OKLAHOMA GEOLOGICAL SURVEY

CARL C. BRANSON, *Director*

Circular 48

CENOZOIC GEOLOGY OF NORTHERN ROGER MILLS COUNTY, OKLAHOMA

By

DAVID B. KITTS

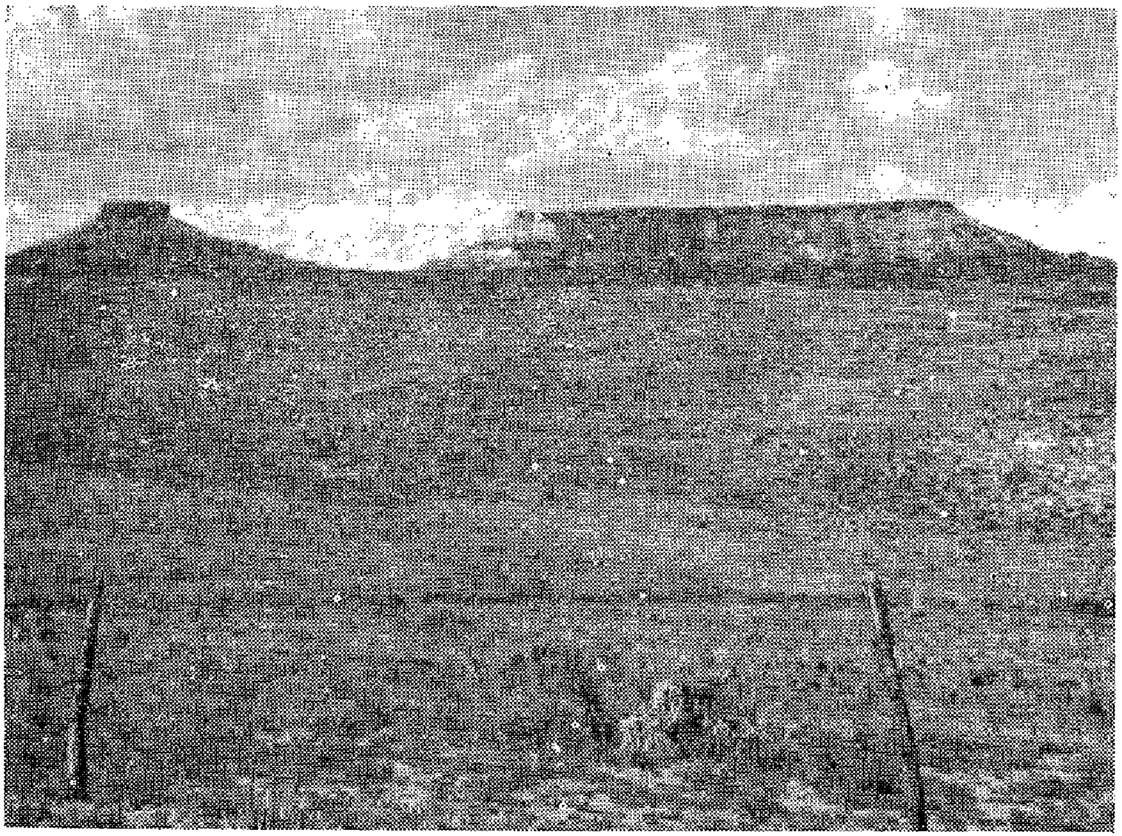
A Pliocene Vertebrate Local Fauna From Roger Mills County, Oklahoma

By

DAVID B. KITTS AND CRAIG C. BLACK

Norman, Oklahoma

September 1, 1959



Two northernmost Antelope Hills in secs. 32 and 33, T. 17 N., R. 25 W. View from the west shows upper 250 feet of Ogallala section. The buttes are capped by a layer of medium-grained sandstone 25 feet thick.

CONTENTS

Part I

Part II

LIST OF ILLUSTRATIONS

PART I

PART II

CENOZOIC GEOLOGY OF NORTHERN ROGER MILLS COUNTY, OKLAHOMA

David B. Kitts

ABSTRACT

The Cenozoic geology of that part of Roger Mills County, Oklahoma, north of the south line of T. 15 N. is considered.

The Pliocene Ogallala group, about 300 feet thick in this area, consists predominantly of fine-to medium-grained quartz sands. This group rests unconformably on the Permian Quartermaster and Cloud Chief formations. In this area the age of the Ogallala group ranges from middle Clarendonian to middle Hemphillian. Bordering the South Canadian River is a succession of three erosional and three depositional terraces. The high terrace deposits which are 80 feet thick are probably Kansan in age. The intermediate terrace deposits which are 50 feet thick may be Illinoian in age. The low terrace deposits which are 60 feet thick are probably Wisconsinan in age.

During early Cenozoic time there was little or no deposition in the area. Early in Pliocene time the rivers began to aggrade and before the end of Hemphillian time over 300 feet of channel and floodplain sediments had been deposited. Late in Pliocene or early in Pleistocene time an east-west trending channel was eroded through the Ogallala sediments and later this channel was filled with gravel. In Middle and Late Pleistocene time the South Canadian River underwent three cycles of erosion and deposition which resulted in a succession of erosional and depositional terraces.

INTRODUCTION

This paper presents the results of the first part of a projected study of the Cenozoic geology and paleontology of western Oklahoma. The area considered includes that part of Roger Mills County, Oklahoma, north of the south line of T. 15 N. (see Figure 1). The Cenozoic deposits of northern Roger Mills County have been briefly considered in Six (1930) and Dott (1942).

The present investigation was begun during the summer of 1955 with a reconnaissance study of the Cenozoic deposits of western Oklahoma. During the summer of 1956 field work was largely confined to Roger Mills County and consisted for the most part of locating and collecting plant and animal fossils. Mapping was undertaken during the summer of 1957.

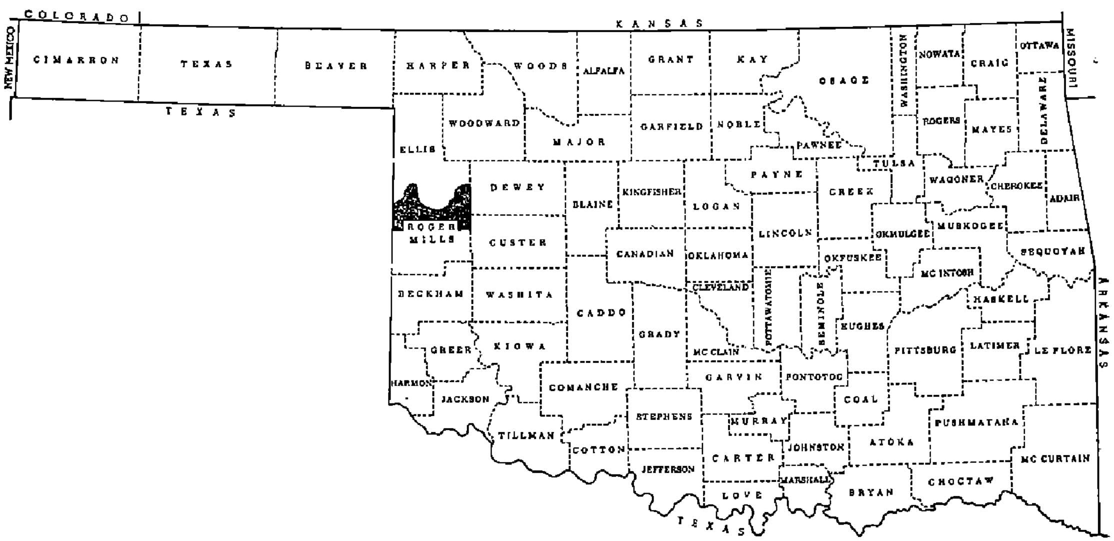


Figure 1. Index map of Oklahoma showing area considered in this report.

The northern part of the area under consideration is drained by the South Canadian River and its tributaries. The drainage basin of the Canadian in this region at no place exceeds 25 miles in width, and the tributaries are small intermittent streams for the most part unnamed. The southern portion of the area is drained by the Washita River, the major tributaries of which are Trunk, Turkey, Dead Indian, Ninemile, Quartermaster and Hay Creeks.

Physiographically the western portion of northern Roger Mills County consists of gently sloping hills which have been developed by the erosion of the underlying Tertiary sands, except in secs. 32 and 33, T. 17 N., R. 25 W. and secs. 9, 10, and 15, T. 16 N., R. 25 W., where a relatively resistant sandstone caps a series of small buttes, the Antelope Hills and the Twin Hills. The eastern half of the County consists of a sharply dissected surface developed upon the sandstones and shales of the Permian Quartermaster and Cloud Chief formations.

ACKNOWLEDGMENTS

Dr. Dwight W. Taylor analyzed a number of Pleistocene gastropod faunas and Dr. A. B. Leonard identified the Tertiary seeds which were recovered. Dr. Ada Swineford examined samples of volcanic ash. Dr. C. W. Hibbard, Dr. Dwight W. Taylor and Mr. A. L. Leonard each spent a day in the field with me and offered many valuable suggestions. Paul DeGroot assisted me during part of the summer of 1955 and Craig C. Black assisted me during the summer of 1956. Messrs. Winston Schindell and Robert Goodwin, both of Durham, Oklahoma, aided me in many ways during the course of my field work.

OGALLALA GROUP

Original Description and History of Usage

The Tertiary beds which are exposed in Roger Mills County are continuous with beds which cover the northeastern part of the Texas panhandle. It has been customary in recent years to apply the name "Ogallala formation" to these beds. The Ogallala formation was described by Darton (1899) from localities in southwestern Nebraska. Elias (in Stirton, 1936, p. 178) applied the name in a greatly extended sense. He stated: "In this paper, however, the term Ogallala is applied to the whole thickness of late Tertiary, predominately arenaceous beds, which overlie the Arikaree of the North Platte valley and are found to range in age from uppermost Miocene to the Middle and possibly the Upper Pliocene. These beds mantle the High Plains from South Dakota in the north to Texas in the south."

There have been objections to applying the name "Ogallala" in this greatly extended sense. In recent years there has been a growing tendency to include all of these beds in the "Ogallala group" (see Wood et al., 1941), a term which is essentially synonymous with the "Ogallala formation" of Elias.

The name "Panhandle beds" was proposed by Gidley (1903) for the Tertiary sediments younger than the "Clarendonian beds" in the Texas panhandle. Matthew in an unpublished manuscript quoted in Sellards, Adkins and Plummer (1932) redefined this unit as a formation to include all of the strata of the Staked Plains above the Cretaceous and Triassic formations and below the recent surface deposits, and consequently to include deposits of Pleistocene age in this area. The name was used in this sense by Sellards, Adkins and Plummer. Neither the name "Panhandle beds" nor the name "Panhandle formation" is in current use.

Reed and Longnecker (1932) applied the name "Hemphill beds" to the "Lower Pliocene" of Hemphill County, Texas, which borders Roger Mills County, Oklahoma, on the west. Wood et al. (1941) suggested that these beds might be definable as a member of the Ogallala.

Lugn in his reclassification of the Ogallala of Nebraska (1938 and 1939) gave the unit group status and recognized four formations: in descending order, Kimball, Sidney, Ash Hollow and Valentine. The Kansas Geological Survey has classed the Ogallala as a formation and applied the Nebraska formation names Kimball (including Sidney), Ash Hollow and Valentine to its members (see Moore, Frye and Jewett, 1944). Frye, Leonard and Swineford (1956) used this classification in their paper on the Ogallala of northern Kansas. In connection with their work on the Ogallala of the Texas panhandle Frye and Leonard state (1957, p. 17) "- - - we here class the Ogallala of the area under study in Texas as of formational rank but judge the subdivisions Valentine, Ash Hollow and Kimball to have insufficient regional lithologic distinctiveness to merit their recognition as members and therefore we treat them as floral zones."

Thickness and Distribution

The Ogallala sediments in northern Roger Mills County rest unconformably upon the Permian Cloud Chief and Quartermaster formations. The contact between the Ogallala group and the Permian red sands and shales is almost everywhere concealed by material which has been eroded from the Ogallala. Over most of the eastern part of the area the contact apparently occurs at about 2,150 feet elevation. In the northwestern part of the area the contact occurs at an elevation of about 2,250 feet. The regional dip of the bedrock in central western Oklahoma is to the southeast at less than a degree. The gentle tilting of the bedrock strata almost certainly occurred before the beginning of Ogallala deposition. The present elevation of the Permian-Ogallala contact is probably close to that of the topographic surface at the time immediately preceding the beginning of Ogallala deposition.

