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THE GEOLOGY AND PALEONTOLOGY OF A LATE PLEISTOCENE BASIN IN SOUTHWEST KANSAS

by
Gerald Edward Schultz

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Abstract

THE GEOLOGY AND PALEONTOLOGY OF A LATE PLEISTOCENE BASIN IN SOUTHWEST KANSAS

By Gerald Edward Schultz

The purpose of this study is to reconstruct the geologic history of a sinkhole collapse basin that formed during late Pleistocene time in Meade County, Kansas; to determine the nature of the vertebrate faunas that lived in and around this basin during Illinoian glacial, Sangamon interglacial, and Wisconsin glacial times; and to reconstruct, on the basis of the fossils, some of the local environments and climatic conditions which existed in the southern High Plains during late Pleistocene time.

Small fossils were recovered from the sedimentary deposits by washing and screening large quantities of matrix. Most of these fossils were identified by comparing them with Recent skeletal remains of the same species. Remains of larger, extinct mammals were also found. Mapping of the geology was facilitated by the use of aerial photographs, topographic maps, and Brunton compass.

The basin under study is called the Butler Spring Basin and is located in southern Meade County, Kansas, about one mile north of the Cimarron River. It is approximately one mile in diameter and is believed to have formed when subsurface solution of salt and anhydrite from Permian beds caused the collapse of overlying beds of Pleistocene age.

Studies of fossils preserved in the sediments filling the basin have demonstrated the presence of four superimposed

vertebrate faunas. Associated with some of these faunas are mollusks, fresh-water ostracodes, and pollen. The oldest fauna occurs in stream deposits of the ancestral Cimarron River which lie topographically below the High Plains surface and which represent a period of downcutting during late Pleistocene time. Younger faunas occur in a series of overlying silts and sands of sinkhole origin. On the basis of stratigraphic position, faunal composition, and associated floral (pollen) evidence, the faunas are assigned to the third (Illinoian) and fourth (Wisconsin) glacials and the intervening third (Sangamon) interglacial.

The Adams local fauna (Illinoian) contains fragmentary remains of large mammals taken from sands and gravels of the ancestral Cimarron River. In the Butler Spring local fauna (late Illinoian), the occurrence of Sorex cinereus, cinereus shrew; Citellus richardsoni, Richardson ground squirrel; and Microtus pennsylvanicus, meadow vole, whose present ranges do not extend as far south as Meade County, Kansas, suggests summers that were cooler and more moist than those in the area today.

The Cragin Quarry local fauna (Sangamon) occurs in sediments which overlie the Butler Spring local fauna. It includes a large and diverse mammalian assemblage; many of the species are upland prairie forms. The remains of the tortoises, Gopherus and Geochelone, indicate a warm, interglacial climate. A massive caliche immediately above the faunal zone suggests a period of prolonged weathering and aridity--perhaps during middle Sangamon time.

The Robert local fauna (late Wisconsin) consists of micro-vertebrates collected from a 1-foot dark gray to black silt or soil zone just below the surface in the immediate vicinity of Butler Spring. Most of the mammals are characteristic of marshy conditions or moist low meadows. A radio-carbon date of 11,100 ± 390 years B. P. was obtained by dating shells of Succinea ovalis Say. Several of the mammalian species represented in the fauna are not found as far south as Meade County, Kansas, at the present time. Eleven of the extant species may be found living today in northeastern South Dakota.

From a study of temperature and effective precipitation in both areas, it appears that the Robert local fauna lived in Meade County, Kansas, during the late Wisconsin glacial in a climate which had cooler summers and more effective moisture than in the area today and that this climate is probably similar to that of northeastern South Dakota today.

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TABLE OF CONTENTS

	Page
Acknowledgments	ii
List of Tables	v
List of Figures	v
List of Plates	v
Introduction	1
Location	2
Physiography	2
Stratigraphy	5
Geologic History	26
Fossil Localities, Faunal Lists and Collecting Methods	33
Adams local fauna	33
Butler Spring local fauna	35
Cragin Quarry local fauna	38
Late Sangamon localities	43
Robert local fauna	43
Systematic Description of Fossil Mammalia	51
Order Insectivora	51
Order Rodentia	56
Order Carnivora	73
Order Proboscidea	78
Order Lagomorpha	78
Order Artiodactyla	79
Order Perissodactyla	91
Interpretation of Faunas	97
Age and Correlation	97
Environment	98
Climate and Present Distribution	100
Plates	105
Literature Cited	107

LIST OF TABLES

Table		Page
1.	Comparison of Sangamon and Wisconsin Faunas from Meade County, Kansas	44

LIST OF FIGURES

Figure		Page
1.	Index Map of Meade County, Kansas	3
2.	Stratigraphic Correlation in Southern Meade County, Kansas	6
3.	Correlation of Stratigraphic Nomenclature in Two Reports on the Butler Spring Area, Meade County, Kansas	10
4.	Geologic History, Butler Spring Area	27
5.	Pleistocene Mammals	53
6.	Pleistocene Mammals	64
7.	Pleistocene Mammals	70
8.	Pleistocene Mammals	81
9.	Pleistocene Mammals	85
10.	Map Showing Present Region of Sympatry of Eleven Extant Mammalian Species Represented in the Robert Local Fauna (Late Wisconsin)	103

LIST OF PLATES

Plate		Page
1.	Geologic Map, Butler Spring Area, Meade County, Kansas	(pocket)
2.	Butler Spring Area, Meade County, Kansas	105
3.	Left Maxillary of Tanupolama macrocephala (Cope)	106

Introduction

In parts of southwestern Kansas and northwestern Oklahoma, circulating ground water has removed considerable quantities of salt and anhydrite from the Permian strata causing the collapse of overlying material. In some instances the collapse has been small and sudden such as that which formed the Meade "salt" sink (Mudge, 1879) just south of Meade, Kansas, in 1879. Other larger basins have been formed over a greater period of time by the slow sagging of the overlying material or by the coalescence of several sinks resulting from a series of collapses. Many of the basins so formed were subsequently filled with sediments, some of which were laid down in small lakes or ponds. These deposits frequently contain fossil remains of animals which lived in and around the lake or in nearby streams.

This paper deals with a small basin approximately one mile in diameter situated just north of the Cimarron River in southern Meade County, Kansas. The area, known as the Butler Spring area, contains sediments of late Pleistocene age from which fossils have been recovered by Hibbard and his field parties since 1937. Four distinct faunal assemblages are superimposed in these deposits. The oldest beds consist of coarse, yellow, cross-bedded sands which are believed to represent stream deposits of the ancestral Cimarron River (Hibbard and Taylor, 1960, p. 41). Fossils from these sands constitute the Adams local fauna which is considered to be Illinoian glacial in age largely on the basis

of stratigraphic and pollen evidence (Kapp, 1965, p. 207). Fossils from the immediately overlying beds constitute a cool biota (Kapp, 1965, p. 202), the Butler Spring local fauna (late Illinoian), which has been described in earlier works (Hibbard and Taylor, 1960; Schultz, 1965). The present study considers the history of the younger deposits of the basin and their associated fossil remains. The fossils indicate the presence of a large interglacial (Sangamon) fauna as well as a somewhat younger cool (late Wisconsin) fauna containing several species found only to the north of Kansas today.

Location

The Butler Spring area is located in southern Meade County, Kansas, about 15 miles south-southwest of the town of Meade. It includes parts of secs. 28, 29, 32, and 33 of T. 34 S., R. 29 W., as well as the northern parts of secs. 4 and 5 of T. 35 S., R. 29 W., on the XI Ranch just north of the Cimarron River (Fig. 1) which flows at an elevation of 2320'. Butler Spring (elev. 2380') is located in the NW ¼, sec 4. It was named for the homesteader who first settled near it.

Physiography

The Butler Spring area lies in the Plains Border section of the Great Plains Province as defined by Fenneman (1931, p. 25). He states (p. 29) that the vicinity of the escarpment along the

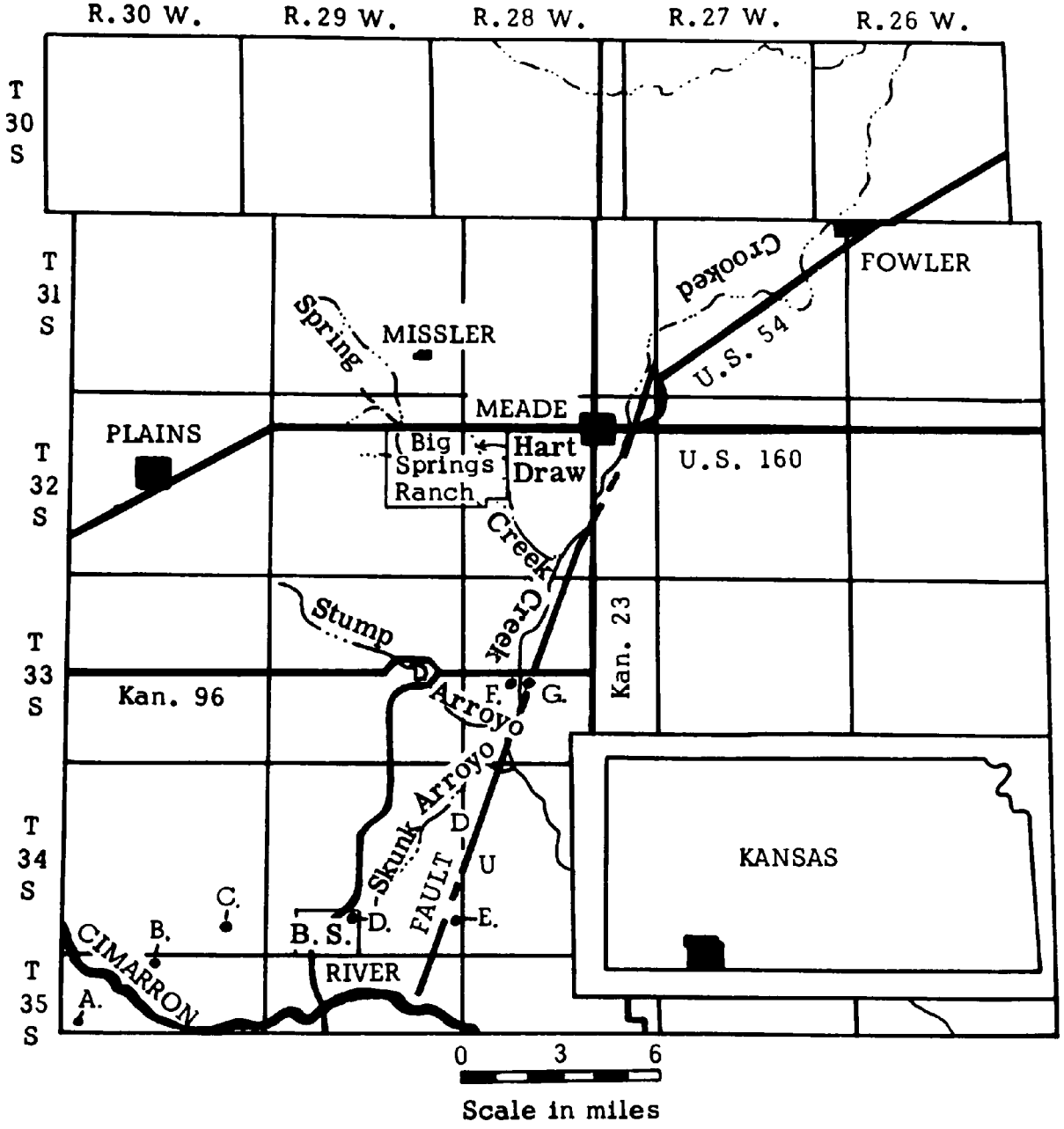


Fig. 1. Index map of Meade County, Kansas. (Butler Spring area is designated B. S. Lettered localities refer to stratigraphic sections in Fig. 2. A - Wolf Canyon, B - Keefe Canyon, C - Fox Canyon, D - Butler Spring, E - Irish Flats, F - West of Borcher Gravel Pit, G - Borcher Gravel Pit.)

east edge of the High Plains is characterized by large, deep, abrupt basins due to solution of salt or, in places, gypsum in the underlying Permian rocks. Frye and Schoff (1942) discussed the origin and formation of these basins in western Kansas and Oklahoma. Some of the basins, such as the Englewood and Sitka basins, are approximately 8 to 10 miles in diameter, while others, such as the Meade salt sink, are only a few hundred feet across. Along the Cimarron River in eastern Harper County, Oklahoma, the presence of large salt flats (Myers, 1959) shows that a large quantity of salt has been dissolved by circulating ground water and later precipitated on the surface.

