Member.

The heterogeneous character of the "fragmental layer" suggests that it is a residual deposit resulting from weathering on a low relief plain paleosol surface containing numerous small lakes and ponds. An example of the widespread occurrence of the "fragmental layer" at the base of the Cap Rock Member is Colbert's (ms.a, 1929, p. 21) observation of its presence on Plum Creek (sect. 31, T. 32 N, R. 22 W), Brown County, Nebraska. Colbert's locality is about 46 mi. east of the type section of the Cap Rock Member.

This 1–2 ft. "fragmental layer" lies at the very base of the Cap Rock Member and rests either on the Devil's Gulch or Burge members of the Valentine Formation. Outcrops show a strong contrast between the light gray to whitish "fragmental layer" and the underlying fine to medium yellow-gray argillaceous sandstone of the Devil's Gulch Member (where the Burge Member is absent), or the gray to greenish gray, fine to medium and coarse, loose, cross-bedded sand and gravel of the Burge Member of the Valentine Formation. The unconsolidated nature of the Burge Member often results in undercuts beneath cliffs of the overlying Cap Rock Member.

Limb bones, teeth, and occasional jaw and skull fragments of rhinos such as *Teleoceras* are among the fossils found in the "fragmental layer" indicating that the ponds were a favorable habitat, as they are for rhinos today in Africa and southeast Asia. Concentration of animals around ponds during droughts would result in the trampling and crushing of skeletons of dead animals. This, combined

with weathering on a low relief surface, may account for the fragmental nature of the fossils.

In addition to the Swallow Ash (p. 290) occasional layers of volcanic ash occur in the Cap Rock Member. One of these, probably higher in the Cap Rock section, occurs above the fossil-bearing section at the Minnechadzu faunal locality (fig. 33).

The base of the Cap Rock Member (fig. 14) provides a datum for the determination of the regional dip, probably structural, which averages between 8 and 9 ft. (i.e., 0°5–6') per mi. from south of Sparks, Nebraska, westward for about 90 mi. to the mouth of Bear Creek. The dip increases to 20–25 ft. per mi. (i.e., 0°13–16') from the mouth of Leander Creek to the western Cherry County line. Even a much lower regional gradient must have existed during the deposition of the Cap Rock Member on a flat plain.

Identifiable fossils are scarce in the Cap Rock Member in the vicinity of its type locality. The best example of a published list of fauna from the Cap Rock Member is the Minnechadzu Fauna, from the Little Beaver B locality (this paper, sect. 31, on fig. 33), referred to as the Valentine Fauna (Chardin and Stirton, 1934, pp. 278–284; Stirton and McGrew, 1935, p. 131; McGrew and Meade, 1938, pp. 202–204). In order to avoid confusion Stirton later (1939, p. 433) used the name "Minnechadzu," which has become widely accepted as a faunal name. Webb (1969, pp. 16–25) reviewed the Minnechadzu Fauna. Fossils from several sites (fig. 3) and from numerous scattered localities in the Cap Rock Member are in the Frick Collection.

#### QUARRIES IN THE CAP ROCK MEMBER

FAIRFIELD CREEK NO. 3 (fig. 25, no. 54): On the east side of the south fork of Fairfield Creek in the south part of the SE ¼, SW ¼, sect. 7, T. 32 N, R. 24 W, Brown County, Nebraska. Norden Quadrangle 1950. Collecting site is 15 ft. below the contact of Tertiary rocks with the Sand Hills. Elevation about 2505 ft.

SYNONYMS: F-III.

REPOSITORY OF FOSSILS: F:AM Collection.

HISTORY: Discovered by M. F. Skinner and J. H. Quinn in 1928.

REMARKS: Collection consists of a jaw and partial skeleton (F:AM 25100) of *Aelurodon* cf. *taxoides* (R. H. Tedford, personal commun.) from a sandstone. Its elevation in relation to the position of the stratigraphic units in this area indicates that it was probably from the upper part of the Cap Rock Member (Skinner, MS.a, 1928; MS., vol. 3, p. 50).

HORSE THIEF CANYON NO. 1 (fig. 27, no. 55): On the north side of Plum Creek in the central part of SE ¼, sect. 35, T. 32 N, R. 23 W, Brown County, Nebraska. Ainsworth NW Quadrangle. Elevation about 2385 ft.

REPOSITORY OF FOSSILS: Small F:AM collection.

HISTORY: Discovered by Skinner and J. H. Quinn in 1928.

REMARKS: In the lower part of Cap Rock Member about 10 ft. above the base of the Ash Hollow Formation (Skinner, MS., vol. 1, p. 37).

Near this locality a skull of *Dinohippus* cf. *leidyani* (F:AM 60632) was collected from sand in a channel of the Merritt Dam Member that cuts into the Cap Rock Member at the northwest corner of the canyon in which the Horse Thief Canyon No. 1 Quarry is located (Skinner, *ibid.*).

HORSE THIEF CANYON NO. 2 (fig. 27, no. 56): In a side canyon on north side of Plum Creek in SE corner of SE ¼, sect. 35, T. 32 N, R. 23 W, Brown County, Nebraska. Ainsworth NW Quadrangle. Elevation about 2382 ft.

SYNONYM: Some confusion with Horse Thief Canyon No. 1 in early collections. Both localities, however, are stratigraphically equivalent (Skinner, MS., vol. 1, pp. 34–35).

REPOSITORY OF FOSSILS: F:AM Collection.

HISTORY: Discovered by M. F. Skinner and J. H. Quinn in 1929.

REMARKS: About 8 ft. above the base of the Cap Rock Member. Frick (1933, pp. 598–599, figs. 15, 12B, 23B) referred a gomphothere skull and mandible (F:AM 25707) and a second skull with tusks (F:AM 25708) to *Eubelodon morrilli*. Osborn (1936, pp. 605–609, figs. 574–576) followed Frick's designation.

JOHNSON RHINO SITE (fig. 24, no. 57): On both sides of an east-west road about 125 ft.

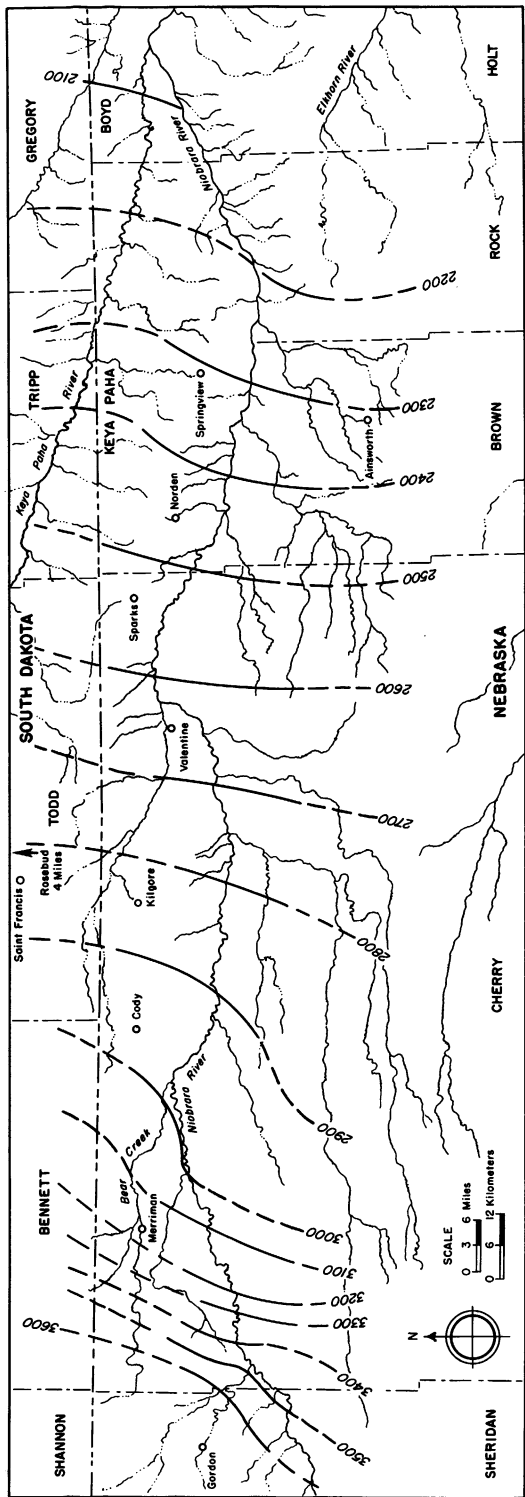


Fig. 14. Contour map on base of Ash Hollow Formation in north-central Nebraska. Contour interval 100 ft.

east of a turn to the northwest near SW corner of SW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 9, T. 33 N, R. 27 W, or  $\frac{5}{8}$  mi. N, 78°E of Railway Quarry "A," Cherry County, Nebraska. Valentine Quadrangle 1950. Air photo CAM-13P-200 dated 10-12-55. Elevation 2641 ft.

SYNONYMS: None.

REPOSITORY OF FOSSILS: F:AM Collection contains six specimens.

HISTORY: Discovered by F. W. Johnson on October 6, 1973.

REMARKS: In a thin clay zone at the base of the Cap Rock Member (Johnson, MS.g, 1973, pp. 34–35; Skinner, MS., vol. 9, p. 37). Although only a few specimens of rhinoceroses have been collected here, a significant aspect of the locality is its position, which is only  $\frac{3}{8}$  of a mi. N, 55°E from the top of the type section of the Valentine Formation. The presence of rhinoceroses at the base of the Cap Rock is a characteristic observed at many localities in north-central Nebraska. Little work has been done at this site and the probability is high that more fossils can be found.

LITTLE BEAVER B (fig. 24, no. 58): In the "NW  $\frac{1}{4}$  of SW  $\frac{1}{4}$  of SW  $\frac{1}{4}$ , sect. 8, T. 34 N., R. 26 W.; on north side of head of westward draining tributary of Little Beaver Creek, very near an east flowing tributary of Crooked Creek (V-3334), and just south of dirt road along plains edge" (Webb, 1969, p. 179, fig. 46a). In Cherry County, Nebraska. Sparks Quadrangle 1950, Air photo CAM-15P-118, dated 10-17-55.

SYNONYMS: UCMP Locality V-3326 and Minnechaduzza Quarry of Skinner.

REPOSITORY OF FOSSILS: UCMP.

HISTORY: Discovered in 1933 by R. A. Stirton's UCMP field party. Worked intermittently through 1941.

REMARKS: The fossil collection was designated the "Valentine Fauna" by Chardin and Stirton (1934, pp. 278–284), and briefly described by Stirton and McGrew (1935, pp. 130–131), who also referred fossils from four other localities to this fauna. A generalized section at Locality V-3326 showed its position in the local lithologic sequence. Stirton (1939, p. 433) changed the name to Minnechaduzza Fauna and Locality V-3326 was designated as its type locality.

Webb (1969, fig. 4) studied the type fauna in detail and referred fossils from 11 other

localities to the Minnechaduzza Fauna. Webb (1969, pp. 18, 179–180) also published a "Type section of the Minnechaduzza Fauna" and showed the position of the "Quarry floor 15 feet below top of the blue-gray volcanic ash; bones in fine to medium light gray calcareous flood plain sands." The quarry is shown in the Cap Rock Member on a cross section in the present paper (sect. 31, fig. 33; Skinner, MS., vol. 4, pp. 92–93).

Two localities, UCMP V-6257 and V-4141 (*Leptarctus* B), listed by Webb as containing Minnechaduzza Fauna, may be in sediments younger than the Cap Rock Member. Using Webb's description of Locality V-6257 as being "22 feet below top of blue-gray volcanic ash bed" (Davis Ash in present paper) our interpretation places it close to the base of the Merritt Member in or near the type section. Webb's description of V-4141 (*Leptarctus* B) suggests that it is in a sand equivalent to that of the F:AM *Leptarctus* Quarry in the Merritt Dam Member.

ROCK LEDGE MASTODON QUARRY (fig. 27, no. 59): On north side of Plum Creek opposite mouth of one of the Hurlbut canyons on a point near the center of NW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 22, T. 32 N, R. 22 W, Brown County, Nebraska. Ainsworth NW Quadrangle 1954. Elevation of quarry about 2350 ft.

REPOSITORY OF FOSSILS: F:AM Collection contains gomphothere skull, mandible, and associated limbs (F:AM 25711).

HISTORY: Discovered by Skinner and Melferd in June of 1931 (Skinner, MS.j, 1931, July 5).

REMARKS: Collected from a clay lens beneath a large ledge of hard sandstone on a point overlooking Plum Creek. Frick (1933, p. 596) referred the gomphothere to *Trilophodon osborni*.

The fossils were immediately above a 2-ft.-thick layer of volcanic ash. This site has not been carefully studied, but, on the basis of its position in relation to known sections in the area, it is placed in the basal part of the Ash Hollow Formation, probably in the Cap Rock Member.

TRILOPHODON GIGANTEUS SITE (fig. 2B, no. 60): On a southwest facing outcrop in the middle of the W  $\frac{1}{2}$  of NW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , sect. 20, T. 95 N, R. 74 W, Tripp County, South Dakota. Paxton, S.D., Quadrangle 1964.

SYNONYMS: Brumbaugh Quarry (Skinner, MS., vol. 3, p. 84), Troxell mastodon.

REPOSITORY OF FOSSILS: AMNH has the mounted skeleton on exhibit.

HISTORY: The holotype of *Trilophodon giganteus* Osborn (AMNH 17359) was obtained by E. L. Troxell in 1916 "in the vicinity of Eastview, South Dakota, about 2 miles from the Nebraska line" (Osborn, 1936, pp. 304-306). In 1949, Skinner located the owner of the land, Mr. Harold Brumbaugh, from which the skeleton was collected. Mr. Brumbaugh showed Skinner the locality described above, which is 2.2 mi. north of the Nebraska line and 2.6 mi. S, 0.45 mi. W of the Sunnyview school. Osborn appears to have erred in placing the locality in Gregory County, which is only 4¼ mi. east of this site.

REMARKS: Osborn (p. 305), referring to a letter from Troxell, stated "the upper zone on the north side of the river (near Dallas) corresponds to a quarry near Springview, and to the beds nearby in which was found the type of *Peraceras troxelli*. This whole formation may be as recent as the Oak Creek beds in which was found the type of *Pliohippus lullianus*."

On the basis of lithostratigraphic relationships and correlation with sections in the Niobrara valley south of Springview it is our interpretation that *T. giganteus* was collected from beds equivalent to the lower part of the Cap Rock Member (fig. 36, no. 60). The type of *Peraceras troxelli* Matthew (AMNH 14434), however, is from sand interpreted as being equivalent to the Burge Member, immediately underlying the Cap Rock Member (fig. 36).

TIMM RANCH SITE (fig. 18, no. 61): On a south and southwest facing outcrop on the east side of Pole Creek near the center of the NW ¼, NE ¼, NW ¼, sect. 3, T. 31 N, R. 40 W, Cherry County, Nebraska. Rushville 4 NE Quadrangle, 1969. Elevation at base of quarry about 3450 ft.

SYNONYMS: Originally called Prospect Locality 288.

REPOSITORY OF FOSSILS: F:AM Collection contains 24 specimens.

HISTORY: Discovered by Skinner and G. Fletcher in 1938.

REMARKS: Quarry in 5 to 10 ft. of channel

sand overlain by about 5 ft. of blue-gray ash. Interpreted as being in the basal part of the Ash Hollow Formation. Tentatively placed in the Cap Rock Member but Merritt Dam Member is not precluded (Skinner, MS., vol. 3, 1949, p. 44; Johnson, MS.g, 1974, p. 69).

WILSON QUARRY (fig. 26, no. 62): Situated on east side of a southwest trending gully on the east side of Plum Creek near the northwest corner of SE ¼, NE ¼, SW ¼, sect. 19, T. 31 N, R. 23 W, or about 350 yards S, 60°E of June Quarry, Brown County, Nebraska. Wood Lake Quadrangle 1950. Air photo CAL-3-104 dated 9-17-39. Elevation at base of quarry about 2430 ft.

REPOSITORY OF FOSSILS: F:AM Collection has a few specimens.

HISTORY: Discovered by Skinner and M. Hestbeck, July 7, 1930. Locality worked intermittently at least through 1947.

REMARKS: Wilson Quarry should not be confused with Jonas Wilson Quarry in the Merritt Dam Member. Wilson Quarry is lithostratigraphically about 15 ft. above the base of the Cap Rock Member (Skinner, MS., vol. 1, p. 144).

#### TYPE SPECIMENS FROM THE CAP ROCK MEMBER

#### CLASS MAMMALIA ORDER RODENTIA FAMILY HETEROMYIDAE

*Diprionomys agrarius* Wood, 1935. (Type FMNH 14932.) Collected by J. H. Quinn in Quinn Canyon, sect. 5, T. 31 N, R. 22 W, Brown Co., Nebraska.

#### ORDER CARNIVORA FAMILY FELIDAE

*Pseudaeluris pedionomis* Macdonald, 1948. (Type UCMP 29186.) From UCMP V-3327 locality. Macdonald (1948, p. 45) stated: "(North Rim). Niobrara Game Preserve, Cherry County, Nebraska, SW ¼, sec. 13, T. 34 N. R. 27 W. Between Big Beaver Creek and Coon Creek, Coon Creek drainage, 5 feet below the level of the plains . . . . The stratigraphic equivalent of UCMP locality V-3325 (Big Beaver 'A') 'caprock bed' of Johnson (1936, p. 472). *Krynitzkia* zone of Elias. Possibly slightly lower stratigraphically than the beds of type locality of Minnechaduza fauna."

ORDER PROBOSCIDEA  
FAMILY GOMPHOTHERIIDAE

*Trilophodon giganteus* Osborn, 1921. (Type AMNH 17359.) Collected by E. L. Troxell in 1916. From *Trilophodon giganteus* Quarry.

ORDER ARTIODACTYLA  
FAMILY MERYCOIDODONTIDAE

*Ustatochoerus skinneri* Schultz and Falkenbach, 1941. (Type F:AM 33630.) Found by Skinner on Turtle Butte, S.D. Skinner, Skinner, and Gooris (1968, pp. 410, fig. 3) "collected about 300 yards east of the Turtle Butte Gap subsection" about 12 ft. above base of Cap Rock Member.

FAMILY ANTILOCAPRIDAE

*Proantilocapra platycornea* Barbour and Schultz, 1934. (Type UNSM 2-5-8-30.) Found by P. O. McGrew and C. Osborne, August 5, 1930 (McGrew, ms.b, 1930, pp. 59, 95-96). Barbour and Schultz (1934, p. 3) stated: "1½ mi. N. of mouth of Steer Creek, on E. side of Snake River, Cherry County . . . 40 feet below top of exposed Tertiary." Johnson (1936, fig. 1) plotted the type locality of *P. platycornea* which McGrew had shown him in the field. Johnson (ms.d, 1934, pp. 150-151) recorded: "specimen was found in N.E. corner of first side canyon south of north line of NW ¼, sect. 27, T. 32 N., R. 30 W. on east side of Snake River." A block of sandstone containing the *P. platycornea* skeleton was lying on talus in the Burge Member at position shown on Johnson's section (1936, fig. 2). There is no reasonable doubt, however, that the block fell from the Cap Rock a few feet above the Swallow Ash, which is represented by a thin section of ash in the section above the Burge Member in the "*Proantilocapra* Loc." section.

MERRITT DAM MEMBER (NEW NAME)  
Figures 15, 32-38

**TYPE LOCALITY AND NAME:** The type section of the Merritt Dam Member (fig. 15) is above the Burge Quarry on the east side of the Snake River canyon in the west-central part of the NW ¼, NE ¼, NE ¼, SE ¼, sect. 15, T. 32 N, R. 30 W, Cherry County, Nebraska. At the type section the Merritt Dam Member is not as thick as in several referred localities. It lies above the Cap Rock Member of the Ash Hollow Formation at the top of

the local Tertiary sequence, and is overlain by Quaternary Sand Hills terrain.

Starting at the water level of the Snake River at this locality (sect. 68, fig. 38), the section, in ascending order, includes three members of the Valentine Formation (Crookston Bridge, Devil's Gulch, and the type section of the Burge), which is overlain by the type sections of the Cap Rock and Merritt Dam members of the Ash Hollow Formation. Included in the Merritt Dam Member is the type section of the Davis Ash. This sequence of sediments, lacking only the Cornell Dam Member of the Valentine in the outcrop, contains the other members of the Valentine making it one of the most complete Valentine and Ash Hollow sections in northern Nebraska. These factors were important in selecting the type section of the Merritt Dam. A photograph of this sequence that appeared in Skinner, Skinner, and Gooris (1968, pl. 25, p. 409) showed the Merritt Dam Member as undifferentiated Ash Hollow Formation overlying the Cap Rock Member of the Ash Hollow Formation.

The Merritt Dam Member is named for the U.S. Bureau of Reclamation Merritt Reservoir Dam situated about 9 mi. south-southwest of the type locality in the SW ¼, sect. 29, T. 31 N, R. 30 W, Cherry County, Nebraska, on the upper reaches of the Snake River Canyon. The footing of the dam is in the Merritt Dam Member. (See Kennedy Quadrangle 1950 and U.S. Department of Agriculture photographs CAM-12P-105 dated 10-7-55 (Burge Quarry area) and CAM-11P-120 dated 10-7-55 for illustrations of the Merritt Reservoir area before construction.)

Johnson (1936, fig. 2) published a generalized section and correlation chart showing an unnamed unit (including the Davis Ash) above the base of the sandy marl that overlies the top of the Cap Rock Member above the Burge Quarry. This is now the type section of the Merritt Dam Member and is further illustrated in a more detailed, modified section (fig. 15).

**DISTRIBUTION:** Outcrops of the Merritt Dam Member occur along the Snake River southward to the Merritt Reservoir and westward up the Snake River Valley among sand dunes for at least 40 mi. to the mouth of

# HYPOSTRATOTYPE SECTION OF MERRITT DAM MEMBER

NW 1/4 sect. 29, T.31N., R.30W.  
Cherry County, Nebraska

57 \*

8.5 Miles  
(15.3 Km.)

## HOLOSTRATOTYPE SECTION OF BURGE, CAP ROCK AND MERRITT DAM MEMBERS AND DAVIS ASH

NE 1/4, SE 1/4 sect. 15, T.32 N., R.30W.  
Cherry County, Nebraska

68

FEET  
200  
150  
100  
50  
0

2940'

2820'

2861'

2779'

2757'

DATUM: Base of Ash Hollow

Snake River

Burge Quarry 35

\* Thickness of Merritt Dam Mbr. is 190 feet on basis additional section exposed on No. 58, fig. 38

Approximately 200' above Snake River

17' Sod covered

10' ss., yel.-gr., moss.

0-8' Channel sd., local, fossiliferous

11' ss., yel.-gr., contains white root casts

5-7' ss., fn. to med. grained

5-8' Volcanic ash, blu.-gr., pure, crse. at base to sdy., fine at top

14-17' ss. at top. Mostly talus covered. Probably channel sd. in basal part

5-6' ss., yel.-gr., compact

3-5' Marl, white, clean to v. sdy., thickness varies. Gastropod casts

17' ss., gr., hd., moss., often contains white fossilized roots

11' Marl to marly ss., v. lt. gr., fn. to med. grained grading downward to residual pebbles and compact ss. Contains bone frags. "fragmental layer." Local clay lenses

17-39' Sd and gravel, gr. to olive gr., med. to crse. congl. channel deposits with grn. clay lenses, clasts, pebbles and some clay boulders

ss., yel.-gr., argillaceous

ASH HOLLOW FORMATION

MERRITT DAM MEMBER

CAP ROCK MEMBER

BURGE MEMBER

DEVIL'S GULCH MEMBER

VALENTINE FM.

SAND HILLS

10.2 ± 0.7 Ma

DAVIS ASH

10.2 ± 0.7 Ma

10.2 ± 0.7 Ma

10.2 ± 0.7 Ma

10.2 ± 0.7 Ma

10.2 ± 0.7 Ma

10.2 ± 0.7 Ma

10.2 ± 0.7 Ma

10.2 ± 0.7 Ma

10.2 ± 0.7 Ma

10.2 ± 0.7 Ma

10.2 ± 0.7 Ma

10.2 ± 0.7 Ma

10.2 ± 0.7 Ma

Clifford Creek (sect. 21, T. 30 N, R. 37 W). In the 1940s Skinner, on a boat trip downriver from Clifford Creek for some 15 mi., observed sediments, including layers of volcanic ash and channel sand, that he believed were equivalent to Merritt Dam rocks.