In the few places where the Permian-Pliocene contact is clearly exposed, as it is for example in secs. 9, 10, 15 and 16, T. 15 N., R. 23 W., less than ten feet of local relief has been observed along several hundred yard of contact. It is of course possible that much greater relief exists along the contact over wide areas where it is concealed.

Frye and Leonard (1957) have suggested that the relief of the sub-Ogallala surface underlying the southern high plains did not exceed 250 feet. Within the area under discussion the relief on the sub-Ogallala surface was probably less than this. To the east and southeast the Ogallala beds have been removed by erosion. The Permian-Ogallala contact rises gradually to the south and north of the area under consideration.

The beds within the Ogallala group are apparently horizontal. Dips of low degree would, however, be impossible to detect because of the rarity of extensive exposures and the complete lack of recognizable beds of broad areal extent.

The Ogallala sediments in northern Roger Mills County cover all or most of T. 16 N., R. 26 W.; T. 15 N., R. 26 W.; T. 17 N., R. 25 W.; T. 16 N., R. 25 W.; T. 15 N., R. 25 W.; and T. 15 N., R. 24 W., and parts of T. 18 N., R. 25 W.; T. 16 N., R. 24 W.; T. 16 N., R. 23 W.; T. 15 N., R. 23 W.; T. 15 N., R. 22 W. and T. 16 N., R. 21 W. In no small area is the total thickness of Ogallala exposed. The vertical distance between the well exposed Permian-Ogallala contact in sec. 9, T. 17 N., R. 25 W. and the highest Ogallala sediments in the area which are exposed in secs. 32 and 33, T. 17 N., R. 25 W. is about 320 feet. From this area where the top of the section is exposed the Ogallala sediments thin in all directions. It is not possible to determine to what extent this thinning is the result of erosion and to what extent the result of primary thinning. It is certain, however that some of the Ogallala sediments have been removed by erosion. Above the capping "mortar bed" of the Antelope and Twin Hills where the top of the section is exposed is an eroded layer of from zero to 25 feet of unconsolidated sand. Nowhere in the area is the "algal limestone" or "pisolitic limestone" which marks the top of the Ogallala over much of the High Plains to be found. This bed is present in the vicinity of Canadian, Texas, thirty miles to the west.

Description

The Ogallala sediments in northern Roger Mills County consist for the most part of fine- to medium-grained well-sorted quartz sands. At places where the lower 50 feet of Ogallala section is exposed the sediments are predominantly yellowish-brown evenly bedded fine-grained quartz sands. Clays and silts are present but are relatively rare. Calcium carbonate cement in the sands is absent or occurs in small quantities. The lithology of the part of the section between 50 and 100 feet from the base is similar to that of the lower 50 feet. In this part of the section calcium carbonate cement in the sands is common. It is not abundant, however, and all of the sands are friable.

The only channel sand of any consequence exposed in the lower 100 feet of section is located in the SE¼ sec. 16, T. 16 N., R. 26 W. The Permian is not exposed in this area but the Permian-Ogallala contact is judged to be about 30 feet below the base of the sand, which is here five feet thick. Part of the vertebrate fauna which is described in the second section of this circular was recovered from this bed.

In the S½ sec. 35, T. 17 N., R. 25 W., a seven-foot bed of volcanic ash is exposed (see measured section no. 2). Dr. Ada Swineford, who has examined samples of the ash, states that because of the weathered condition of the glass it is impossible to measure the index of refraction. She has found that the shards are characteristically rather flat and that some of them are thick. Bubble junctures are uncommon and mostly straight. Regarding possible similarities to other ashes she states (personal communication) "The features are definitely not characteristic of the Pleistocene Pearlette ash, and I am not able to make any definite correlations with Ogallala ash falls."

The uppermost 200 feet of Ogallala section is preserved only in the vicinity of the Antelope Hills (secs. 32 and 33, T. 17 N., R. 25 W.) (see measured section no. 5) and in the vicinity of the Twin Hills (secs. 9, 10, 15, T. 16 N., R. 25 W.). This part of the section consists largely of light brown, gray, and almost white massive fine- to medium-grained quartz sands all of which contain calcium carbonate cement, but few of which could be classed as sandstones. In one area several beds of sandy clay are exposed at about the 185-foot level (see measured section no. 4). Near the top of the section is a well-cemented medium- to coarse-grained sandstone or "mortar bed" which contains fossil seeds. This bed caps the Antelope Hills and the Twin Hills. Above the mortar bed lies an eroded bed of from zero to 25 feet of fine unconsolidated sand. As in the lower part of the section channel sands are rare in the upper 200 feet. In the NE¼ sec. 32, T. 17 N., R. 25 W. 15 feet of medium- to coarse-grained cross-bedded sand is exposed. The base of this sand is ninety feet below the base of the mortar bed mentioned above. Two horse teeth which are described in the section on the age of the Ogallala were recovered from this sand.

In secs. 6 and 7, T. 15 N., R. 22 W., along the eastern edge of the Ogallala outcrop area, is a deposit of coarse sand, pebbles and cobbles about 40 feet thick. The relationships of this deposit are difficult to determine. It rests unconformably upon Permian shales and sands, and along its western edge apparently lies against fine sands of typical lower Ogallala aspect. To the south the deposit thins rapidly and in secs. 19, 20, 29, 30, 31, and 32 consists of a thin layer of cobbles and pebbles resting on lower Ogallala fine sands. Gravels of similar lithologic character top some of the hills in secs. 2, 3, 4, 5, 7, 8, 9, 10 and 11, T. 16 N., R. 21 W. (see measured section no. 7). In the latter area some of the gravels are underlain by two feet of dense caliche. In both areas where the gravels are present the base of the deposits is about 300 feet above the flood plain of the Canadian River and consequently 150 feet above the base of the high terrace deposits which are discussed in the next section of this report.

In characterizing the lithology of the Ogallala of northwestern Texas Frye and Leonard (1957 b, p. 13) state; "The formation consists predominantly of fine to medium sand, and the most common colors are hues of reddish to pale pinkish gray. It is generally marked by discontinuous and variable zones of weak cementation by calcium carbonate, except in the uppermost part where cementation is commonly dense and tough. Except for the uppermost part there is no apparent continuity of the distinctive lithologic elements that are locally prominent and it lacks the more or less regular vertical change in lithologic character that has been observed in the formation farther north in the Great

Plains." It is clear that the character of the Ogallala in the Texas panhandle and in western Oklahoma prevents regional correlation within the group on the basis of lithology.

Age

A vertebrate fauna has been recovered from a reddish-brown medium-grained sand and from an overlying channel sand in the SE¼ sec. 15, T. 16 N., R. 26 W. The base of the lowest of these beds is estimated to be about 20 feet above the Permian-Ogallala contact. This fauna is described in the second part of this paper. It is concluded that this vertebrate assemblage is Middle Clarendonian in age. A faunal list follows:

Reptilia
- *Testudo* sp.
- *Coluber?* sp.

Mammalia
- *Mylagaulus* cf. *M. laevis* Matthew
- *Perognathus* cf. *P. pearlettensis* Hibbard
- *Vulpes* sp.
- Subfamily Mephitinae gen. and sp. indet.
- *Nannippus* cf. *N. gratus* (Leidy)
- *Neohipparion* sp.
- Family Merycoidodontidae gen. and sp. indet.
- *Megatylopus* sp.
- Family Antilocapridae gen. and sp. indet.

In several localities (NW¼ sec. 28, T. 16 N., R. 26 W.; NE¼ sec. 3, T. 15 N., R. 25 W.; SE¼ sec. 9, T. 16 N., R. 23 W.) in beds varying from less than 10 feet to 50 feet above the Permian-Ogallala contact horse teeth of the *Nannippus gratus* type have been recovered. The presence of these teeth strongly indicates Clarendonian age for the beds in question.

In the NE¼, sec. 32, T. 17 N., R. 25 W. 15 feet of medium-to coarse-grained cross-bedded sand is exposed. The base of this sand is 90 feet below the base of the mortar bed. Two *Nannippus* upper molars were recovered from this bed. They are advanced over the *Nannippus* teeth recovered from the Durham locality only in that both possess on open hypoconal groove. I judge them to be late Clarendonian or early Hemphillian in age.

Abundant seeds of the genus *Biorbia* were recovered from the mortar bed within 35 feet of the top of the Ogallala section. The presence of this genus on the high plains is generally considered to be indicative of Hemphillian age.

I conclude on the bases of the faunal evidence that the Ogallala sediments in northern Roger Mills County range in age from about middle Clarendonian to middle Hemphillian.

HIGH TERRACE DEPOSITS (T-3)

Character and Distribution

The high terrace deposits are best preserved in T. 18 and T. 19, R. 22 W., and T. 18 and T. 19, R. 21 W. in the northeastern corner of the county. They are also preserved in T. 17 N., R. 23 W. and T. 15 and 16, R. 22 W. and are probably present in T. 17 and 18, R. 25 W. These deposits parallel the present general course of the Canadian River and are bordered by hills composed of older sediments.

In the eastern part of the county where the terrace deposits rest upon and against Permian red beds it is a simple matter to distinguish them from bedrock. Because of the gradient of the river, about four feet per mile in this region, the high terrace deposits would, if present, rest against lithologically similar sediments of the Ogallala group in the western part of the county. It is entirely possible that eroded remnants of high terrace deposits are preserved but have not been recognized where they are associated with Ogallala deposits.

In the northern part of T. 18 N., R. 21 W. the high terrace deposits are well exposed in bluffs along the river. The contact of the terrace deposits with the underlying Permian red shales occurs at an elevation of from 140-160 feet above the present floodplain of the river. The depositional terrace level is about 220 feet above the floodplain. Deposition of sand upon, and erosion of, the terrace surface have made it difficult to determine the exact terrace level.

The terrace deposits exposed in the bluffs are up to eighty feet in thickness and consist of medium- to coarse-grained cross-bedded quartz sands and gravels containing quartzite pebbles and cobbles. To the south the deposits are finer, and because of the gradually rising terrace deposit-Permian contact become thinner.

Along the southern edge of T. 17 N., R. 21 W. the high terrace deposits feather out against the Permian red shales. A line of east-west trending Permian hills whose summits are more than 300 feet above the flood plain of the river border the terrace on the south. Some of these hills are capped by the gravel described in the section of this report devoted to the Ogallala group.

The high terrace deposits which cover parts of T. 17 N., R. 23 W. and T. 15 and 16, R. 22 W. are deeply eroded and only in a few restricted localities is the terrace surface preserved. These deposits are nowhere more than 50 feet in thickness and consist of fine sands and silts. The coarse sediments so much in evidence to the east are absent in this area. The deposits are bordered on the south by a line of hills formed of Permian rock.

In secs. 25 and 36 T. 17 N., R. 25 W., Secs. 1, 2, 11 and 12 T. 16 N., R. 25 W. and secs. 6 and 7, T. 16 N., R. 24 W. are deposits which have been mapped as high terrace because their surface is in some localities level and occurs at an elevation about 220 feet above the present flood plain of the Canadian River. These deposits are lithologically similar to the surrounding lower Ogallala fine-grained sands. The terrace is bordered on the west (away from the river) by hills composed of Ogallala sediments.

Age of High Terrace Deposits

The following faunal list and discussion has been extracted from a report by Dwight W. Taylor, Paleontology and Stratigraphy Branch, U. S. Geological Survey, dated October 8, 1958:

"U. S. G. S. Cenozoic locality 21338. Roger Mills County, Okla. S. edge SE¼ sec. 8, T. 17 N., R. 21 W. About 35 feet below 200+ foot terrace level; 20 feet above Permian. D. B. Kitts, 1957.

Land snails:

Gastrocopta armifera (Say)
G. contracta (Say)
G. cristata (Pilsbry and Vanatta)
Pupoides albilabris (Adams)
Vallonia perspectiva Sterki
Helicodiscus parallelus (Say)
H. singleyanus (Pilsbry)
Hawaiia minuscula (Binney)
Stenotrema leai (Binney)

The assemblage from locality 21338 is small and not diagnostic. It may be either glacial or interglacial age, and anywhere in the Pleistocene."