Meade County is drained by the Cimarron River, which flows eastward across the southwest corner of the county, and by Crooked Creek which flows south-southwest along the Crooked Creek fault (H. T. U. Smith, 1940, p. 133) and then southeastward into the Cimarron Valley. Hibbard and Taylor (1960, p. 21) state that in the late Pleistocene "Crooked Creek flowed into the Cimarron River along the course of present Skunk Arroyo, following the southwestward trend of the fault. Subsequently (the date is uncertain), a southeastward-flowing tributary of the Cimarron River, a tributary which occupied approximately the present lower course of Crooked Creek, captured the greater part of ancestral Crooked Creek, probably aided by sinkhole collapse near the present right-angle bend of Crooked Creek. As a result the southwestward-flowing lower course of the former stream was reversed to become a minor tributary (Skunk Arroyo) of Crooked Creek."

Stratigraphy

The Butler Spring area is about 3 miles west of the Crooked Creek fault (Fig. 1). On the east or upthrown side of the fault, the Ogallala Formation (lower Pliocene) overlies the Permian and is exposed at the Borcher gravel pit (Fig. 1, Loc. G; Fig. 2, Column G) 8 miles south of Meade. Here the contact with the underlying Permian lies at the level of Crooked Creek (elev. 2355') which here follows the southwestward trend of the fault. The Ogallala exposures at the gravel pit have yielded remains of Serridentinus meadensis Hibbard (Hibbard, 1951) and a right P^2 (No. 47108) of Griphippus gratus (Leidy) of lower Pliocene age (Hibbard, personal communication). It should be noted that the Ogallala Formation as here used includes only the exposures east of the Crooked Creek fault, in Meade County. At the Borcher gravel pit the Ogallala is directly overlain by the Crooked Creek Formation of middle Pleistocene age.

West of the fault, sediments of middle Pliocene (Laverne Formation in Kansas based on lithology), upper Pliocene (Rexroad Formation) and lower Pleistocene (Ballard Formation) ages were deposited in the trough formed on the downthrown side. The Rexroad Formation reached a thickness of at least 120 feet locally as a result of slow subsidence of the trough. Renewed movement on the fault during the late Pleistocene caused these strata to be down-dropped, thus producing artesian water conditions over a large part of central Meade County.

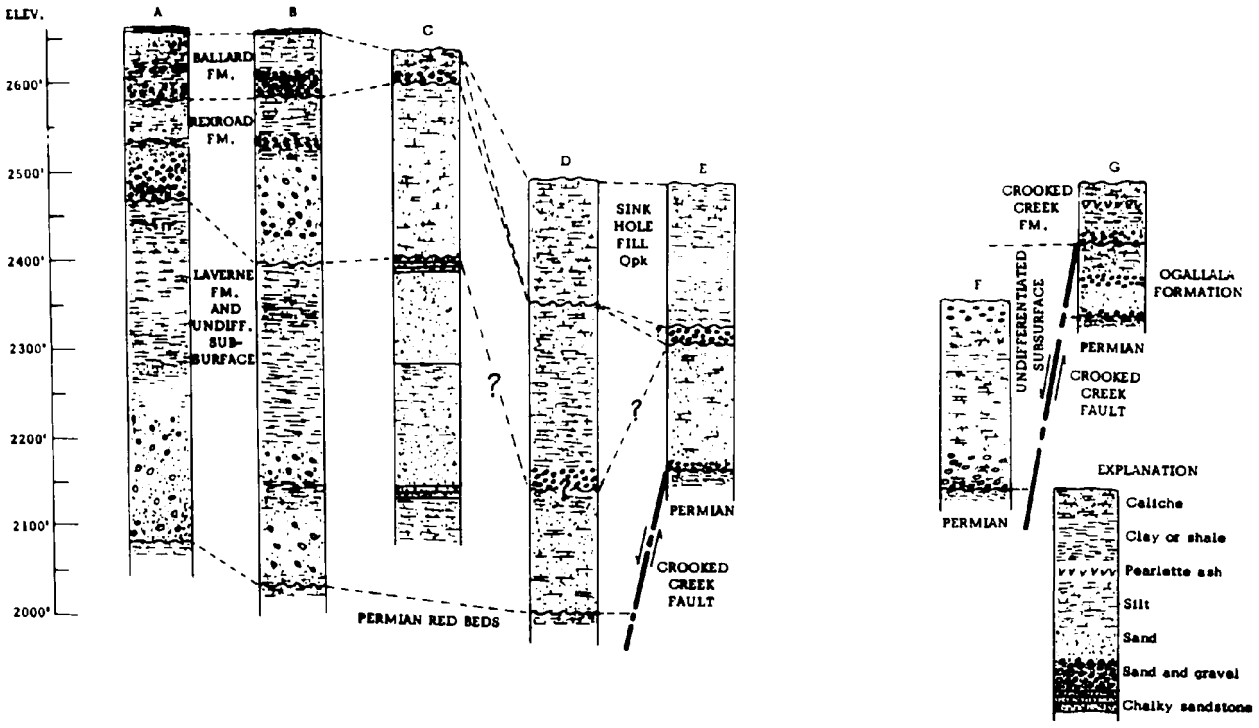


Fig. 2. Stratigraphic correlation in southern Meade County, Kansas. (Location of lettered sections is shown in Fig. 1. A - Wolf Canyon, B - Keefe Canyon, C - Fox Canyon, D - Butler Spring, E - Irish Flats, F - West of Borcher Gravel Pit, G - Borcher Gravel Pit.)

The Ogallala Formation as here used is nowhere exposed west of the fault in Meade County. Its possible presence at depth must be determined from a careful study of well logs (Stevens, 1965, p. 217-218). The Laverne, Rexroad, and Ballard Formations are exposed in Wolf Canyon (Fig. 1, Loc. A; Fig. 2, Column A) and along the Cimarron River in southwestern Meade County and southeastern Seward County. In Keefe Canyon (Fig. 1, Loc. B; Fig. 2, Column B) and Fox Canyon (Fig. 1, Loc. C; Fig. 2, Column C) the Ballard and Rexroad Formations are exposed and the Laverne Formation has been detected by means of well logs. At Keefe Canyon the Permian red beds occur at a depth of about 600 feet.

In the Butler Spring area (Fig. 1, Loc. D; Fig. 2, Column D) a well drilled by the Kansas Geological Survey (Frye, 1942, p. 145, hole 23) encountered the Permian at a depth of 483 feet. It is difficult to identify any of the Pliocene or Pleistocene formations from this well log, particularly since much of the upper part of the sequence appears to represent late Pleistocene sinkhole fillings.

A possible correlation of beds in southern Meade County is shown in Figure 2. Data for each stratigraphic column was taken from measured sections and well logs as follows:

A. Wolf Canyon: Byrne and McLaughlin (1948, p. 74 and p. 124, test hole 23)
Hibbard (1949b, p. 94)

B. Keefe Canyon: Byrne and McLaughlin (1948, p. 117, test hole 17)
Hibbard and Riggs (1949, p. 833)

C. Fox Canyon: modified from Frye (1942, p. 145, test hole 24)

D. Butler Spring: modified from Frye (1942, p. 145, test hole 23)

E. Irish Flats: modified from Frye (1942, p. 145, test hole 22)

F. West of Borcher gravel pit: Frye (1942, p. 140, test hole 12)

G. Borcher gravel pit: Hibbard (1951, p. 220)

Figure 1 shows the location of the numbered sections given above.

Correlation of existing data is complicated by the presence of several large coalescing sinks along the Cimarron River in the southern part of the county and also by the fact that renewed movements occurred along the Crooked Creek fault during late Pleistocene time. Future studies may reveal whether or not the broad expanse known as Irish Flats which lies between Skunk Arroyo and the lower course of Crooked Creek to the east is held up by the Ogallala Formation or is the result of some other factors. Further studies of outcrops and well logs are necessary for a more complete understanding of stratigraphic relationships in southern Meade County.

The sediments of the Butler Spring area are all found below the regional High Plains surface. Although topographically lower,

they are stratigraphically younger than the Crooked Creek Formation of Kansan and Yarmouth age and, therefore, may be referred to the undifferentiated Sanborn Group of late Pleistocene age, a group defined primarily by age, stratigraphic and topographic position rather than by physical characteristics or rock type (Hibbard, 1958, p. 58). Nearly all of the sediments represent sinkhole deposits as evidenced by "the lenticular nature of some gypsiferous silt and clay beds, the lack of cross bedding, the fine grain size, and thin to medium interbedded relationship of many silt, clay, and fine sand beds" (Hibbard and Taylor, 1960, p. 41). Basin fills of this type from the region along the Cimarron River in southwest Meade County were termed the Odee Formation by H. T. U. Smith (1940, p. 100). Hibbard (1949a, p. 79) proposed that this term could be applied to all of the scattered basin fill deposits of local origin despite the heterogeneity of these deposits or the diverse histories of the local basins in which they were formed. Figure 3 shows the correlation of mapping symbols used in this report with those used in that of Hibbard and Taylor (1960). On the basis of more recent stratigraphic and paleontologic information it is now possible to subdivide the Sanborn Group locally into Kingsdown Formation (Illinoian and Sangamon age beds) and Post-Kingsdown (Wisconsin age beds).

The oldest beds exposed in the Butler Spring area are the yellow, limonitic-stained sands and gravels containing the Adams local fauna. These beds were designated as Qs_1l (Quaternary,

Age	Hibbard and Taylor, 1960			This Report		
	Rock Unit	Mapping Symbols	Fauna	Rock Unit	Mapping Symbols	Fauna
Wisconsin	Sanborn Group (Kingsdown and Vanhem Fms.)	Qs		Post-Kingsdown	$Qppk_2$	Robert local fauna (11,100 ± 390 years B.P.)
					$Qppk_1$	
Sangamon				Kingsdown Fm.	Qpk_4	
		Qs_2			Qpk_3	
		caliche Qs_1u			caliche Qpk_2-Qpk_2l	Cragin Quarry local fauna
Illinoian		Qs_1l	Butler Spring local fauna		Qpk_1	Butler Spring local fauna
						Adams local fauna

Fig. 3. Correlation of stratigraphic nomenclature in two reports on the Butler Spring area, Meade County, Kansas.