For at least 17 mi. west of the junction of the Snake and Niobrara rivers remnants of Merritt Dam sediments crop out in headward eroding canyons on the north side of the Niobrara River (e.g., Cooper, McFarland, and McCann canyons) and near the mouth of Medicine Creek on the south side of the Niobrara River. For some distance westward, volcanic ash deposits in sediments that resemble those of the Merritt Dam Member are exposed above the Cap Rock Member.

Along the Niobrara River from the mouth of Leander Creek westward to near the Lions Bridge the cross section (fig. 31) shows a cut and fill complex resulting from later Tertiary tectonic readjustment and probable faulting. This is on the east flank of the Chadron Arch where the river has intricate meanders and is entrenched in a narrow valley. Distinguishing the Merritt Dam and Cap Rock members at specific outcrops in this area becomes increasingly difficult due to the variable nature of the sediments filling the cuts. Consequently, this part of the section for some 15 mi. is designated as "Ash Hollow undifferentiated" (fig. 31). The Cap Rock Member, however, is recognized at Lions Bridge and westward to the mouth of Hay Creek.

**THICKNESS:** The Merritt Dam Member is at least 65 ft. thick in the type section, whereas nearly 100 ft. are recognized on the west side of the Snake River just below the Snake River Falls. Between the falls and the Merritt Reservoir 190 ft. of sediments are referred to this member. South of Kilgore, Nebraska, and north of the Kilgore floral locality of MacGinitie (1962, pp. 69–71, fig. 2) the Ash Hollow Formation includes at least 125 ft. of the Merritt Dam Member. The original thickness of the Merritt Dam Member is unknown, since the Ash Hollow Formation has been exposed to widespread erosion during late Clarendonian and Hemphillian to Recent time.

From the mouth of the Snake River eastward along the Niobrara River much of the

Merritt Dam Member is either covered by sand dunes or has been removed by erosion. Scattered remnants of the Merritt Dam Member crop out north of the river in the heads of canyons and in uplands in the vicinity of Sparks in eastern Cherry County, Norden, in western Keya Paha County, at least as far east as Beeman Creek in the W  $\frac{1}{2}$ , sect. 2, T. 32 N, R. 20 W. Springview Quadrangle 1964, on the north side of the Niobrara River and south of the Niobrara River in Brown County. The Merritt Dam Member is 86 ft. thick between Flattop (elev. 2656 ft., a prominent landmark northwest of Sparks) and the Niobrara River 3 or 4 mi. south and southeast of Sparks.

**LITHOLOGY:** The Merritt Dam Member has the classical calcareous "grit or mortar bed" appearance similar to the Cap Rock Member. The Cap Rock Member, however, is more indurated than the Merritt Dam Member, forms cliffs in the canyons, and is often capped by a hard caliche-like sandstone suggesting a paleosol (Schultz and Stout, 1980, p. 192).

The principal difference is that the sandstones are thinner-bedded and less continuous in the Merritt Dam Member than in the more massive and indurated Cap Rock Member. The Merritt Dam Member contains more local channel deposits, has a higher frequency of calcareous or marly zones (pond and oxbow lake sediments), fewer occurrences of hackberry and grass seeds, and siliceous root tubules than the Cap Rock. Merritt Dam rocks form fewer cliffs than does the Cap Rock and weather into more rounded topography and irregularly occurring sandstone ledges. Both members are characterized by the presence of intermittent layers of vitric tuff, in strong contrast to the lack of ash layers in the Crookston Bridge, Devil's Gulch, and Burge members of the Valentine Formation, which were deposited during a period of volcanic quiescence in the source areas of the ash in the Ash Hollow and Cornell Dam.

Thin layers of unconsolidated channel sand occur at the base and near the top of the type section of the Merritt Dam Member (fig. 15). A few fossils have been found in one of the upper channel sands of the type section. At other localities in the Niobrara River watershed large collections have been obtained



from several channel sand deposits that fill paleo-drainages cut into the middle and basal part of the Merritt Dam Member, or into the underlying Cap Rock Member and the Valentine Formation, thus indicating several cycles of cutting and filling (figs. 17, 32, 37, 38).

In the Snake River Valley these channel sediments can be traced laterally into massive overbank alluvial sand and silty sand, clay and pond deposits, such as the diatomaceous marl at the *Platybelodon* Quarry (fig. 38), interbedded with channel sand at the *Alligator mefferdi* site. This is in contrast to conditions that existed during formation of the caliche-like Cap Rock Member in which channel cuts and fills are seldom encountered.

Another characteristic of the Merritt Dam Member is the frequent occurrence of tuffaceous sand and layers of sand to pure volcanic ash. The Davis Ash occurs 25 ft. above the base of the type section of the Merritt Dam Member (fig. 15). Several beds of vitric tuff and fluvial sand occur at different levels in the Merritt Dam Member at other localities. Cronin and Newport (1956, p. 19) noted three ash beds and several channel sands in a section near the site of the Merritt Reservoir. Several ashes were recorded in the hypostatotype section that we measured in the same area (fig. 15). The two upper beds occur along the irrigation ditch downstream from the outlet at the dam. The most prominent ash occurs at the river level in the NW  $\frac{1}{4}$ , sect. 29, T. 31 N, R. 30 W, about  $\frac{1}{2}$  mi. below the reservoir, is probably the Davis Ash which crops out in the section above the Mizner Quarry and at its type locality in the Merritt Dam Member above the Burge Quarry (figs. 15, 38).

Volcanic ash occurs in the channel fills above several fossil-bearing deposits. Good examples were observed at Wade Quarry on the Snake River and above the Xmas, Kat, and *Machaerodus* quarries in eastern Cherry County, and at the Bear Creek Quarry in western Cherry County. These ashes have the potential of linking stratigraphy with radiometric dating and biochronology, particularly in view of the large assemblage of fossils collected from these and other sites.

**STRATIGRAPHIC RELATIONS:** The Merritt Dam Member appears to be in conformable

contact with the Cap Rock in the type section and at most other localities at which the contact was observed. There are localities, however, at which sediment-filled channels within this unit have incised deeply into the underlying beds. Fossiliferous sand-filled channels in the Merritt Dam Member have cut into the Cap Rock Member at Wade and Horn quarries on the Snake River upstream from the type section (fig. 38) and in the area of Xmas and Kat quarries in eastern Cherry County.

South of Merriman in western Cherry County, on the eastern flank of the Chadron Arch, extensive deposits of fluvatile sand carrying fossils, clastic gravel, and pebbles fill channels that cut through Cap Rock into the Valentine Formation, Hemingfordian, and Arikareean rocks. In that area a slight increase in stream gradient during post Valentine deposition induced the erosion of channel cuts at least 150 ft. deep (e.g., Mensinger Quarry and Gallup Gulch, fig. 31), and at other places where most or all the Valentine Formation was removed before deposition of the later sediments. Faunal data and relative stratigraphic position indicate that many of these channel fills are temporally equivalent to the Merritt Dam Member.

The upper part of the Merritt Dam Member was extensively eroded, but channel cuts filled with silt, sand, and gravel are preserved in some localities. A good example is at the "Bear Tooth Slide" on Deep Creek in Brown County (Skinner and Hibbard et al., 1972, p. 22, fig. 4). In turn the Merritt Dam Member is disconformably overlain by Pleistocene and Holocene clays, sands, and gravels. Recent erosion has cut deeply through Pleistocene and late Tertiary sediments over the entire area, exposing thick sections for geologic study and fossil collecting.

**AGE, FAUNAS, AND CORRELATION:** The fauna from most collecting sites in the Merritt Dam Member is late Clarendonian in age. At least one site, the Bear Tooth Slide (sect. 39 on fig. 34) contains a late Hemphillian fauna (Tedford et al., ms.) which was initially thought to be early Hemphillian (Skinner and Hibbard et al., 1972, fig. 4). A gap in the faunal record in north-central Nebraska is indicated by the lack of early Hemphillian fossils in the Frick Collection.

Only two of the several layers of vitric tuff

in the Merritt Dam Member have been dated by the fission track method. One of these, the Davis Ash in the type section (fig. 15), was dated by Boellstorff and Izett (see p. 297) at about 10 million years. Boellstorff (personal commun.) determined a date of  $9.5 \pm 0.8$  Ma (glass shards) from the Machaerodus Ash (New Name) which was found above the fossil-bearing zone in the Machaerodus Quarry (fig. 17) in eastern Cherry County.

The Machaerodus Ash, consisting of 5 to 6 ft. of volcanic ash and sandy ash discovered during excavation of the Machaerodus Quarry, also occurs above the fossil-bearing channel sand in other quarries in the Xmas-Kat quarries area (fig. 3, 17). At the Wade Quarry (fig. 38) on the Snake River, in a channel cut deeply into the Cap Rock Member, an ash probably equivalent to the Machaerodus Ash overlies sand containing fossils similar to those found in the Xmas-Kat quarries.

A lithic differentiation between the Machaerodus and Davis ashes is not apparent. The Machaerodus Ash overlies sediments (figs. 3, 17, 38) in a channel system cut deeply into the Cap Rock Member while the Davis Ash is above a 27 ft. section of sandstone, sand, and marl which overlies the type section of the Cap Rock. Boellstorff's fission track dates indicate that the Davis Ash may be somewhat, but not significantly, older than the Machaerodus Ash.

On the basis of available evidence, it is postulated that the Machaerodus Ash occurs in a channel system which cuts through sediments younger than the Davis Ash of the Merritt Dam Member downward into the Cap Rock Member in a relationship illustrated on figure 3.

The Frick Collection has more than 3000 fossils taken from 29 quarries in the Merritt Dam Member. The stratigraphic position of many of the quarries in the Merritt Dam is illustrated on the cross sections, and the quarries are listed on the chart showing generalized stratigraphic relationships (fig. 3). Details of the relative temporal allocation of some of the quarries are subject to revision upon completion of faunal studies and when additional radiometric dates and geochemical studies on ash samples are available.

The fossils from the type section of the Merritt Dam Member are from a channel sand 47–55 ft. above the contact with the

underlying Cap Rock Member (fig. 15). Among these are a maxilla of *Mylagaulus* sp. (F:AM 65836), a partial left ramus of *Cormohipparion* sp. (UNSM 32008), and a partial skull of *Macrogenis crassigenis* (F:AM 101961). Beryl Taylor (personal commun.) identified a partial ramus as *Hemiauchenia* sp. (F:AM 25090) and stated that "it is close in size and morphology to specimens from the Bear Creek Quarry and intermediate in size between rami from Clayton Quarry at the base of the Merritt Dam Member and the Xmas quarries (in the Merritt Dam Member)." A left maxilla (F:AM 37385) of a tapir from the same channel sand is referred to *?Tapirus johnsoni*; its size and morphology are similar to specimens from the *Leptarctus*-Xmas quarries area.

Faunal evidence from the channel sand 50 ft. above the base of the type section of the Merritt Dam Member indicates that the age of its deposition is close to that of the sediments in the Xmas-Kat channel quarries. These channel deposits are part of a complex network of sand-filled channels in the late Clarendonian sediments of north-central Nebraska.

The Xmas Quarry channel deposit in particular, and also the stratigraphically equivalent Hans Johnson Quarry, yielded a population sample of 63 complete and partial skulls of *Cormohipparion occidentale* (Skinner and MacFadden, 1977, figs. 1–2).

A mandible (F:AM 103262) identified by H. Tobien (ms.) as *Amebelodon* cf. *fricki*, is from about 90 ft. above the base of the Ash Hollow Formation in the vicinity of the hypostratotype section (57 on figs. 15, 23, 38) of the Merritt Dam Member. The mandible was collected from channel sand in a gully on the east side and 38 ft. above the Snake River, about ¼ mi. southeast of the "Narrows," or approximately ¾ mi. northeast of Merritt Dam, in the SE ¼, SE ¼, SW ¼, sect. 20, T. 31 N, R. 30 W, Cherry County, Nebraska. (See air photo CAM-11P-120 and Kennedy 15 minute Quadrangle.)

Tobien (ms., 1981) comments as follows: "The large size; the indications of a long and massive symphysis with flaring tendency at its base and a large anterior alveolar canal; by the complicated wear pattern (frequent secondary trefoiling, six lophids, cementodontology) it is most probable that F:AM 103262

belongs to the genus *Amebelodon*, nearly related if not identical with *Amebelodon fricki*."

It is significant that this is the first proboscidean identified as *Amebelodon* from the Merritt Dam Member in north-central Nebraska. Its elevation position in relation to measured lithostratigraphic sections along the Snake River is shown between sections 57 and 58 on figure 38. Although it appears to occur in a channel sand shown on these two sections, there is no solid evidence that this is correct since the area between the sections is covered by talus, dune sand, and prairie grasses. The possibility that the mandible is from a Hemphillian channel cut deeply into the Merritt Dam Member, such as at Bear Tooth Slide (fig. 34, Deep Creek sect.), cannot be precluded. Unfortunately, no associated fauna was found with F:AM 103262.

#### QUARRIES IN THE MERRITT DAM MEMBER

**ALLIGATOR MEFFERDI QUARRY** (fig. 23, no. 63): On east side of the Snake River on a west facing outcrop in SE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 5, T. 31 N, R. 30 W, or 280 yards S, 32°E of *Platybelodon* Quarry, Cherry County, Nebraska. Kennedy Quadrangle 1950. Air photo CAM-11P-193 dated 10-7-55. Elevation at base of quarry 2810 ft.

**HISTORY:** Discovered by R. L. Mefferd during the summer of 1941.

**REPOSITORY OF FOSSILS:** F:AM Collection has at least 18 specimens of fossil vertebrates.

**REMARKS:** The type of *Alligator mefferdi* Mook is from unconsolidated sand between the first and second layer of diatomite above the contact with the underlying Cap Rock Member. A left maxilla referred to *Ustatochoerus major* (F:AM 109517) was collected about 100 ft. south of the *A. mefferdi* site, from a sand that appears to be in the upper part of the same pond deposit. Several other taxa have been collected at the *Alligator mefferdi* site, which appears to be stratigraphically equivalent to the section at the *Platybelodon* Quarry (Johnson, ms.f, 1972, pp. 48–50; Skinner, ms., vol. 1, pp. 74–75).

**CLAYTON QUARRY** (fig. 27, no. 64): On east side of Quinn Canyon near center of north line of SE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 5, T. 31 N, R. 22 W, Brown County, Nebraska. Ains-

worth NW Quadrangle 1954. Elevation at base of quarry about 2390 ft.

**REPOSITORY OF FOSSILS:** F:AM Collection has 270 specimens. A small collection is in FMNH.

**HISTORY:** Discovered by L. Quinn prior to the fall of 1940 and named for Clayton Quinn, owner of the land at time of discovery. Skinner and party worked the quarry during the fall of 1940.

**REMARKS:** Clayton Quarry occurs in a gray to buff soft sand containing sandstone clasts deposited in a channel cut into the top of the Cap Rock Member. The base of the channel (fig. 40) is about 7 ft. below a light gray clay and a sandy clay that may grade laterally into the Quinn limestone (Osborn, 1936, fig. 272) near the base of the Merritt Dam Member. The Quinn limestone is a local pond deposit, most of which has been removed by quarrying (Skinner, ms., vol. 10, p. 14; Johnson, ms.f, 1972, p. 40). Clayton Quarry is older than the Quinn Rhino (RH-I and RH-II) quarries of Skinner and Quinn (p. 310). A heavy cover of vegetation and trees near the quarry makes it difficult to establish details of the lithostratigraphic relationships. Available evidence favors placing Clayton and East Clayton quarries at the base of the Merritt Dam Member (fig. 40) but the possibility of its being a channel sand in the upper part of the Cap Rock has not been ruled out (Johnson ms.f, 1972, p. 40; Skinner, ms., vol. 9, pp. 112–115, including a section measured by R. H. Tedford, ms.a, 1975).

**EAST CLAYTON QUARRY** (fig. 27, no. 65): On north side of an east trending canyon off east branch of Quinn Canyon near the NW corner of SW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 5, T. 31 N, R. 22 W, Brown County, Nebraska. Ainsworth NW Quadrangle 1954. Elevation at base of quarry about 2390 ft.

**REPOSITORY OF FOSSILS:** F:AM Collection contains 376 specimens.

**HISTORY:** Discovered by G. K. Fletcher on September 27, 1940 and worked during October 1940.

**REMARKS:** Stratigraphically in the same position as Clayton Quarry. Type locality of *Lichnocyon phoeniceus* Baskin.

**EGGERS QUARRY** (fig. 26, no. 66): On the east side of Plum Creek, 110 yards S, 70°E

of June Quarry, in SE corner of SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 19, T. 31 N, R. 23 W, Brown County, Nebraska. Wood Lake Quadrangle 1950. Air photo CAL-3-104 dated 9-17-39.

REPOSITORY: F:AM Collection contains 131 specimens.

HISTORY: Discovered in 1940 by Skinner. Worked intermittently through 1976.

REMARKS: Local channel deposit cut into Cap Rock Member (Skinner ms., vol. 1, p. 144).

EMRY QUARRY (fig. 26, no. 67): On south side of a small gully on west side of Plum Creek near west line of SE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 24, T. 31 N, R. 24 W, or 440 yards W, 15°N of June Quarry, Brown County, Nebraska. Wood Lake Quadrangle 1950. Air photo CAL-3-104 dated 9-17-39. Elevation at base of quarry about 2445 ft.

REPOSITORY OF FOSSILS: F:AM Collection has 60 specimens.

HISTORY: Discovered by Robert, Raleigh, and Sue Emry August 25, 1965. Worked during 1965 and 1966.

REMARKS: In sand-filled channel cut into Cap Rock. Stratigraphically, a probable equivalent to Jonas Wilson and Eggers quarries (Skinner, ms., vol. 1, p. 144). A mandible of *Ustatochoerus major* (F:AM 109516), from this quarry is a taxon typical of the Merritt Dam Member.

HORN QUARRY (fig. 23, no. 68): Just south of a large west facing escarpment about 100 yards northeast, or down the Snake River from Swallow Quarry in SE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 22, T. 32 N, R. 30 W, Cherry County, Nebraska. Kennedy Quadrangle 1950. Air photo CAM-12P-105. Elevation at base of quarry about 2758 ft.

REPOSITORY OF FOSSILS: F:AM Collection has 27 specimens.

HISTORY: Discovered on August 25, 1955, by Skinner, Sr., and M. F. Skinner, Jr. Worked in 1955 and 1961.

REMARKS: In channel sand with reworked Cap Rock pebbles in cut incised to within 6 ft. of base of Cap Rock Member. A probable stratigraphic equivalent of Wade Quarry (Skinner, ms., vol. 5, p. 65).

HURLBUT QUARRY (fig. 27, no. 69): On west side of head of Hurlbut Canyon in SW  $\frac{1}{4}$ , SW

$\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 27, T. 32 N, R. 22 W, Brown County, Nebraska. Ainsworth NW Quadrangle 1954.

REPOSITORY OF FOSSILS: F:AM Collection.

HISTORY: Discovered in 1928 by Skinner and J. H. Quinn and worked during 1928, 1929, and 1972.

REMARKS: In channel sand filling a cut incised about 10 ft. into the upper part of the Cap Rock Member (Johnson, ms.g, 1975, pp. 112–116; Skinner, ms., vol. 9, pp. 100–103).

JIM LESSIG CAMEL SITE (fig. 27, no. 70): On a point on south side of Plum Creek 0.35 mi. N, 75°W of Hurlbut Quarry in the SE corner of NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , sect. 28, T. 32 N, R. 22 W, Brown County, Nebraska. Elevation about 2380 ft. Ainsworth NW Quadrangle 1954.

REPOSITORY OF FOSSILS: F:AM Collection.

HISTORY: Discovered in 1929 by Skinner and J. H. Quinn.

REMARKS: Fossils in 3 or 4 ft. of channel sand correlated with the lower part of the Merritt Dam Member about 38 ft. above the base of the Ash Hollow (Skinner, ms., vol. 3, pp. 4–5). An articulated camel skeleton (F:AM 37652) and mylagaulid (F:AM 65008) skull were collected here.

JONAS WILSON QUARRY (fig. 26, no. 71): In NW corner of SW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 19, T. 31 N, R. 23 W, or 520 yards N, 40°E of June Quarry in Brown County, Nebraska. Wood Lake Quadrangle 1950. Air photo CAL-3-104 dated 9-17-39. Not to be confused with Wilson Quarry, which is in the Cap Rock Member.

REPOSITORY OF FOSSILS: F:AM Collection has more than 57 specimens.

HISTORY: Discovered by H. Dehlin and Skinner July 1, 1933, and worked intermittently until 1941. Named after Jonas Wilson, owner of the property at time of discovery.

REMARKS: Quarry was in a channel sand cut into the top of the Cap Rock Member, and a probable temporal equivalent to the Emry, Eggers, and Xmas-Kat Channel quarries (Skinner, ms., vol. 1, p. 144). Type locality of *Pseudoceras wilsoni* Frick.

PLATYBELODON QUARRY UNSM Cr-22 (fig. 23, no. 72): Near center of a large south facing outcrop on west side of Snake River in center of NW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 5, T. 31

N, R. 30 W, or 4 mi. S, 40°W of Burge Post Office (no longer extant), Cherry County, Nebraska. Kennedy Quadrangle 1950. Air photo CAM-11P-193 dated 10-7-55. Elevation about 2823 ft.

REPOSITORY OF FOSSILS: UNSM has at least 16 specimens and F:AM has about 12.

HISTORY: Discovered by P. O. McGrew June 21, 1931. McGrew and G. Meade returned to the site July 3 and began removing the hard matrix in which a proboscidean jaw was embedded. By July 6 they had determined that it was a rare short-tusked "shovel tusk" with perfectly preserved, but badly worn teeth (UNSM 1-10-7-31). Johnson and C. S. Osborne joined the crew in providing the mandible with a plaster jacket and turning it over, but found little additional material (Johnson, MS.a, 1931, pp. 25-31).

REMARKS: This site is at the base of a 10-12 ft. bed of white diatomaceous marl in the lower part of the Merritt Dam Member. The marl appears to be the lateral equivalent of the lacustrine sediments at the *Alligator melferdi* site, 280 yards S, 32°E on the other side of the Snake river (Skinner, MS., vol. 1, pp. 140-141).

The proboscidean mandible, lying on a hard, thin layer of argillaceous sandstone, was embedded in the basal part of the overlying diatomaceous marl and sandy marl (McGrew, MS.c, pp. 14, 29-34 and section by Johnson and Osborne in McGrew, *ibid.*, pp. 100-101) and this paper figure 38, section 61. Within a month of its discovery, E. H. Barbour (1931, pp. 191-198) described the mandible as the type of *Torynobelodon barnumbrowni* (UNSM 1-10-7-31) and stated that "it approaches *Platybelodon grangeri*." After H. F. Osborn and W. Granger had studied the specimen Barbour (1932, pp. 191-198) decided that it was morphologically similar to the platybelodons from the Tung Gur horizon of Mongolia and should be placed in the genus *Platybelodon*. Osborn (1936, pp. 470-472), however, restored the genus to *Torynobelodon*, stating that "*T. barnumbrowni* appears to be a collateral branch, and somewhat less perfect mechanically, of the *Platybelodonts* of Central Asia."

Gastropod casts in the diatomaceous marl at the same level as the *Torynobelodon* specimen provide further evidence that the sediments were deposited in a pond. Between

1931 and 1972 specimens belonging to several other taxa of vertebrates, including two carnivore jaws and horse material, have been collected from the large outcrop of weathered marl on both sides of the principal collecting site. A fragment of a left ramus (UNSM 1-11-7-35) from near the top of the diatomaceous layer overlying the *T. barnumbrowni* specimen was referred by Frick (1937, p. 652) to *Pseudoceras wilsoni*, the type of which came from the Merritt Dam Member at Jonas Wilson Quarry.

PRATT QUARRY (fig. 26, no. 73): On northwest facing bank on east side of Plum Creek where it makes a sharp loop near the center of south line of NE ¼, SW ¼, sect. 30, T. 31 N, R. 23 W, Brown County, Nebraska. Wood Lake Quadrangle 1950. Elevation at base of quarry about 2411 ft.

SYNONYMS: Pratt Slide, also McConnell Slide 1929-1930.

REPOSITORY OF FOSSILS: F:AM Collection has 179 specimens.