Deposits of Pearlette ash occur in the high terrace sediments of Dewey County which adjoins Roger Mills County on the east. Because the ash deposits are found at elevations between 180 feet and 220 feet above the South Canadian River, it is probable that the high terrace deposits in Roger Mills County are Kansas in age.

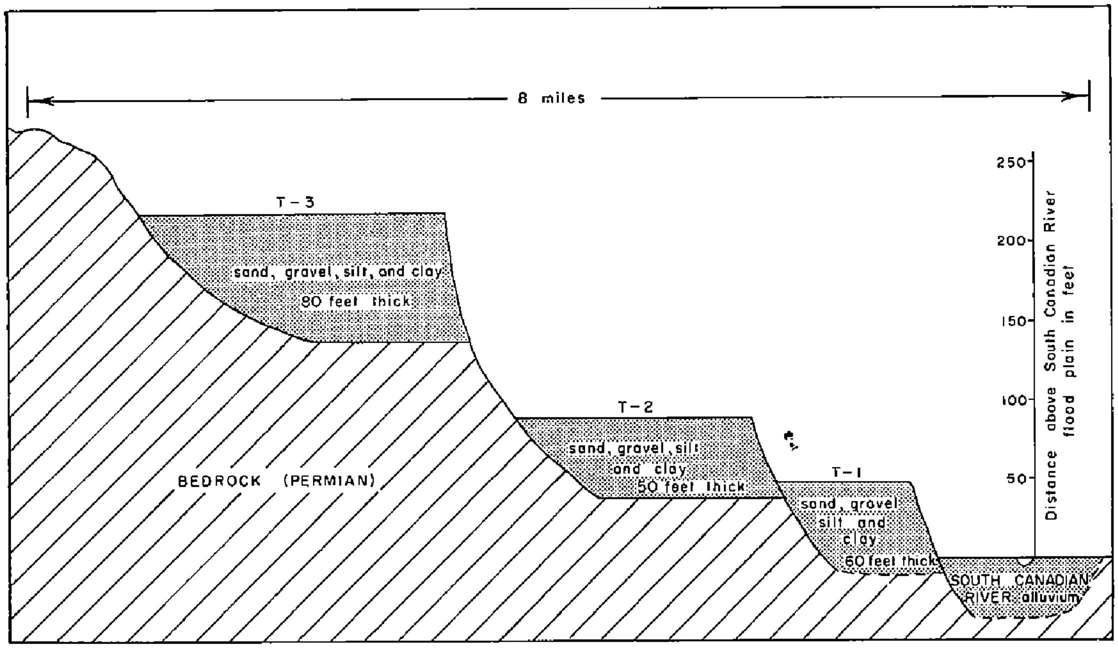


Figure 2. Diagrammatic sketch showing Pleistocene terrace deposits along the south side of the South Canadian River in Roger Mills County. Maximum thicknesses of terrace deposits and minimum elevations of bedrock benches are shown.

INTERMEDIATE TERRACE DEPOSITS

Character and Distribution

The intermediate terrace is the best preserved of the three South Canadian River terraces described in this report. The deposits parallel the south side of the river almost continuously from the Texas border on the west to the eastern border of Roger Mills County on the east. In most localities the intermediate terrace deposits are less than a mile in width but in T. 16 N., R. 26 W. they are nearly three miles in width. On the north side of the river the intermediate terrace deposits remain only as isolated remnants.

The intermediate terrace deposits lie upon an erosional terrace which has been cut into Permian bed rock. The level of the unconformity where it is exposed along the river varies in elevation from 40 to 50 feet above the flood plain of the river. Judging from the limited number of outcrops the erosional terrace is relatively flat throughout most of its extent and the bedrock surface rises rather abruptly along the edge of the terrace away from the river. The sediments of the depositional terrace range in thickness from 40 to 50 feet in places where the terrace surface is preserved. The terrace surface occurs at an elevation 90 feet above the floodplain of the river. The relationship of the intermediate erosional and depositional terraces to each other and to a lower terrace described in the next section are clearly revealed on the north side of the river in secs. 27, 33, and 34, T. 17., R. 22 W. where erosion has exposed the sequence in a steep cliff.

Throughout the western part of the county there is a remarkable similarity among sections of intermediate terrace deposits. Typically there is a basal coarse sand, pebble, cobble gravel, an intermediate zone of cross-bedded sands and an upper zone of sandy clay and silt. The basal gravels are wide-spread. For example in the SE¼ sec. 18, T. 16 N., R. 26 W. (see measured section no. 10) they are present two and one-half miles south of the present channel of the river.

In the eastern part of the county there are localities, for example in the NE¼ sec. 28, T. 16 N., R. 23 W. (see measured section no. 12), where intermediate terrace medium-grained sands rest directly upon bedrock.

No known intermediate terrace exposure reveals the thick deposits of sands and gravels which are so common in the upper terrace deposits.

In secs. 1, 2, 3, 10, 11 and 12, where the terrace deposits lie directly west of the river, the intermediate terrace surface and the adjacent Ogallala hills are covered by inactive sand dunes. Recent active dune formation occurs on the east side of the rivers in Oklahoma. Along the northwestern border of Roger Mills County the South Canadian River forms a horseshoe bend and consequently the river lies only five miles to the west of the dune-covered area which lies over a low line of Ogallala hills. If at the time of intermediate terrace formation the river followed the general course that it does today, and the distribution of the terrace deposits indicates that it did, the flood plain to the west could have been the source area for the sand which was deposited in the lee of the hills just west of the dune-covered area. The terrace deposits in the suggested source area are poorly preserved. Dunes are absent on the terrace surface to the south and here the river to the west is screened by a line of higher Ogallala hills. The dune deposits must be post-intermediate terrace in age. They are apparently pre-low terrace in age as there are no dunes on the low terrace surface.

In NE¼ sec. 26, T. 17 N., R. 25 W. is a deposit of limited areal extent which is slightly higher than any of the intermediate deposits. The section is unusual for the area in that it is capped by a dense layer of caliche a few inches thick. The relationships of this deposit to the surrounding beds is not clear because of local accumulations of recent sand and silt. It is probable that the sediments were deposited in a basin which may have originated as a result of local collapse in the underlying bedrock. A faunule from these deposits is described in the section devoted to the age of the intermediate terrace deposits.

Age of the Intermediate Terrace Deposits

The following faunal list and discussion has been extracted from a report of Dwight W. Taylor dated February 21, 1958.

"U. S. G. S. locality 21009. Roger Mills Co., Okla. NE¼ sec. 26, T. 17 N., R. 25 W. Hanawalt Ranch, 15 feet above terrace T-2 surface. D. B. Kitts, 1957.

Freshwater snails:

Stagnicola reflexa Say
Stagnicola caperata Say
Stagnicola bulimoides techella Haldeman
Fossaria dalli Baker
Gyraulus circumstriatus (Tryon)
Helisoma trivolvis (Say)
Planorbula
Menetus dilatatus (Gould)
Promenetus cf. *P. exacuous* (Say)
Physa gyrina Say
Physa anatina Lea

Land snails:

Gastrocopta cristata (Pilsbry and Vanatta)
Gastrocopta procera (Gould)
Gastrocopta tappaniana (Adams)
Pupoides albilabris (Adams)
Vertigo ovata Say
cf. *Succinea*
Nesovitrea electrina (Gould)
Hawaiia minuscula (Binney)

U. S. G. S. locality 21010. Roger Mills Co., Okla. NE¼ sec. 21, T. 16 N., R. 24 W. Merritt gravel pit. 15 feet below terrace T-2 surface. D. B. Kitts, 1957.

Freshwater clams:

Sphaerium occidentale Prime
Pisidium casertanum (Poli)
Pisidium obtusale Pfeiffer

Freshwater snails:

Stagnicola cf. *S. reflexa* Say
Stagnicola caperata Say
Fossaria dalli Baker
Fossaria obrussa Say
Gyraulus circumstriatus (Tryon)
Promenetus cf. *P. exacuous* (Say)
Promenetus umbilicatellus (Cockerell)
Physa skinneri Taylor
Aplexa hypnorum (Linnaeus)

Land snails:

Carychium exiguum (Say)
Strobilops labyrinthica (Say)
Gastrocopta armifera (Say)
Gastrocopta cristata (Pilsbry and Vanatta)
Gastrocopta procera (Gould)
Gastrocopta tappaniana (Adams)
Pupoides albilabris (Adams)
Pupilla muscorum (Linnaeus)
Vertigo ovata Say
Vertigo morsei Sterki
Vertigo milium (Gould)

Cinella lubrica (Müller)
Vallonia
Vallonia parvula Sterki
cf. *Succinea*
Oxyloma retusa (Lea)
Discus cronkhitei (Newcomb)
Helicodiscus parallelus (Say)
Helicodiscus singleyanus (Pilsbry)
Euconulus fulvus (Müller)
Nesovitrea electrina (Gould)
Hawaiia minuscula (Binney)
Zonitoides arboreus (Say)
Stenotrema leai (Binney)

"Both assemblages are probably of glacial, rather than interglacial, age. Species living today only considerably farther north than Oklahoma (such as *Lymnaea caperata, Gyraulus circumstriatus, Pupilla muscorum, Discus cronkhitei*) suggest former summers with considerably fewer and less marked hot, dry spells. There are also many species not now living so far west in the Great Plains, which suggest more rainfall and locally more vegetation providing suitable habitats.

"In the present state of knowledge it is difficult to distinguish between Illinoian and Wisconsin faunas purely on the basis of mollusks. Probably both these faunas are Wisconsin, rather than Illinoian, however. There are not many specific ranges that do not include both of the last two glacial ages, but a lineage in *Promenetus* seems to be stratigraphically useful. The Pliocene to middle Pleistocene *Promenetus kansasensis* apparently evolved into *Promenetus exacuous* in late Sangamon or early Wisconsin time. There are several Illinoian occurrences of *P. kansasensis,* but not enough Wisconsin localities in the southern Plains of *P. exacuous* for complete confidence in this phyletic dating. Nevertheless, on present knowledge the Roger Mills County material is more probably Wisconsin, for the *Promenetus* are closer to *P. exacuous* than to *P. kansasensis.* This slender basis is the only purely faunal evidence for dating.

"Occurrence of two species is of special interest. *Menetus dilatatus* has not been found fossil in the Plains previously. *Physa* *skinneri,* although known as an Illinoian fossil and in the living state also, has not previously been found in Wisconsin deposits in the United States."

The following faunal list and discussion has been extracted from Taylor's report of October 8, 1958.

"U. S. G. S. Cenozoic locality 21339. Roger Mills County, Okla. SW¼ sec. 20, T. 16 N., R. 26 W. Meek's gravel pit. Fifteen feet below 90-foot terrace level. D. B. Kitts, 1957.

Freshwater clams:

Pisidium casertanum (Poli)
P. obtusale Pfeiffer

Freshwater snails:

Stagnicola ref. *S. reflexa* (Say)
S. caperata (Say)
Fossaria dalli (Baker)
Gyraulus circumstriatus (Tryon)
Promenetus umbilicatellus (Cockerell)
Aplexa hypnorum (Linnaeus)

"The assemblage from locality 21339 is of glacial age. It includes *Pupilla muscorum,* living today only far to the north or in high mountains, as well as other species of less markedly northern distribution (*Pisidium obtusale, Stagnicola caperata, Gyraulus circumstriatus, Promenetus umbilicatellus, Aplexa hypnorum, Vallonia gracilicosta, Discus cronkhitei*). It is closely similar to that from locality 21010 (report dated February 21, 1958), and unless stratigraphic evidence is contrary, I would say that the two are of essentially the same age.

"In the interval since my earlier report (February 21, 1958) I have been studying the Illinoian Butler Spring local fauna from Meade County, Kansas. It is sufficiently similar to the assemblages from localities 21010 and 21339 that the three may be approximately contemporaneous. Wisconsin assemblages in this part of the Great Plains are not well enough known for a reliable age determination, however.