Sanborn Group, Unit 1, lower member) by Hibbard and Taylor (1960), but are here mapped (Pl. 1) as Qpk_1 (Quaternary, Pleistocene, Kingsdown Formation, Unit 1). About 35 feet of these coarse, conspicuously cross-bedded sands and gravels are exposed in the SE ¼, sec. 32, T. 34 S., R. 29 W., XI Ranch, Meade County, Kansas. They are considered to represent the deposits of the ancestral Cimarron River during part of Illinoian time when the river flowed at a much higher level than it does today. A more detailed description of these beds is given in measured sections by Hibbard and Taylor (1960, p. 43) and Schultz (1965, p. 238) and will not be repeated here.

Conformably overlying the yellow sands locally is a 1- to 2-foot greenish gray clayey sand containing numerous mollusks, vertebrate and pollen remains constituting the Butler Spring local fauna (Kapp, 1965, p. 205 and Schultz, 1965, p. 239). This unit is exposed in the SE ¼, SE ¼, sec. 32, T. 34 S., R. 29 W., Meade County and is mapped as part of Qpk_1.

Above the Butler Spring local fauna zone is a 15- to 100-foot sequence of reddish to buff colored silts, clays, and sands which forms the greater part of the beds exposed on the west side of the basin. These beds were referred to as Qs_1u (Quaternary, Sanborn Group, Unit 1, upper member) by Hibbard and Taylor (1960) who include them in several measured sections. They are here designated Qpk_2 (Pl. 1). In the SE ¼, sec. 32, T. 34 S., R. 29 W., these beds are about 15 feet thick and are flat lying. To the south they are eroded and to the southeast, at Kansas

University (KU) Locality 7, they are tilted to the southeast as a result of local collapse. To the north and west they are covered. To the northeast, in the NW ¼, sec. 33, T. 34 S., R. 29 W., their thickness increases to about 100 feet. Here the interbedded relationship of the silt, clay and fine sand lenses together with the presence of shallow dips to the northeast and the absence of coarse grain sizes indicates that these sediments accumulated in a large but slowly subsiding sag or sinkhole depression. A line on the map (Pl. 1) roughly parallel to the west section line of sec. 33 marks the approximate position of a hinge line, with more or less flat lying beds to the west and dipping beds to the east. A stratigraphic section through these dipping beds in the SE ¼, NE ¼, sec. 32 and the SW ¼, NW ¼, sec. 33 is given below. These are the Qs_1u and Qs_1l beds of Hibbard and Taylor (1960).

Unit	Description	Thickness in feet
9.	Silt, buff to brown, thick-bedded to massive, moderately indurated and locally sandy. Contains thin seams of clay up to 1 inch. Top eroded off and overlain by caliche rubble and 2 feet of recent loess and soil. Locality UM-K3-59 near base of unit. Lower contact sharp	45.0
8.	Silt, gray to black or reddish black, hard, moderately well indurated, firm, thick-bedded to massive near top. Grades downward to light greenish gray to yellow sandy silt near the base.	

Unit	Description	Thickness in feet
	Streaked with limonite throughout. Land snails abundant in upper black part. Bone fragments common in gray zone. Nearly complete specimen of Gopherus recovered from burrow in red silts just above this unit. Lower contact irregular. .	5.0
7.	Sand, silt, and clay in alternating beds up to 3 feet; sand, buff to dark brown, silty, fine to medium-grained, poorly sorted, loosely consolidated, subangular to subrounded, limonite streaked; silt, buff to brown, moderately well indurated; clay, reddish brown, loosely consolidated, contains gypsum crystals. Thin stringers and nodules of indurated sand and $CaCO_3$ near top. Lower contact irregular	14.0
6.	Silt, light green, limonite streaked, moderately well indurated; some sand, silty, poorly sorted. Contains thin beds of hard white indurated limestone 1 to 3 inches thick and thinly laminated pink to buff, fine-grained, silty indurated sandstone in undulating beds 1 inch thick at the top. Beds strike N. 10° E. and dip 15° S.E. Lower contact irregular	5.0
5.	Sand, rusty brown, fine to medium-grained, fairly well sorted, loosely consolidated, massive. Contains beds of reddish brown clay or mudstone up	

Unit	Description	Thickness in feet
	to 4 feet thick, loosely consolidated. Capromeryx jaw taken from this unit (Loc. UM-K3-62). Lower contact gradational	17.0
4.	Sandstone, buff, thick-bedded to massive, well indurated, fine-grained, silty, poorly sorted. Forms prominent ledge locally where cemented by $CaCO_3$. Beds strike N. 15° E. and dip 15° S. E. Lower contact sharp	8.0
3.	Sand, silt, and clay in alternating beds 6 inches to 5 feet thick; sand, buff and light brown to dark reddish brown, fine-grained, silty, poorly sorted, loosely consolidated, subangular to subrounded; silt, buff to light reddish brown, medium to thick bedded, fairly well indurated; clay, light brown to dark reddish brown, silty and hard to loosely consolidated or blocky. Clay mostly near the top. Lower contact irregular	35.0
2.	Clay, greenish gray to brown, silty, blocky; contains abundant mollusks (Butler Spring local fauna). Lower contact irregular	2.0
1.	Sand, yellow, limonitic, medium to coarse-grained, unconsolidated to loosely consolidated, fairly well sorted, subangular to subrounded; sand, white, fine to coarse-grained, crossbedded, loosely consolidated, moderately well sorted, subangular to subrounded with	

Unit	Description	Thickness in feet
	lenses of grit and clay, pebbles near the top.	
	Base not exposed	5.0
	Total	136.0

Fossil localities UM-K3-59, UM-K2-62, and UM-K3-62, in Units 5 and 9, have yielded vertebrate fossils which may be assigned to the Sangamon interglacial (see discussion of faunas below). Locality UM-K3-59 has also yielded remains of land snails. To the east these beds are flat lying and grade laterally eastward into a sequence of lacustrine deposits in the center of the large sag basin. These lake deposits are exposed in Butler Spring Arroyo.

In the SE ¼, sec. 32 there is exposed at several places in the lower part of the reddish buff silts a coarse sand and gravel layer 3 to 5 feet thick which contains subrounded to rounded pebbles of chert and quartz and is separated from the underlying Butler Spring local fauna horizon by about 5 feet of red silt. In all probability, this layer represents a high terrace sand and gravel of the ancestral Cimarron River, which formed during late Illinoian time about 190 feet above the bed of the present river. To the north these sands and gravels thin out and are absent altogether in the lower part of the measured section cited above. It is possible that some of the finer sands and red silts near the bottom of this section represent an equivalent phase of flood plain deposition farther from the main river channel.

In places these late Illinoian terrace gravels appear to have been let down onto the basal Illinoian sands as a residual deposit during erosion of the finer silts and sands. Occasional cobbles of scoriaceous basalt over 6 inches in diameter occur scattered over the surface among the finer gravels (Hibbard, 1944, Pl. 2, fig. 2). Hibbard (personal communication) considers the basalt to occur in an early Wisconsin terrace, however. The nearest source for the basalt is in the Raton highlands of northeastern New Mexico in the headwaters region of the present Cimarron. The large size of the basalt cobbles indicates a much larger and swifter flowing stream with a considerably greater competence than that of the present Cimarron River.

In the N ½, SW ¼, sec. 33, the upper part of the reddish buff silts (Qpk_2) can be seen to grade laterally eastward into a sequence of lacustrine deposits (Qpk_2l on Plate 1, cross-section X-X'). About 400 feet northeast of Locality UM-K3-59 there is a thin gray to black organic rich silt horizon (Bed 8 of above measured section) which contains land snails. In the reddish silts immediately overlying this zone a nearly complete specimen of the tortoise Gopherus was found preserved in a 2-foot-deep burrow. Kapp (1965, p. 230) reported an abundance of decayed plant remains within the black zone. This "organic" zone may represent the humus of a buried soil profile or perhaps the remains of a former marsh bed. A few hundred feet down the arroyo, the reddish buff silt above and below the gray zone grades into a yellow silt and silty sand while the gray zone pinches out

within it. The yellow silt and sand unit thickens eastward to Butler Spring Arroyo where it is best exposed. Higher up, the reddish buff silt grades into other units which overlie the yellow sand and silt in Butler Spring Arroyo. A measured section taken along the west side of this arroyo in the NE ¼, SW ¼, sec. 33, is given below. Units 1 to 9 are mapped (Pl. 1) as Qpk_2l (Kingsdown, Unit 2, lacustrine facies).

Unit	Description	Thickness in feet
9.	Caliche, white, massive, hard, sandy limestone and limey sandstone. Strongly pitted and weathered on surface. Forms a flat mesa top about 42 feet below the general upland surface to the west . . .	1.5
8.	Silt, medium to dark brown, massive, weathers to light buff on surface. Locally hard and light buff in color where enriched by $CaCO_3$ from above	6.0
7.	Clay, silty, grayish green with scattered zones of red, loosely consolidated, contains abundant Sphaerium fingernail clams and snails locally. Clay is locally somewhat thicker with a thin bed of loose yellow brown sand above. Clay pinches out to the north. Lower contact gradational . . .	1.5
6.	Clay, dark reddish brown to maroon, loosely consolidated, chunky--almost a mudstone. Selenite crystals abundantly scattered throughout. Lower contact gradational	18.0

Unit	Description	Thickness in feet
5.	Clay, greenish gray to reddish brown, loosely consolidated, calcareous, weathers white on surface. Lower contact irregular	5.0
4.	Silt, orange brown, massive moderately well indurated, richly stained with limonite. Lower contact irregular	2.0
3.	Clay, silty, reddish brown, loosely consolidated, limonite stained. Lower contact irregular	3.0
2.	Silt and sand. Upper part is a fine brownish yellow to yellow sand which grades down into a sandy silt, yellow buff, massive to thick-bedded with lenses up to 1 foot of yellow to gray clay containing Lymnaea and other snails (Locality UM-K2-61). Well formed selenite crystals occur in the silt unit but are concentrated in clay lenses. Lower contact gradational-interbedded gray clay and yellow silt in beds up to 8 inches thick	24.5
1.	Clay, gray to black, hard, blocky, calcareous. Lower 1 foot black, medium to thick-bedded and calcareous with occasional snails. Base not exposed	3.5
	Total	65.0

Augering in the bed of Butler Spring Arroyo to a depth of 10 feet at this location revealed only bluish gray clay under-

lying the yellow silts. The total depth of this clay is unknown as is the relationship of the clay to the older beds exposed to the west.

The yellow silt and sand (Unit 2) are characterized by the presence of fresh-water mollusks including Lymnaea (Locality UM-K2-61) and by thin zones of abundant selenite crystals indicating deposition in permanently ponded water. (The indurated limestone and laminated sandstone in Unit 6 of the first measured section given above may represent a tributary or channel meander which flowed into this lake.) The dark maroon clay or mudstone (Unit 6 of the lacustrine sequence) is devoid of mollusks but contains scattered selenite crystals. Periodic drying up of the lake would favor oxidizing conditions and would account for the dark red color of these beds.

The ashy gray silts and clays of Unit 7 contain some land and numerous fresh-water mollusks. The abundance of Sphaerium and Helisoma indicates a perennial body of shallow, quiet fresh water. At Locality UM-K4-59 a few vertebrates were collected along with the mollusks. Most of these are fragmentary and were probably carried into the lake by a small stream or by slope wash. The land mollusks are predominantly forms found in moist situations near bodies of fresh water. This gray zone thickens considerably to the south in the south central part of sec. 33 where slow subsidence over a longer period of time allowed a greater accumulation of sediment.