HISTORY: Discovered July 14, 1930 by M. Hestbeck and Skinner and worked in 1930 and 1938 through 1941, and intermittently thereafter.

REMARKS: Pratt Quarry is in a channel cut through the basal Merritt Dam and Cap Rock Members of the Ash Hollow Formation, Burge Member of the Valentine Formation and about 22 ft. into the underlying Devil's Gulch Member of the Valentine Formation (Skinner, MS., vol. 1, p. 104). About equal to, or possibly later in age than, the Xmas-Kat Channel quarries.

QUINN RHINO QUARRIES I AND II (fig. 27, no. 74): RH-I (Quinn Rhino Quarry I). On an east facing mostly sod-covered outcrop directly across Quinn Canyon 0.20 mi. northwest of Stony Ridge where the Quinn limestone (Osborn, 1936, fig. 272; this paper, fig. 40), overlies section correlated with the Clayton Quarry Channel and the Cap Rock Member. RH-II (Quinn Rhino Quarry II) is about 20-30 yards south and at the same stratigraphic position as RH-I. Both quarries are in the NW ¼, SE ¼, SE ¼, NW ¼, sect. 5, T. 31 N, R. 22 W, Brown County, Nebraska. Ainsworth NW Quadrangle 1954. Elevation at base of RH-I and RH-II is about 2420 ft. (Skinner, MS., vol. 10, pp. 13-14).

SYNONYMS: RH-I and RH-II, UNSM Bw 101, UCMP V-65235.

**HISTORY:** Quinn Rhino Quarries I and II were discovered by Skinner and J. H. Quinn in the spring of 1926.

**REPOSITORY OF FOSSILS:** Some rhinoceros material was acquired by UNSM, one *Teleoceras fossiger* skull and mandible (UCMP 31034) was acquired by W. D. Matthew at UCMP (Matthew, 1932, pls. 76–79), and other specimens were sent to CMNH. Two rhinoceros skulls and other fossils collected in 1927 and 1928 went to the F:AM Collection.

**REMARKS:** These quarries are in a sandy clay in the lower part of the Merritt Dam Member, probably about 10–15 ft. above the section equivalent to the Quinn limestone (sect. 51 on figs. 37, 40). Most of the fossils were rhinoceroses. A horse palate (F:AM 108235) from 10 ft. above the main fossil concentration in RH-I is morphologically close to the type of *Neohipparion affine* (Leidy, 1869).

**RH-III QUARRY** (fig. 27, no. 75): On east side of head of a small north-northwest trending gully on west side of a ridge west of main Quinn Canyon and over the ridge northwest of RH-I near center of the SE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 5, T. 31 N, R. 22 W, Brown County, Nebraska. Ainsworth NW Quadrangle 1954.

**REPOSITORY OF FOSSILS:** F:AM Collection has 204 specimens.

**HISTORY:** Discovered by Skinner and Quinn on July 13, 1928. Locally, the sand in which this quarry occurs appears to be deposited in a channel cut into the sediments carrying RH-I and RH-II quarries indicating that RH-III is younger. The base of the quarry, at an elevation of about 2418 ft., is projected as being about 18 ft. above the base of the Quinn limestone which crops out 0.25 mi. southeast on the east side of Quinn Canyon (Skinner, MS., vol. 10, p. 14).

**WADE QUARRY** (fig. 23, no. 76). On a south facing outcrop in a small canyon on west side of Snake River 1030 yards N, 37°E of mouth of Steer Creek near SW corner of the SE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 28, T. 32 N, R. 30 W, Cherry County, Nebraska. Kennedy Quadrangle 1950. Air photo CAM-1P-65 dated 8-22-55. Elevation at base of quarry is about 2765 ft.

**REPOSITORY OF FOSSILS:** F:AM Collection has 164 specimens.

**HISTORY:** Discovered by Skinner on Sep-

tember 6, 1939 and worked intermittently until 1952.

**REMARKS:** Fossils were collected from the basal 7 ft. layer of channel sand underlying a 5 ft. layer of ash and sandy ash (sect. 65 on fig. 38). The channel cut and fill, with a thickness of about 18 ft., is cut through the basal Merritt Dam Member to within 17 ft. of the base of the Cap Rock Member (Skinner, MS., vol. 1, pp. 132–133).

Three large skulls of *Cormohipparion cf. occidentale* (F:AM 71869–71871) are comparable in size to *C. occidentale* skulls from the Xmas-Kat quarries channels. Also, the presence of a partial skull (F:AM 61850) and a partial mandible (F:AM 61980) referred to *Barbourofelis morrissi*, other taxa from this quarry, and the presence of ash overlying the fossil-bearing channel sand indicate that it may be temporally equivalent to the quarries of the Xmas-Kat quarries area.

#### Xmas-Kat Channels

Figure 16 and air photo CAM-14P-127 dated 10-15-55

The Xmas-Kat channels were discovered in 1931 by R. L. Mefferd and M. F. Skinner. Their initial discovery became an excavation called Kat Quarry, where they found a *Barbourofelis ramus* and other fossils. During the next six years other fossiliferous channel deposits were found in the vicinity of the Kat Quarry site, in an area 3 mi. south and south-east of Sparks, eastern Cherry County, Nebraska.

In the summer of 1931 a similar channel deposit was discovered at Balanced Rock Quarry on a point about one-half mile south of Kat Quarry. Although the channel sand and clasts were similar to those at Kat Quarry, no stratigraphic continuity was inferred at that time. A partial skeleton of a camel was collected from the consolidated Cap Rock Member directly below the Balanced Rock Quarry, showing superposition of two faunal bearing units.

During Christmas vacation of 1931–1932 Skinner returned to the area and, seeing a few fossil fragments across the canyon west of Balanced Rock Quarry, made a test hole that revealed a channel containing complete rhinoceros skulls and a concentration of post-cranial elements. This was the start of Xmas

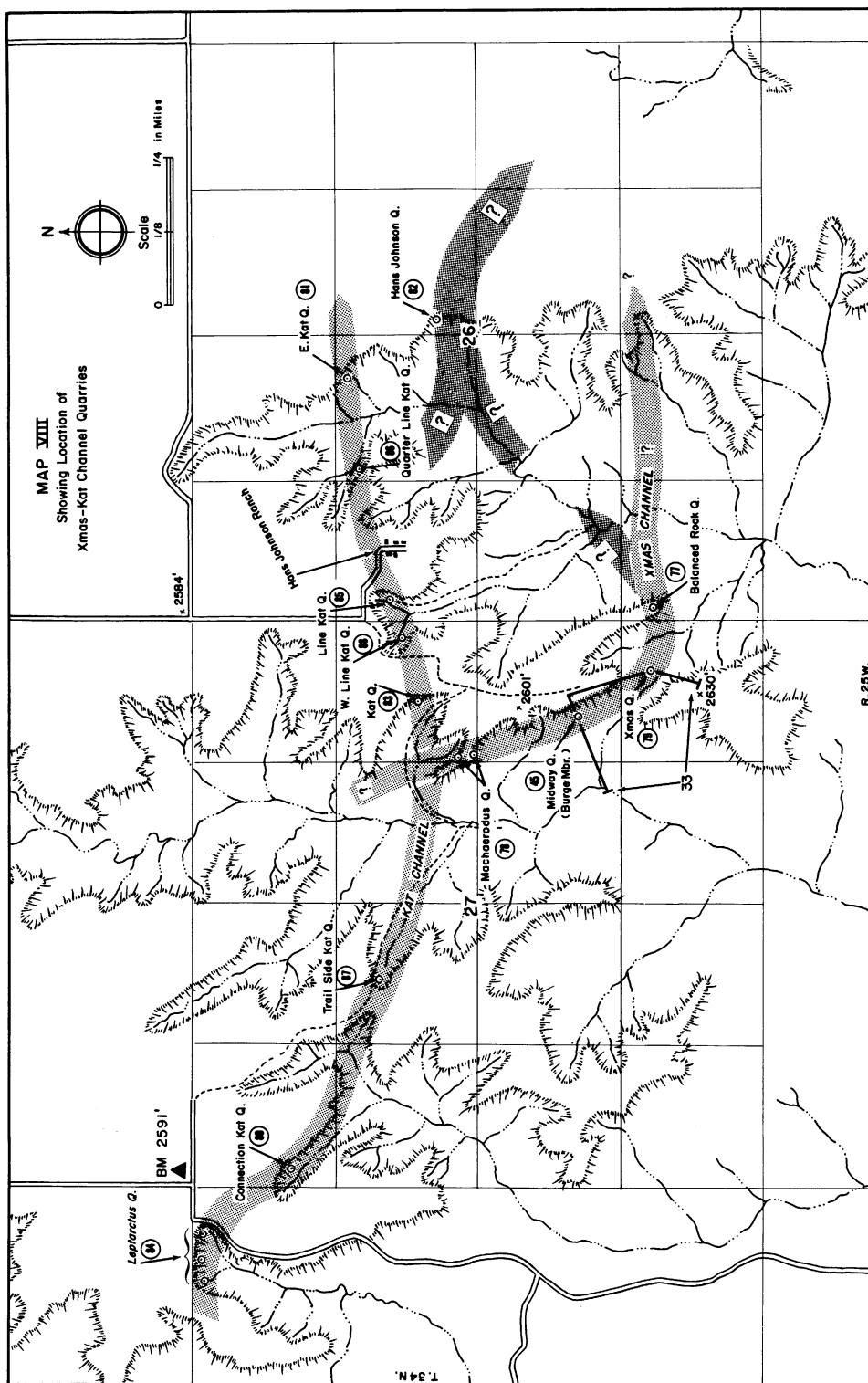


FIG. 16. Map VIII, showing Xmas-Kat channels and location of fossil quarries, eastern Cherry County, Nebraska. Trend of channels is postulated from location of fossil quarries and field observations.





Quarry, where the Frick party collected from 1931 to 1936. At the south end of the main deposits, excavations showed that the deep channel cut of a paleostream had flowed against a former Cap Rock bluff and was diverted to the east. Large blocks derived from the Cap Rock Member had slumped into the channel. Prospect holes dug along the side of the canyon showed that the Xmas Channel extended only a short distance to the south. The 50-ft.-deep channel cut was not more than 15 ft. wide in the basal 15 ft., but became wider (up to 150 ft.) on the point bar higher in the section (fig. 17).

In searching for more channel deposits the Frick party reasoned that headward erosion of recent drainages would follow the less resistant sand-filled channels. During the 1932 drought additional prospecting showed that the Kat Channel was seldom more than 100 yards wide. In the lower part of the cut fossils were usually present as lag concentrate among clean, well-sorted, moderately coarse, quartz sand and clasts reworked from the Cap Rock Member. Outcrops of this loose channel fill, lying in cuts eroded into the Cap Rock Member along the canyon rims, held the available moisture, and supported a growth of sumac that turned bright red in autumn. During the fall of the drought years the sumac bushes were like beacons among the seared vegetation. Prospecting such places from 1932 to 1936 resulted in discovery of the *Leptarctus* and five more Kat equivalent quarries (fig. 16). This trend, named the Kat Channel, extended in an east-west direction for about two mi.

In November 1932 F. S. Ballou and M. F. Skinner discovered bone chips weathering out on the south side of a small knob about  $\frac{1}{8}$  mi. north of Xmas Quarry. Excavations through the sod showed a fossiliferous, clean, quartz channel sand similar to the Xmas Quarry. Concentrations of small garnets were also found suggesting the Black Hills as the source for some of the sediments of this channel system. This site was named Machaerodus Quarry. Its occurrence in a north-south trending channel cut which crops out on both sides of a ridge (fig. 16) suggests that the Xmas Quarry channel entered the area from the north, or perhaps from the west as a southward distributary of the Kat quarries channel.

Downstream extensions from the Xmas Quarry through the Balanced Rock Quarry may have trended northeast to the Hans Johnson Quarry or eastward into section 25 in separate distributaries. An extensive outcrop of sand containing a few fossils with preservation resembling that of Xmas Quarry, occurs in a small canyon in section 25 east of the area shown on figure 16. This could be an extension of the channel eastward from the Balanced Rock Quarry, or southeastward from the Hans Johnson Quarry.

Discovery of Midway Quarry in 1934 and numerous Burge Member outcrops directly below the Cap Rock Member in these canyons provided a lithic sequence which left no doubt that the faunas from the Xmas-Kat channels were post-Burge Member and post-Cap Rock Member as well. Also, lithostratigraphic relationships show that the Xmas-Kat channels were deposited later than the lower part of the Merritt Dam Member. Work in this area helped to establish a concept of the lithic sequence of various channel deposits above and below the Cap Rock Member of the Ash Hollow Formation.

The highly fossiliferous Xmas-Kat channels yielded at least 18 genera: *Mylagaulus*, *Barbourofelis*, *Aelurodon*, *Epicyon*, *Leptarctus*, *Serbelodon*, *Aphelops*, *Teleoceras*, *Tapirus*, *Cormohipparion*, *Hypohippus*, *Griphippus*, *Ustatochoerus*, *Aepycamelus*, *Protolabis*, *Parablastomeryx*, *Cranioceras*, and *Pseudoceras*. No comprehensive study of the fauna from the Xmas-Kat channels has been made.

The Xmas and Kat quarries are plotted on map VIII, figure 16.

#### Xmas Channel Quarries

Figures 16-17

**BALANCED ROCK QUARRY** (fig. 16, no. 77): On the southwest end of a ridge between canyons west center of the W  $\frac{1}{2}$ , NW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 26, T. 34 N, R. 25 W, Cherry County, Nebraska.

**REPOSITORY OF FOSSILS:** F:AM Collection has at least 100 specimens. No field numbers were assigned in 1931 to this collection.

**HISTORY:** Discovered by R. L. Mefferd and Skinner July 22, 1931. This was the first of the Xmas Channel quarries. Although not unusually productive its discovery led indi-

rectly to the discovery of the Xmas Quarry five months later. A rare find was the postcranial elements of a camel skeleton just below the main part of the quarry in the underlying Cap Rock Member.

REMARKS: The Xmas channel extends eastward from the Xmas Quarry through the Balanced Rock Quarry, and its trend eastward through the Hans Johnson Quarry is postulated.

MACHAERODUS QUARRY (fig. 16, no. 78): The main quarry is on the southeast side of a small isolated knob on a south facing outcrop in the SW corner of SE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 27, T. 34 N, R. 25 W, Cherry County, Nebraska. An extension of this quarry is about 50 yards directly north on the north side of the saddle and faces northeast. Elevation at base of channel is 2557 ft.

REPOSITORY OF FOSSILS: F:AM Collection has 185 specimens.

HISTORY: Discovered by F. S. Ballou and Skinner November 17, 1932 and worked in 1932, 1934, and 1936.

REMARKS: Fossils occur in a channel fill cut to within 12 ft. of the base of the Cap Rock. A sample of the Machaerodus Ash taken at an elevation of about 2578 ft. was dated at  $9.95 \pm 0.8$  Ma by the fission track method by J. Boellstorff (personal commun.), Conservation and Survey Division, University of Nebraska, Lincoln (Johnson, ms.g, 1974, p. 97; Skinner, ms., vol. 1, p. 90).

XMAS QUARRY (fig. 16, no. 79): On the divide between two small canyons in SE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , sect. 27, T. 34 N, R. 25 W, Cherry County, Nebraska. Fossils were in sand deposited in a deep channel cut to an elevation of about 2540 ft. or 3 ft. above base of the Cap Rock Member (Johnson, ms.g, 1974, p. 98; Skinner, ms., vol. 1, pp. 86–87).

REPOSITORY OF FOSSILS: F:AM Collection has at least 29 catalog numbers.

HISTORY: Discovered in December 1931 by Skinner and worked in 1932, 1936, 1944, and 1965.

REMARKS: Fossils from Xmas Quarry appear to have been deposited on a point bar. Most of the specimens were found on the inside (north side) of a deep channel cut that was filled with coarse blocks of Cap Rock.

The Xmas Quarry has clean, well-sorted

quartz sand containing a concentration of almost pure garnet sand from which nearly a quart of garnets was pan washed. Other paleochannels in northern Nebraska and southern South Dakota known to be rich in garnets are exposed in the Rosebud Gravel Pit just west of the town of Rosebud, and in the Thin Elk Formation of Harksen and Green (1971, p. 3), near Mission, South Dakota. These occurrences imply a source in the garnet schists of the Black Hills Uplift which apparently contributed sediments to paleostreams trending to the southeastward.

The types of *Serbelodon barbourensis* Frick and *Parablastomeryx gregorii* Frick were collected here. Skinner and MacFadden (1977, pp. 912–926) recognized the presence of *Cormohipparion occidentale* in the Xmas and Hans Johnson quarries. Leidy's (1856, 1869) type of *C. occidentale* (ANSP 11287) closely resembles F:AM 71800 and 71801 from Xmas Quarry.

#### Kat Channel Quarries

Figures 16–17

Fossils were collected from eight quarries in sand-filled channel cut through the lower part of the Merritt Dam Member into the Cap Rock Member. The Kat Channel has been traced from *Leptarctus* Quarry to at least the East Kat Quarry (fig. 16).

Although the exact relationship between the Kat and Xmas channels has not been determined, they probably represent one channel system in the Merritt Dam Member in this area.

CONNECTION KAT QUARRY (fig. 16, no. 80): On north side of the head of a small canyon in the SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 27, T. 34 N, R. 25 W, Cherry County, Nebraska.

REPOSITORY OF FOSSILS: F:AM Collection has 43 specimens.

HISTORY: Discovered by Skinner, R. L. Mefferd, and Fletcher October 14, 1936, and worked that year.

EAST KAT QUARRY (fig. 16, no. 81): On east side of a canyon in NE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 26, T. 34 N, R. 25 W, Cherry County, Nebraska.

REPOSITORY OF FOSSILS: F:AM Collection has 152 specimens.

**HISTORY:** Discovered by Skinner and party May 6, 1936, and worked that summer.

**REMARKS:** Type locality of *Pseudoceras skinneri* Frick.

**HANS JOHNSON QUARRY** (fig. 16, no. 82): At the head of a small canyon in SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 26, T. 34 N, R. 25 W, or  $1\frac{1}{2}$  mi. E and  $3\frac{3}{8}$  mi. S of Sparks Post Office and General Store, Cherry County, Nebraska.

**REPOSITORY OF FOSSILS:** F:AM Collection has 167 specimens.

**HISTORY:** Discovered by R. L. Mefferd and Skinner July 23, 1931, and worked in 1931, 1934, and 1936.

**REMARKS:** Quarry in channel sand deposited in cut incised into Cap Rock Member, but it could not be determined on field evidence whether it represents the easternmost extension of the Kat Channel. This is the type locality of *Pseudoceras potteri* Frick.

**KAT QUARRY** (fig. 16, no. 83).<sup>13</sup> On east side of a small canyon in NE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 27, T. 34 N, R. 25 W, Cherry County, Nebraska. Elevation at base of quarry 2554 ft. (Johnson, ms.g, 1974, p. 99); Skinner, ms., vol. 9, p. 88; vol. 1, p. 90).

**REPOSITORY OF FOSSILS:** F:AM Collection.

**HISTORY:** Discovered by R. L. Mefferd and Skinner on July 17, 1931 and worked in 1931, 1932, 1934, and 1936.

**REMARKS:** The base of the channel cut is 14 ft. above base of the Cap Rock Member.

**LEPTARCTUS QUARRY** (fig. 16, no. 84): At head of a canyon near center of north line of NE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 28, T. 34 N, R. 25 W, Cherry County, Nebraska. Elevation at base 2559 ft. (Johnson, ms.g, 1974, p. 100; Skinner, ms., vol. 9, p. 40).

**REPOSITORY OF FOSSILS:** F:AM Collection has 409 specimens; UCMP has several specimens.

**HISTORY:** Discovered by R. L. Mefferd and Skinner July 30, 1932 and worked in 1932 and 1936.

**REMARKS:** *Leptarctus* Quarry is the type locality of *Barbourofelis morrisi* Schultz,

Schultz, and Martin, and *Cranicoeras granti* Frick. Most of its large fauna remains to be studied.

**LINE KAT QUARRY** (fig. 16, no. 85): On east side of a canyon near center of SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 26, T. 34 N, R. 25 W, Cherry County, Nebraska. Elevation at base 2558 ft. (Johnson, ms.g, 1974, p. 100).

**REPOSITORY OF FOSSILS:** F:AM Collection has 19 specimens.

**HISTORY:** Discovered by Skinner and party on June 30, 1932. Worked in 1936, 1938, and 1950.

**REMARKS:** This is one of the best sections (fig. 17) to show the stratigraphy of the Kat Channel quarries and their relationship to the Cap Rock Member (Skinner, ms., vol. 1, p. 91).

**QUARTER LINE KAT QUARRY** (fig. 16, no. 86): On south side of a small canyon in SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 26, T. 34 N, R. 25 W, Cherry County, Nebraska.

**REPOSITORY OF FOSSILS:** F:AM Collection has 101 specimens.

**HISTORY:** Discovered by Skinner and party July 20, 1936, and worked that year.

**TRAILSIDE KAT QUARRY** (fig. 16, no. 87): On south side of trail at head of a small canyon in NE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 27, T. 34 N, R. 25 W, Cherry County, Nebraska.

**REPOSITORY OF FOSSILS:** F:AM Collection has 47 specimens.

**HISTORY:** Discovered by G. K. Fletcher, R. L. Mefferd, and Skinner September 26, 1936, and worked that year. A horse skull (F:AM 107664) from this quarry is referred to *Hipparion tehonense*.

**WEST LINE KAT QUARRY** (fig. 16, no. 88): Situated in a side gully on west side of canyon in SE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 27, T. 34 N, R. 25 W, Cherry County, Nebraska.

**REPOSITORY OF FOSSILS:** F:AM Collection has about 213 specimens.

**HISTORY:** Discovered by Skinner and party on July 31, 1936.

#### QUARRIES IN WESTERN CHERRY COUNTY IN THE ASH HOLLOW FORMATION

Four quarries, Bear Creek, Eli Ash Pit, Galup Gulch, and Mensinger (with reservations), are assigned to the Merritt Dam Mem-

<sup>13</sup> First called "Cat Quarry" because a jaw of *Barbourofelis* was discovered there, Frick asked that the spelling be changed to "Kat" to avoid an interpretation of relationship with living felids.

ber. Bolling and Garner quarries, however, could not be assigned definitely to a member in the stratigraphic section because of the complex deposition of sediments on parts of the east flank of the Chadron Arch. Relative stratigraphic position, however, indicates that Bolling and Garner quarries are in the Ash Hollow Formation and are thus designated as Ash Hollow Formation undifferentiated.

#### Quarries in the Merritt Dam Member:

**BEAR CREEK QUARRY** (fig. 21, no. 89): On a point between two short south branching gullies at head of a small canyon on south side of Bear Creek 2 mi. above its mouth. Near center of NW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 36, T. 34 N, R. 35 W, Cherry County, Nebraska. Eli Quadrangle 1952. Air photo CAM-14-P-181 dated 10-15-55. Elevation at base of quarry about 3013 ft.

**REPOSITORY OF FOSSILS:** F:AM Collection contains at least 258 specimens.

**HISTORY:** Discovered July 14, 1934 by G. K. Fletcher of Skinner's field party. Worked in 1934, 1937, 1949, 1952, 1961, and 1972.

**REMARKS:** Bear Creek Quarry is in about 30 ft. of channel fill incised to within 7 ft. of the base of the Cap Rock (Johnson, ms.f, 1972, pp. 61–62; Skinner, ms., vol. 3, pp. 24–27). The type of *Longirostromeryx merriami* Frick was collected here.

This quarry is 1½ mi. N, 35°E of the Warren-Hayden campsite of October 15–19, 1857 shown on Snowden's map (Warren, ms., 1857; Snowden, ms.a, ms.b, 1857). The Snowden surveying party had been in the same camp for two days prior to the arrival of Warren, Hayden, and the remainder of the 1857 Military Expedition along the Niobrara River. A careful plotting of their route indicates that they could have passed within 100 yards west of Bear Creek Quarry before crossing Bear Creek on October 19, 1857 (Warren, *ibid.* and Snowden, *ibid.*). Hayden, or other members of the expedition, possibly collected fossils here or in the general vicinity while they were camped.