"*Pupilla sinistra* occurs in the southern Great Plains in Kansan and Illinoian deposits, besides those at locality 21339. It has not yet been found in Wisconsin deposits, but probably will turn up in them inasmuch as the species is still living. It tends to suggest a correlation of locality 21339 with the Butler Spring local fauna (Illinoian), and is probably a little more reliable than the identification of a few specimens as the Wisconsin and Recent *Promenetus exacuous* (Report of February 21, 1958). The evidence is not very strong, and I hope stratigraphic evidence will be adequate to date locality 21339."

LOW TERRACE DEPOSITS (T-1)

The low terrace deposits are discontinuously distributed along the south side of the South Canadian River throughout its course in Roger Mills County. They are absent at most places on the north side of the river. The deposits lie upon an erosional surface on Permian bed rock which ranges in elevation between some level below the present floodplain and 15 feet above the present floodplain of the river. There is as much as 20 feet of relief along the erosional surface within several hundred feet of the exposed contact. The bedrock surface apparently rises abruptly along the edge of the terrace away from the river.

The depositional terrace surface occurs at an elevation of 50 feet above the floodplain and consequently the deposits range in thickness from 30 feet to something over 50 feet where the terrace surface is preserved. The low terrace surface is in most places a little higher than the contact between the intermediate erosional and depositional terraces.

Good exposures of low terrace deposits are not numerous, but on the whole the sediments are apparently distinctly finer-grained than the higher terrace sediments. Coarse sands are rare and the few gravel deposits which have been observed are confined to a position high in the section and consist of sand containing a few quartzite pebbles and small cobbles.

No low terrace faunas have been analyzed. Regarding a fauna from the middle of the low terrace section in the SE¼ sec. 16, T. 16 N., R. 24 W. Taylor expressed the opinion in the field that it was glacial rather than interglacial. In view of this opinion and of the possible age of the intermediate terrace deposits, I consider it very likely that the low terrace deposits are Wisconsinan in age.

Reed and Longnecker (1932) in their paper on the geology of Hemphill County, Texas, have described a sequence of terraces along the south side of the South Canadian River which is essentially identical to the terrace sequence in Roger Mills County.

PLIOCENE AND PLEISTOCENE HISTORY OF NORTHERN ROGER MILLS COUNTY

Ogallala sediments from southern Nebraska southward rest upon Paleozoic and Mesozoic bedrock. Over this area no pre-Pliocene Tertiary sediments have been discovered. In the limited area of northern Roger Mills County the relief on the pre-Ogallala surface probably did not exceed 100 feet. It is generally agreed that the Tertiary drainage in the High Plains area trended west to east. It has not been possible to conclude on the basis of limited exposures the direction of drainage during the Tertiary in the limited area under consideration.

Early in the Pliocene, probably about mid-Clarendonian time, the rivers in the area began to aggrade. Deposition continued at least until mid-Hemphillian time and probably longer. The general lack of coarse-grained channel deposits and the fine-grained character of the floodplain deposits suggests that the sediments in the area are deposited at some distance from a major channel, perhaps along one or more tributary valleys. In the limited area in question the bedrock surface was probably covered with sediments by the end of Clarendonian time although over the southern High Plains in general areas of bedrock remained exposed until the end of Hemphillian time.

After the deposition of typical Ogallala sediments a deep, apparently east-west trending channel was cut through these sediments into the underlying Permian bedrock and later filled by deposits of gravel. Whether this represents a Late Pliocene or an Early Pleistocene cycle cannot at this time be established.

Erosion by the Canadian River during Early Pleistocene, probably Kansan time, again breached the Ogallala sediments and cut into Permian bedrock. At the beginning of this period of erosion the river had attained its present general course as the area of bedrock exposure closely parallels the recent channel of the river. It is almost certain that the two bends in the river course between the Texas border and the eastern border of the County were superposed on an Ogallala surface in Late Pliocene or Early Pleistocene time. Lateral planation subsequent to down-cutting resulted in the formation of a valley which was eight miles wide in the eastern part of the County. After this period of erosion the river began to aggrade and up to 80 feet of gravels, sands and silts accumulated. The distribution of gravels indicates that during this time the channel of the river was relatively restricted. During the late part of the period of high terrace deposition there was a marked decrease in the competence of the river.

The deepest Pleistocene erosion followed the period of high terrace deposition. There is a difference in elevation of up to 180 feet between the high terrace surface and the erosional surface underlying the intermediate terrace deposits. A period of extensive lateral erosion followed the down-cutting and a floodplain which was over five miles wide in the western part of the County was eroded from the Permian bedrock. During the early part of the depositional period that followed the channel migrated widely over the floodplain. A gradual decrease in the competence of the river occurred during the period in which up to 50 feet of sediments accumulated.

After the deposition of the intermediate terrace deposits the river again began to reduce the level of its channel by erosion, cutting down more than 90 feet in some localities. Subsequent lateral planation by the river was not as extensive as in the previous cycle and considerable relief remained on the narrow valley floor. Competence of the river was quite low during the early phase of aggradation. Competence may have increased somewhat just before low terrace deposition was completed.

After the deposition of low terrace sediments the river was again rejuvenated and reduced its channel to an undetermined level below the level of the present floodplain before it again began to aggrade to bring the channel and the floodplain to their present level.

Throughout its history in this area the Canadian River, although following the same general course, migrated slowly northward. This fact is indicated by the much greater volume and width of terrace sediments on the south side of the river compared to the north side.

During the Pleistocene drainage tributary to the Canadian and Washita rivers reduced the divides adjacent to the rivers. The highest elevations in the area are capped by a relatively resistant sandstone 300 feet above the base of the Ogallala group.

REFERENCES

Darton, N. H., 1899, Preliminary report on the geology and water resources of Nebraska west of the one hundred and third meridian: U. S. Geol. Survey, 19th Ann. Rept., Pt. 4, p. 727-785.

Dott, Robert H., 1942, Geology of Oklahoma ground water supplies: Oklahoma Geol. Survey, Mineral Report 11, p. 1-30.

Frye, John C., and Leonard, A. Byron, 1957a, Ecological interpretations of Pliocene and Pleistocene stratigraphy in the great plains region: Amer. Jour. Science, vol. 225, p. 1-11.

Frye, John C., and Leonard, A. Byron, 1957b, Studies of Cenozoic geology along eastern margin of Texas high plains, Armstrong to Howard Counties: Texas, Bureau of Economic Geology, Report of Investigations, no. 32, p. 1-59.

Frye, John C., Leonard, A. B., and Swineford, Ada, 1956, Stratigraphy of the Ogallala formation (Neogene) of northern Kansas: Kansas, State Geol. Survey, Bull. 118, p. 1-92.

Gidley, J. W., 1903, The fresh-water Tertiary of northwestern Texas: American Museum expeditions of 1899-1901. Amer. Museum Nat. History, Bull., vol. 19, p. 617-636.

Lugn, A. L., 1938, The Nebraska State Geological Survey and the "Valentine problem": Amer. Jour. Science, vol., 236 p. 220-; 227.

Lugn, A. L., 1939, Classification of the Tertiary system in Nebraska: Geol. Soc. America, Bull., vol. 50, p. 1245-1276.

Moore, R. C., Frye, J. C., and Jewett, J. M., 1944, Tabular description of the outcropping rocks in Kansas: Kansas, State Geol. Survey Bull. 52, pt. 4 p. 137-212.

Reed, L. C., and. Longnecker, O. M., 1932, The geology of Hemphill County, Texas: Texas, Univ., Bull., no. 3231, p. 1-98.

Sellards, E. H., Adkins, W. S., and Plummer, F. B., 1932, The geology of Texas. Vol. I Stratigraphy: Texas, Univ., Bull., no. 3232, p.1-1006.

Six, Ray L., 1930, Oil and gas in Oklahoma: Blaine, Dewey, Custer and Roger Mills Counties: Oklahoma Geol. Survey, Bull., 40-UU, p. 1-53.

Stirton, R. A., 1936, Succession of North American continental Pliocene mammalian faunas: Amer. Jour. Science, vol. 232, p. 161-206.

Wood, H. E., Chaney, R. W., Clark, J., Colbert, E. H., Jepsen, G. L., Reeside, J. B., and Stock, C., 1941, Nomenclature and correlation of the North American continental Tertiary: Geol. Soc. America, Bull., vol. 52, p. 1-48.

MEASURED SECTIONS

1. Lower part of Ogallala group in the NE¼ sec. 9, T. 17 N., R. 25 W.

		Feet
15.	Silt, dark brown grading into soil	3
14.	Clay, sandy, tan	2
13.	Sand, fine-grained, yellowish-brown	4
12.	Sand, fine-grained, clayey, yellowish-brown	5
11.	Sand, fine-grained, yellowish-brown	1
10.	Clay, sandy, yellowish-brown	4
9.	Conglomerate, caliche pebble	½
8.	Sand, fine-grained. yellowish-brown	9
7.	Sand, fine-grained, clayey, yellowish-brown	12
6.	Sand, fine-grained, yellowish-brown	14
5.	Sandstone, fine-grained, thinly bedded, yellowish-brown	2
4.	Sand, fine-grained, light-gray	15
3.	Conglomerate, caliche pebble	½
2.	Sand, fine-grained, light-gray	10
1.	Conglomerate, red shale pebble	5
		87

Permian

2. Lower part of Ogallala group in middle of sec. 26, T. 17 N., R. 25 W.

4.	Sand, fine-grained, massive, reddish-brown	15
3.	Ash, volcanic	7
2.	Sand, medium-grained with calcareous concretions	7
1.	Silts and fine-grained sands (partly grass covered)	35
		64

Permian

3. Middle part of Ogallala group in the NE¼ sec. 28, T. 17 N., R. 25 W.

2.	Sand, fine-grained, massive, tan	34
1.	Clay, silty, gray	1½
		35½

4. Middle part of Ogallala group in the SW¼ sec. 28, T. 17 N., R. 25 W.

8.	Clay, Silty, yellowish-brown	1
7.	Clay, silty, dark reddish-brown	½
6.	Clay, sandy, light tan	6
5.	Sandstone, fine-grained, light-brown	1
4.	Sand, fine-grained, yellowish-brown	2½
3.	Clay, sandy, reddish-brown	1
2.	Clay, sandy, greenish-gray	1½
1.	Clay, sandy, dark reddish-brown	4
		17½

5. Upper part of Ogallala group in NE¼ sec. 5, T. 16 N., R. 25 W.

7.	Sand, fine-grained, light-gray	20
6.	Sandstone, medium- to coarse-grained, massive, friable yellowish-brown	25
5.	Sand, medium-grained, massive, light-gray	50
4.	Sand, fine- to medium-grained, light-gray and yellowish-brown (partly grass-covered)	85
3.	Sandstone, medium-grained, light-gray	1½
2.	Sand, fine-grained, yellowish-brown	2½
1.	Sandstone, medium- to fine-grained, light-gray	1
		185

6. Lower part of Ogallala group in the S½ sec. 18, T. 15 N., R. 23 W.

2.	Clays, silts and fine-grained sands, yellowish-brown-and light-gray (partly grass-covered)	70
1.	Conglomerate, red shale pebble	2
		72

Permian

7. Ogallala group in the NW¼ sec. 8, T. 16 N., R. 21 W.

2.	Gravel, coarse sand, pebble and cobble	22
1.	Caliche, dense	1½
		23½

8. High terrace deposits in NE¼ sec. 30, T. 16 N., R. 22 W.

Sand and silt, massive, dark-brown and reddish-brown (partly grass-covered)	36

Permian

9. High terrace deposits in SW¼ sec. 36, T. 18 N., R. 21 W.

2.	Sand, fine- to medium-grained, massive dark-brown	24
1.	Sand, medium- to coarse-grained, and gravel, pebble and cobble, cross-bedded, local lenses of clay and clay balls	53
		77

10. Intermediate terrace deposits in the SE¼ sec. 18, T. 16 N., R. 26 W.

4.	Silt grading into silty soil	20
3.	Clay, sandy, blue-gray, containing gastropods	4
2.	Sand, coarse- to medium-grained, cross-bedded, yellowish-brown	2
1.	Sand, coarse and gravel, pebble and cobble, cross-bedded, base not exposed	

11. Intermediate terrace deposits in the NE¼ sec. 21, T. 16 N., R. 24 W.

4.	Sand, large grass-covered	10
3.	Sand, medium- to coarse-grained	10
2.	Clay, sandy, gray, containing gastropods	4
1.	Sand, coarse- to medium-grained, containing lenses of cobble and pebble gravel	15
		39

Permian

12. Intermediate terrace deposits in the NW¼ sec. 28, T. 16 N., R. 23 W.

2.	Sands and silts, largely grass-covered	35
1.	Sand, fine- to medium-grained, massive, reddish-brown, containing a few quartzite pebbles and cobbles	6
		41

Permian

13. Low terrace deposits in the SE¼ sec. 7, T. 16 N., R. 26 W.

4.	Sand, medium- to fine-grained, massive, light reddish-brown	4
3.	Sand, medium- to coarse-grained, light reddish-brown, containing quartzite pebbles and cobbles	5
2.	Clay, silty, light-gray	12
1.	Clay, light blue-gray	15
		36

Permian

A PLIOCENE VERTEBRATE LOCAL FAUNA FROM ROGER MILLS COUNTY, OKLAHOMA

David B. Kitts and Craig C. Black

ABSTRACT

A vertebrate fauna from the Ogallala group is described. The Durham locality is two and one half miles northwest of the town of Durham, Roger Mills County, Oklahoma, in the SE¼ sec. 15, T. 16 N., R. 26 W. The specimens were recovered from a buff sand layer six feet thick and from an overlying cross-bedded sand layer 11 feet thick. The fauna includes *Testudo* sp., *Coluber* ?, *Mylagaulus* cf. *M. laevis, Perognathus* cf. *P. pearlettensis, Vulpes* sp., Mephitinae gen. and sp. indet., *Nannippus* cf. *N. gratus, Neohipparion* sp., Merycoidodontidae gen. and sp. indet., *Megatylopus* sp., and Antilocapridae gen. and sp. indet. The Durham local fauna is Clarendonian in age, probably middle Clarendonian.