The exact boundaries of this Sangamon lake are not known. The west shoreline can be located approximately where the lake deposits intertongue with reddish buff silts. To the south, however, the lake deposits are either eroded or buried by a more recent sinkhole collapse which was covered in part by later Wisconsin deposits. To the east and north they are concealed by younger deposits although the upper ashy gray zone can be seen to thin northward along Butler Spring Arroyo. A water well drilled at the north end of Butler Spring Arroyo (SW ¼, SE ¼, sec. 28, T. 34 S., R. 29 W.) penetrated the yellow silt and sand unit at a depth of 50 feet below the upland surface but did not encounter the younger ash gray zone. Below the yellow silt and sand approximately 80 feet of bluish gray and red clay were encountered; beneath this was an unidentified buff to light brown coarse sand about 20 to 25 feet thick, lying at a depth of 140 to 150 feet below the upland surface. Underneath the sand was a reddish brown clay extending to the bottom of the well at 240 feet. Although the size of the lake undoubtedly varied with seasonal and climatic changes, its greatest extent may have been from three-quarters of a mile to a mile in length from north to south and approximately one-half mile in width east and west.

A massive caliche layer overlies the lacustrine deposits along both sides of Butler Spring Arroyo. It occurs as a much weathered and pitted, well-indurated layer of limey sandstone and sandy limestone 12 to 18 inches thick. On the west bank of the arroyo it caps a flat mesa the surface of which lies 42 feet

below the nearby upland. North and west of this mesa, the upland surface (elev. 2510') is strewn with caliche rubble. It would appear that sinkhole collapse has allowed these lake beds and caliche to be dropped over 40 feet in essentially a flat-lying position. Southwest of the mesa in the SW ¼, SW ¼, sec. 33, particularly at KU Locality 7, the caliche layer overlies the reddish buff silts and is tilted about 10° to the southeast as the result of another sinkhole collapse. North and west of KU Locality 7, the caliche occurs mostly as a surface rubble in the western part of sec. 33 and the eastern part of sec. 32.

Bretz and Horberg (1949, p. 509) state: "The profile (caliche) development is believed to be best explained by conditions of alternating saturation and dessication in a relatively dry climate with periodic rains. Solution occurred as the soil waters moved downward during a rainy period, and precipitation took place with the capillary rise of saturated alkaline solutions as the soil zone dried out." The presence of the caliche above the lake deposits indicates a semiarid period with good drainage after the deposition of the lake sediments and its thickness may be the result of a low water table during the beginning of caliche-forming time. The age of the caliche is probably middle Sangamon on the basis of stratigraphic and faunal evidence. Hibbard and Taylor (1960, p. 30) described a similar caliche overlying the Cragin Quarry local fauna on the Big Springs Ranch, Meade County, Kansas. They considered the two caliches to be equivalent in age.

Although caliche probably formed on most of the upland surfaces, in lower places, close to the water table or below it, it is absent. In the SW ¼, sec. 33, a small lake or playa formed in a small depression during middle or late Sangamon time. Its relationship to the caliche can be seen at KU Locality 7 where the overlying caliche dips toward and disappears beneath the playa deposits and becomes merely a friable brown sandstone. The playa deposits are a part of the Qs_2 beds of Hibbard and Taylor (1960) but are here mapped (Pl. 1) as Qpk_3. Although they have been deformed and tilted by a sinkhole collapse near Butler Spring, they can be traced for approximately a quarter of a mile beyond which their eastward extent is obscured by erosion and by the deposition of recent alluvium along Butler Spring Arroyo. A few fossils have been recovered from these beds as indicated in the stratigraphic section below. The playa beds, like the nearby caliche, dip about 10° in a southeasterly direction, as a result of sinkhole collapse. They are overlain unconformably near Butler Spring by a local but thick deposit of brown and gray sands, silts, and clays in the SW ¼, SW ¼, sec. 33. These deposits, mapped as $Qppk_1$ (post-Kingsdown, Unit 1), represent the filling of another small sinkhole which developed during late Sangamon or, more likely, early Wisconsin time a few hundred feet west of the present site of Butler Spring. The sediments filling it were probably derived from the older (pre-caliche) lake deposits, carried in by slope wash and deposited in a small body of water which occupied the sinkhole; there are no reworked red silts present. Remains of

mollusks and the prairie vole, Microtus (Pedomys) ochrogaster, (Hibbard, 1943, p. 190) were recovered from these deposits. Capping this sequence are remnants of an indurated sandstone. Locally a marsh or bog developed in a small depression near the surface and a 2-foot bed of organic rich black silt and clay ($Qppk_2$) formed during late Wisconsin time. This bed contains a cool fauna (see Locality UM-K1-57, Robert local fauna, described under Fossil Localities).

A measured stratigraphic section along the southeast trending draw from KU Locality 7 to Butler Spring (SW ¼, SW ¼, sec. 33, T. 34 S., R. 29 W., Meade County, Kansas) is given below. A cross-sectional view of these and older beds is shown on Plate 1, cross-section Y-Y'. Units 1 to 4 below are mapped (Pl. 1) as Qpk_3.

Unit	Description	Thickness in feet
6.	Silt and clay, black, hard, firmly indurated. Contains abundant organic matter, snails, including Succinea ovalis Say, and vertebrate remains (Loc. UM-K1-57, Robert local fauna). Interpreted as a soil zone and former marsh ($Qppk_2$)	2.0
5.	Sand, silt and clay, interbedded in lenses up to 3 feet thick; sand, yellow to brown, fine to medium-grained, moderately well sorted, loosely consolidated, subangular to subrounded, limonite streaked; silt, gray to brown, moderately well indurated with scattered snails and bone fragments; clay, gray to	

Unit	Description	Thickness in feet
	brown, silty. Unit capped by a thin bed of indurated buff, medium-grained sandstone. Lower contact of beds fairly sharp, angular unconformity ($Qppk_1$)	45.0
4.	Marl, argillaceous, yellowish brown to white, diatomaceous. Firm to slightly indurated. Contains abundant ostracodes and clear opalescent snail shells (Locality UM-K1-61). Lower contact fairly sharp	2.0
3.	Clay, gray to light gray with dark limonitic streaks. Nodules and fissure fillings of selenite crystals and limonite common. Scattered bone fragments of *Equus* and *Camelops*. Lower contact sharp	26.0
2.	Marl, argillaceous, gray to light gray, limonite streaked, firm to slightly indurated with scattered calcite crystals, silt and sand. *Capromeryx* horn core and turtle remains including *Gopherus*. Lower contact irregular	7.0
1.	Sand, white to brown, fine to medium-grained, moderately well sorted, loosely consolidated, limonite streaked. In part, the lateral equivalent of the massive limey sand caliche overlying the red silts of KU Locality 7	16.0
	Total	98.0

A small outlier of yellow silt is exposed in the NW ¼, NW ¼, sec. 4, T. 35 S., R. 29 W. This bed dips steeply to the north and disappears beneath the sinkhole deposits. The outlier can be traced east across Butler Spring Arroyo and appears to represent a portion of the older lake sediments (pre-caliche) which were affected by local collapse in the vicinity of Butler Spring during late Sangamon or early Wisconsin time.

A continuation of the sagging which produced the large lake basin in early Sangamon time took place during the late Sangamon after the caliche had formed. This allowed a younger sequence of red silts and clays (Qpk_4) to be deposited to the north and east of Butler Spring. These sediments have yielded scattered fossils of horse, mammoth and prairie dog as well as a few land snails. Evidence of this sag can be seen where the upper red silts have been eroded, exposing the caliche. Along Butler Spring Arroyo, the caliche surface appears to have been let down about 42 feet below the upland surface to the west.

Several ponds or 'buffalo wallows' of local origin formed from time to time on the upland surface and became filled with gray clay. Several of these are exposed at the headward end of some of the smaller gullies but are not of mappable dimensions. In addition, the upland surface is covered in places by a thin layer of loess. Caliche of recent or post-Sangamon age can be seen as small stringers around roots or as nodules in the upper red silts and soil zones.

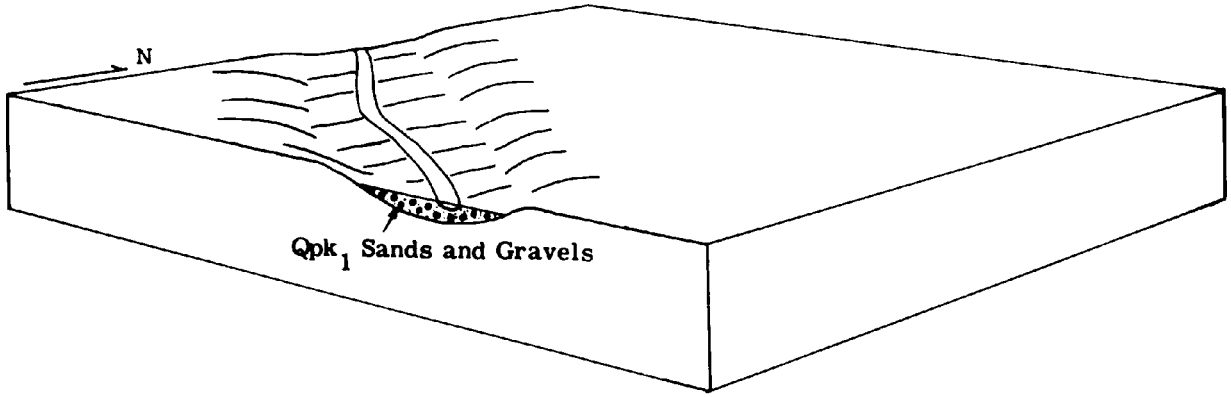
Scattered surface gravels occur on the breaks south of Butler Spring. Some of these gravels appear to have been transported by slope wash from nearby exposures of the basal sands and gravels of Illinoian age, whereas the remainder of the gravels may represent a Wisconsin terrace of the Cimarron River.

Considerable stream alluvium is present along the lower portions of the larger gullies in the vicinity of Butler Spring. The deposits consist of gray to reddish brown silts and silty clays up to 20 feet thick. Most of the alluvium is probably of late Wisconsin age and represents cut and fill phases during the downcutting of the Cimarron River to its present level and the development of the present drainage. Accelerated stream erosion and widening of the Cimarron valley during the past 50 years has resulted in renewed headward erosion in the smaller tributaries in the Butler Spring area.