**ELI ASH PIT** (fig. 21, no. 90): On north side of Bear Creek inside of a U-shaped bend of the creek in NW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 28, T. 34 N, R. 35 W, Cherry County, Nebraska. Eli Quadrangle 1952. Air photo CAM-14P-183 dated 10-15-55. Elevation of quarry about 3078 ft.

**SYNONYM:** Also Prospecting Locality No. 500 in F:AM records.

**REPOSITORY OF FOSSILS:** F:AM Collection has 62 specimens.

**HISTORY:** Discovered by Skinner and party July 30, 1952 and collections made intermittently through 1961.

**REMARKS:** This site was a borrow pit of the Nebraska State Highway Department. Specimens were exposed by wind erosion of about 10 ft. of vitric tuff after the pit was abandoned. A palate referred to *Neohipparion affine* (F:AM 108236) was collected here.

Stratigraphically assigned to the lower part of the Merritt Dam Member:

**GALLUP GULCH QUARRY** (fig. 20, no. 91): On north side of head of Gallup Gulch near center of the W  $\frac{1}{2}$ , SW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , sect. 24, T. 33 N, R. 38 W, or 7 mi. south, 2¼ mi. west of Merriam, Cherry County, Nebraska. Merriam Quadrangle 1951. Air photo CAM-13P-81 dated 10-12-55. Elevation at base of quarry about 3160 ft. (Johnson, ms.f, 1972, pp. 77–79).

**REPOSITORY OF FOSSILS:** F:AM Collection has 530 specimens.

**HISTORY:** Discovered in 1962 by Ted Galusha and worked in 1962 and 1963 (Galusha, ms.b, 1962, pp. 63–89).

**REMARKS:** About 145 ft. above the Niobrara River and 90 ft. above an active spring. The quarry is at the base of a 19-ft. bed of channel sand overlain by at least 11 ft. of ash and sandy ash (Skinner, ms., vol. 9, pp. 28–29). The fauna from this quarry is similar to other quarries in the Merritt Dam Member.

On the southwest side of the gulch, a short distance downstream from a spring, additional fossils were collected in 1972 from the basal part of a massive, friable, poorly sorted sandstone containing irregularly dispersed pebbles (pudding sandstone) at an elevation of about 3088 ft. This is 34 ft. above the water level of the brook immediately below the site, or 18 ft. above the level of the spring located at the head of the gulch upstream from the site. Among the fossils from here are a palate of *Martes* sp. (F:AM 112550) and a ramus of *Carpocyon robustus* ref. (F:AM 107858). This site may be at (or close to) the same lithostratigraphic level as Galusha's (ms.b, 1962) Gallup Springs Prospect on the northeast side of the gulch.

Sediments in this canyon are characteristic of those in the deep cut and fill complex in the Ash Hollow Formation at other localities on the east flank of the Chadron Arch.

**MENSINGER QUARRY** (fig. 20, no. 92): On a prominent south facing bluff on north side of Niobrara River in northern part of the S  $\frac{1}{2}$  of NW  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 29, T. 33 N, R. 37 W, Cherry County, Nebraska. Merriman Quadrangle 1951. Air photo CAM-13-P-81 dated 10-12-55. Base of quarry at approximate elevation of 3120 ft.

**REPOSITORY OF FOSSILS:** F:AM Collection has 72 specimens.

**HISTORY:** Discovered July 18, 1952 by Skinner and party and worked in 1952, 1955, and 1972.

**REMARKS:** This site is in the area of a deep cut and fill complex on the east flank of the Chadron Arch. At least 150 ft. of the 155 ft. of sediments exposed are referred to the Ash Hollow Formation. The quarry is in channel sand immediately underlying a thin tuffaceous sand and is associated with blocks of laminated vitric tuff. The quarry is placed, tentatively, in the Merritt Dam Member. The basal 25 ft. of the Ash Hollow is in a channel cut into 30 ft. of yellow gray sand referred to the Valentine Formation (possibly Devil's Gulch Member) (Skinner, MS., vol. 4, p. 86).

Johnson (MS.f, 1972, p. 57) measured a section at this site and found the base of the quarry at 140 ft. (elevation 3140 ft.), which is 20 ft. more than measured by Skinner in 1955. Obviously, one of us is in error, and unfortunately we have been unable to check our measurements at the site. Also, Johnson recorded 171 ft. of Tertiary instead of the 155 ft. shown on Skinner's section, which is reproduced on figure 31, section 13.

Undifferentiated quarries in Ash Hollow:

**BOLLING QUARRY** (fig. 21, no. 93): On small divide between two northernmost gullies in western part of SW  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , sect. 34, T. 34 N, R. 35 W, Cherry County, Nebraska. Eli Quadrangle 1952. Air photo CAM-14P-58.

**REPOSITORY OF FOSSILS:** F:AM Collection has 99 specimens.

**HISTORY:** Discovered November 22, 1939 by Skinner and G. K. Fletcher. Worked in 1939, 1941, 1952, and 1972.

**REMARKS:** Bolling Quarry is in a local chan-

nel sand (sect. 17 on fig. 39) in the lower part of the Ash Hollow Formation immediately below an ash layer and about 8 ft. above a sandstone which may be in the Devil's Gulch Member of the Valentine Formation (Johnson, MS.f, 1972, p. 68; Skinner, MS., vol. 4, p. 84).

**GARNER QUARRY** (fig. 21, no. 94): On south side of first east-west ravine on north side of Niobrara River at approximate center of east line of NW  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 3, T. 33 N, R. 35 W, Cherry County, Nebraska. Garner Quarry is about  $1\frac{3}{8}$  mi. west of the Warren-Hayden Camp of October 15-19, 1857 (Snowden, MS.a, 1857). Eli Quadrangle 1952. Air photo CAM-14P-58. Elevation of quarry about 3010 ft.

**REPOSITORY OF FOSSILS:** F:AM Collection has 21 specimens.

**HISTORY:** Discovered July 11, 1952 by Skinner and M. F. Skinner, Jr., and worked only that year.

**REMARKS:** Garner Quarry appears to be slightly younger in age than Bolling Quarry, on the basis of its relative stratigraphic position (sect. 74 on fig. 39). Excavation did not reach the base of the channel (Johnson, MS.f, 1972, p. 67; Skinner, MS., vol. 4, p. 85).

#### SOUTH DAKOTA QUARRIES IN THE VALENTINE-ASH HOLLOW FORMATIONS UNDIFFERENTIATED

Big Springs Canyon, Hollow Horn Bear, Joe Thin Elk, and the Rosebud Agency quarries are in sediments referred to the Ash Hollow Formation. The source of the sediments in these quarries may be, at least partially, from a paleodrainage system with a source in the Black Hills (fig. 42). They are 26 to 32 mi. north of the Niobrara River and 10 to 20 mi. north of the Nebraska-South Dakota state line. These quarries have yielded significant assemblages of fossils that are now in the Frick Collection and other institutions. The present paper does not give a detailed stratigraphic study of the sediments exposed in the vicinity of the Little White River and the Rosebud Reservation.

Skinner and Taylor (1967, pp. 8-13, fig. 1) showed the undifferentiated Valentine-Ash Hollow formations on the Bijou Hills. Skinner, Skinner, and Gooris (1968, pp. 386-401, figs. 2-6), however, showed the Valentine-

Ash Hollow formations in stratigraphic detail on the Turtle Butte section (present paper, sect. 53 on fig. 36) as well as their type section of the Rosebud Formation and the post-Cretaceous Pierre Shale Formation.

Stratigraphic sections and specimen lists on the South Dakota quarries are on file in the Frick Archives of AMNH. Quarry descriptions are included in this paper for reference in the regional framework and future studies.

**BIG SPRING CANYON QUARRIES** (fig. 2A, no. 95): At several sites at the head of Big Spring Canyon, a tributary of the Little White River "in the eastern side of sections 5 and 8, T. 36 N, R. 39 W" according to Gregory (1942, pp. 309–310, and fig. 2 for detailed map of sites). About 10 mi. west, 4 mi. south of Martin, Bennett County, South Dakota. Elevation of principal collecting sites is just above the 3550-ft. contour in a channel sand.

**SYNONYMS:** AMNH Big Spring Canyon, F:AM Big Springs Quarry, FMNH Big Spring Quarry and UCMP Locality V-3322. Gregory (1942, fig. 2) shows numbered collecting sites on "map of Big Spring Canyon Fossil Locality."

**REPOSITORY OF FOSSILS:** F:AM Collection contains 46 specimens, AMNH has a small collection made by Matthew and Gidley and large collections are in UCMP and FMNH.

**HISTORY:** Discovered and worked by Matthew and Gidley in 1903 (1904, p. 243) for AMNH. In 1933 a UCMP field party under R. A. Stirton (ms.a, 1933, May 6) relocated the quarry sites and made a large collection of fossils during 1933, 1934, and 1936. Skinner worked the sites in Big Spring Canyon intermittently from 1938–1961, and P. O. McGrew and A. Potter collected for the FMNH in 1939. Gregory (1942, pp. 310–312) gave more information on the history of collecting in this area.

A partial skeleton of *Procamelus* and associated material was collected by Matthew and Gidley (1904, p. 243) from a sand 25–30 ft. below the channel that yielded most of the UCMP Collection.

**REMARKS:** Gregory's (1942, pp. 330–332) analysis of the faunal data (particularly the horses), led him to conclude that the fauna at Big Spring Canyon is "distinctly later than the Burge Fauna, about equivalent to the Minnechadua and probably Clarendonian and

Beaver faunas." Gregory (1942, p. 433) also thought that the fauna "from several levels in the formation" was contemporaneous. His study, however, did not include AMNH specimens, some of which came from the basal part of the section. Big Spring Canyon is the type locality of *Neophrontops dakotensis* Compton, *Aelurodon inflatus* Vanderhoof and Gregory, *Martes campestris* Gregory, *Procamelus grandis* Gregory, and *Pliauchenia magnifontis* Gregory.

Faunal evidence to date suggests that the entire section above the Arikaree at Big Spring Canyon may be referred to Ash Hollow Formation, undifferentiated (possibly Merritt Dam Member), in a regional setting similar to that along the Niobrara River on the east flank of the Chadron Arch. Additional studies may reveal that a basal portion of the section is equivalent to the Valentine Formation.

**HOLLOW HORN BEAR QUARRY** (fig. 2A, no. 96): In NE  $\frac{1}{4}$ , sect. 28, T. 37 N, R. 32 W, Todd County, South Dakota. SDGS Spring Creek Quadrangle 1960.

**REPOSITORY OF FOSSILS:** F:AM Collection contains 915 specimens.

**HISTORY:** Discovered by Skinner on May 23, 1940; 912 specimens were collected that year. Additional fossils were collected in 1952 and 1960.

**REMARKS:** Hollow Horn Bear Quarry is in a channel sand in the basal part of the Ash Hollow Formation in an area in which Sevon (1960) mapped the presence of both Ash Hollow and Valentine formations on the Spring Creek Quadrangle sheet. The fossil-bearing section at this site was overlain by 4 or 5 ft. of volcanic ash exposed during excavation. This assemblage has not been studied in detail (Skinner, ms., vol. 1, pp. 58–59).

**JOE THIN ELK GRAVEL PITS** (fig. 2B, no. 97): In SE  $\frac{1}{4}$ , sect. 26, and NE  $\frac{1}{4}$ , sec. 35, T. 40 N, R. 28 W, or 7 mi. N, 3 mi. E of Mission, Mellette County, South Dakota. Mission Quadrangle (Agnew, 1963, map and text).

**SYNONYM:** Mission Fauna of Macdonald (1960). Mission Gravel Pit.

**REPOSITORY OF FOSSILS:** F:AM Collection has 60 specimens. A larger collection is in SDSM.

**HISTORY:** This locality was brought to the attention of Skinner in 1940 who collected here intermittently through 1967. SDSM

Collection was obtained through cooperation with the gravel pit operators in section 35, a short distance southwest of the F:AM locality, but in the same sediments.

REMARKS: Fossils were scattered through a sand and gravel bed named the Thin Elk Formation by Harksen and Green (1971, pp. 1–7). This bed fills a paleochannel cut into the Rosebud Formation in sects. 26 and 35, T. 40 N., R. 28 W. Harksen and Green (*ibid.*) found an abundance of southern Black Hills minerals in the Thin Elk Formation and that “placers of garnets are common.” The evidence available at this site indicates clearly that the paleodrainage that deposited these gravels was part of a system that transported sediments from the Black Hills area.

Macdonald (1960, p. 963) who described the fauna, stated, “In general the Mission Fauna is a correlative of the Big Spring Canyon Fauna,” suggesting a fauna characteristic of the Ash Hollow Formation. Macdonald, however, observed that a jaw from the Mission Fauna, which he referred to *Tomarctus euthos* (McGrew), is almost identical with one in the Burge Fauna from which the type specimen of *T. euthos* was collected. Further evidence of the presence of fossils from an older fauna is a partial maxilla (F:AM 43134) and a partial mandible (F:AM 43133) of *Ustatotherus medius* listed by Schultz and Falkenbach (1941, p. 30) as collected here by Skinner, further suggesting a reworking of fossils from the Valentine Formation faunas at this locality or a long range mixing of taxa from several stratigraphic levels traversed by the paleostream system (Skinner, MS., vol. 1, p. 60; vol. 4, p. 73).

Macdonald (1960) described the type of *Procamelus foxi* from the Mission Fauna.

ROSEBUD AGENCY QUARRY (fig. 1A, no. 98): Situated on east side of the Rosebud-Crookston highway (as of 1935), about 1 mi. southeast of the Rosebud Dam in SE  $\frac{1}{4}$ , NE  $\frac{1}{4}$ , sect. 35, T. 38 N., R. 30 W., Rosebud, Todd County, South Dakota. Rosebud Quadrangle 1969.

REPOSITORY OF FOSSILS: F:AM Collection contains 19 specimens.

HISTORY: Discovered in 1935 by Skinner's F:AM field party.

REMARKS: This quarry occurs in a local channel sand fill in a cut shown at an ele-

vation of 2815 ft. (corrected to 2788 ft.)<sup>14</sup> on a section by Skinner, Skinner, and Gooris (1968, fig. 6) in sediments identified as “Undifferentiated Valentine-Ash Hollow equivalent.” Recent correlation studies and comparison with the cross section along the Niobrara River (fig. 32) about 2 mi. south of Rosebud indicates that the Rosebud Agency Quarry is in the basal Ash Hollow Formation about 5 ft. above the base of a massive 32-ft. bed of siliceous root-filled sandstone that may be the Cap Rock Member. This places the base of the Ash Hollow Formation on a regional strike with outcrops on the Niobrara River about 6 mi. west of the Crookston Bridge Quarry (Skinner, MS., vol. 1, pp. 146–147). A skull of *Hipparion tehonense* ref. (F:AM 107663) is among the fossils from this quarry (MacFadden, MS.).

TYPE SPECIMENS FROM THE MERRITT  
DAM MEMBER

CLASS REPTILIA  
ORDER EUSUCHIA  
FAMILY ALLIGATORIDAE

*Alligator mefferdi* Mook, 1946. (Type F:AM 7016.)  
Found by R. L. Mefferd in 1941 in *Alligator mefferdi* Quarry. Erroneously reported by Mook (1946, p. 1) as from “SE  $\frac{1}{4}$ , Sect. 5, T. 31 N., R. 30 W.” (See p. 308 for location based on air photos and USGS maps, unavailable to Mook in the 1940s.)

CLASS MAMMALIA  
ORDER CARNIVORA  
FAMILY URSIDAE

*Hemicyon barbouri* Colbert, 1941. (Type UNSM 1-26-6-28 L. & C.) Collected by A. L. Lugen and E. H. Colbert June 25, 1928, on E side of Lessig Canyon in SE  $\frac{1}{4}$ , SE  $\frac{1}{4}$ , NW  $\frac{1}{4}$ , sect. 4, T. 31 N., R. 22 W., Brown Co., Nebr. USGS Ainsworth NW Quadrangle 1954, scale 1:24,000. Colbert

<sup>14</sup> A check on the USGS Rosebud Quadrangle 1969 shows that the elevation of the bottom of the section in Skinner, Skinner, and Gooris (1968, pp. 394–395) should be 2563 ft. instead of 2610 ft., which was estimated from USGS 1:250,000 scale Martin Quadrangle, 1958. Also, through a drafting error, about 20 ft. of section were omitted from the published section. These revisions place the Rosebud Quarry at an elevation of 225 ft. above the base of the section or approximately at 2788 ft.

(1941, p. 51) erroneously gave the type locality as Dutch Creek Canyon. Lugn (ms.a, pp. 8, 11–12) and Skinner (ms., vol. 1, p. 145) documented that the specimen came from Lessig Canyon in white marly layer 30 ft. above base of Merritt Dam Member.

#### FAMILY CANIDAE

*Cynarctus crucidens* Barbour and Cook, 1914. (Type UNSM 25465.) Collected by A. C. Whitford in 1913 from Williams Canyon, Brown Co., Nebr. (Barbour and Cook, 1914, p. 225). This is now Quinn Canyon. The record is not clear but Whitford (ms.a, 1913, pp. 118–119) inferred that the specimen was from his Quarry No. 2, on the east side of the canyon "about ¼ mile from head of canyon" which places it about SE of Quinn Mastodon Quarry in SW ¼, SE ¼, sect. 5, T. 31 N, R. 22 W. Whitford stated that Quarry No. 2 "was at the base of the sand layer next to the greenish hard sandy clay. The bones, mostly teeth and jaws, with a few leg bones . . . were in pockets of coarse sand in the clay." Whitford's use of the term "jaws" suggests that he was referring to the jaws of both *Cynarctus crucidens* and *Barbourofelis whitfordi*.

#### FAMILY PROCYONIDAE

*Lichnocyon phoenix* Baskin, 1982. (Type n.g. et sp. F:AM 25210.) Collected by M. F. Skinner from East Clayton Quarry, Brown County, Nebraska.

#### FAMILY NIMRAVIDAE

*Barbourofelis whitfordi* (Barbour and Cook), 1915. (Type UNSM 7-2-11-13.) Right ramus collected by A. C. Whitford, probably on August 10, 1913 (Whitford, ms.a, 1913, pp. 118–119). Barbour and Cook (1914b, pp. 235–238, pl. 1) gave only Brown County as the locality.

*Barbourofelis morrissi* Schultz, Schultz, and Martin, 1970. (Type F:AM 79999.) Skull collected by M. F. Skinner in 1936 from the *Leptarctus* Quarry.

We believe that *B. whitfordi* is also from Quarry No. 2 in Williams Canyon (see *Cynarctus crucidens*) and that the sand at Quarry No. 2 is equivalent to the section at the Clayton quarries at the base of the Merritt Dam Member. In 1980 a carton was found in UNSM containing miscellaneous specimens from Whitford's Quarry No. 2 in Williams Canyon (=Quinn Canyon) that had isolated teeth of *Griphippus gratus*, fossilization

of which is comparable to that of the type of *B. whitfordi*. These fossils suggest that they came from a channel pocket in the base of the Merritt Dam Member.

No *Barbourofelis* limbs or dentition have been found in the more than 6000 specimens from the Burge Member in the present study area, whereas *Barbourofelis* occurs in Clayton and East Clayton quarries at the base of the Merritt Dam Member.

A left ramus of *B. whitfordi* (F:AM 61858) from Clayton Quarry and a right ramus (F:AM 61857) from East Clayton Quarry are morphologically similar to the type of *B. whitfordi*, adding support to our interpretation.

#### ORDER PROBOSCIDEA

##### FAMILY GOMPHOTHERIIDAE

*Serbelodon barbourensis* Frick, 1933. (Type F:AM 25730.) Collected by M. F. Skinner in 1932 from Xmas Quarry.

*Torynobelodon barnumbrowni* Barbour, 1931. (Type UNSM 1-10-7-31.) Found by P. O. McGrew on June 21, 1931. See *Platybelodon* Quarry (p. 309, quarry 72 on sect. 61, fig. 38).

#### ORDER PERISSODACTYLA

##### FAMILY TAPIRIDAE

?*Tapirus johnsoni* Schultz, Martin, and Corner, 1975. (Type UNSM 1096.) G. Meade, C. Osborne, and F. W. Johnson found the partial left ramus of the type mandible June 19, 1933, on talus 2 ft. above the Cap Rock Member. Johnson and K. Rathbun recovered the right ramus and partial left ramus 12 ft. above the Cap Rock Member June 28, 1935. T. M. Stout and Johnson recovered the symphysis and remaining fragments August 8, 1935. From UNSM Cr-104, N side of small box canyon, S side of Steer Creek near NW corner SE ¼, SE ¼, sect. 29, T. 32 N, R. 30 W, Cherry County, Nebraska (sect. 63 on fig. 23). USGS Kennedy Quadrangle 1950, scale 1:62,500. Photo CAM-1P-65 dated 8-22-55. From unconsolidated channel sand cut into top of Cap Rock Member (fig. 38, sect. 63).

#### ORDER ARTIODACTYLA

##### FAMILY GELOCIDAE

*Pseudoceras skinneri* Frick, 1937. (Type F:AM 33723.) Found by M. F. Skinner in 1936 in East Kat Quarry.

*Pseudoceras wilsoni* Frick, 1937. (Type F:AM



31561.) Found by M. F. Skinner in 1933 in Jonas Wilson Quarry.

*Pseudoceras potteri* Frick, 1937. (Type F:AM 33722.) Found by M. F. Skinner in Hans Johnson Quarry.

#### FAMILY MOSCHIDAE

*Blastomeryx (Parablastomeryx) gregorii* Frick, 1937. (Type F:AM 31360.) Found by M. F. Skinner in 1932 in Xmas Quarry.

*Longirostromeryx merriami* Frick, 1937. (Type F:AM 32405.) Found by M. F. Skinner in 1934 in Bear Creek Quarry.

#### FAMILY DROMOMERYCIDAE

*Cranioceras granti* Frick, 1937. (Type F:AM 32064.) Found by M. F. Skinner in 1936 in Leptarctus Quarry.

#### FAMILY ANTILOCAPRIDAE

*Plioceros dehlini* Frick, 1937. (Type F:AM 32101.) Found by M. F. Skinner in 1954 on E side Snake R., near S line SE corner, sect. 32, T. 32 N, R. 30 W, Cherry County, Nebraska. Kennedy Quadrangle 1950, scale 1:62,500. From 16 ft. above base of Merritt Dam Member and 6 ft. below ash bed in Mizner section (sect. 62 on fig. 38). Section in Skinner (ms., vol. 1, pp. 74–75).

*Plioceros floblairi* Frick, 1937. (Type F:AM 31570.) Found by M. F. Skinner on point between E and W branches of Deep Creek in N ½, NE ¼, NE ¼, sect. 11, T. 31 N, R. 23 W, Brown County, Nebraska. Ainsworth NW Quadrangle 1954. In massive soft sand at elevation of 2427 ft. or 30 ft. above base of Merritt Dam Member (Skinner, ms., vol. 1, pp. 50–51).

#### TYPE SPECIMENS FROM THE ASH HOLLOW UNDIFFERENTIATED OF SOUTH DAKOTA

#### CLASS AVES

#### ORDER ACCIPITRIFORMES

#### FAMILY ACCIPITRIDAE

*Neophrontops dakotensis* Compton, 1935. (Type UCMP 30942.) Collected in 1934 by UCMP field party under R. A. Stirton in "Big Spring Canyon, on the Ed. Ross Ranch, 15 miles southwest of Martin, Bennett County, South Dakota."

#### CLASS MAMMALIA

#### ORDER INSECTIVORA

#### FAMILY TALPIDAE

*Domninoidea riparensis* Green, 1956. (Type SDSM 53107.) Type locality SDSM 5334 in NE ¼, NE

¼, SW ¼, sect. 15, T. 35 N, R. 44 W, Shannon County, South Dakota. Sandstones and ash (Green, 1956, pp. 149–154).

#### ORDER CARNIVORA

#### FAMILY CANIDAE

*Aelurodon inflatus* VanderHoof and Gregory, 1940. (Type UCMP 32328.) In the UCMP Collection from "Big Spring Canyon, 10 mi. west and 4 mi. south of Martin, South Dakota, Lower Pliocene age" (VanderHoof and Gregory, 1940, p. 154).

#### FAMILY MUSTELIDAE

*Martes campestris* Gregory, 1942. (Type UCMP 32314.) In the UCMP Collection from Big Spring Canyon, South Dakota.