INTRODUCTION

The material described in this report was collected two miles northwest of the town of Durham, Roger Mills County, Oklahoma, on the farm of Mr. Bruce Thomas in SE¼ sec. 15, T. 16 N., R. 26 W. The strata from which the fossils were obtained are exposed in a blowout which is about 5,000 square yards in area. It is located approximately in the center of the SE¼ of the section along the east bank of an intermittent stream which drains north into the South Canadian River at a point about two miles distant.

The locality was discovered by Kitts in July 1955. Collecting was carried on intermittently during the summer of 1955 with the assistance of Mr. Paul DeGroot, then an undergraduate at the University of Oklahoma. Black joined Kitts during the summer of 1956 and it was during this time that most specimens were obtained.

ACKNOWLEDGMENTS

Dr. R. A. Stirton examined the Durham horses and Dr. Max Hecht identified the snake. Mr. Bruce Thomas allowed us access to his land. The figures, except for those of the rodent material which were prepared by Black, were drawn by Elinor Cline. The plate was prepared with the assistance of Dr. T. W. Amsden.

LOCAL GEOLOGY

The local section at the Durham locality is, except for the presence of a channel sand, typical of the lower part of the Ogallala formation in northern Roger Mills County. It consists for the most part of fine-grained sands. The bottom of the section shown in figure 2 is no more than 30 feet above the Permian contact.

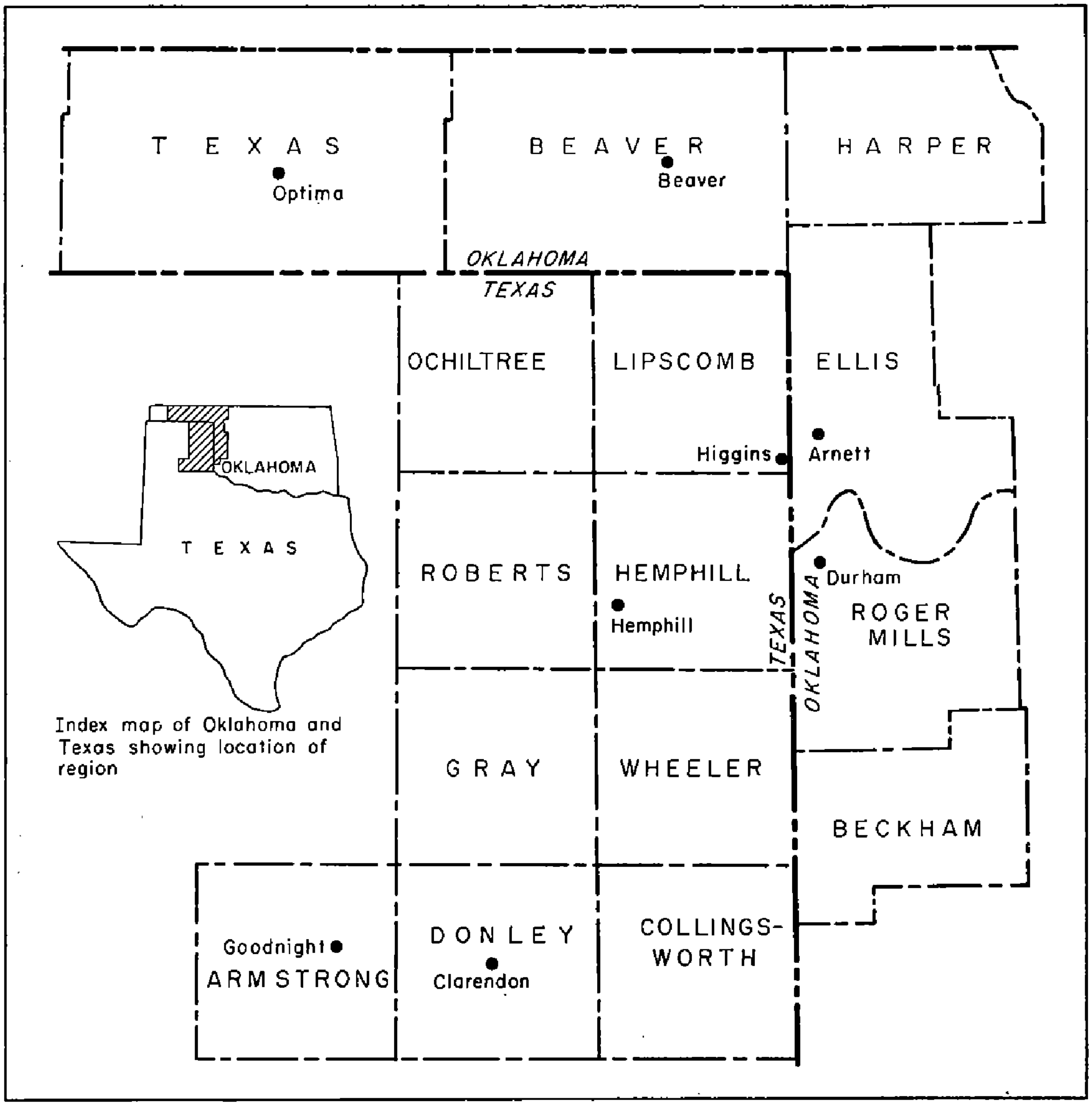


Fig. 1. Principal Clarendonian and Hemphillian vertebrate localities in Oklahoma and the Texas panhandle.

The fossils described in this paper are contained in two beds, a lower buff sand and lying directly above it a cross-bedded channel sand. The contained fossils do not reveal any age difference in the two beds. An age difference of some magnitude between the two beds might go undetected, however, because of the

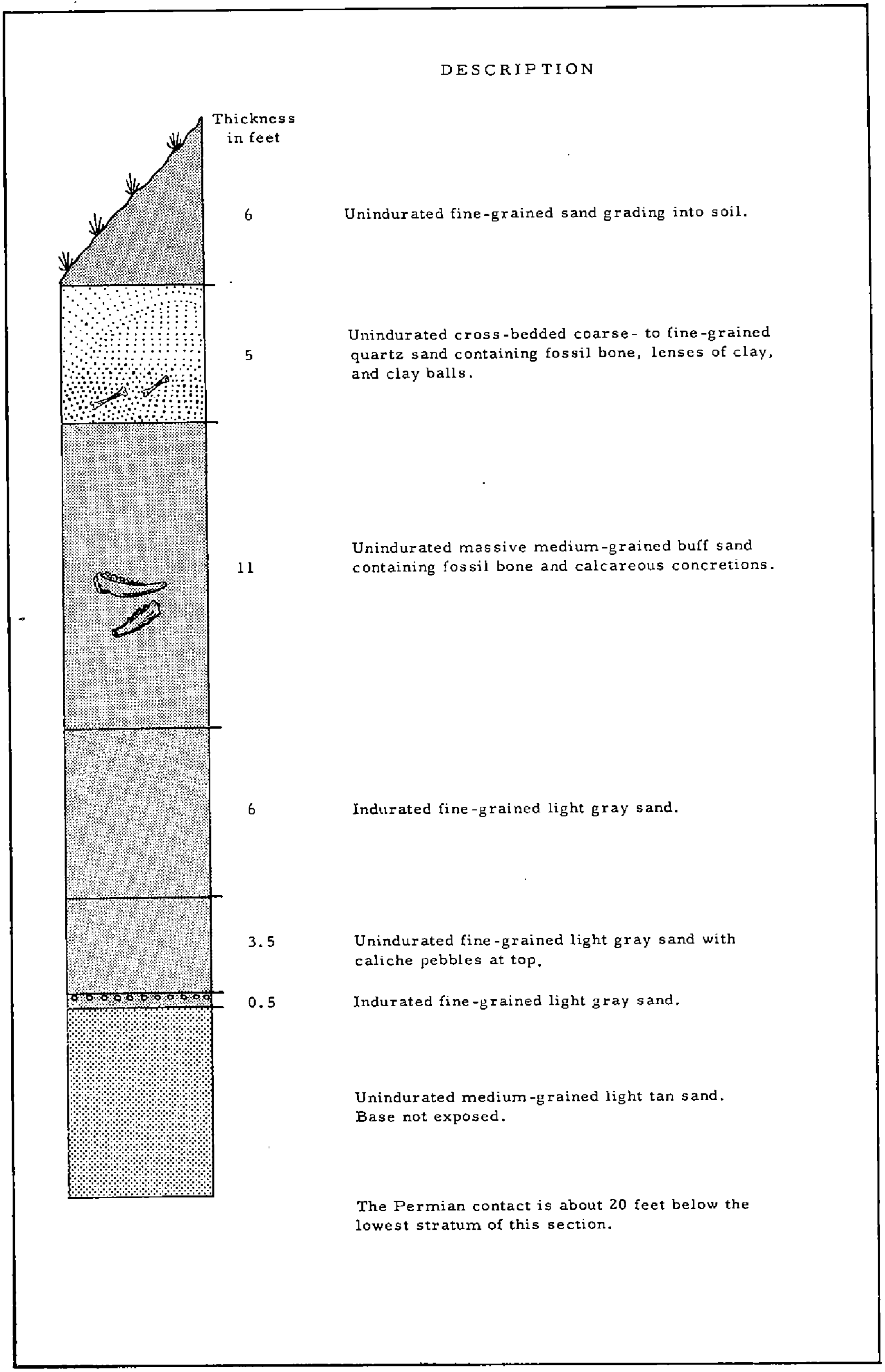


Figure 2. Columnar section of the Ogallala group at the Durham locality, Roger Mills County.

low degree of biostratigraphic precision which we have attained. We have regarded the fossils contained in the two beds as a single biostratigraphic unit.

The lower bone-bearing bed consists of reddish-buff, fine- to medium-grained massive sand containing calcium carbonate concretions. The deposit is probably of flood plain origin. The abundance of concretions and the lack of bedding indicate that for a prolonged period in its history the deposit was located at or near the surface and subjected to weathering. The fossil bone recovered from this layer is poorly preserved.

The upper bone-bearing bed which lies unconformably on the buff sand layer consists of uncemented, cross-bedded sand. The sand grains vary in size between fine and very coarse. The deposit contains lenses of clay and clay balls and is locally iron-stained. Repeated efforts were made to locate concentrations of bone within the deposit but without success. Apparently the fossils are rather evenly and sparsely distributed throughout much of the deposit. Almost all of the bone occurs as small fragments which show evidence of having been transported over a considerable distance. About 10 percent of the fossils recovered from this deposit were found in place, the remainder having been picked up on the surface. The channel in which the sand was deposited apparently trended east and west since the degree of cross-bedding decreases and the material becomes finer to the north and south. The channel must have been over a hundred feet in width since the deposits are exposed over an area about 100 by 150 feet.