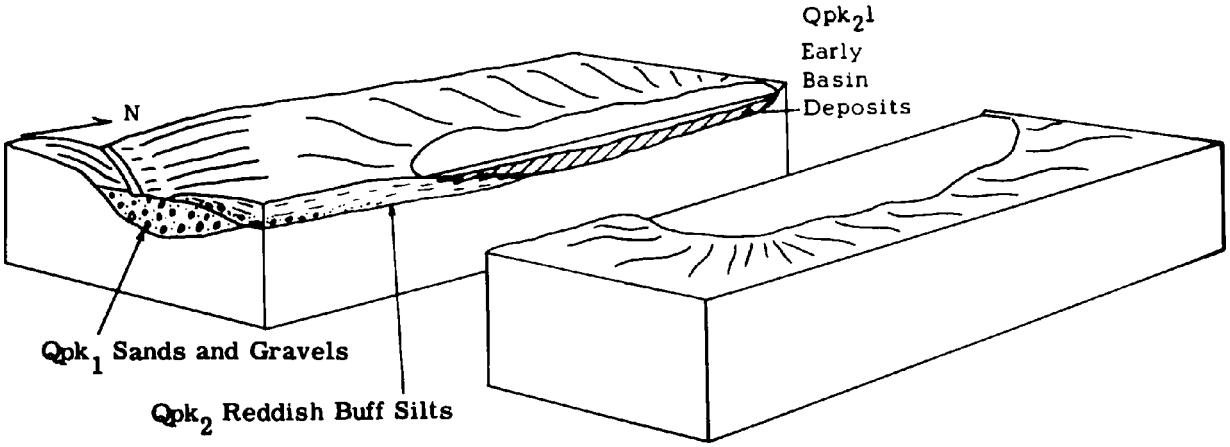
Geologic History

The geologic history of the Butler Spring area may be summarized as follows:

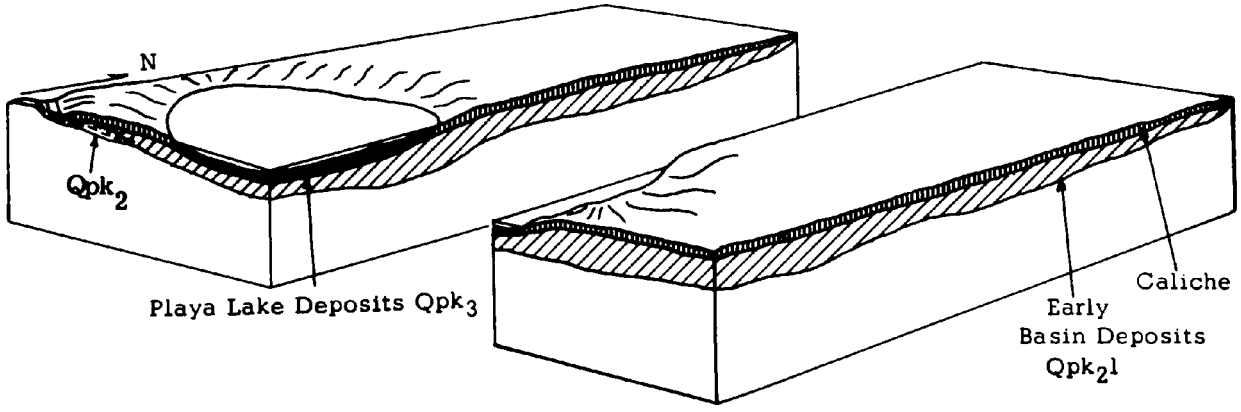
1. A late Yarmouth--early Illinoian erosional interval during which stream entrenchment below the High Plains surface took place (Block Diagram, Fig. 4A).
2. Deposition during Illinoian time of the basal sands and gravels (Qpk_1 on Fig. 4A and Plate 1) of the ancestral Cimarron River at an elevation of about 185 feet above



A - CIMARRON RIVER DURING ILLINOIAN TIME

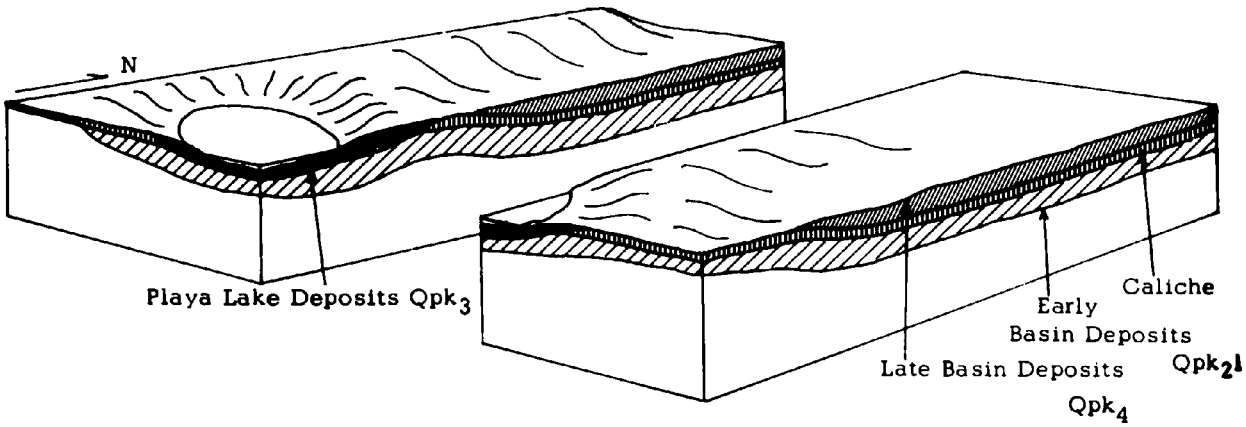


B - SUBSIDENCE TO FORM BASIN DURING EARLY SANGAMON TIME

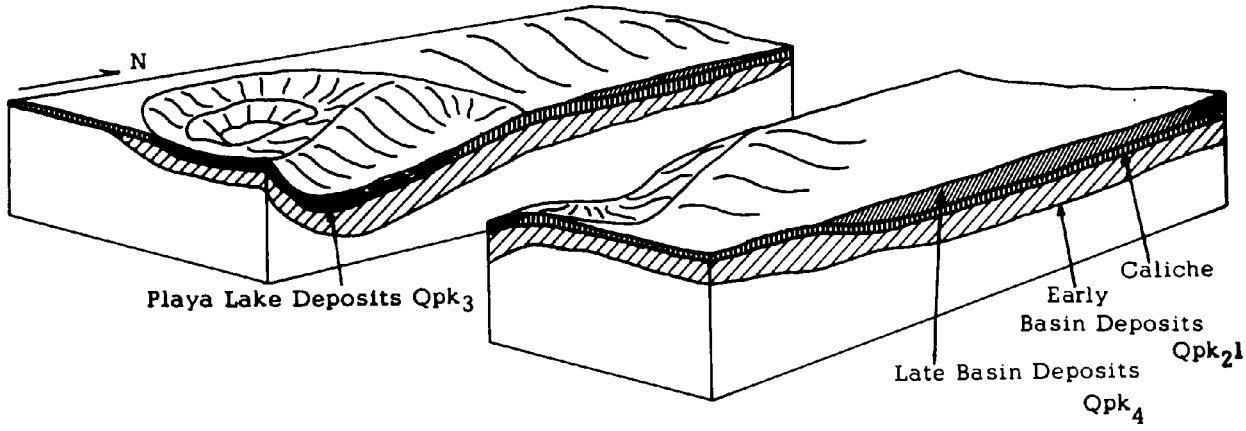


C - SMALL PLAYA LAKE IN SOUTHERN PART OF AREA, CALICHE ON UPLAND SURFACES DURING MIDDLE SANGAMON

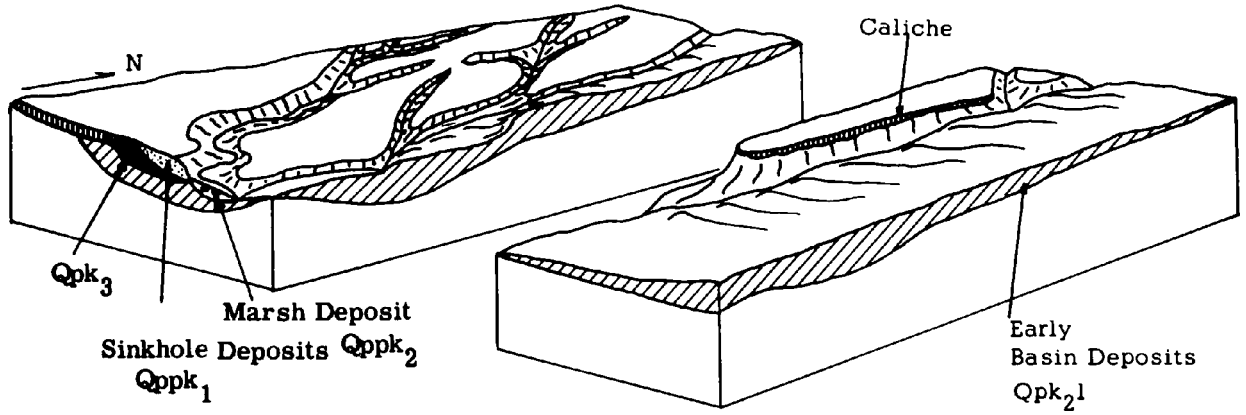
Fig. 4 (A-C). Geologic history, Butler Spring area. Showing six stages of development. Area covered approximates map area (Pl. 1).



D - RENEWED SUBSIDENCE IN EASTERN PART OF BASIN, LATE SANGAMON



E - MULTIPLE COLLAPSE SINKHOLES, PROBABLY EARLY WISCONSIN



F - PRESENT-DAY DRAINAGE AND STRUCTURE

Fig. 4 (D-F). Geologic history, Butler Spring area - continued.

the present level of the Cimarron. These sands are exposed primarily in the SE ¼, sec. 32, T. 34 S., R. 29 W., and in the NE ¼, sec. 5, T. 35 S., R. 29 W.; they contain the Adams local fauna.

3. A shift of the channel of the Cimarron River during late Illinoian is indicated by the fact that the greenish gray clayey sand (upper part of Qpk_1) which contains the Butler Spring local fauna, and which overlies the basal sands and gravels, was deposited in quiet, shallow water not far from the main stream.

4. Renewed uplift and downcutting in the headwaters region of the ancestral Cimarron River in northeastern New Mexico during latest Illinoian time with the deposition of a high terrace sand and gravel (basal part of Qpk_2 on Fig. 4B and Plate 1) in the Butler Spring area.

5. Development during early Sangamon time of a slowly subsiding basin in the central and eastern part of sec. 33 (Fig. 4B). As this basin developed it became larger and it tilted even the Illinoian sands and silts which show eastward dips in places. The western limit of deformation can be seen at the present time as a "hinge" line along the west section line of sec. 33 separating flat-lying beds to the west from dipping beds to the east. Over a hundred feet of reddish buff silts, sands and clays (Qpk_2) accumulated in this sag.

6. At some time during the development of this basin a lake formed in its center (Fig. 4B). At first, deposition occurred in a more or less permanent body of ponded water as evidenced by the presence of organic rich bluish gray clay and yellow silts and sands (Qpk_2l on Fig. 4B and Plate 1) containing selenite crystals. But later periodic drying up of the beds permitted oxidation of some of the higher sediments to a dark maroon color. This was followed by a period when the lake again became permanent and the presence of certain mollusks in the ashy gray silts indicates that there were freshwater streams with slow currents supplying the lake. The Cragin Quarry local fauna recovered from the basin and lake sediments records a warm, semiarid, interglacial climate.

7. A period of weathering and increased aridity followed during which a massive caliche formed under most of the upland surface. This caliche (Fig. 4C) overlies the lake deposits and the red silts of early Sangamon age. In lower places close to or below the water table, caliche formation did not take place.

8. After the development of the caliche a small lake or playa developed in a small depression in the SW ¼, sec. 33, T. 34 S., R. 29 W. (Fig. 4C). This depression may have been formed in part by a local sagging or tilting of the caliche and older beds. Gray clays and

argillaceous marls (Qpk_3 on Fig. 4C and Plate 1) accumulated in this small basin.

9. Regional subsidence in the eastern half of the Butler Spring basin continued during late Sangamon time after the caliche had formed. Along Butler Spring Arroyo the caliche lies nearly 45 feet below the upland surface to the west. The upper red silts and clays (Qpk_4 on Fig. 4D and Plate 1) accumulated in this sag. These sediments were probably the result of erosion and reworking of the older red silts and clays exposed at a higher level to the west.