*Pliogale manka* Green, 1956. (Type SDSM 5372.) Type locality SDSM V5326 in SE ¼, NW ¼ sect. 21, T. 35 N, R. 43 W, Sheridan County, Nebraska. From "an ash and sandstone exposure, just over the South Dakota boundary. *Tes-tudo*, *Pliogale*, *Nannippus*, *Pliohippus*, *Meryc-hippus*" (Green, 1956, pp. 148–149, 157–158).

#### ORDER PERISSODACTYLA

#### FAMILY EQUIDAE

*Neohipparion whitneyi* Gidley, 1903. (Type AMNH 9815.) Collected by H. C. Wells of the William C. Whitney Expedition of 1902 led by J. W. Gidley. The locality from which the skeleton of the type and parts of several other skeletons of *N. whitneyi* were collected is "four miles west of Rosebud Agency" according to Gidley (ms., 1902). A photo opposite page 28 in the 1903 Annual Report of AMNH shows the site from which *N. whitneyi* was collected. This photo, 18047 in the AMNH photo collection, carries the caption "camp on Indian trail 5 mi. west of Rosebud Agency, So. Dak." Photos 18050 and 18051 show partially excavated skeletal material at this locality. The discrepancy on the record has not been resolved but it should be possible to relocate the site in the field using photograph 18047 as a guide. While the section from which this horse was collected is assigned to the Ash Hollow Formation undifferentiated, further investigation of the site may determine that it is from the Merritt Dam Member.

#### ORDER ARTIODACTYLA

#### FAMILY CAMELIDAE

*Procamelus grandis* Gregory, 1939. (Type UCMP 32864.) In the UCMP Collection from Big Spring Canyon, South Dakota.

*Procamelus foxi* Macdonald, 1960. (Type SDSM 53251.) From a SDSM Collection made under the direction of J. R. Macdonald. Type was collected from the Fox sand pit locality; V5314, on the "Thomas Fox ranch in the NW ¼ of the NE ¼ of Section 35, T. 40 N, R. 28 W, Mellette County, South Dakota." This is from the same sand as the type locality of the Thin Elk Formation (Harksen and Green, 1971). Macdonald (1960, p. 963) correlated his Mission fauna from the Thin Elk Formation with the Big Spring Canyon fauna.

*Procamelus dakotensis* Green, 1956. (Type SDSM 5281.) Type locality SDSM "V527 in SW ¼, SW ¼, Sect. 16, T. 35 N, R. 43 W. Shannon County, South Dakota. Clean white loosely consolidated volcanic ash in a small canyon on the south side of the creek the entrance of which is almost directly opposite V525. *Neohipparion*, *Pliohippus*, *Teleoceras*, *Procamelus*" (Green, 1956, pp. 148, 162–165).

*Pliauchenia magnifontis* Gregory, 1939. (Type UCMP 33014.) In the UCMP Collection from Big Spring Canyon, South Dakota.

## PALEOGEOMORPHOLOGY AND DEPOSITION OF THE VALENTINE AND ASH HOLLOW FORMATIONS

In a classical study W. D. Johnson (1901, p. 626) described the sediments now known as Ogallala Group of the Great Plains as a "debris apron" that covered pre-Ogallala topography with a great mass of sediments deposited by streams that flowed eastward from the Rocky Mountains. The debris apron consists of a vast system of intercoalescing alluvial fan deposits that extended from southern Texas and eastern New Mexico northward across Oklahoma and Kansas, northeastern Colorado and southeastern Wyoming, and a broad section of Nebraska into south-central and southeastern South Dakota (Seni, 1980, fig. 1; Frye and Leonard, 1959, fig. 1; this paper, fig. 1).

Marsh (1875, p. 52) thought these sediments were deposited in "A great Pliocene lake" and named the extensive area in which they occur "the Niobrara basin."

The nature of these alluvial fans is best known in northwestern Texas where Seni (*ibid.*, figs. 11, 14), using data from 15,000 water wells drilled into the Ogallala, has mapped three lobes of coalescing alluvial fans with various interchannel lake deposits in the area from south of Lubbock northward to the Texas-Oklahoma boundary. Seni's work serves as a well-documented model of Ogallala sedimentation that may be applied to other parts of the Great Plains.

A comprehensive study has not been made

of the geometry of paleodrainages and depositional history of the Ogallala Group in Nebraska. It is postulated, however, that overlapping and coalescing fans or lobes of fluvial sediments similar to those mapped in Texas, but differing in detail, formed the depositional framework of the Ogallala Group in Nebraska. Following the above premise, the Niobrara River cuts a slice through one or more of these lobate fan deposits in a line which may be approximately parallel to the easterly flowing drainage systems that existed during the deposition of the Ogallala Group in north-central Nebraska.

**VALENTINE DEPOSITION:** The Valentine Formation of north-central Nebraska was deposited on a dissected surface ranging from steep-sided valleys and outliers of older formations on an eastward tilting plain of moderately low relief on which erosion had exposed Pierre Shale of Cretaceous age, and sediments of the Arikaree and Hemingford groups. Along the old and deeply eroded Chadron Arch additional uplift and regional eastward tilting occurred during the late Hemingfordian which induced degradation. Such activity was declining when Valentine sedimentation began. Volcanism associated with mountain building in the western states continued, however, during the earliest Valentinian as shown by the presence of the Hurlbut Ash and the abundance of volcanic

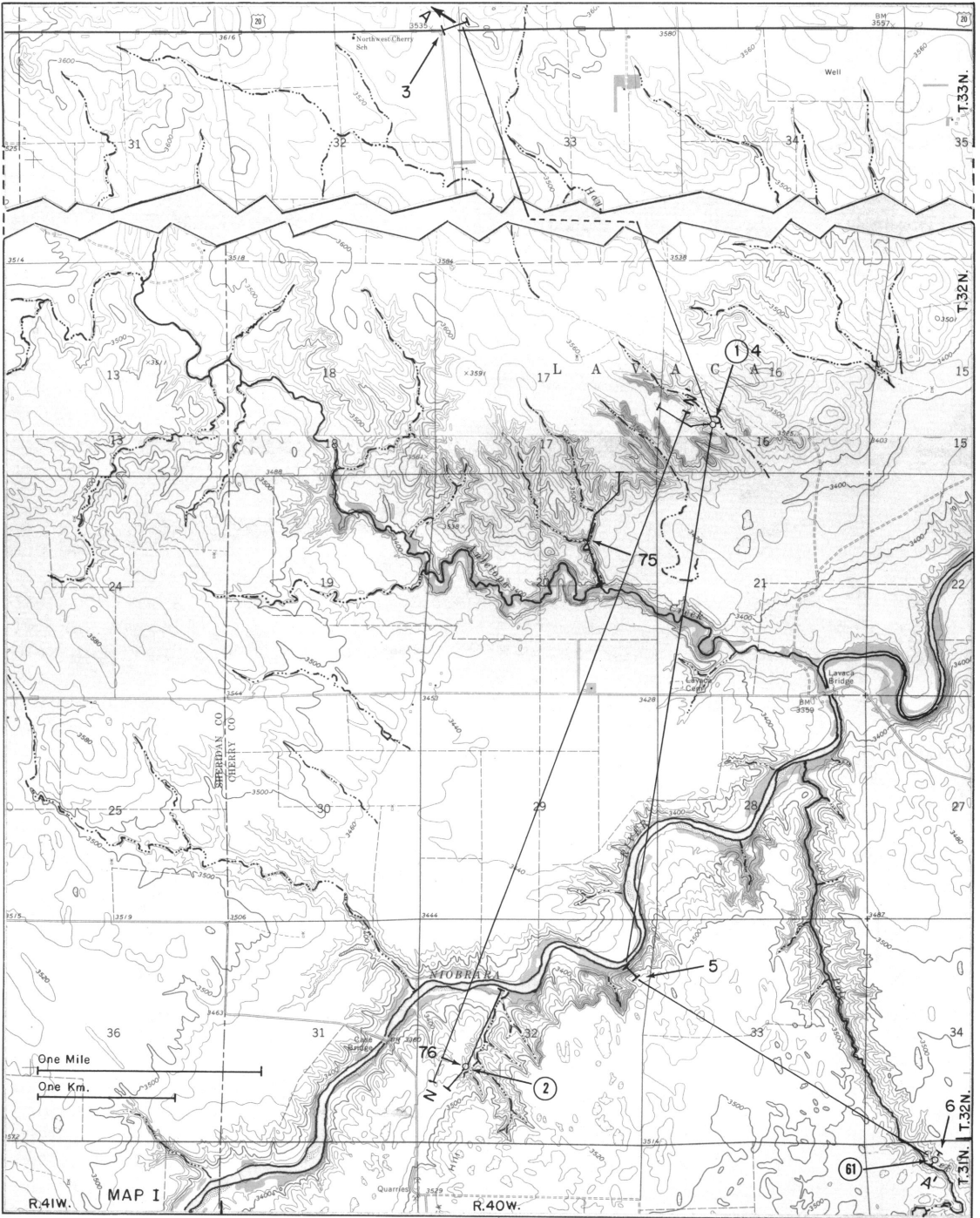


FIG. 18. Map I, *Aletomeryx* Quarry area, western Cherry County, Nebraska. Identity of quarries (in circles): 1, *Aletomeryx*; 2, 2 mi. W of Pole Creek; 61, Timm Ranch. Identity of sections: 3, Hwy. 20; 4, *Aletomeryx* Quarry; 5, SW of mouth of Antelope Creek; 75, Antelope Creek; 76, 2 mi. W of Pole Creek. See sections on figure 30.

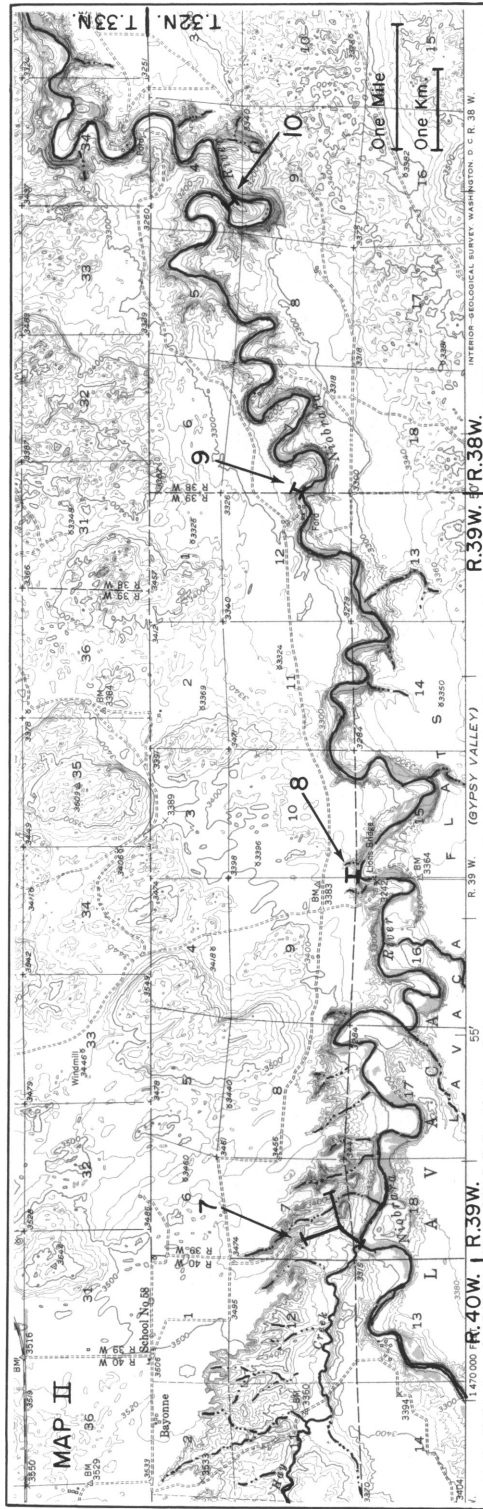


FIG. 19. Map II, La Vaca flats area, Cherry County, Nebraska. Identity of sections: 7, mouth of Hay Creek; 8, Lions Bridge; 9, Thayer Ranch; 10, the Loop. See sections on figure 31.

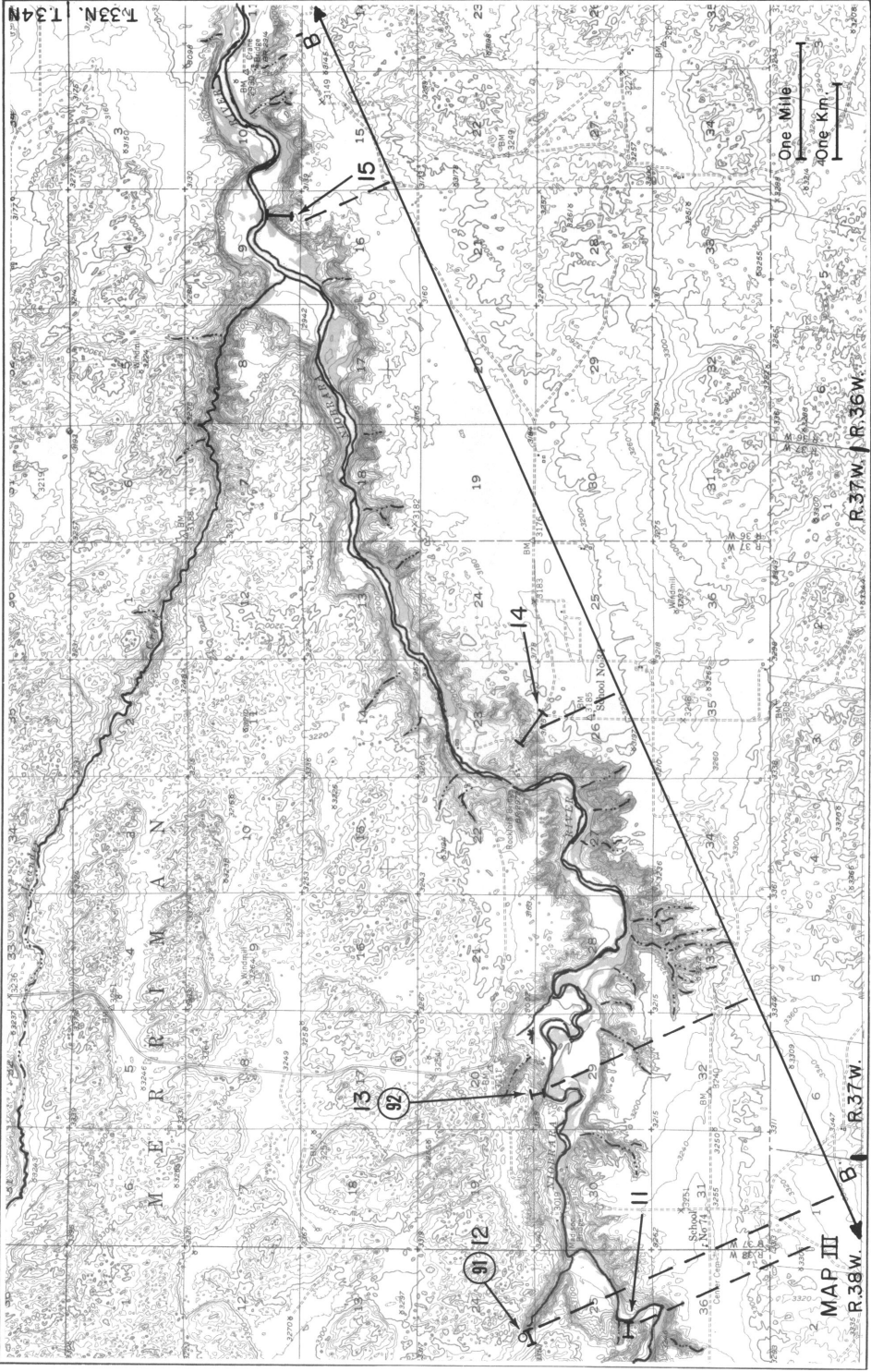


FIG. 20. Map III, vicinity of Madison and Rockford bridges and Leander Creek, Cherry County, Nebraska. Identity of quarries: 91, Gallup Gulch; 92, Mensinger. Identity of sections: 11, Beaver Bluff; 12, Mensinger Quarry; 14, Rockford Bridge; 15, Leander Creek. See sections on figure 31.



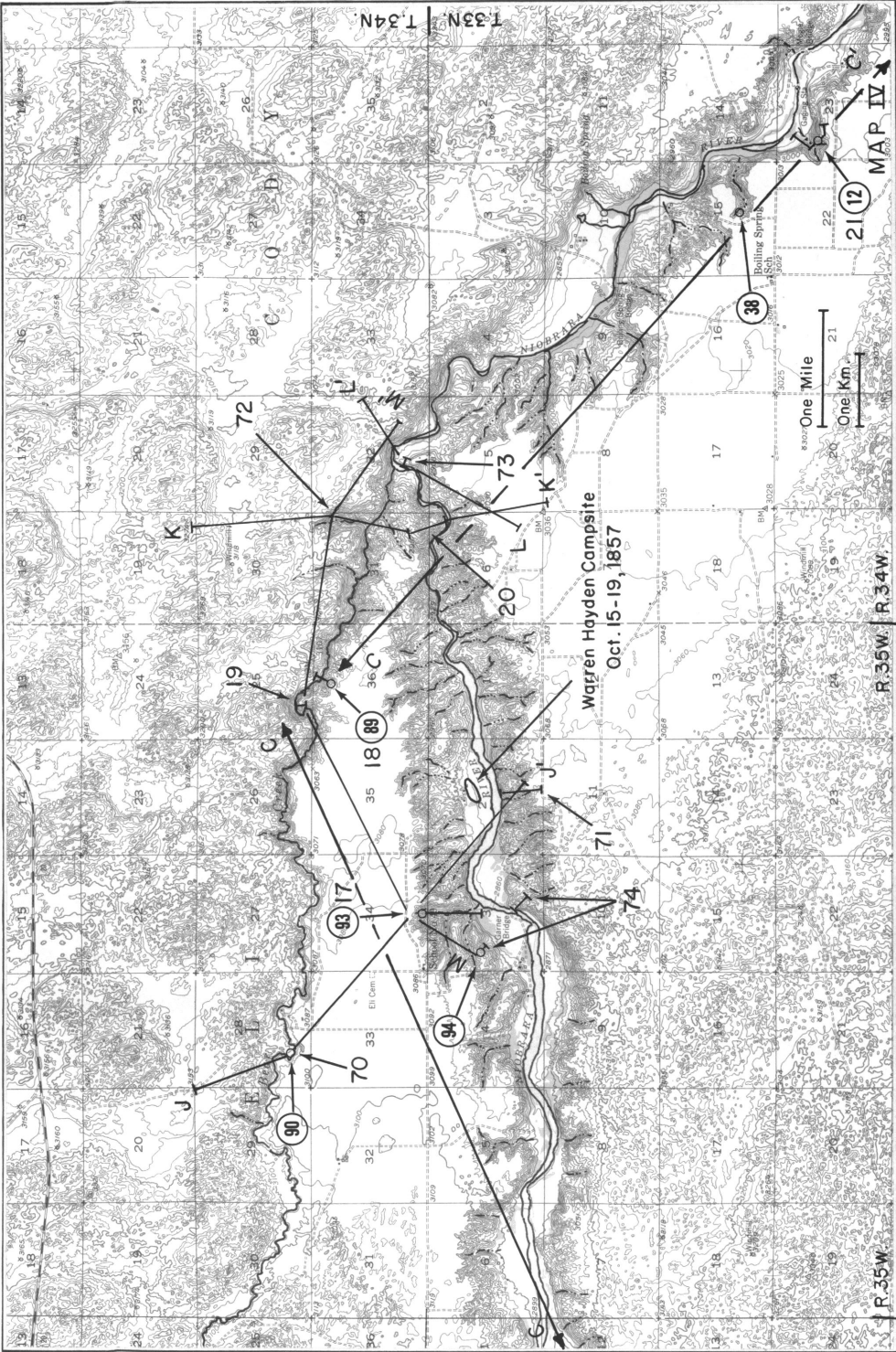


FIG. 21. Map IV, mouth of Bear Creek, Cherry County, Nebraska. Identity of quarries: 12, Devil's Jump Off; 38, Ewert; 89, Bear Creek; 90, Eli Ash Pit; 93, Bolling; 94, Garner. Identity of sections: 17, Bolling; 18, Bear Creek; 19, Warren Crossing; 20, above mouth of Bear Creek; 21, East Devil's Jump Off. Section 20 is projected to line L-L'. See sections on figures 32 and 39.

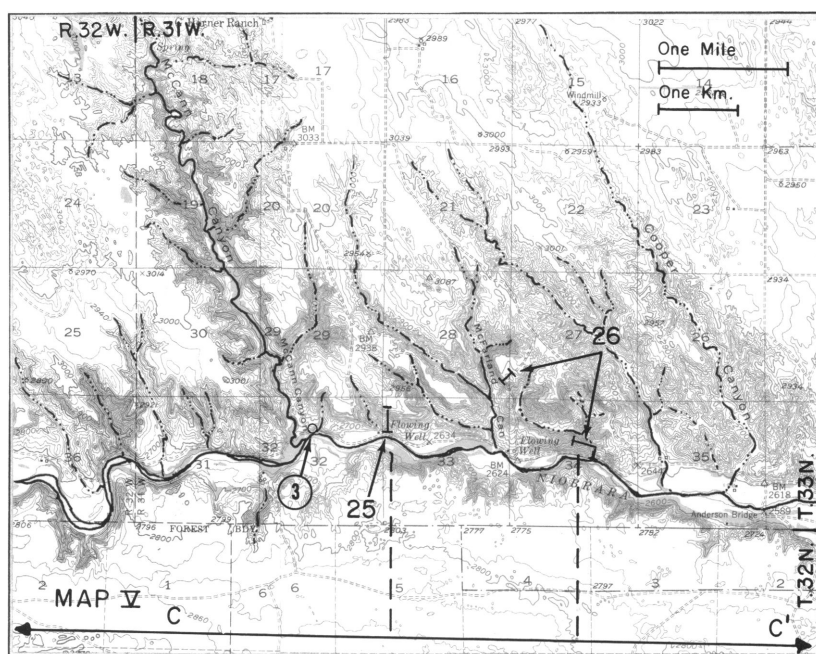


FIG. 22. Map V, McCann Canyon and Kilgore floral locality, Cherry County, Nebraska. Identity of quarries: 3, McCann Canyon. Identity of sections: 25, Olson Ranch; 26, Kilgore Flora. See sections on figure 32.

ash shards in the Cornell Dam Member of the Valentine Formation.

At least 162 ft. (figs. 33–34) of siltstone, sandstone, and basal channel sands of the Cornell Dam Member were deposited before they were removed over much of the area by degradation that again exposed the underlying Rosebud and Pierre Shale in many places. As a result, the Crookston Bridge Member rests successively (east to west) on the Pierre Shale, Rosebud Formation, and the Cornell Dam Member in Brown, Keya Paha, and eastern Cherry counties. On the east flank of the Chadron Arch (fig. 31) the Crookston Bridge Member is underlain by sediments of Arikareean age.

The widespread occurrence in the Crookston Bridge Member of predominantly fine to medium-grained unconsolidated channel sand, local beds of massive sandstone containing silicified roots and occasional tree trunks, and layers of clay suggests deposition by braided streams in a broad paleovalley.

The Crookston Bridge in the Kennedy basin, part of the Niobrara basin of Marsh (1875, p. 52), was deposited under less turbulent conditions and further downstream from the source area than were the earliest Ogallala sands and gravels that occur in deep valleys described by Frye and Leonard (1959, fig. 1) and Seni (1980, pp. 16–23) in northwest Texas.

The deposition of valley filling sediments of the Crookston Bridge Member was followed by the development of a widespread aggradational plain on which was deposited the sand, argillaceous sandstone, and silty sandstone of the Devil's Gulch Member of the Valentine Formation. The loess-like character of some of the section suggests periods of drought and eolian process in the deposition of silty argillaceous sediments. Channel sands in the Devil's Gulch Member are infrequent but do occur.