Fossil-bearing channel deposits present a frustrating problem to the paleontologist. Properties of the fossil material such as size, shape and density, which determine their behavior in fluids, may have been more important factors in determining the composition of the association than the ecological requirements of the animals whose remains are represented. Facts which suggest the importance of postmortem physical factors in determining the composition of the Durham channel sand assemblage are evidence that the bone has been stream transported, and that the fossils tend to be small regardless of the size and implied ecological requirements of the animals to which they pertain. All that can be said, consequently, about the ecological and geographic distribution of the animals involved is that they lived in the drainage basin of the river in whose channel deposits they were found. Judging from the nature and extent of the deposits in the present case the drainage basin may have been extensive.

There is no direct evidence to suggest that any of the fossils in the Durham channel sands were derived from older rocks by erosion. This is a possibility which must be considered, however, particularly because several of the forms described might as well be Barstovian or Hemphillian in age as Clarendonian.

DESCRIPTION OF THE FAUNA

Class Reptilia
Order Chelonia
Family Testudinidae
Genus *Testudo* Linnaeus, 1758
Testudo sp.

A nearly complete carapace and plastron of a large *Testudo* was recovered from the buff sand layer. The carapace is approximately 68 centimeters long and 49 centimeters wide.

Order Squamata
Suborder Ophiida
Family Colubridae
Subfamily Colubrinae

Two snake vertebrae recovered from the buff sand layer have been identified by Dr. Max Hecht. He believes that the specimen is probably referrable to the genus *Coluber* or to a closely related genus.

CLASS MAMMALIA
ORDER RODENTIA
FAMILY MYLAGAULIDAE

Genus *Mylagaulus* Cope 1878
Mylagaulus cf. *laevis* Matthew, 1902

Two of the five specimens (O. U. S. M. Nos. 2009 and 2020) are too badly broken and crushed to be of any descriptive value while the other three (O. U. S. M. Nos. 2018 and 2019, Fig. 3) are in a good state of preservation. All five specimens, which were recovered as float, seem to be more closely related to *Mylagaulus* *laevis* than to any other species of the genus on the basis of size, number of lakes, and arrangement of lakes. These specimens also resemble in size and in number of lakes those described by Hesse (1936, p. 57) from Beaver County, Oklahoma, and assigned to *Mylagaulus* sp.

The two fourth lower premolars are alike in having seven lakes arranged in four anteroposterior rows as stated by Matthew (1902, p. 298) for *M. laevis*. The buccal row is composed of only one lake whereas the other three rows are made up of two lakes. There is a very thin investment of cement on the teeth which, although broken and worn away in spots, appears to have reached the grinding surface. The one fourth upper premolar in the collection also shows seven lakes and a thin covering of cement.

As Wilson (1937), McGrew (1941) and many others have pointed out, until a comprehensive study of individual and age variations in a large series of mylagaulid populations has been carried out, the number of species and the interpretation of their relationships can not be fully understood. The tendency of most authors to refer specimens from the Pliocene of the Great Plains and Great Basin to *Mylagaulus* sp. reflects our lack of understanding of the development of this family. Unfortunately, there seems to be no other alternative at present.

In the belief that any amount of information as to the variation of crown pattern with wear will be of value one of the two fourth lower premolars was sectioned using the technique of Black and Wood (1956, p. 672). Before the first section was taken all the fossettids were closed (Fig. 3c). The pattern remained unchanged until 1 mm had been removed when the mesofossettid lost its small buccally extending arm (Fig. 3d). During the removal of the next 2 mm, the hypofossettid began to constrict near its posterior end until finally two lakes were formed (Figs. 3e, f). After the removal of 5 mm, the small circular portion of the hypofossettid was lost (Fig. 3g) and the pattern remained unchanged through the next 2 mm where the small lingual anterofossettid was lost and the posterofossettid divided, forming two small lakes (Fig. 3h). With another 2 mm of wear, one of the posterofossettids was lost and all the fossettids had become greatly reduced in size (Fig. 3i). Finally with the removal of one more

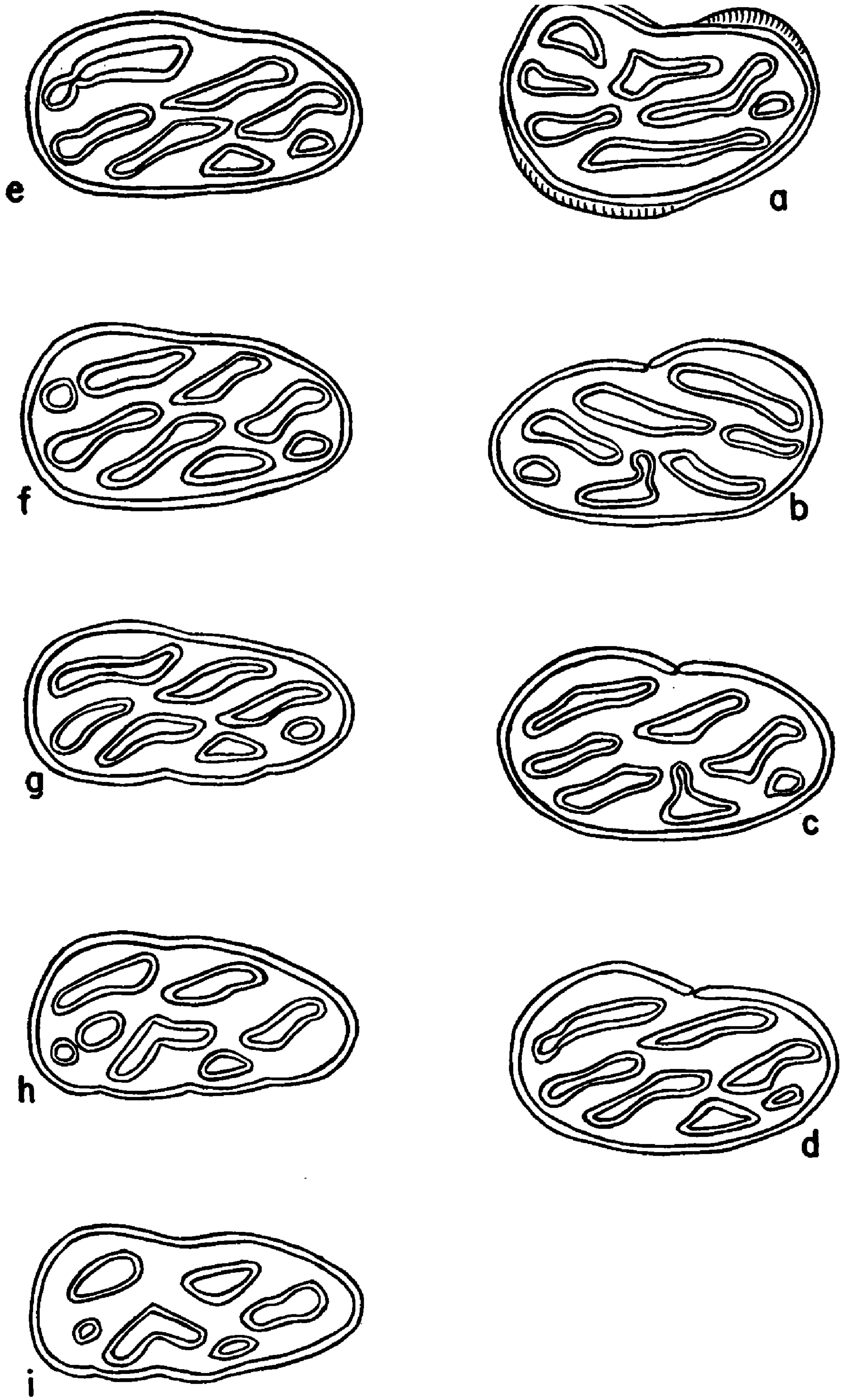


Fig. 3. *Mylagaulus* cf. *M. laevis,* a. O.U.S.M. No. 2019 Right P^4, b. O.U.S.M. No. 2018a Right P^4, c.-i. O.U.S.M. No. 2018b Left P^4 wear stages. All X3.

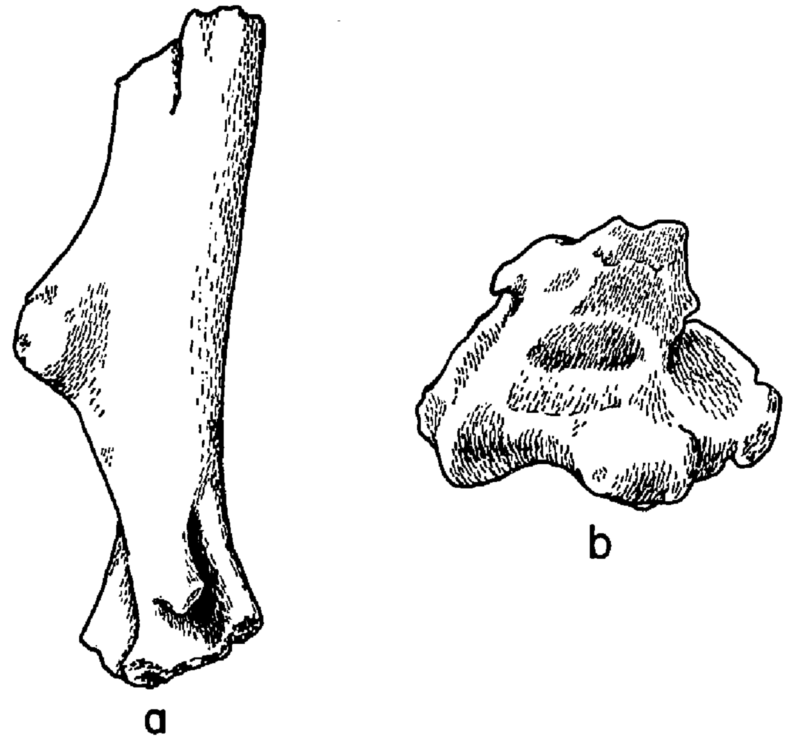


Fig. 4. *Mylagaulus* cf. *M. laevis*, a O.U.S.M. No. 2019 O.U.S.M. No. 2036, partial right humerus, internal view. b. Distal end of left humerus, anterior view. Both. X1.

millimeter (making a total of 10 mm, removed) all the fossettids were lost leaving only the external ring of enamel around the tooth. The pattern thus passed from seven lakes to eight, back to seven and finally to six, after which the entire pattern was lost.

TABLE 1

Measurements of Teeth of *Mylagaulus* cf. *laevis*.

	Anterior-Posterior Diameter	Transverse Diameter	Height
O.U.S.M. No. 2018 Right P/4	10.7	6.1	16.0
O.U.S.M. No. 2018 Left P/4	10.8	6.1	15.8
O.U.S.M. No. 2020 Right P/4	12.3	5.3 (crushed laterally)	
O.U.S.M. No. 2019 Right P/4	9.9	6.9	10.0

FAMILY HETEROMYIDAE

Perognathus Maximilian 1839

Perognathus cf. *pearlettensis* Hibbard, 1941

One badly water worn and broken left ramus with P_4-M_3 (O.U.S.M. No. 2022, Fig. 5) was collected in place in the buff sand layer and may be tentatively assigned to this species. The alveolar length of the tooth row is 3.20 mm, which is the size given by Hibbard (1956) for a specimen from the Meade formation. This is at the upper size limit of the known specimens but is still within two standard deviations of the mean for the species.

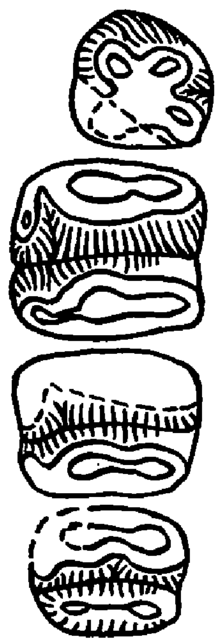


Fig. 5. *Perognathus* cf. P. *pearlettensis*, O.U.S.M. No. 2022, fragment of left mandibular ramus with P_4-M_3, crown view of teeth. X20.