10. A sinkhole centered northeast of the present Butler Spring collapsed probably during early Wisconsin time and imparted the southeastward dips to the playa deposits (Qpk_3) and the caliche near KU Locality 7 and the steep northward dips to the pre-caliche lake deposits exposed south of Butler Spring (Fig. 4E). The lower course of Butler Spring Arroyo appears to be structurally controlled by a low trough which formed in the middle of the collapsed area. Any sediments which may have filled this trough have been eroded away.

11. Another small sinkhole collapse, centered a few hundred feet west of Butler Spring, occurred during Wisconsin time (Fig. 4E). Accumulation of locally derived brown and gray sands and silts ($Qppk_1$ on Fig. 4F and Plate 1)

occurred through slope wash and these were deposited in a small body of water which occupied the sink. The sink was completely filled to a depth of nearly 50 feet and was capped by a bed of indurated sandstone.

12. Development of a marsh ($Qppk_2$ on Fig. 4F and Plate 1) near Butler Spring during a cool phase of the late Wisconsin (Robert local fauna; 11,100 $\pm$ 390 years B.P.). Development of other small upland ponds or 'buffalo wallows' also occurred from time to time.

13. Discontinuous downcutting of the Cimarron River to its present level 215 feet below the upland surface. Development of the present drainage in the Butler Spring area (Fig. 4F). Erosion and removal of sediments in the area especially some of the upper red silts. Formation of thin terraces and deposits of alluvium (Qal on Plate 1) in the lower courses of minor valleys during periods of cut and fill in late Wisconsin time.

14. Deposition of loess and sand dunes on the uplands. This event may be in part contemporaneous with the deepening of the stream valleys.

15. Accelerated erosion and widening of the Cimarron valley during the last 50 years in Seward County and to some extent in Meade County has resulted in renewed headward erosion in the smaller valleys and the tributaries.

Fossil Localities, Faunal Lists and Collecting Methods

Vertebrate and invertebrate fossils have been collected from the Butler Spring area for nearly 30 years. Hibbard (1939) reported and described a lower jaw of Canis (Aenocyon) dirus, the dire wolf, from one locality in this area. H. T. U. Smith (1940, p. 102) in a study of the regional geology reported the presence of mollusks in a silt and clay horizon from the area.

During the period from 1953 to 1961, bulk collecting of fossil matrix from selected localities within the area was done by Hibbard and his co-workers. By means of the washing and screening technique developed by Hibbard (1949c) several significant microvertebrate and molluscan faunas were recovered from various horizons. On the basis of geological and paleontological studies completed by Hibbard and Taylor (1960), Kapp (1965), and by the author (1965 and present study), these faunas can now be assigned with some degree of accuracy to glacial-interglacial sequences. At present, four superimposed faunas, summarized below, are recognized within the area. All fossil localities occur within the area covered by the Irish Flats Quadrangle sheet (U.S.G.S. Topo. Maps--7.5 minute series).

Adams local fauna

E. H. Taylor (1943); Hibbard (1949a); Hibbard and Taylor (1960); Tihen (1955, 1962); Kapp (1965); Schultz (1965)

This name was first applied by Kapp (1965, p. 202) to an assemblage consisting of a number of mollusks and scattered remains

of vertebrates collected over a period of years from the basal yellow limonitic sands and gravels and associated silt lenses exposed in the SE ¼, SE ¼, sec. 32, T. 34 S., R. 29 W., XI Ranch, Meade County, Kansas. The fossils from these beds along with the abundant mollusks and vertebrates from an overlying gray clayey sand horizon were originally included in one assemblage--the Butler Spring local fauna (Hibbard and Taylor, 1960). However, differences in the pollen profiles of these two horizons as reported by Kapp (1965) have shown that the fossils from these horizons actually constitute two distinct biotic assemblages. Pollen associated with the lower horizon (viz. presence of spruce, wormwood, composites, grasses and a high percentage of pine) suggests a maximum or near maximum glacial age (probably Illinoian) for the Adams local fauna. This assemblage, known chiefly from Localities 2, 3, 4 and 5 of Hibbard and Taylor, (1960) includes the following forms:

Invertebrates--numerous (see Hibbard and Taylor, 1960, Loc. 2)

Amphibia

Ambystoma tigrinum (Green)--Tiger salamander (Tihen, 1955)

Bufo cf. B. cognatus Say--Plains toad (Tihen, 1962)

Reptilia

Emydoidea twentei (Taylor)--Plains semibox turtle (E. H. Taylor, 1943)

Mammalia

Megalonyx sp.--Ground sloth

Citellus sp.--Ground squirrel

Geomys sp.--Eastern pocket gopher

Castoroides cf. *C. ohioensis* Foster--Ohio giant beaver

Microtus pennsylvanicus (Ord)--Meadow vole

Canis latrans Say--Coyote

Mammuthus sp.--Mammoth

Camelops sp.--Camel

Equus scotti Gidley--Scott horse

Equus sp.--Horse

Butler Spring local fauna

Hibbard (1943); Herrington and Taylor (1958); C. L. Smith (1958); Hibbard and Taylor (1960); Kapp (1965); Schultz (1965)

The term Butler Spring local fauna was first used by Herrington and Taylor (1958) for an assemblage of mollusks occurring in a clayey sand just above the basal yellow sands and gravels in the SE ¼, SE ¼, sec. 32, T. 34 S., R. 29 W., XI Ranch, Meade County, Kansas. C. L. Smith (1958) reported several species of fish from this horizon. Hibbard and Taylor (1960), having made bulk collections from this horizon in 1953 and 1957, reported the molluscan fauna in detail and included within the fauna not only the vertebrates known from this horizon but also those from the underlying sands and gravels. As a result of pollen studies by

Kapp (1965), the Butler Spring local fauna has been restricted to the upper mollusk-bearing zone, including only the first of the five collecting localities designated by Hibbard and Taylor (1960, p. 46). The pollen profile at Locality 1 shows an abundance of juniper, grasses and deciduous tree pollen with less pine than in the Adams local fauna horizon and is characterized by the absence of spruce. This led Kapp to consider that the mollusk-bearing zone represented a transitional period between glacial (Illinoian) and interglacial (Sangamon) periods and is therefore definitely younger than the Adams assemblage.

In 1961, additional vertebrates from beds equivalent to the mollusk-bearing horizon at Locality 1 were collected from the NE ¼, NW ¼, sec. 5, T. 35 S., R. 29 W., XI Ranch, Meade County, Kansas. These vertebrates (University of Michigan Locality UM-K3-61) were reported by Schultz (1965) and suggest a late Illinoian glacial age for the fauna. The fauna includes the following:

Mollusca--numerous (see Herrington and Taylor, 1958; Hibbard and Taylor, 1960)

Ostracoda--(see list in Schultz, 1965)

Pisces--(see C. L. Smith, 1958; Schultz, 1965)

Lepisosteus osseus (Linnaeus)--Longnose gar

Lepisosteus platostomus? Rafinesque--Shortnose gar

Lepisosteus sp.--Gar

Catostomus commersoni (Lacepede)--White sucker

Ictalurus melas (Rafinesque)--Black bullhead

Ictalurus punctatus (Rafinesque)--Channel catfish

Pisces--Cont.

Lepomis cyanellus Rafinesque--Green sunfish

Micropterus sp.--Bass

Perca flavescens (Mitchill)--Yellow perch

Amphibia

Frog and toad remains--unstudied

Reptilia

Chelydra serpentina (Linnaeus)--Common snapping turtle

Chrysemys picta (Schneider)--Painted turtle

Pseudemys cf. *P. scripta* (Schoepff)--Red-eared turtle

Pseudemys sp.--Turtle

Trionyx sp.--Softshell turtle

Snake remains--unstudied

Aves--(Cohn, in preparation)

Mammalia

Sorex cinereus Kerr--Cinereus shrew

Paramylodon harlani (Owen)--Harlan ground sloth

Cynomys ludovicianus (Ord)--Blacktail prairie dog

Citellus richardsoni (Sabine)--Richardson ground squirrel

Citellus cf. *C. tridecemlineatus* (Mitchell)--Thirteen-lined ground squirrel

Geomys cf. *G. bursarius* (Shaw)--Eastern pocket gopher

Perognathus hispidus Baird--Hispid pocket mouse

Perognathus sp.--a small pocket mouse

Dipodomys cf. *D. ordi* Woodhouse--Ord Kangaroo rat

Mammalia--Cont.

Onychomys cf. *O. leucogaster* (Wied-Neuwied)--Northern grasshopper mouse

Reithrodontomys cf. *R. megalotis* Baird--Western harvest mouse

Microtus pennsylvanicus (Ord)--Meadow vole

Microtus (*Pedomys*) *ochrogaster* (Wagner)--Prairie vole

Sylvilagus sp.--Cottontail

Camelops kansanus Leidy--Kansas camel

Equus cf. *E.* (*Asinus*) *conversidens* Owen--Mexican ass

Equus cf. *E. niobrarensis* Hay--Niobrara horse

Equus sp.--Horse

Cragin Quarry local fauna

Hibbard (1939, 1949a); Hibbard and Taylor (1960)

The term Cragin Quarry local fauna has been used to designate the large and diverse interglacial (early Sangamon) fauna from the Kingsdown Formation exposed on the Big Springs Ranch in secs. 17 and 18, T. 32 S., R. 28 W., Meade County, Kansas. Although four collecting localities have been sampled (Hibbard and Taylor, 1960), nearly all of the vertebrates are from Locality 1 (Kansas University Locality 6).

The use of the term Cragin Quarry local fauna is here extended to include a fauna collected from beds in the Butler Spring area of the XI Ranch which are considered by the author to be equivalent in age to those on the Big Springs Ranch. These beds are

stratigraphically above those containing the Butler Spring local fauna and, like those on the Big Springs Ranch, they occur beneath a massive layer of caliche. The following localities have yielded fossils belonging to this fauna.

Kansas University Locality 7 (elev. 2430').--This locality as first used included a considerable area and stratigraphic thickness in the Butler Spring region but was later restricted by Hibbard and Taylor (1960, p. 46) to an exposure of silt and sand in the SW ¼, SW ¼, sec. 33, T. 34 S., R. 29 W., Meade County, Kansas, from which remains of Canis (Aenocyon) dirus (Leidy) were recovered (Hibbard, 1939). Fossils are mostly from the lower third of an 18 foot exposure of light brown to light gray silt to fine sand (Qs_1u bed 4 of Hibbard and Taylor) along the east side of a tributary of Butler Spring Arroyo and 950' N. and 300' E. of the southwest section corner. Other fossils from this locality include Camelops and Equus (Hibbard, 1949a, p. 79), Tanupolama, Panthera, and Platygonus (this paper).

Locality UM-K3-59 (elev. 2450').--NW ¼, SW ¼, sec. 33, T. 34 S., R. 29 W., Meade County, Kansas. Fossils are from a reddish sandy silt on the southwest side of a main tributary to Butler Spring Arroyo, 2000' N. and 450' E. of the southwest section corner. Six tons of matrix were collected and washed by Hibbard and party during the summer of 1959 and a microvertebrate and molluscan fauna was obtained.

Locality UM-K4-59 (elev. 2450').--SW ¼, SE ¼, sec. 33, T. 34 S., R. 29 W., Meade County, Kansas. Fossils are from a

gray to white sandy silt just below the caliche near the head of a west-flowing tributary of Butler Spring Arroyo, 1050' N. and 2100' W. of the southeast section corner. One ton of matrix was collected during the summer of 1959 and 5 tons during the summer of 1961. A fresh-water molluscan fauna, several species of ostracodes and a small microvertebrate fauna including a lower jaw of Mustela were collected from this site.