A minor uplift (or regional tilting) or a dramatic change in climate halted deposition of

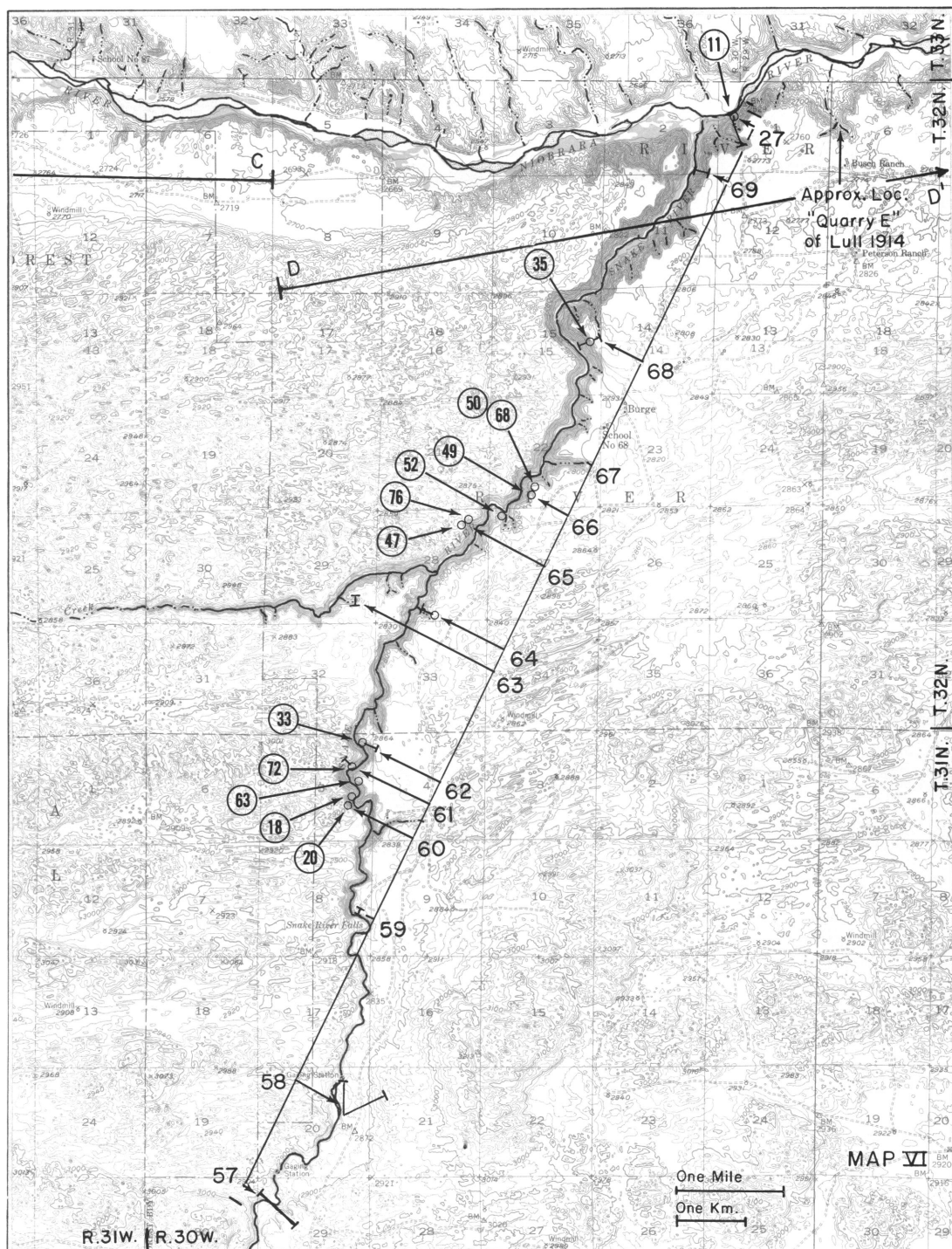


FIG. 23. Map VI, Snake River, Cherry County, Nebraska. Identity of quarries: 11, Crookston Bridge; 18, Ripple; 20, Sawyer; 33, Mizner; 35, Burge; 47, Quarry 379; 49, Swallow; 50, *Tetrabelodon* skull; 52, Whiteface; 63, *Alligator mefferdi*; 68, Horn; 72, *Platybelodon*; 76, Wade. Identity of sections: 27, Crookston Bridge; 57, below Merritt Reservoir; 58, Gauging Station; 59, below Snake Falls; 60, Sawyer Quarry; 61, *Platybelodon*; 62, Mizner and *Plioceras*; 63, Steer Creek; 64, *Megabelodon hulli*; 65, Wade; 66, Swallow and Horn; 67, Snake Den; 68, Burge; 69, Snake River. See sections on figures 15 and 38.



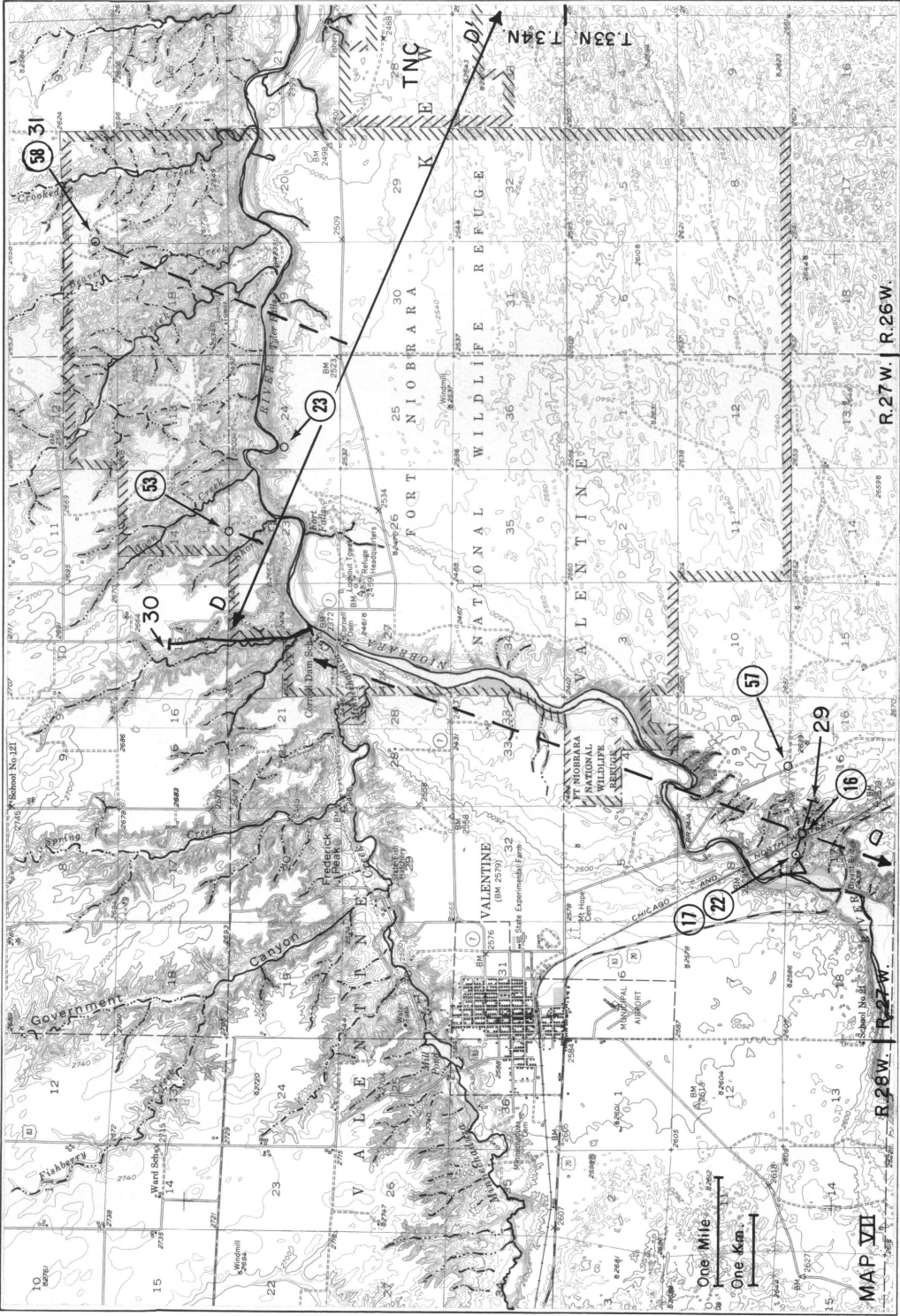


FIG. 24. Map VII, Valentine and Fort Niobrara area, Cherry County, Nebraska. Identity of quarries: 16, Railway Quarry "A"; 17, Railway Quarry "B"; 22, West Valentine; 23, Yale Quarry "D"; 53, Yale Mastodon; 57, Johnson Rhino; 58, Little Beaver B. Identity of sections: 29, type section Valentine Formation; 30, Fort Niobrara; 31, Little Beaver B, Minnechadza Fauna. TNC is The Nature Conservancy property. See sections on figure 33.

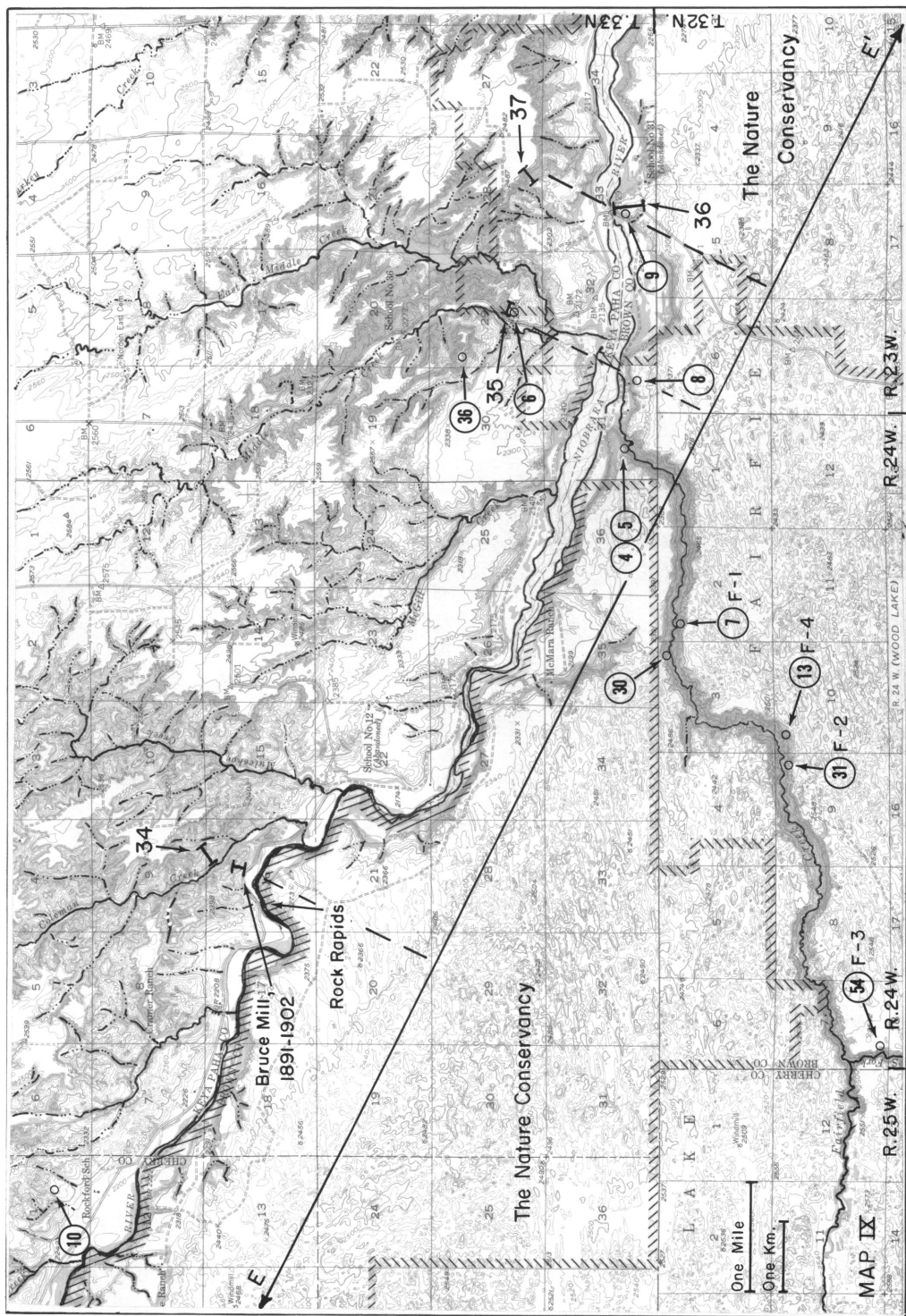


FIG. 25. Map IX, Fairfield Creek and Norden Bridge area, Brown and Keya Paha counties, Nebraska. Identity of quarries: 4, Achilles; 5, Carrot Top; 6, Egelhoff; 7, Fairfield No. 1; 8, Kuhre; 9, Norden Bridge; 10, Rockford; 13, Fairfield Creek No. 4; 30, Fairfield Falls; 31, Fairfield Creek No. 2; 36, Buzzard Feather; 54, Fairfield Creek No. 3. Identity of sections: 34, E side Coleman Creek; Bruce Mill and Rock Rapids; 35, Egelhoff; 36, Norden Bridge; 37, NE of Norden Bridge. See sections on figure 34.

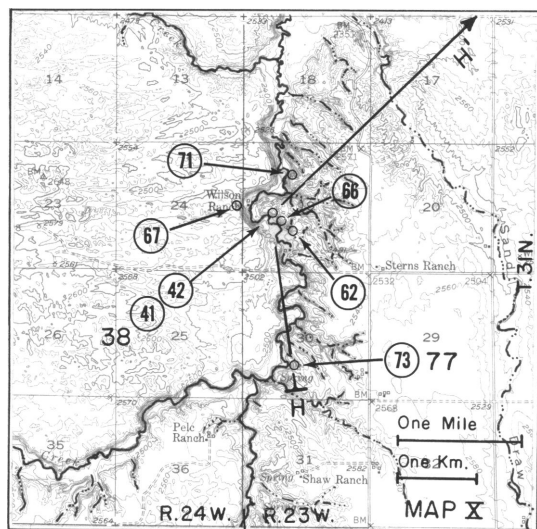


FIG. 26. Map X, north of Johnstown, Brown County, Nebraska. Identity of quarries: 41, June; 42, West June; 62, Wilson; 66, Eggers; 67, Emry; 71, Jonas Wilson; 73, Pratt. Identity of sections: 38, June; 77, Pratt. See sections on figures 34 and 37.

the Devil's Gulch and initiated limited pre-Burge degradation. This created a paleovalley similar to that seen today on the headwaters of the Elkhorn River in north-central Nebraska. Deposition of channel sands containing olive green quartz pebbles, lithic pebbles, and boulders of clay and frequent occurrences of vertebrate fossils, including skeletons, suggest vigorous stream activity which may have been the result of episodic flooding.

Valentine deposition was terminated by the filling of the Burge valleys, often marked by the presence of massive well-sorted finer grained sand, suggestive of waning stream activity, at the top of the member.

**ASH HOLLOW DEPOSITION:** The regional setting for the deposition of the Ash Hollow Formation in north-central Nebraska was a widespread gently eastward-sloping floodplain of very low relief. The regional dip of the easterly sloping base of the Ash Hollow was less but similar, in a regional sense, to the gradient of the Niobrara River from the mouth of Bear Creek eastward (figs. 14, 32–34). Extensive valley filling during the Valentinian had eliminated most of the topography of the Chadron Arch and in the Kennedy Basin east of the Arch.

Deposition of the lower part of the Ash Hollow (early Clarendonian) was by a network of slowly aggrading streams flowing eastward across great floodplains. The history of the late Clarendonian and Hemphillian deposition involved short periods of degradation and aggradation in a complex channel and floodplain framework of sediment accumulation.

The frequent occurrence of sediment debris, poorly sorted sand, lithic pebbles, and fragments of vertebrate fossils (the “fragmental layer”) at the Valentine-Ash Hollow contact in many localities indicates a period of weathering but little removal of sediments by erosion at the disconformable contact between the two stratigraphic units.

The formation of the “fragmental layer” and the irregular deposition of pond deposits at the base of the Ash Hollow Formation were followed by widespread slow aggradation on broad savannas and forest-fringed parklands during the deposition of the Cap Rock Member of early Clarendonian age. The poorly sorted sands throughout this member contain fragments of reworked sediments, and wind activity may have been a factor in the distribution of sand on grass covered plains during times of drought. The presence of soils is represented by the root filled caliches or mortar beds that are suggestive of the pedogenic character of the Cap Rock Member.

Volcanic activity, presumably in mountains of the western part of the continent, is documented by the presence of the Swallow Ash near the base of the Cap Rock and at least three other layers of vitric tuff higher in the Ash Hollow Formation (figs. 3, 13).

Deposition of the lower part of the Merritt Dam Member is very similar to that of the Cap Rock but differs in having more clean channel sands and pond deposits represented by beds of diatomaceous marl.

Tectonic activity along the Chadron Arch, and possibly a slight increase in eastward regional tilt across northern Nebraska, followed the deposition of the Cap Rock Member and the lower part of the Merritt Dam Member. The presence of sediment filled deep channels in the late Tertiary section east of the southeasterly trending extension of the White Clay Fault mapped by DeGraw (1971, fig. 6) and this paper (figs. 2A, 42) suggests that the locus of minor uplift increased the

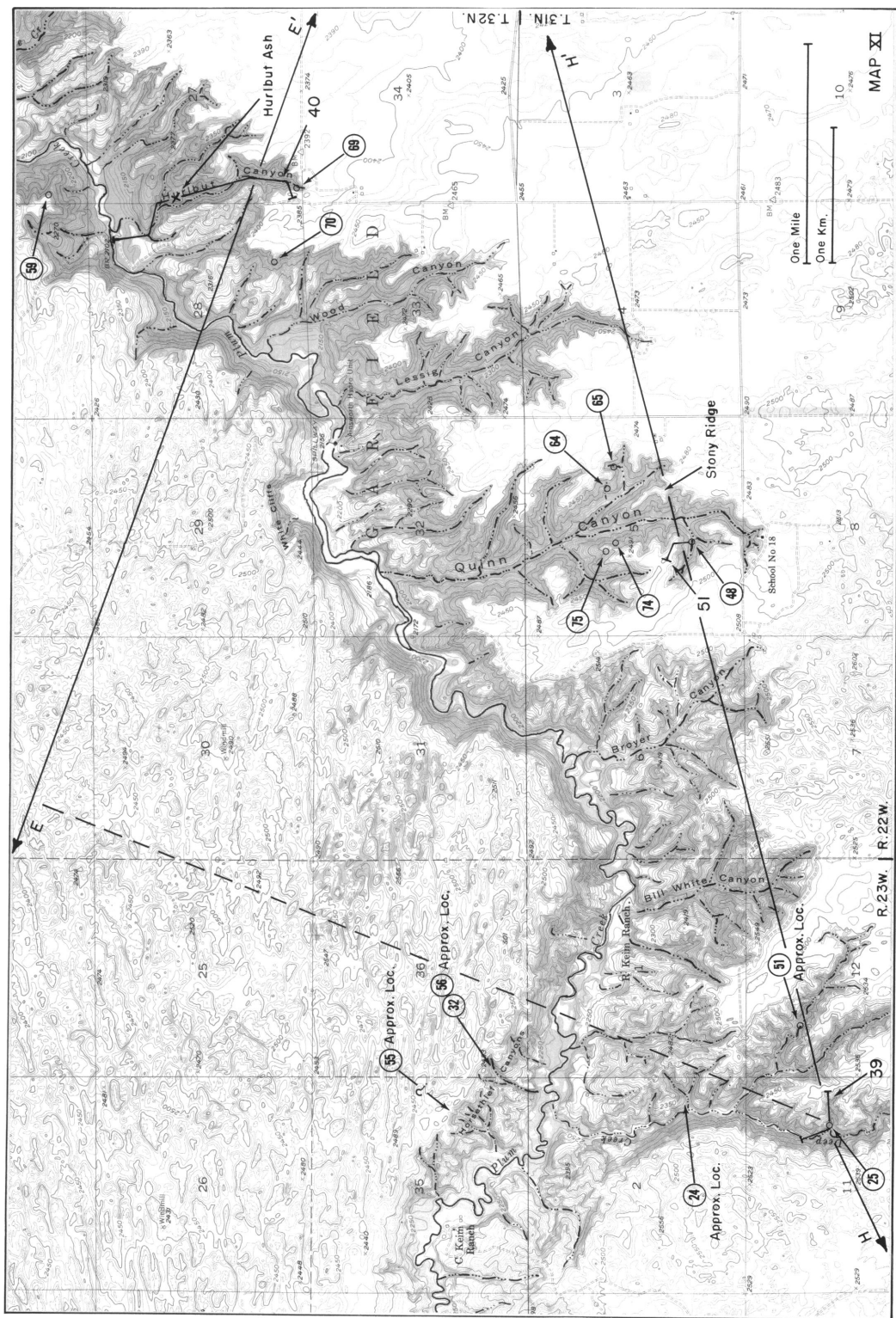


FIG. 27. Map XI, Plum Creek, Brown County, Nebraska. Identity of quarries: 24, Deep Creek No. 1; 25, Deep Creek (UNSM); 32, Horse Thief Canyon No. 3; 48, Quinn Mastodon; 51, White Point; 55, Horse Thief Canyon No. 1; 56, Horse Thief Canyon No. 2; 59, Rock Ledge Mastodon; 64, Clayton; 65, East Clayton; 69, Hurlbut; 70, Jim Lessig Camel; 74, Quinn Rhino Nos. 1 and 2; 75, RH No. 3. Identity of sections: 39, Deep Creek; 40, Hurlbut; 51, Quinn Mastodon. See sections on figures 34, 37 and 40.



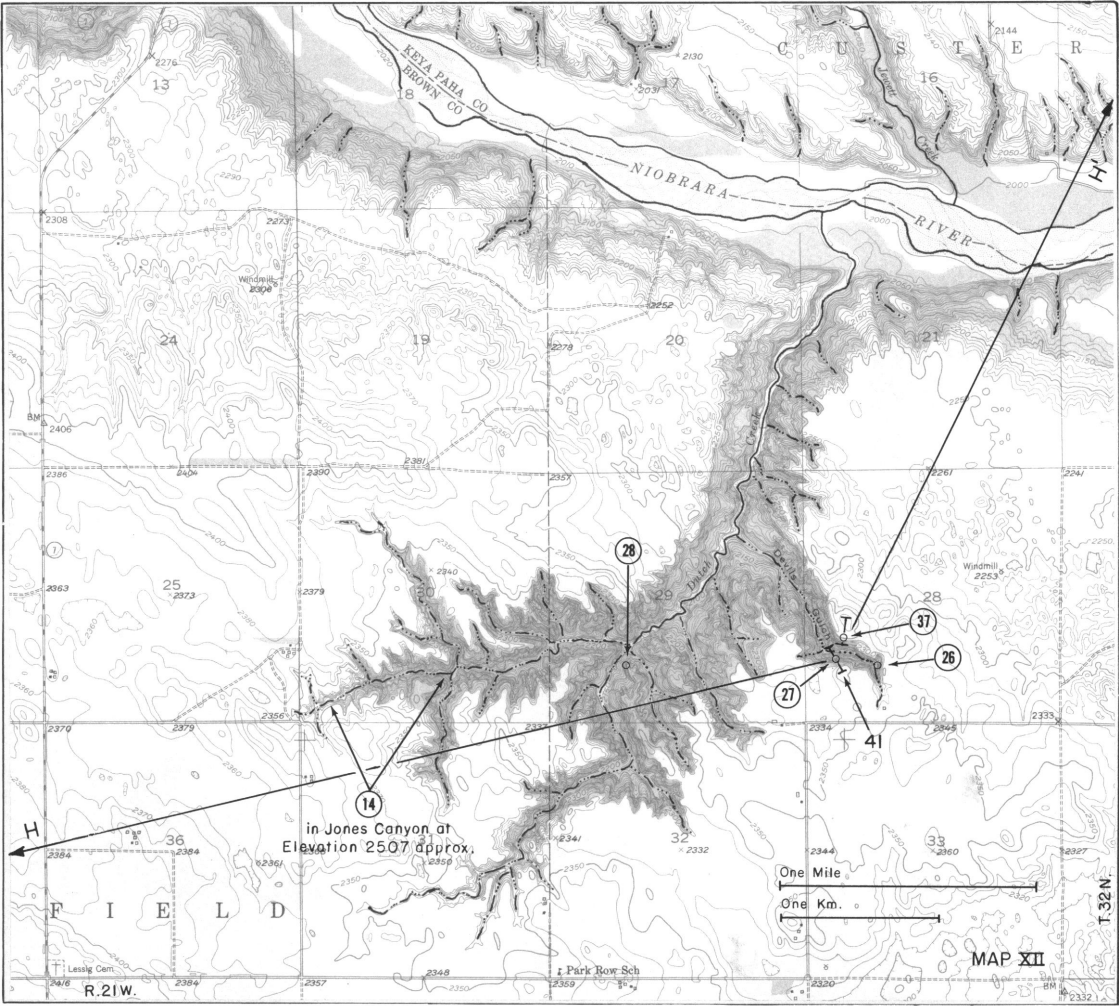


FIG. 28. Map XII, Dutch Creek and Devil's Gulch, Brown County, Nebraska. Identity of quarries: 14, Jones Canyon; 26, Devil's Gulch; 27, Devil's Gulch Horse; 28, Dutch Creek No. 1; 37, *Eubelodon morrilli*. Identity of section: 41, Devil's Gulch. See sections on figure 37.

stream gradient on the east side of the Chadron Arch.<sup>15</sup> These conditions provided the setting for erosion of paleovalleys into older

sediments, shown diagrammatically on figure 3 and on cross-sections (figs. 17, 31–34, 38). The deep cut and fill complex of poorly sorted sediments, found on the east flank of the Chadron Arch and eastward across Cherry County into Brown and Keya Paha counties, provides evidence of an abrupt change in fluvial activity from a period of aggradation to temporary degradation prior to resumption of aggradation during the late Clarendonian. Episodic rainfall and massive regional flooding during a late Miocene wet period (Thompson, Fields, and Alt, 1982) could have

<sup>15</sup> Most recent evidence of the presence of this fault is the location of the epicenter of the Nebraska earthquake of May 7, 1978 (Burchett, 1982, fig. 6; this paper figs. 2A, 31, 42) near the postulated trend of this fault. Reports of the earthquake, with a modified Mercalli intensity of V (Richter Scale 3.5–4), came from several localities near the postulated fault, and shocks of lesser intensity were reported from other localities in the vicinity of the Chadron Arch.