P_3, M_2, and M_3 are broken and M_2 has been slightly displaced bucally (restored in the figure). The cusps of P_4 form the usual X pattern with the grooves between the cusps shallow in all cases. The protostylid on M_1 and M_2 is narrowly connected to the metalophid. There is no buccal connection between the metalophid and hypolophid on M_1-M_3 and one would appear only with considerably more wear. This is the earliest record of the species, which has been previously reported from the Rexroad, Sanders, and Borchers faunas of Kansas.

TABLE 2
Measurements of teeth *Perognathus* cf. *pearlettensis*

	Anterior-Posterior Diameter	Transverse Diameter
P/4	.72	.75
M/1	.97	1.02
M/2	.79	.95
M/3	.72	.85

ORDER CARNIVORA

Family Canidae

Genus *Vulpes* Frisch, 1775

Vulpes sp.

The specimen which has been referred to *Vulpes* consists of a fragment of the left mandibular ramus with P_2, partial P_3, and P_4 (O.U.S.M. No. 2025, fig. 6). The specimen was recovered as float. The character of the adhering matrix indicates that it originated in the buff sand layer.

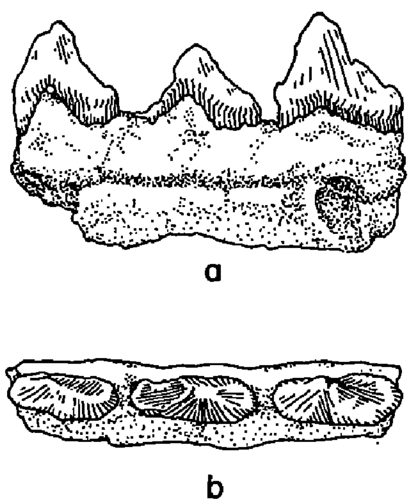


Fig. 6. *Vulpes* sp., O.U.S.M. No. 2025, fragment of left mandibular ramus with P_2-P_4. a. Dorsal view. b. Lateral view. X2.

The teeth are moderately worn. P_2 and P_3 are without a posterior accessory cusp. The posterior margin of the crown of P_3 is turned up to form a faint posterior cingular cusp. A well-developed posterior accessory cusp is present on P_4 and in this tooth the posterior cingular cusp is more prominent than in P_3.

In the tooth characters cited above the Durham specimen resembles *Urocyon* quite as much as it does *Vulpes,* although a posterior accessory cusp on P_3 may be present in individuals referable to these genera. In *Urocyon* however, the premolars are relatively much wider than in *Vulpes* and in the Durham specimen. This is particularly true of the posterior portion of the tooth.

TABLE 3
Measurements of the teeth of *Vulpes* sp. (O.U.S.M. No. 2025)

P_2 anterior-posterior diameter	5.7
transverse diameter	2.0
P_4 anterior-posterior diameter	6.6
transverse diameter	2.5

FAMILY MUSTELIDAE

Subfamily Mephitinae genus and species indeterminable

The specimen which has been referred to the subfamily Mephitinae consists of a right mandibular ramus with M_1 and M_2 (O.U.S.M. No. 2032, fig. 7). It was recovered as float on the surface of the channel deposits and must have originated in that layer. The specimen was unfortunately lost subsequent to being described and drawn.

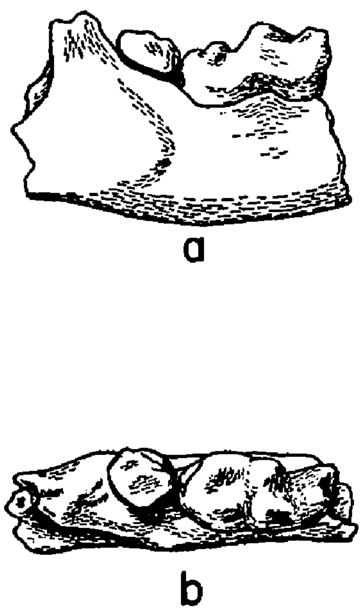


Fig. 7. Mephitinae genus and species indet., O.U.S.M. No. 2032, fragment of right mandibular ramus with M^2-M^3. a. Dorsal view. b. Lateral view. X2.

The anterior tip of M_1 is missing but it is clear that the paraconid was relatively high. In the worn condition of the specimen it is possible to detect a separate protoconid and metaconid. The points of these cusps must have been quite widely separated in the unworn tooth. The metaconid is posterior to the protoconid by about one half its anterior-posterior diameter. The trigonid is nearly twice the length of the talonid. The hypoconid is only faintly discernable owing to the worn condition of the tooth. A ridge of nearly constant height extends from the posterior edge of the tooth at the midline around the posterior and internal edges of the talonid. The remains of the entoconid are visible as a slight projection near the posterior edge of the ridge directly behind the metaconid and a little posterior of the hypoconid. This ridge is separated from the hypoconid by a transverse groove which extends across the talonid from the internal-anterior to the external-posterior corner. The talonid is relatively broad, extending internally farther than any part of the trigonid.

There is little doubt that the specimen described above may be assigned to the subfamily Mephitinae. It cannot, however, be confidently assigned to any described genus of skunk. The specimen resembles *Brachypotoma* quite closely, but in no specimen which pertains to that genus is the talonid so relatively broad. The Durham specimen may well represent an undescribed genus of mephitine. To erect a new genus on the basis of such limited material, however, would seem unwise.

ORDER PERISSODACTYLA

Family Equidae

Genus *Nannippus* Matthew, 1926

Nannippus cf. *N. gratus* (Leidy), 1869

Specimens referable to *Nannippus* constitute by far the most abundant element in the Durham fauna. Most of the material consists of isolated teeth, all worn to some extent, which were recovered as float. The character of the adhering matrix indicates that the specimens originated in the buff sand layer and in the channel sands in about equal numbers.

The fossette borders of the upper molars are relatively simple. In two upper molars (O. U. S. M. No. 2012b, fig. 8b, and 2050) a small hypostylar fossette is present. In a third (O. U. S. M. No. 2051) the hypostylar portion of the tooth is missing and in a fourth rather large well-worn specimen (O.U.S.M. No. 2058) the hypostylar groove is opened. The presence of a hypostylar fossette in *Nannippus* is characteristic of *N. retrusus* (Cope) and *N. gratus* (Leidy) (see Stirton, 1940).

The protocone is free of the protoconule for about half the crown height. It is free at the crown in three moderately worn specimens (O.U.S.M. Nos. 2012a fig. 8b, 2063 and 2058) and united with the protoconule at the crown in two well worn specimens (O.U.S.M. Nos. 2012b and 2060). The protocone is regularly and broadly oval.

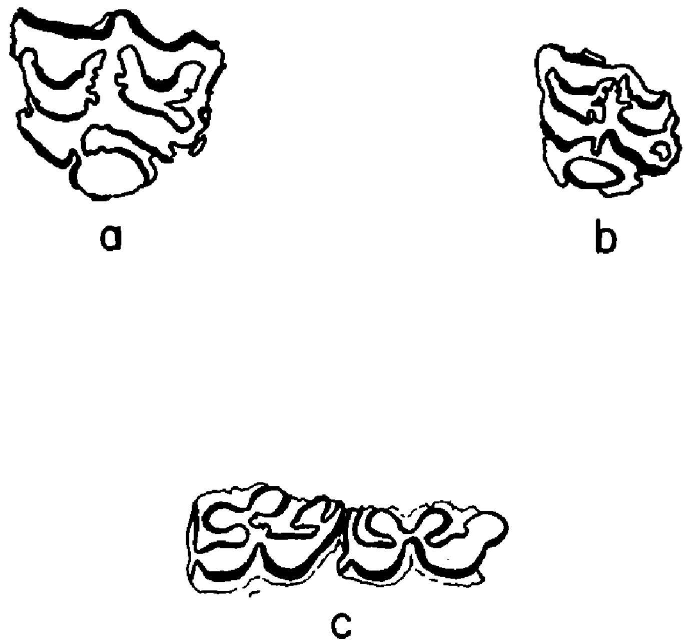


Fig. 8. a. *Neohipparion* sp., O.U.S.M. No. 2071, upper molar, crown view, XI.
b. *Nannippus* cf. *N. gratus*, O.U.S.M. No. 2012, upper molar, crown view. X1.
c. *Nannippus* cf. *N. gratus*, O.U.S.M. No. 2000, lower molars, crown view. X1.

In the lower teeth (O.U.S.M. No. 2000, fig. 8c) the metaconid and the metastylid are distinctly separated and broadly oval. The angle between the long axis of the ovals of the metaconid and the metastylid approaches 90 degrees in many specimens.

There are, unfortunately, no unworn specimens in the sample. The greatest crown height represented is 44.1 mm measured along the metaconid of a lower molar (O.U.S.M. No. 2053a).

Gregory (1942), who discussed the Clarendonian species of *Nannippus* at some length, states that the crown height of Burge local fauna lower molar specimens ranges up to 41.5 mm, whereas those in the Big Spring Canyon local fauna range between 48.0 mm and 50.0 mm. He states further that the crown height of lower molars from the Clarendonian local fauna is slightly less than that of specimens from Big Spring Canyon. It is probable that the Durham specimens were in unworn condition higher crowned than Burge specimens and may well have been somewhat lower crowned than specimens from Big Spring Canyon.

The Durham and Big Spring Canyon *Nannippus* samples are very similar even to the presence of a single specimen with an open hypostylar groove in each fauna. Stirton (1940) has pointed out that in the type specimen of *N. retrusus* the hypoconal groove is partly open. The condition displays a good deal of intraspecific variation. Gregory (1942) states that in the Burge *Nannippus* an open hypoconal groove is the common condition although specimens with a closed fossette do occur. Apparently the frequency of the closed fossette is about the same in the Durham sample as in the Big Spring Canyon sample. Gregory has tentatively assigned the Big Spring Canyon *Nannippus* to *N. gratus* and Johnston (1938) has assigned the Clarendon *Nannippus* to the same species. Judging from the crown height it is probably safe to conclude that the Durham form is closer to the Clarendon form than to the form from Big Spring Canyon. Stirton has examined the Durham horses and states that they look very much like those in the Clarendon local fauna.

Neohipparion sp.

A single well worn upper molar (O.U.S.M. No. 2071 fig. 8a) is referable to *Neohipparion*. Specific identification of this specimen is not possible.

ORDER ARTIODACTYLA

Family Merycoidodontidae

Genus and species indeterminate

A fragment of a left maxilla with the root of the canine and a well worn first premolar (O.U.S.M. No. 2010) and a nearly complete pes (O.U.SM. No. 2002) from the buff sand layer are clearly referable to this family. On the basis of the size and relationship of the teeth the specimen might well be assigned to *Ustatochoerus* Schultz and Falkenbach (1941). In view of the very limited character of the material, however, we prefer not to make any generic assignment.

FAMILY CAMELIDAE

Genus *Megatylopus* Matthew and Cook, 1909

Megatylopus sp.

The specimen referred to this genus consists of the fragmented parts of the skull and lower jaws of a juvenile camel (O.U.S.M. No. 2074, plate II). It was discovered in the buff sand layer by Peter Kitts. Although only a small portion of the skull was exposed when it was discovered, it was in a poor state of preservation. The skull was badly fragmented and much of the facial region was missing. The surfaces of the bones are badly pitted. It is possible that this specimen lay exposed for a considerable length of time before burial.

As finally recovered the specimen consists of a nearly complete upper and lower dentition (M^1, M^2, DP^3, DP^4, and M_1-M_3, DP_2-DP_4) and parts of the cranium. At the time of death M^3 and M_3 were unerupted and the deciduous teeth were worn almost to the roots.

No incisors or canines were recovered from the badly fragmented anterior portion of the skull. No trace of DP^2 was found and this tooth was probably absent in life. The maxillaries are in such a poor state of preservation, however, that it is possible that its absence has resulted from postmortem loss.

DP^3 is badly worn. A small complete enamel lake is present between the internal lobes of the tooth. This structure may be homologous to the rudimentary internal pillar present on the molars. DP^4 is well-worn and complete. In this tooth the enamel border of the internal pillar is continuous with the enamel borders of the internal lobes. The parastyle, mesostyle and external ribs are prominent.

M^1 and M^2 are well preserved. M^1 is but slightly worn and M^2 is virtually unworn. In both upper molars the external styles and ribs are prominent. The rib on the anterior lobe is slightly stronger than the rib on the posterior lobe. A rudimentary pillar extends from the root about half way to the crown of the unworn tooth.