Locality UM-K2-62 (elev. 2480').--NW ¼, SW ¼, sec. 33, T. 34 S., R. 29 W., Meade County, Kansas. Fossils are from a reddish sand and silt a few feet below the upland surface and caliche rubble on the north side of a small east-trending draw which runs into a major tributary of Butler Spring Arroyo. The locality is approximately on the west section line and 2350' N. of the southwest section corner. The only fossils collected here are a jaw of Vulpes velox, a tooth of Odocoileus, and two Castor teeth.

Locality UM-K3-62.--SW ¼, NW ¼, sec. 33 and SE ¼, NE ¼, sec. 32, T. 34 S., R. 29 W., Meade County, Kansas. Fossils are from a reddish sand and silt (Qs_1u beds of Hibbard and Taylor, 1960) exposed along both sides of a major southeast-trending tributary of Butler Spring Arroyo approximately along the west section line of sec. 33 and 2050' S. of the northwest section corner. The only fossils from this locality are a Capromeryx jaw and some Equus teeth.

In addition to the above localities, there are a few scattered finds of fossils which may be assigned to this fauna.

The complete faunal list for the Cragin Quarry local fauna equivalent is as follows:

Mollusca--numerous but unstudied

Ostracoda--(all from UM-K4-59). (E. O. Gutentag, personal communication.)

Candona nyensis Gutentag and Benson

Candona truncata Furtos

Cyprideis littoralis Brady

Ilyocypris bradyi Sars

Cyprinotus sp.?

Pisces--unstudied

Amphibia--(identified by J. Tihen)

Ambystoma cf. *A. tigrinum* (Green)--Tiger salamander

Bufo woodhousei Girard--Rocky Mountain toad

Rana sp.--Frog

Scaphiopus sp.--Spadefoot toad

Reptilia

Geochelone sp.--Tortoise

Gopherus sp.--Gopher tortoise

Snake and lizard remains--unstudied

Aves-(Cohn, in preparation)

Mammalia

Cynomys ludovicianus (Ord)--Blacktail prairie dog

Citellus cf. *C. tridecemlineatus* (Mitchill)--Thirteen-lined ground squirrel

Geomys sp.--Pocket gopher

Mammalia--Cont.

Perognathus hispidus Baird--Hispid pocket mouse

Perognathus sp.--a small pocket mouse

Castor canadensis Kuhl--Canada beaver

Onychomys cf. O. leucogaster (Wied-Neuwied)--Northern grasshopper mouse

Reithrodontomys megalotis Baird--Western harvest mouse

Peromyscus progressus Hibbard--Plains deer mouse

Microtus pennsylvanicus (Ord)--Meadow vole

Microtus (Pedomys) ochrogaster (Wagner)--Prairie vole

Canis (Aenocyon) dirus (Leidy)--Dire wolf

Vulpes velox (Say)--Swift fox

Vulpes sp.--Fox

Mustela cf. M. frenata Lichtenstein--Longtail weasel

Mephitis sp.--Skunk

Panthera atrox (Leidy)--Fierce jaguar

Mammuthus sp.--Mammoth

Lepus sp.--Jack rabbit

Sylvilagus sp.--Cottontail

Platygonus cf. P. compressus LeConte--LeConte peccary

Camelops kansanus Leidy--Kansas camel

Camelops sp.--Camel

Tanupolama macrocephala (Cope)--Extinct llama

Odocoileus sp.--Deer

Capromeryx furcifer Matthew--Forked pronghorn

Mammalia--Cont.

Equus cf. E. (Hemionus) calobatus Troxell--Stilt-legged ass

Equus cf. E. scotti Gidley--Scott horse

Equus cf. E. (Hemionus)--Asiatic ass

Equus sp.--Horse

The above fauna is very similar to that from Cragin Quarry Locality 1 (see Table 1).

Late Sangamon Localities

A number of fossils which cannot as yet be assigned to any particular fauna were collected from scattered localities in the Butler Spring area. These were taken from the younger red silts (Qpk_4) or the gray silts and marls (Qpk_3) above the caliche.

Robert local fauna

The term Robert local fauna is here given to an assemblage of late Wisconsin microvertebrates and mollusks recovered from a one-foot gray to black silt or soil zone just below the surface in the immediate vicinity of Butler Spring (C^{14} date, Socony Mobil Laboratory No. SM-762, age 11,100 ± 390 B.P. years). The fauna is named for William Robert, the original owner of the XI Ranch. Only one locality is known.

Locality UM-K1-57 (elev. 2410').--SW ¼, SW ¼, sec. 33, T. 34 S., R. 29 W., Irish Flats Quad., Meade County, Kansas. The fossil site is located on the east side of a major tributary of Butler Spring Arroyo and is 100' N. and 800' E. of the southwest

Table 1

Comparison of Sangamon and Wisconsin Faunas

from Meade County, Kansas

Form	Sangamon Cragin Q. lf.					Wisconsin	
	Big Springs Loc. 1	KU Locality 7	UM-K3-59	UM-K4-59	Isolated localities	Robert local fauna 11,100 ± 390 yrs. B.P.	Jones local fauna > 30,000 yrs. B.P.
Ictalurus sp.	x						
Ambystoma tigrinum (Green)	x		x				x
Scaphiopus sp.			x				
Bufo woodhousei Girard			x				
Rana sp.	?		x			?	
Terrapene llanensis (Oelrich)	x						
Geochelone sp.	x		x				
Gopherus sp.		x	x				
Crotaphytus collaris (Say)	x						
Phrynosoma cornutum (Harlan)	x						
Phrynosoma modestum Girard	x						
Holbrookea texana (Troschel)	x						
Cnemidophorus sexlineatus (Linnaeus)	x						

Table 1 cont.

Form	Sangamon Cragin Q. 1f.					Wisconsin	
	Big Springs Loc. 1	KU Locality 7	UM-K3-59	UM-K4-59	Isolated localities	Robert local fauna 11,100 ± 390 yrs. B.P.	Jones local fauna > 30,000 yrs. B.P.
Eumeces obsoletus (Baird and Girard)	x						
Sorex cinereus Kerr						x	x
Sorex palustris Richardson						x	
Blarina brevicauda (Say)						x	
Notiosorex crawfordi (Coues)	x						
Lasiurus cinereus (Beauvois)	x						
Dasypterus golliheri Hibbard	x						
Paramylodon harlani (Owen)	x						
Cynomys ludovicianus (Ord)	x			x	x	x	x
Citellus richardsoni (Sabine)						cf.	x
Citellus tridecemlineatus (Mitchill)	x			x		x	x
Geomys sp.				x		x	x
Geomys bursarius (Shaw)	x						
Thomomys talpoides (Richardson)						cf.	
Perognathus hispidus Baird	x		x				
Perognathus sp.	x		x	x			x
Dipodomys ordi Woodhouse	cf.						

Table 1 cont.

Form	Sangamon Cragin Q. lf.					Wisconsin	
	Big Springs Loc. 1	KU Locality 7	UM-K3-59	UM-K4-59	Isolated localities	Robert local fauna 11,100 ± 390 yrs. B.P.	Jones local fauna > 30,000 yrs. B.P.
Castor canadensis Kuhl					x		
Onychomys leucogaster (Wied-Neuwied)	cf.		cf.	cf.			x
Reithrodontomys megalotis Baird	x		x	x			
Reithrodontomys sp.						x	
Peromyscus maniculatus Wagner						cf.	
Peromyscus progressus Hibbard	x		x				
Peromyscus leucopus (Rafinesque)						cf.	
Peromyscus cochrani Hibbard	cf.						
Peromyscus sp.							x
Neotoma micropus Baird	x						
Microtus (Pedomys) ochrogaster (Wagner)	?			x		x	x
Microtus pennsylvanicus (Ord)			x			x	x
Synaptomys cooperi Baird						x	
Zapus hudsonius (Zimmermann)						cf.	

Table 1 cont.

Form	Sangamon Cragin Q. lf.					Wisconsin	
	Big Springs Loc. 1	KU Locality 7	UM-K3-59	UM-K4-59	Isolated localities	Robert local fauna 11,100 ± 390 yrs. B.P.	Jones local fauna > 30,000 yrs. B.P.
Canis latrans Say	x						
Canis (Aenocyon) dirus (Leidy)	x	x					
Vulpes velox (Say)	x						x
Vulpes sp.				x			
Mustela frenata Lichtenstein				cf.			
Taxidea taxus (Schreber)							x
Spilogale interrupta (Rafinesque)	x						
Mephitis mephitis (Schreber)				?			x
Felis concolor Linnaeus	cf.						
Panthera atrox (Leidy)	x	x					
Mammuthus columbi (Falconer)	x						
Mammuthus sp.					x		
Lepus sp.	x	x					
Sylvilagus sp.	x			x		x	
Platygonus cf. P. compressus LeConte	x	x					?
Camelops kansanus Leidy	x	x		x	x		
Camelops sp.					x		x

Table 1 cont.

Form	Sangamon Cragin Q. lf.					Wisconsin	
	Big Springs Loc. 1	KU Locality 7	UM-K3-59	UM-K4-59	Isolated localities	Robert local fauna 11,100 ± 390 yrs. B.P.	Jones local fauna > 30,000 yrs. B.P.
Tanupolama macrocephala (Cope)		x					
Tanupolama sp.	x						
Odocoileus sp.	x				x		
Capromeryx furcifer Matthew	x				x		
Equus cf. E. (Hemionus) calobatus Troxell		x					
Equus conversidens Owen	x						
Equus scotti Gidley	x	x		x	x		
Equus cf. E. (Hemionus)		x			x		
Equus sp.	x	x		x	x		x

section corner. It is downstream from KU Locality 7 and only about 100' N. of the present site of Butler Spring. Stratigraphically this bed lies above the caliche that overlies the deposits that contain the Cragin Quarry local fauna equivalent and appears to be the youngest deposit exposed in the area with the exception of recent alluvium. One and one-half tons of matrix were collected and washed by the University of Michigan field party during the summers of 1957 and 1959. During the summer of 1961, 5 tons were collected and washed. The most abundant fossil from this locality is the mollusk Succinea ovalis Say which can be easily collected at the site. The faunal list is as follows:

Mollusca--numerous but unstudied

Ostracoda--(E. O. Gutentag, personal communication)

Eucypris meadensis Gutentag and Benson

Candona cf. C. renoensis Gutentag and Benson

Cypridopsis vidua (O. F. Müller)

Ilyocypris bradyi Sars

Candona sp.?

Pisces--unstudied

Amphibia

Frog and toad remains--unstudied

Reptilia

Turtle fragments--unstudied

Snake and lizard remains--unstudied

Aves--unstudied

Mammalia

Sorex cinereus Kerr--Cinereus shrew

Sorex palustris Richardson--Water shrew

Blarina brevicauda (Say)--Shorttail shrew

Cynomys ludovicianus (Ord)--Blacktail prairie dog

Citellus cf. C. richardsoni (Sabine)--Richardson ground squirrel

Citellus tridecemlineatus (Mitchill)--Thirteen-lined ground squirrel

Geomys sp.--Pocket gopher

Thomomys cf. T. talpoides (Richardson)--Northern pocket gopher

Reithrodontomys sp.--Harvest mouse

Peromyscus cf. P. leucopus (Rafinesque)--White-footed mouse

Peromyscus cf. P. maniculatus Wagner--Deer mouse

Microtus pennsylvanicus (Ord)--Meadow vole

Microtus (Pedomys) ochrogaster (Wagner)--Prairie vole

Synaptomys cooperi Baird--Southern bog lemming

Zapus cf. Z. hudsonius (Zimmermann)--Meadow jumping mouse

Sylvilagus sp.--Cottontail

Systematic Description of Fossil Mammalia

A systematic description is given below for each member of the mammalian faunas. Catalog numbers, if not otherwise identified, refer to specimens in the collections of the University of Michigan Museum of Paleontology (U.M.M.P.). Specimens in the collection of the University of Kansas Museum of Natural History are designated by KU. The classification and nomenclature used for Recent species is that of Miller and Kellogg (1955).