FIG. 29. Map XIII, north of Long Pine, Brown and Rock counties, Nebraska. Identity of quarries: 19, Runlofson; 29, Elliott; 34, Rattlesnake Gulch. Identity of sections: 43, Rudnick; 44, Long Pine Creek; 47, Rattlesnake Gulch; 48, Elliott. See sections on figures 34 and 35.

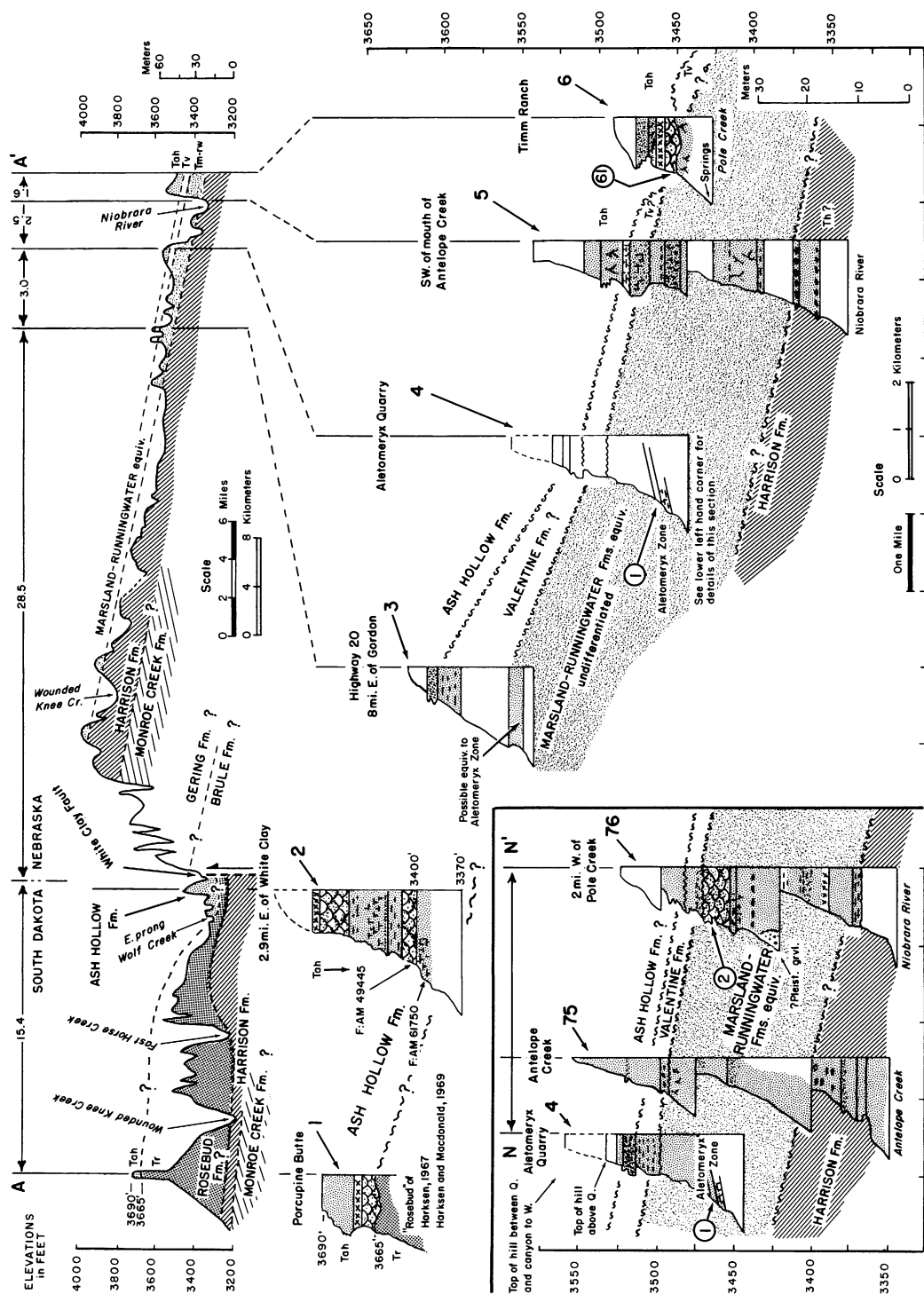


FIG. 30. Cross section A-A', Porcupine Butte, South Dakota, to Timm Ranch, Nebraska. F:AM 49445 *Hemicyon*; and F:AM 61750 *Aletomeryx* are from same general area as the Wolf Creek Fauna (Green, 1956). Cross section N-N', *Aletomeryx* Quarry to 2 mi. west of Pole Creek section. See map on figures 2A and 18.

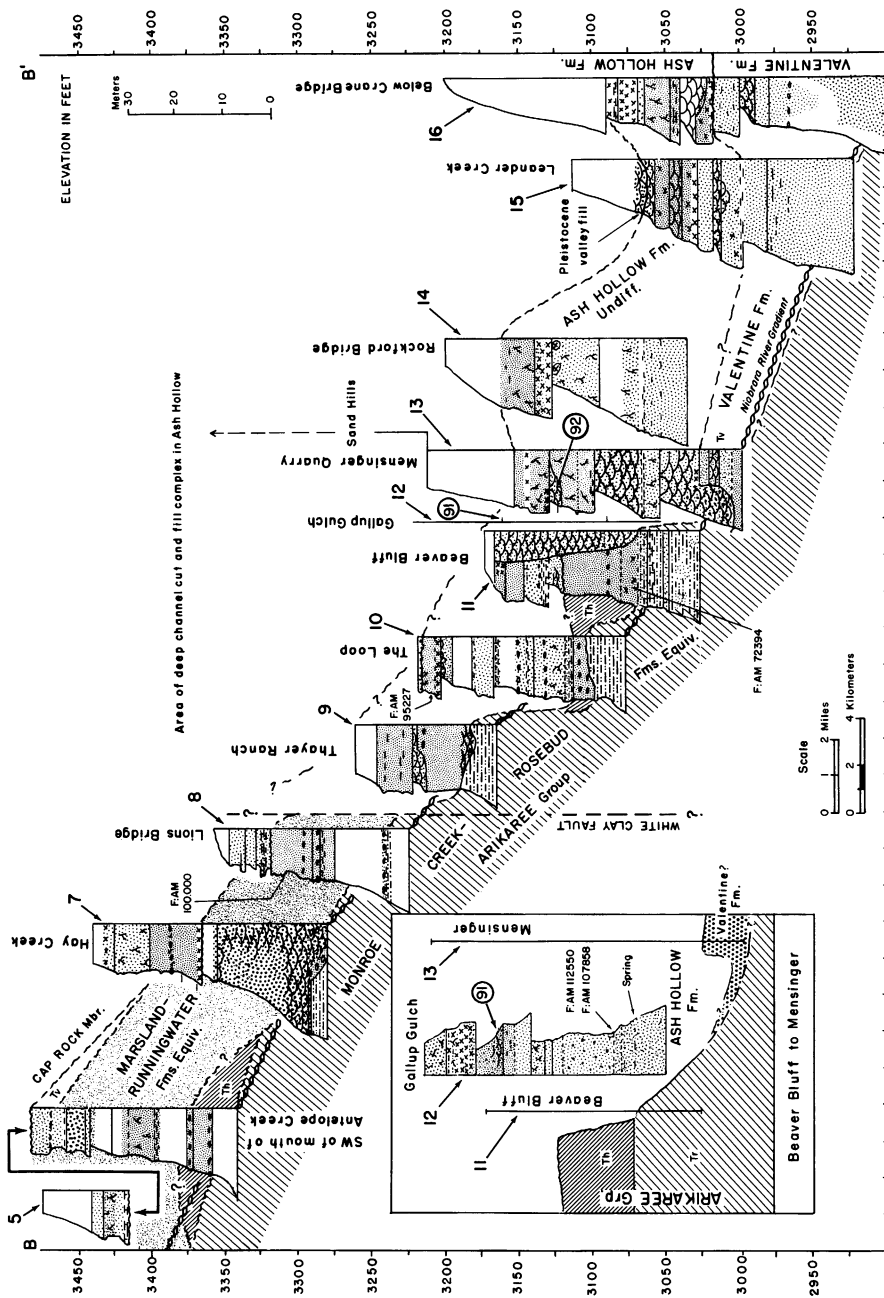


FIG. 31. Cross section B-B', SW of mouth of Antelope Creek to Below Crane Bridge. F:AM 95227 *Pseudoceras* sp., F:AM 100000 *Merychys elegans* ref., F:AM 107858 *Carpocyon robustus* ref., F:AM 112550 mustelid. See map on figures 2A, 18, 19 and 20.





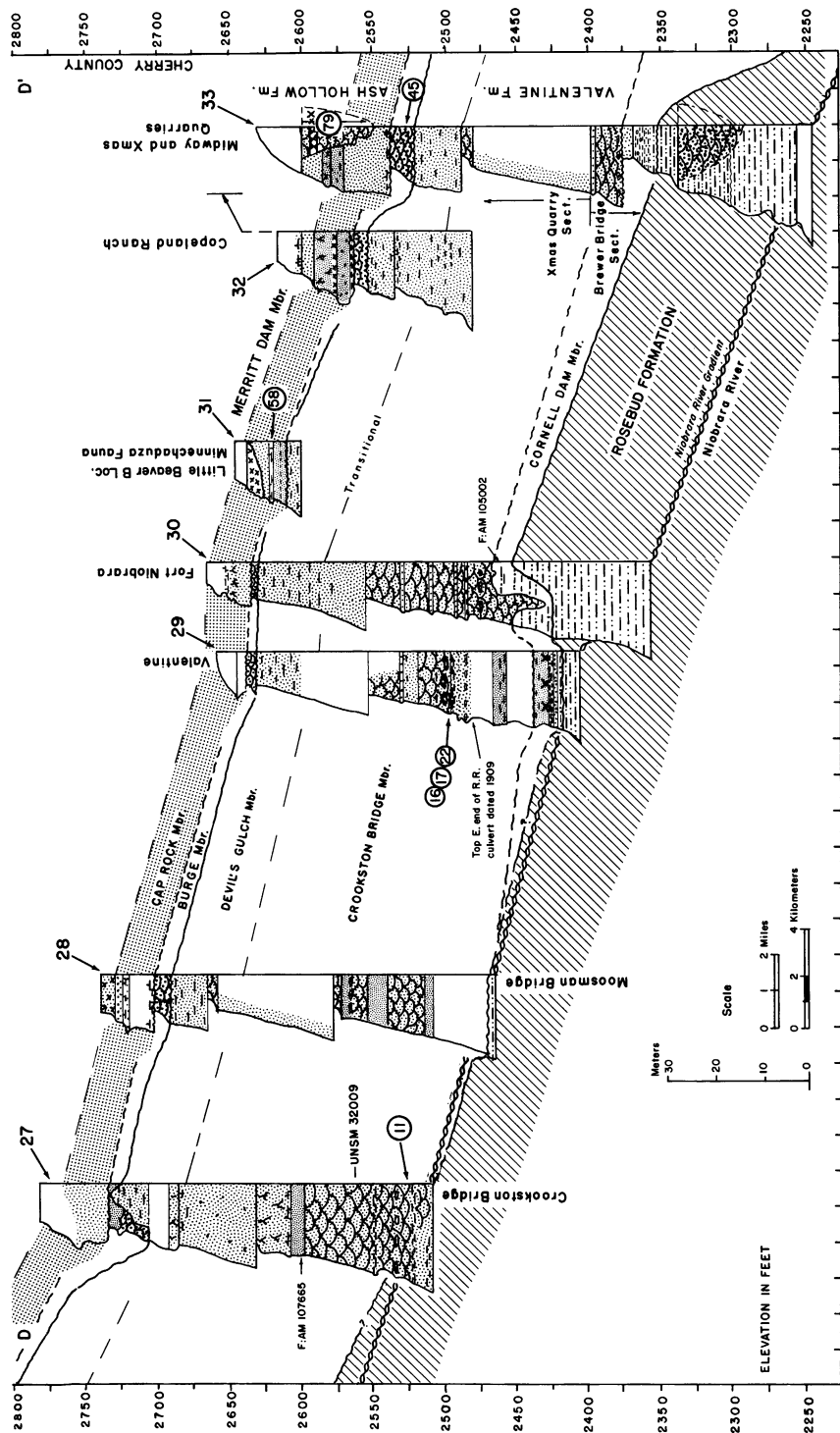


FIG. 33. Cross section D-D', Crookston Bridge to Midway and Xmas quarries. F:AM 107665 *Protohippus perditus*; UNSM 32009 *Leptocyon vae*; F:AM 105002 *Ustatochoerus medius*. See map on figures 2A, 2B, 23 and 24.

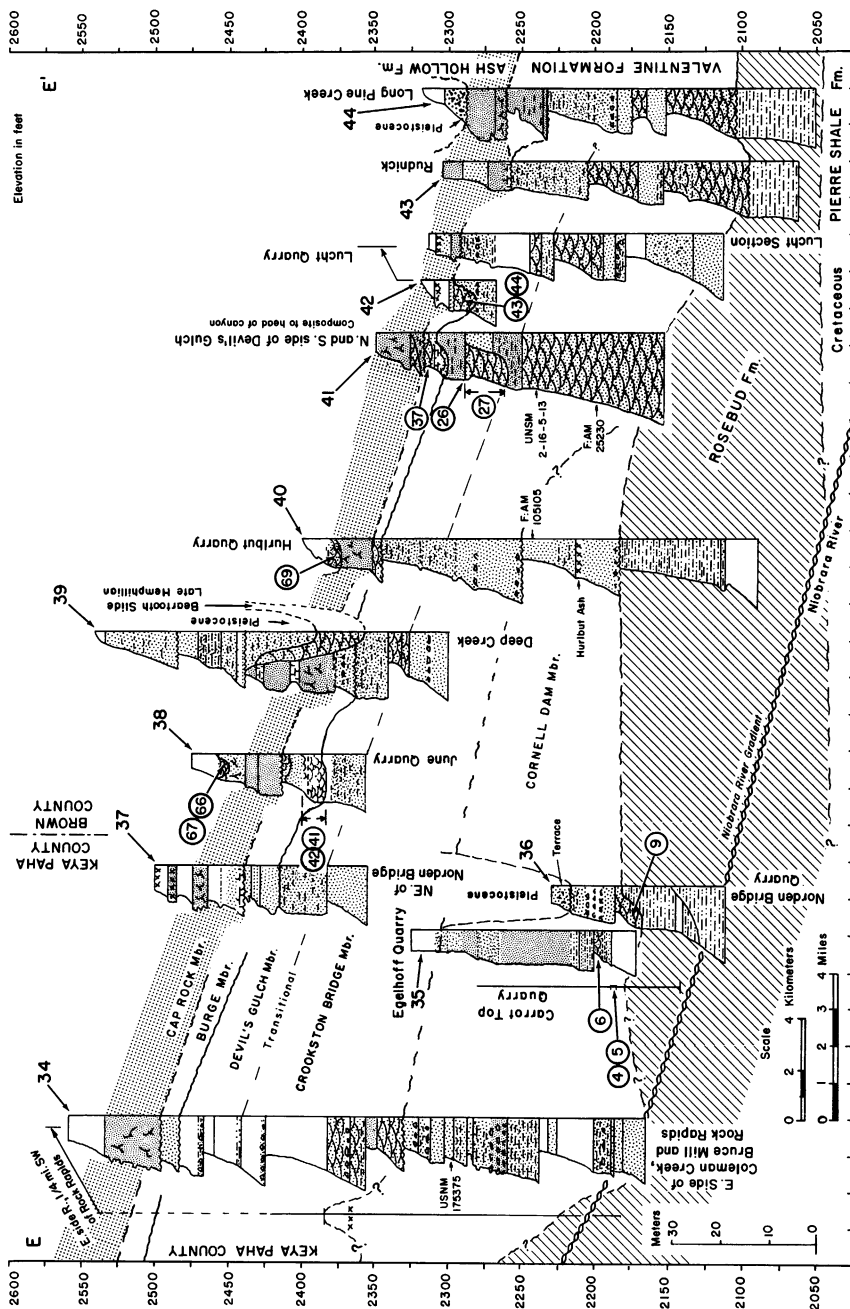


FIG. 34. Cross section E-E', east side of Coleman Creek, Bruce Mill and Rock Rapids, to Long Pine Creek. USNM 175375 *Meghippus* cf. *mekennai*; USNM 2-16-5-13 *Tetralodon willistoni* type; F:AM 25230 *Aelurodon*, F:AM 105105 cf. *Calippus*. See map on figures 2B and 25-29.



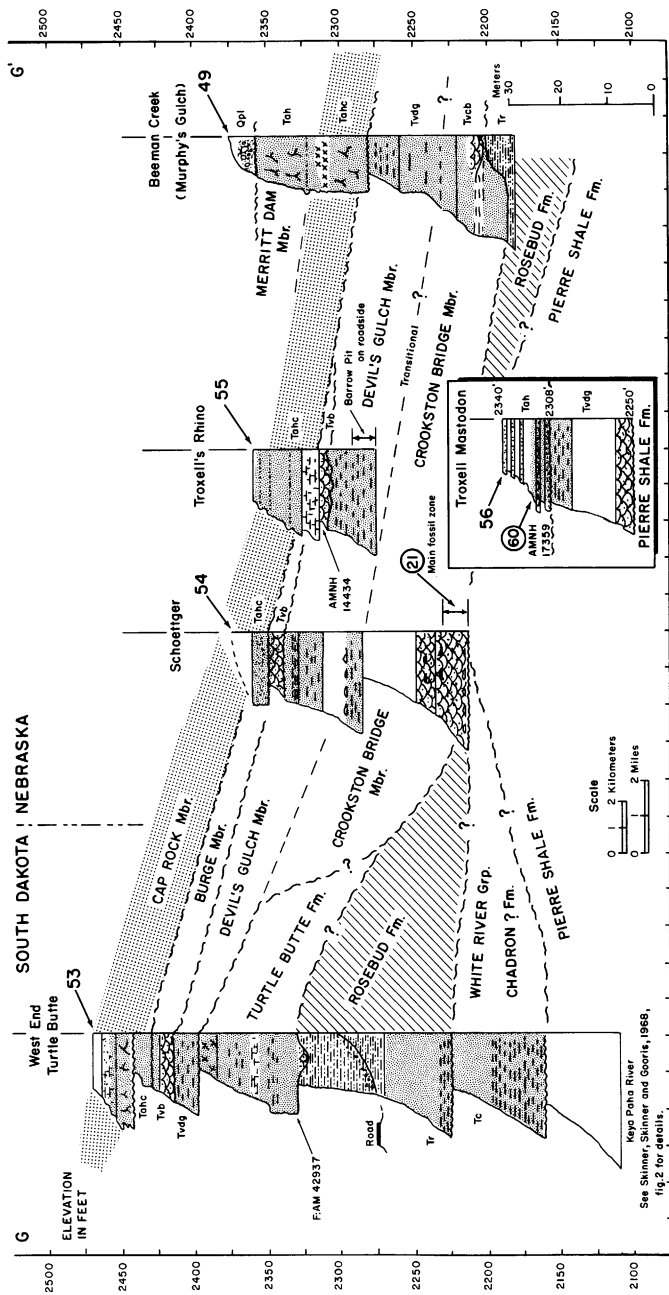


FIG. 36. Cross section G-G', west end of Turtle Butte to Beeman Creek (Murphy's Gulch). AMNH 14434 *Peraceras troxelli* type; AMNH 17359 *Trilophodon giganteus* type. F:AM 42937 *Archaeotherium trippensis* type. See map on figure 2B.

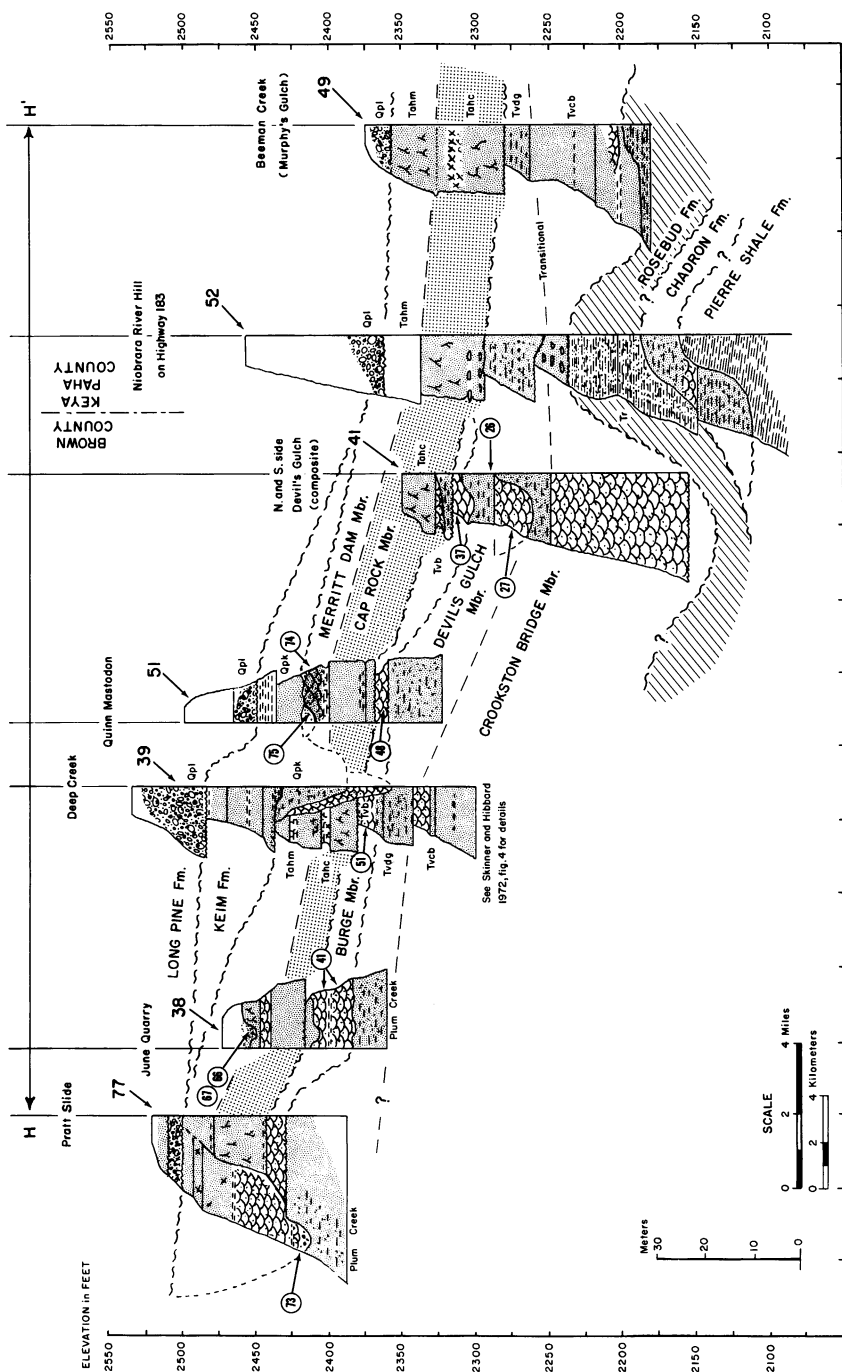


FIG. 37. Cross section H-H', Pratt Slide to Beeman Creek (Murphy's Gulch). See map on figures 2B and 26-28.