The most anterior portion of the dentary is missing from both lower paws. DP_2 is the first tooth of the cheek tooth series. It is a small double-rooted tooth which in its present state of wear is flat-crowned. It was undoubtedly sharp-crowned in unworn

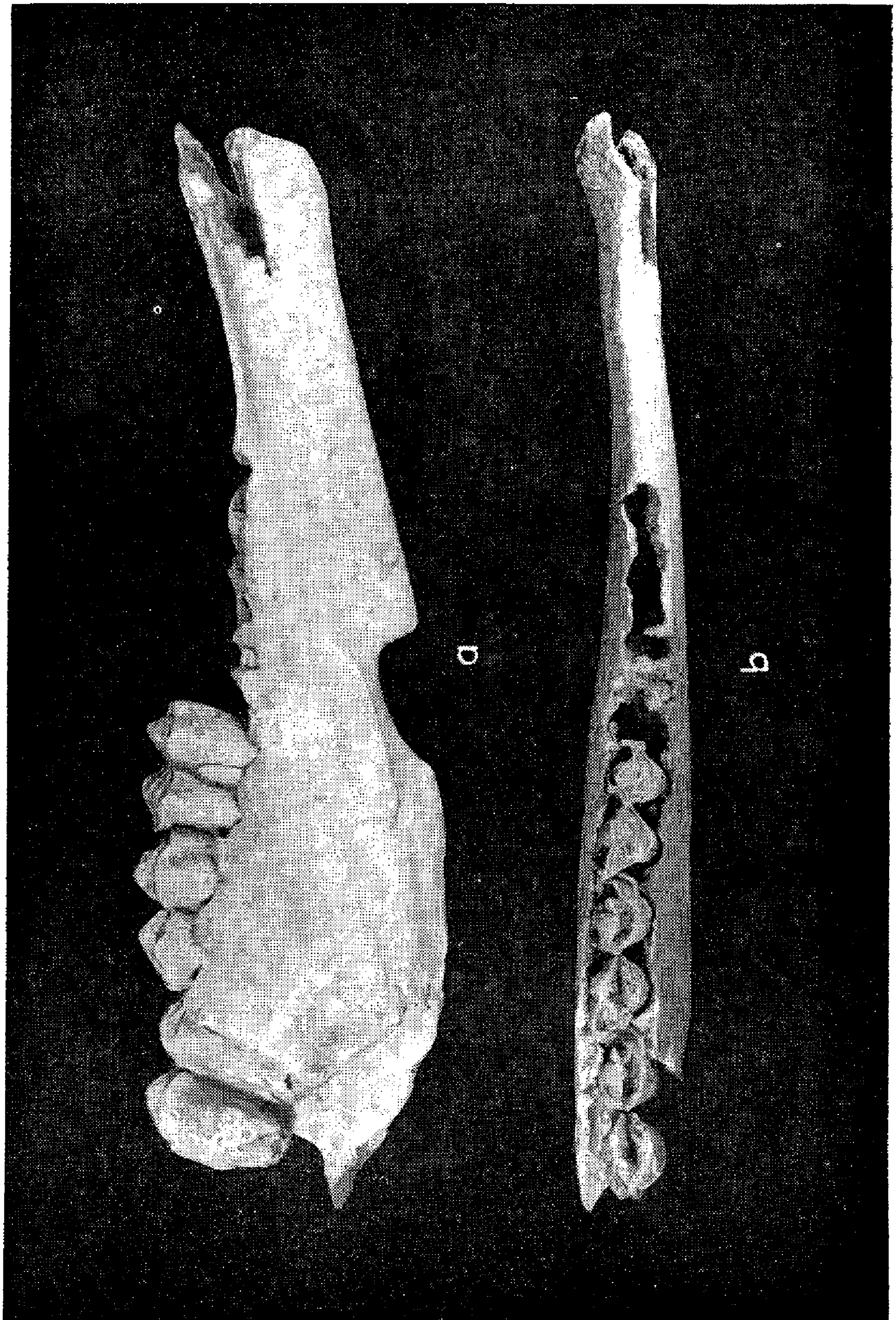


Plate II. *Megatylopus* cf. *M. gigas*, O.U.S.M. No. 2074, left mandibular ramus with M^1-M^3. a. Lateral view. b. Dorsal view. X½.

condition. DP_3 is missing on the right side and badly broken on the left. DP_4 is a long trilobate tooth worn almost to the roots.

The lower molars are high-crowned and have prominent ribs and styles. Between the external lobes of M_1 is a rudimentary pillar very similar to the internal pillars on the upper molars. The top of this pillar is well below the crown of the tooth at the stage of wear represented in this specimen. M_3 was unerupted at the time of death and may have been incompletely formed. It should be noted, however, that the heel of this tooth is rudimentary.

The Durham *Megatylopus* bears a close resemblance to *M. gigas* (Matthew and Cook, 1909) from the Snake Creek beds. In view of the lack of corresponding parts between the two specimens, however, we are reluctant to assign the Durham specimen to this species.

TABLE 4

Measurements of the teeth of *Megatylopus* sp. (O.U.S.M. No. 2074)

	Anterior-Posterior Diameter at Crown	Anterior-Posterior Diameter at Root	Transverse Diameter at Crown	Transverse Diameter at Root	Crown Height
DP^{3}	23.0		17.2		
DP^{4}	26.8		17.8		
M^{1}	33.1	25.6	19.7	26.9	
M^{2}	39.6	33.1	19.6	27.5	67.0
DP_{2}	12.7		6.4		
DP_{3}	19.9		—		
DP_{4}	33.9		14.6		
M_{1}	32.5		14.0		
M_{2}	39.2		14.5		
M_{3}	41.9		15.6		46.3

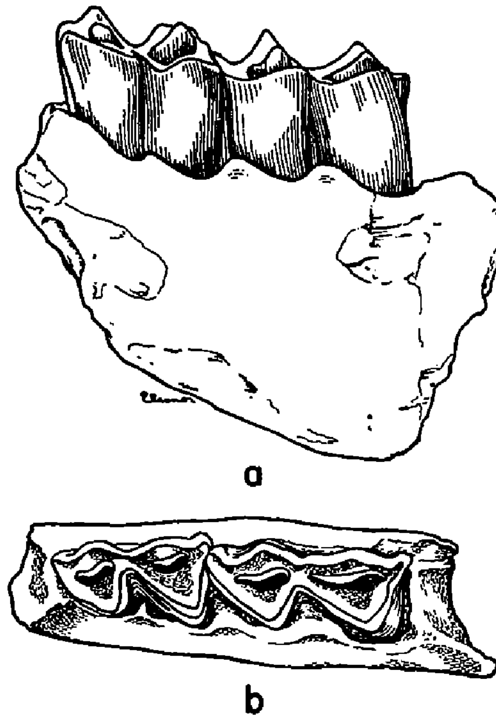


Fig. 9. Antilocapridae genus and species indet., O.U.S.M. No. 2007, fragment of left mandibular ramus with M^1 and M^2. a. Dorsal view. b. Ventral view. X2.

Family Antilocapridae genus and species indeterminate

Several lower jaw fragments containing molars and premolars (O.U.S.M. Nos. 2007 fig. 9, 2024, 2031) are certainly antilocaprid. In the absence of more complete material, particularly of horn cores, more precise determination is not possible.

AGE OF THE FAUNA

As in the case of so many Cenozoic local faunas, the age determination of the Durham local fauna rests primarily upon the identification of the equids. The most abundant horse at the Durham locality certainly belongs in *Nannippus* and seems to fall quite clearly into *N. gratus* as redefined by Gregory (1942) who stated (p. 329), "As redefined in this paper, this species is characteristic of the later part of the lower Pliocene, more advanced than *N. restrusus* from the Burge fauna, and about equivalent to the *Nannippus* of the Clarendonian and Minnechaduza faunas." The Durham *Nannippus* specimens are particularly close to those from the Clarendon local fauna in general morphology, size and crown height.

In the present state of our understanding of mylagaulid taxonomy any conclusions as to the age of an assemblage based upon the members of this family must be tentative. The resemblance of the Durham specimens to *M. laevis* and to *Mylagaulus* specimens from the Beaver local fauna, however, is suggestive of Barstovian or Clarendonian age, and the presence of this family indicates an age no younger than Hemphillian.

Because some of the other elements in the assemblage strongly suggest an age older than Late Pliocene, we regard the presence of *Perognathus* cf. *P. pearlettensis* in the Durham assemblage as evidence for an extended temporal range of this species rather than a Late Pliocene age for the fauna.

Vulpes, or an extremely *Vulpes*-like fox, is known from as early as Late Miocene. The presence of this genus in the fauna is consequently of little utility in precise age determination.

The skunk specimen apparently represents a new form. On the basis of the inadequate material at hand it appears to have been more specialized in the direction of recent skunks than the Early Pliocene genera placed in Mephitinae by Simpson (1945).

Even though we have been unable to assign the merycoidodontid material to a particular genus, the mere presence of a member of this family indicates that the fauna is no younger than Hemphillian. If we could be certain of our assignment of the specimen to *Ustatochoerus* we should have gained little because this genus has been recorded from both Clarendonian and Hemphillian deposits.

The classification of the late Cenozoic camels appears to be in a state of considerable confusion. This confusion apparently results primarily from the rarety of associated skulls, dentitions and limb bones, all of which appear to be necessary for generic determination. *Megatylopus* has been reported from beds ranging in age from Clarendonian to Nebraskan (Blanco beds). We are moderately impressed with the resemblance of the Durham *Megatylopus* to Matthew's and Cook's *M. gigas* (1909) from the Snake Creek beds. We are not, however, inclined to ascribe any great stratigraphic significance to resemblance at this time.

From the above considerations we conclude that the Durham local fauna is of Clarendonian age, probably about equivalent to the Clarendon local fauna. We freely admit that this conclusion is based largely upon the presence of *Nannippus gratus* in the assemblage. It can only be said that the remainder of the fauna is not inconsistent with this conclusion.

REFERENCES

Black, C. C. and Wood, A. E., 1956, Variation and tooth replacement in a Miocene mylagaulid rodent: Jour. Paleontology, vol. 30, p. 672-684.

Gregory, J. T., 1942, Pliocene vertebrates from Big Spring Canyon, South Dakota: Calif., Univ., Publ. Dept. Geol. Sciences, Bull., vol. 26, p. 307-439.

Hesse, C. J., 1936, The Lower Pliocene vertebrate fossils from the Ogallala formation (Laverne zone) of Beaver County, Oklahoma: *In*: Chaney, R. W. and Elias, M., Washington, Carnegie Inst., Publ. no. 476, p. 47-72.

Hibbard, C. W., 1941, The Borchers fauna, a new Pleistocene fauna from Meade County, Kansas: Kansas, State Geol. Survey, Bull., vol. 38, p. 197-220.

Hibbard, C. W., 1956, Vertebrate fossils from the Meade formation of southwestern Kansas: Michigan Acad. Science Arts and Letters, Papers, vol. 41, p. 145-203.

McGrew, P. O., 1941, The Aplodontoidea: Chicago Nat. History Museum, Geol. Ser., vol. 9, p. 1-30.

Matthew, W. D., 1902, A horned rodent from the Colorado Miocene, with a revision of the *Mylagauli*, beavers and hares of the American Tertiary: Amer. Museum Nat. History, Bull., vol. 16, p. 291-310.

Matthew, W. D. and Cook, H. J., 1909, A Pliocene fauna from western Nebraska: Amer. Museum Nat. History, Bull., vol. 26, p. 361-414.

Schultz, C. B. and Falkenbach, C. H., 1941, Ticholeptinae, a new subfamily of oreodonts: Amer. Museum Nat. History Bull., vol. 79, p. 1-105.

Simpson, G. G., 1945, The principles of classification and a classification of mammals: Amer. Museum Nat. History Bull., vol. 85, p. i-xvi, 1-350.

Stirton, R. A., 1940, Phylogeny of North American Equidae: Calif. Univ. Publ., Dept. Geol. Sciences, Bull., vol. 25, p. 165-197.

Wilson, R. W., 1937, New Middle Phiocene rodent and lagomorph faunas from Oregon and California: Washington, Carnegie Inst., Publ. no. 487, p. 1-19.

INDEX