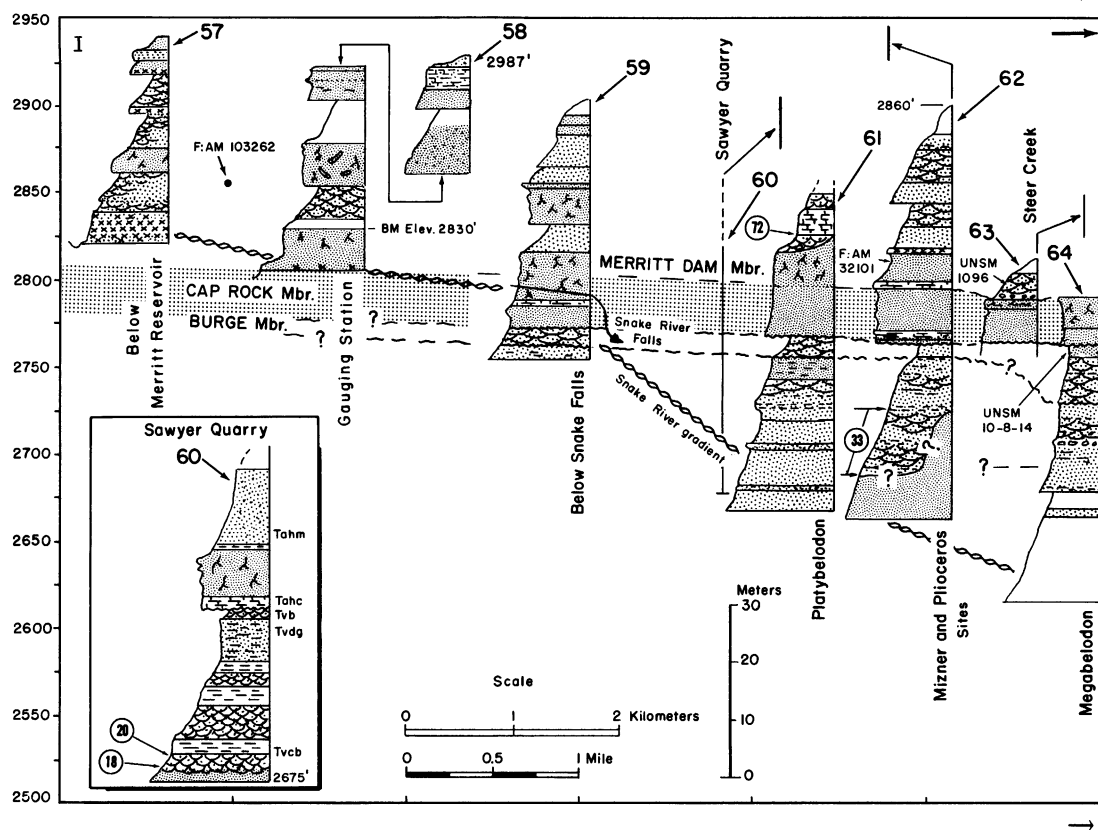


FIG. 38. Cross section I-I', section on Snake River from below Merritt Reservoir to Crookston Bridge Quarry. F:AM 103262 *Amebelodon fricki* ref.; F:AM 32101 *Plioceros dehlini* type; UNSM 10-8-14 *Megabelodon lulli* type; UNSM 1096 *Tapirus johnsoni* type; F:AM 107665 *Protohippus perditus* ref., UNSM 32009 *Leptocyon vafer* ref. See map on figure 23.

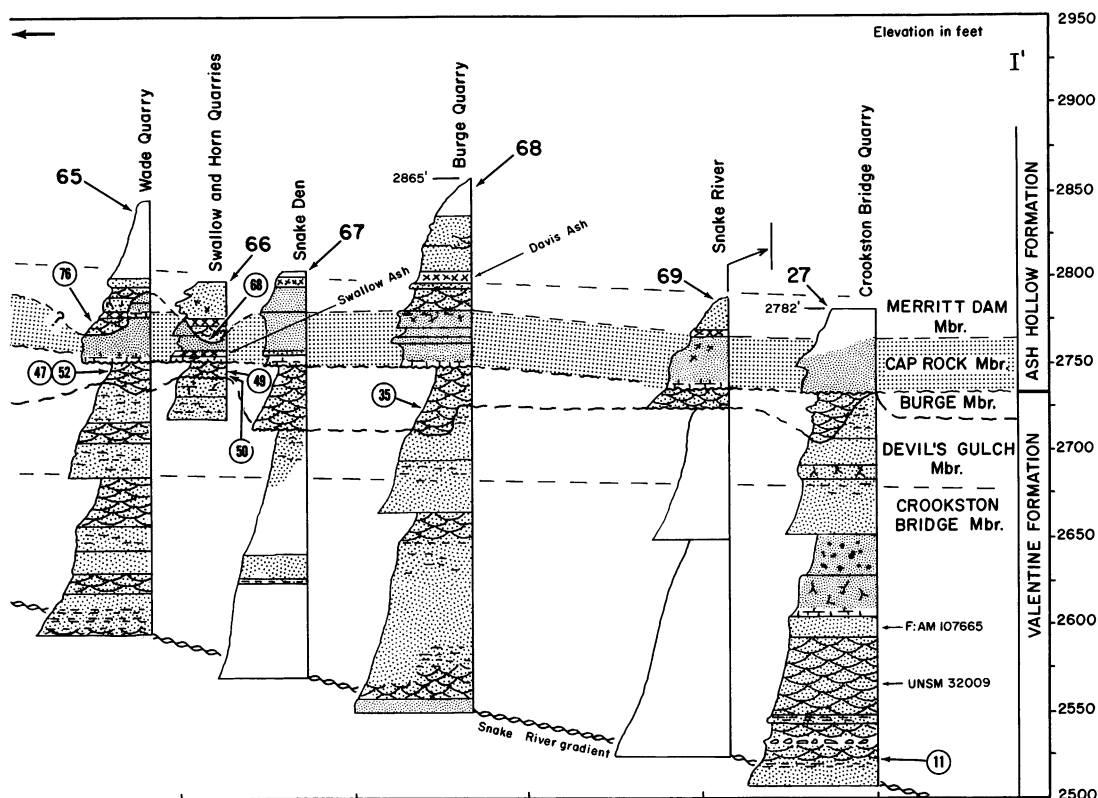
been a factor in the stream incision and entrapment of fossil vertebrates.

A pre-late Hemphillian period of degradation cut channels through the older Merritt Dam sediments and the Cap Rock into the Valentine Formation. These channels are filled with sediments consisting of quartz sand, sandstone clasts, and bone fragments reworked out of the older Ash Hollow section, and contain fossils of late Hemphillian age. An example of such a channel is at the Bear Tooth Slide (Skinner and Hibbard et al., 1972, fig. 4; this paper, sect. 39 on fig. 34) on Deep Creek, Brown County, Nebraska.

Several sources of sediments may have contributed to the paleodrainage systems and fluvial fans or lobate sheets that were formed

during deposition of the late Clarendonian and late Hemphillian sediments in north-central Nebraska. Lack of fossils of early Hemphillian age in northern Nebraska suggests a hiatus in the sedimentary record or that sediments containing fossils of that age have not been discovered.

We envision a major drainage flowing eastward into northern Nebraska from its headwaters in the Rocky Mountains of Wyoming during the deposition of the Ogallala Group (fig. 42). Either deposition did not occur or erosion east of the mountains has eliminated evidence of sediments deposited in the paleodrainage until remnants of Ash Hollow are found in outcrops in the Niobrara valley in southeastern Dawes County, northwestern



Nebraska. A stream system flowing eastward since late Arikareean time in a paleovalley system confined by uplands has been shown by Skinner, Skinner, and Gooris (1977, pp. 314–321, figs. 1, 8–13). Further confirmation that a broad west-east paleodrainage existed is provided by a north-south line of stratigraphic holes across Dawes, Box Butte, and northern Sheridan counties (Souders, Smith, and Swinehart, 1980, figs. 11, 15; Souders, 1981, pl. 1–3). Eastward in western Cherry County the geometry of this drainage system is further defined on the east flank of the Chadron Arch where pre-late Clarendonian erosion has cut deeply through the section into Arikareean sediments (fig. 31).

Epeirogeny simultaneous with movement on the Chadron Arch may have caused minor uplift along the Siouxana Arch that would have diverted paleostreams slightly to the northeast across the Kennedy Basin in a man-

ner similar to that documented by Stanley and Wayne (1972, pp. 3680–3682, fig. 6) for early Pleistocene streams moving across the same area from the panhandle.

Furthermore, a paleodrainage system trending southeasterly from the Black Hills seems indicated. Again, erosion has eliminated sediments of the upstream trunk and its tributaries. Evidence that such a fluvial system existed is the presence of garnets and other granitic minerals derived from the Black Hills in sands and gravels in the Thin Elks gravel pit, Mellette County (Harksen and Green, 1971, p. 3) and adjacent areas in South Dakota. Similar garnets occur in the Xmas Quarry in Brown County, Nebraska. The presence of the Chadron Arch and movement along the White Clay Fault may have deflected the Black Hills paleodrainage eastward and southeasterly into and across the Kennedy Basin.





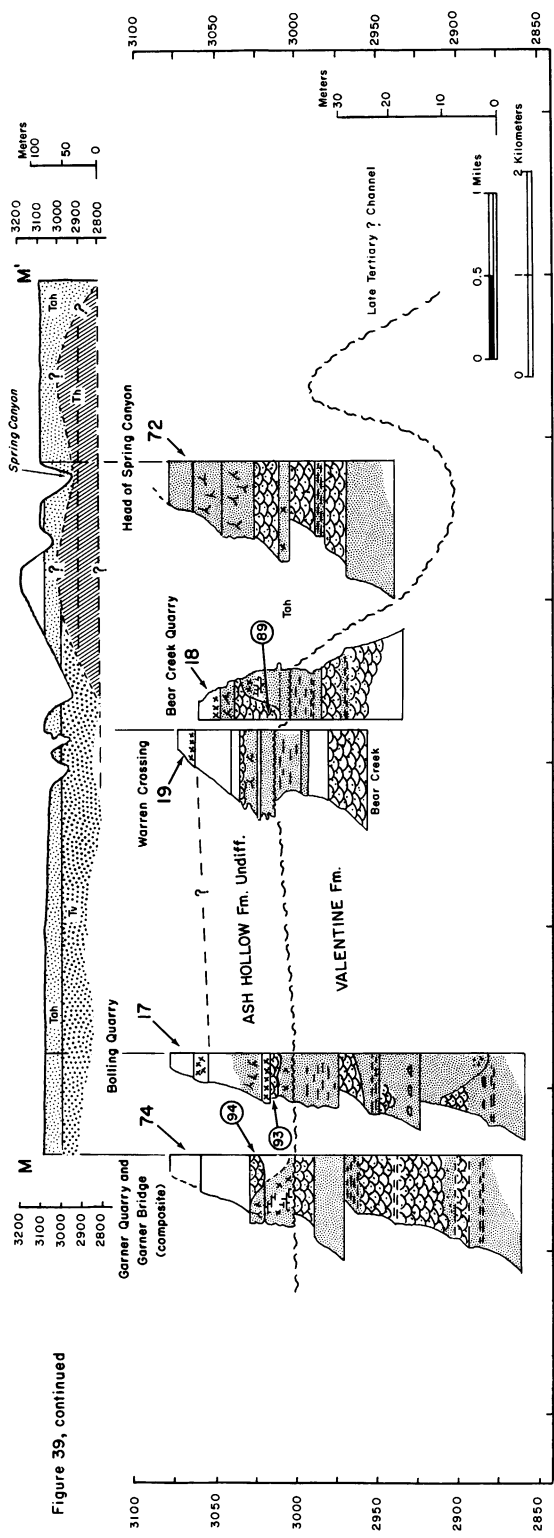


Figure 39, continued

FIG. 39. Cross section J-J', Eli Ash Pit to Bolling Slide.  
 Cross section K-K', Sand Hills to B.M. 3036 on south side of Niobrara River.  
 Cross section L-L', east of mouth of Bear Creek. Includes section 20 projected. F:AM 99791 *Diceratherium*; F:AM 99931 *Promerychochoerus carrikeri*; F:AM 99932 *P. carrikeri*; F:AM 99933 *Merychys crabilli*; F:AM 101930 *M. crabilli*.  
 Cross section M-M', Garner Quarry and Garner Bridge (composite) to head of Spring Canyon. See map on figure 21.



Stanley (1971, fig. 5) and Breyer (1975, fig. 1) have documented a major paleodrainage system that flowed westward from the anorthosite-bearing Laramie Range across southeastern Wyoming and the panhandle of Nebraska. The Panhandle Paleovalley and its tributaries are filled with locally derived sandy clay and sandstone, gravels, and layers of granitic sands and gravels carried in streams from the Rocky Mountains (Lugn, 1938, 1939; Lugn and Lugn, 1956; Stanley, 1971; Stout, 1971; Breyer, 1975; Swinehart, 1979; Stout and Schultz 1980; Diffendal, 1982). Hesse (1935a) described an early Hemphillian vertebrate assemblage (the Feltz fauna) from the lectotype locality of the Ogallala near the town of Ogallala in Keith County, Nebraska. Swinehart (1979) found Clarendonian and Hemphillian fossils in Garden and Morrill counties and Breyer (1981) identified late Clarendonian vertebrate fossils in the UNSM collection from the Kepler Quarry and early Hemphillian fossils from the Greenwood Canyon, Oshkosh, and Potter quarries.

Skinner, Skinner, and Gooris (1977), with detailed geologic sections and carefully documented collecting sites in Sioux County, Nebraska, described a complicated system of cut and fill deposits containing distinctive faunal assemblages, now in the AMNH and F:AM collections. Faunas from several of these sites range from early Clarendonian through late Hemphillian. The paleovalleys in which the central Sioux County deposits occur, some of which are rich in granitic sands and gravels of Rocky Mountain origin, may be a northern remnant of the major paleovalley system of the Nebraska Panhandle or part of a more localized system which had its headwaters in the mountains to the west. Evidence of an eastward extension of the same drainage system into southern Box Butte County is shown on a map prepared by Souders, Smith, and Swinehart (1980, fig. 16) as a part of their groundwater studies.

A composite model of paleodrainages involved in the deposition of the Ogallala in Nebraska may have been very similar to the better documented Texas example. The geometry of the depositional framework in Nebraska is demonstrated mainly from outcrops and a few wells in most areas,

particularly in southwestern and north-central Nebraska. Nevertheless the record supports a model that involves at least three major fluvial systems: the Panhandle System, the Northern Nebraska system, and a Black Hills System (fig. 42). The Black Hills and Northern Nebraska systems interfingered and overlapped, particularly after the major valleys had filled and anastomosing streams had spread sediments over the Kennedy Basin. Sometime late in the process of deposition, perhaps in late Hemphillian, as the lobes spread across the plains, the system in north-central Nebraska was overlapped by or interfingered with the Panhandle System. The result was the vast "debris apron" or multilobate sheet of sediments that covered a major portion of Nebraska.

Removal by erosion of the Ogallala Group in eastern Nebraska precludes determination of the geometry of the eastern terminus of the extensive network of alluvial fan deposits. It is postulated, however, that a major mid-continent north-south paleodrainage trunk, similar to that shown by Dott and Batten (1981, p. 463) in the late Cenozoic, intercepted the easterly and southeasterly flowing system in a relationship similar to that of the Kosi alluvial fan to the Ganges River in India (Holmes, 1965, fig. 388); but on a vastly greater scale.

**YOUNGER DEPOSITS:** Erosion and deposition during Blancan, Pleistocene, and Holocene time has eliminated much of the evidence of the characteristics of the upper part of the Merritt Dam Member. Stanley and Wayne (1972) have shown that the processes of erosion and valley fill active during deposition of the upper part of the Merritt Dam Member were still in operation during deposition of Blancan sediments in north-central Nebraska described by Cronin and Newport (1956) and Skinner and Hibbard (1972). Some of these events (Hay, 1895, pp. 578–579; Hayden, 1869, p. 14; Reed and Dreeszen, 1965; Stanley and Wayne, 1971; Wayne and Stanley, 1972) contributed sand for the formation of the Sand Hills during the Holocene about 12,000 years ago (Ahlbrandt and Fryberger, 1980, pp. 1–2).

Degradation and more localized deposition during the later Pleistocene and Holo-

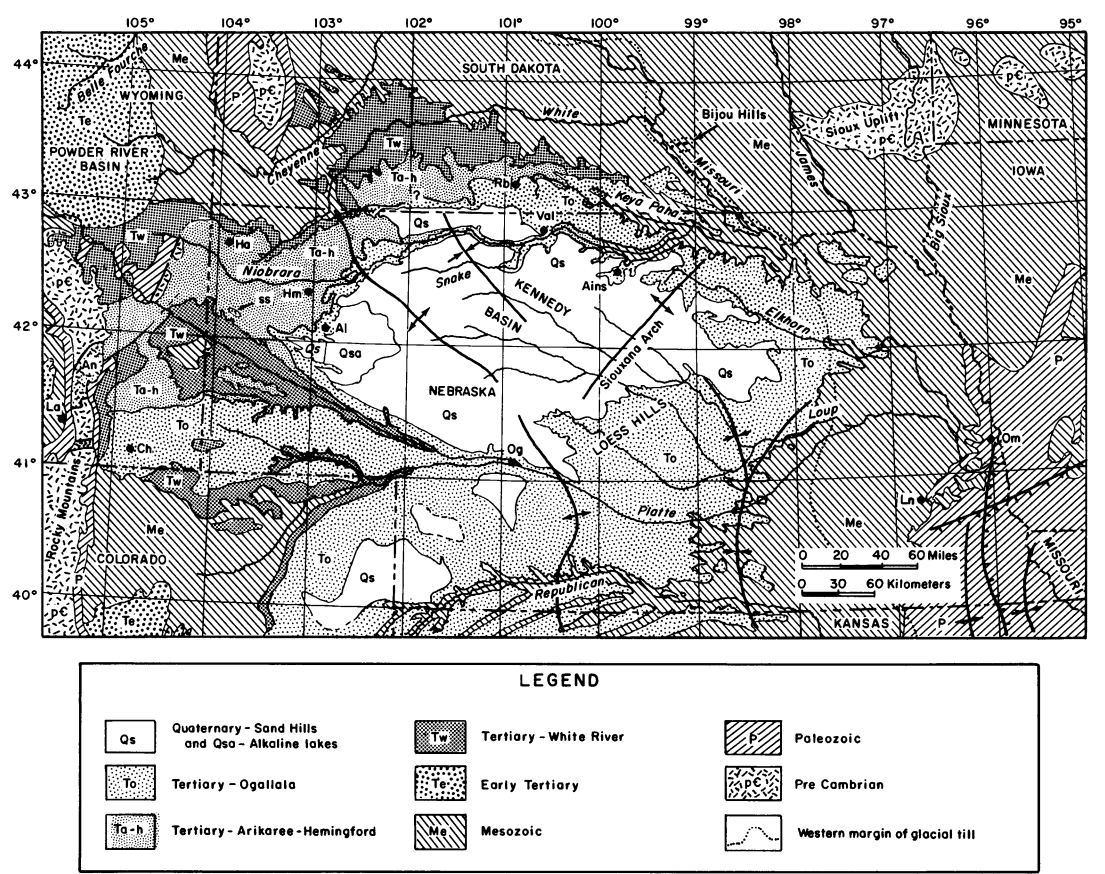


FIG. 41. Geologic map of Nebraska and adjacent areas. Modified after Nebraska, South Dakota, and Wyoming State Geological Surveys and U.S. Geological Survey maps. Towns: Ains-Ainsworth, Al-Alliance, Ch-Cheyenne, Ha-Harrison, Hm-Hemingford, La-Laramie, Ln-Lincoln, Og-Ogallala, Om-Omaha, Rb-Rosebud, Val-Valentine. An: Anorthosite, Qsa: Sand Hills with poor drainage and alkali lakes, SS: Sheep Creek-Snake Creek area.

cene time, however, is more related to the present Missouri River drainage system. Recent erosion has cut valleys through the Holocene Sand Hills, the Pleistocene, and late Tertiary into the Cretaceous in the lower part

of the Niobrara River drainage system. An area of poor drainage containing alkali lakes (fig. 41) occurs in the Sand Hills west of the Chadron Arch.

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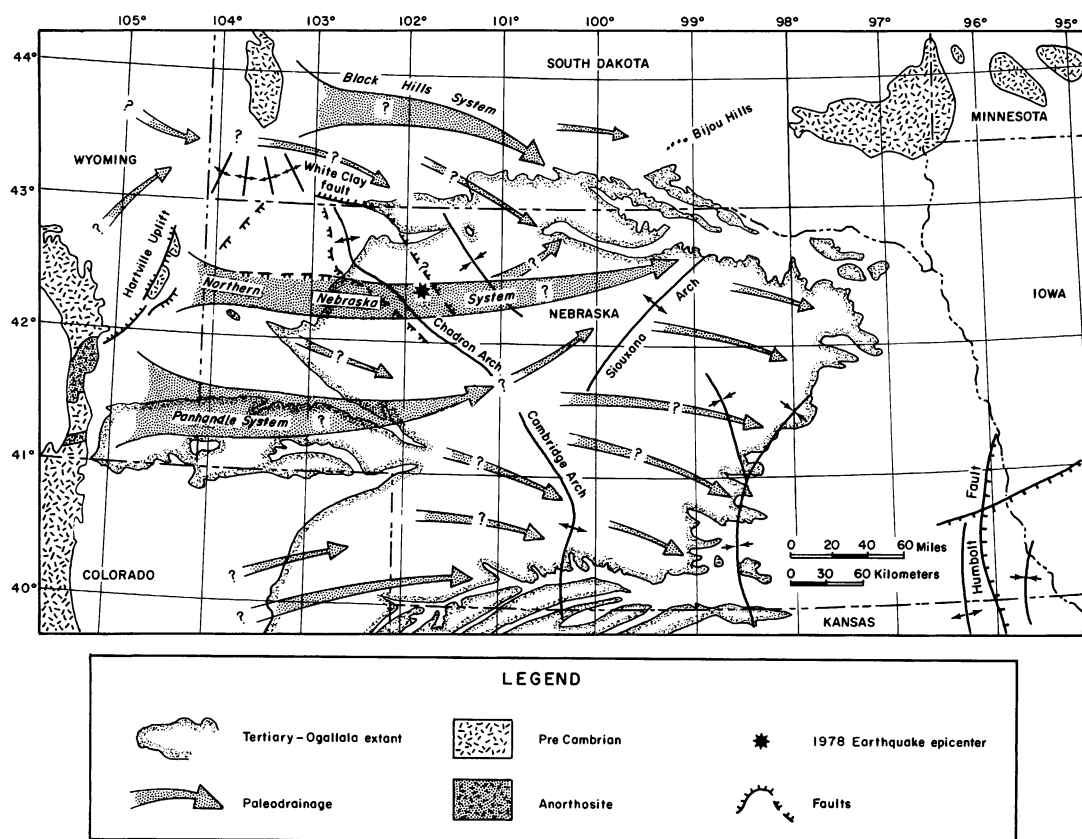


FIG. 42. Principal structural features of Nebraska, modified after Burchett (1970), De Graw (1971), Hunt (1981) USGS and AAPG (1962); and postulated paleodrainage systems during deposition of Ogallala Group.

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