Class Mammalia

Order Insectivora

Family Soricidae

Sorex cinereus Kerr
(Fig. 5B)

Geologic Range. - Late Kansan to Recent.

Distribution. - Alaska southward to central Washington, east to the Divide, south along the Divide to New Mexico, eastward through Nebraska to the Appalachians, south to Georgia and the Atlantic Coast, north to Labrador, west to Alaska (Burt and Grossenheider, 1964, p. 4).

Habitat. - "The cinereus shrew prefers a moist or damp but not necessarily watery habitat, preferably in woods either coniferous or deciduous, or sometimes marshes or grassy bogs, such as damp mossy woods, spruce-cedar swamps, alder thickets along brooks, mossy banks, and spruce, tamarack, or leatherleaf sphagnum bogs,

Explanation of Figure 5

A, Blarina brevicauda: UMMP 46022, right lower jaw, M_1 - M_2: lateral and occlusal views

B, Sorex cinereus: UMMP 46021, left lower jaw, M_1 - M_3: lateral and occlusal views

C, Sorex palustris: UMMP 46020, left lower jaw, I, P_4 - M_1: lateral and occlusal views

D, Cynomys ludovicianus: UMMP 46045, left lower P_4 - M_3: occlusal view

E, Castor canadensis: KU 5628, right P^4: occlusal view

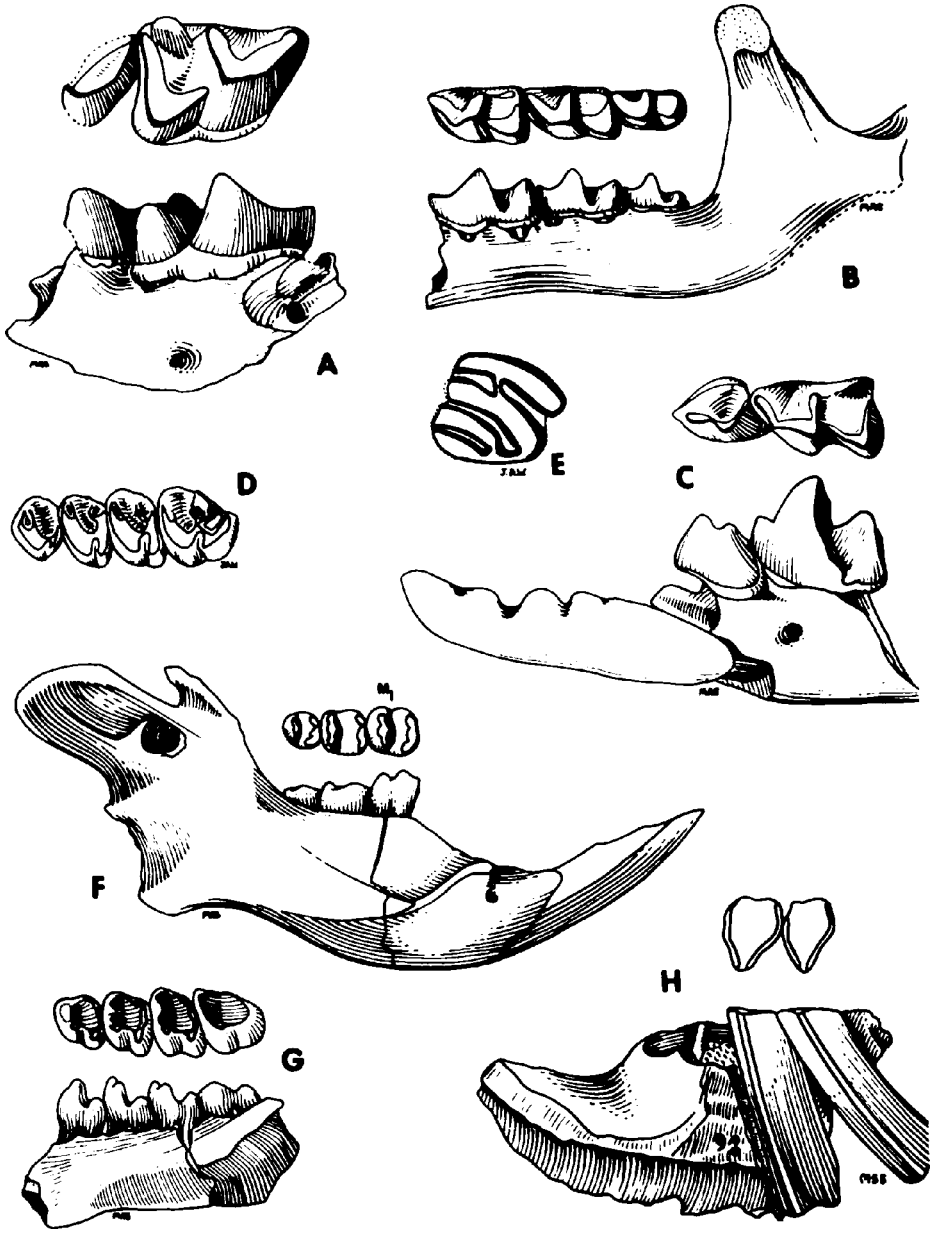
F, Perognathus sp.: UMMP 41563, right lower jaw, I - M_3: lateral and occlusal views

G, Citellus tridecemlineatus: UMMP 46025, left lower jaw, P_4 - M_3: lateral and occlusal views

H, Thomomys cf. T. talpoides: UMMP 46031, right lower jaw, M_1 - M_2: medial and occlusal views

A-C, G, H Robert local fauna; D-F Cragin Quarry local fauna. A-C, x10; D, E, x2; F, x8; G, x4; H, x6. Drawings by Janet A. Walerstein (J.A.W.) and Margaret (Skeels) Stevens (M.A.S. and M.S.S.).

Figure 5



and rarely are found in dry woods or even fields" (Jackson, 1961, p. 29).

Occurrence. - Robert local fauna.

Material. - UM-K1-57 locality: no. 46002, part of right jaw with I - M_1; no. 46003, part of left jaw; no. 46021, left jaw with M_1 - M_3.

Remarks. - The left jaw, no. 46021 (Fig. 5B), is broken just anterior to M_1. The occlusal length of M_1 - M_3 is 3.3 mm. The cinereus shrew is a northern form and does not live in Kansas at the present time. It is found about 280 miles to the north in Nebraska and about 290 miles to the west in Colorado.

Sorex palustris Richardson
(Fig. 5C)

Geologic Range. - Illinoian to Recent.

Distribution. - Southeastern Alaska to central California, east to central Colorado, north to central Alberta, southeast through the Great Lakes region to New York, south through Appalachians to Tennessee; Labrador west to Alaska (Burt and Grossenheider, 1964, p. 13).

Habitat. - "This species, being near aquatic or at least amphibious, inhabits marshes, bogs, and wet areas near the borders of streams, lakes, or water holes. It frequently inhabits beaver and muskrat houses, particularly in winter. It seems to prefer a more or less wooded habitat and is rarely found in marshes devoid of bushes or trees" (Jackson, 1961, p. 38).

Occurrence. - Robert local fauna.

Material. - UM-K1-57 locality: no. 46020, part of left jaw with incisor, P_4 and M_1.

Remarks. - The dentition and lower jaw (Fig. 5C) are like those of the northern water shrews from the Doby Springs local fauna (Stephens, 1960, p. 1689). The water shrew, a northern form, does not live in Kansas at the present time. It is found to the north and to the west in the southern Rocky Mountain region.

Blarina b. brevicauda (Say)
(Fig. 5A)

Geologic Range. - Illinoian to Recent.

Distribution. - Central Saskatchewan south through eastern Plains region to Gulf Coast of Texas; east through Canada to the Gaspe Peninsula (Burt and Grossenheider, 1964, p. 15).

Habitat. - "In times of its lower population densities it occurs more plentifully in damp brushy woodlands, bushy bogs and marshes, and weedy and bushy borders of fields, but may be taken almost any place where there is vegetative litter sufficient to offer cover. During normal or heavy populations it may be found in heavy timber of oak, spruce, white cedar, birch or especially hemlock; in shrubby or weedy growth along brooks, lakes, sloughs or marshes; in tamarack and spruce swamps and in sphagnum bogs; in damp grassy and willowy patches, or wet alder thickets" (Jackson, 1961, p. 44).

Occurrence. - Robert local fauna.

Material. - UM-K1-57 locality: no. 46004, a right lower incisor; no. 46022, part of a right jaw with M_1.

Remarks. - The right jaw fragment (Fig. 5A) contains M_1 and fragments of the premolar and M_2. The M_1 is larger and broader than any of the specimens from the Mt. Scott local fauna assigned by Hibbard (1963, p. 201) to Blarina b. carolinensis.

B. b. carolinensis is presently found in eastern and northern Kansas but the species is absent altogether from the southwestern corner of the state including Meade County. B. b. brevicauda extends as far south as southern Nebraska and Iowa but does not reach Kansas. The larger specimens found in the Berends and Doby Springs local faunas of Oklahoma are referable to this subspecies.

Order Rodentia

Family Sciuridae

Cynomys ludovicianus (Ord)
(Fig. 5D)

Geologic Range. - Illinoian to Recent.

Distribution. - Southern Alberta and Saskatchewan south through the Great Plains to southeastern Arizona, northern Mexico, and west Texas. This species has been restricted on the east by cultivation and on the west by the Rocky Mountains (Burt and Grossenheider, 1964, p. 102).

Habitat. - The blacktail prairie dog inhabits the broad flats of the open shortgrass plains country and prefers deep soil.

Occurrence. - Cragin Quarry local fauna (UM-K4-59); upper Sangamon red silts; and Robert local fauna (UM-K1-57).

Material. - Cragin Quarry local fauna: red silts north of UM-K3-59, no. 46045, part of left jaw with P_4 - M_3; Qpk_2l bed, no.

46040, a lumbar vertebra and no. 46054, a left ulna; UM-K4-59, no. 41597, a right P^3. Upper Sangamon red silts: nos. 46043 and 48010, assorted limb bones; no. 46047, a left jaw with P_4 - M_3 and assorted limb bones; Robert local fauna: locality UM-K1-57, no. 48459, an upper molar.

Remarks. - The remains of the blacktail prairie dog are common throughout these beds. The teeth are like those of the Recent form living in Meade County. The occlusal length of P_4 - M_3 in the left jaw fragment, no. 46045 (Fig. 5D), is 14.0 mm. The left jaw, no. 46047, is nearly complete but badly weathered. The occlusal length of P_4 - M_3 is 14.0 mm.

Citellus cf. C. richardsoni (Sabine)

Occurrence. - Robert local fauna.

Material. - UM-K1-57 locality: no. 41466, three molar teeth.

Remarks. - An upper left M^1 or M^2 and two lower left molars are the size of those of C. richardsoni (Sabine). This species is a more northern form and is not found in Kansas at the present time.

Citellus tridecemlineatus (Mitchill) (Fig. 5G)

Geologic Range. - Illinoian to Recent.

Distribution. - The thirteen-lined ground squirrel inhabits the Great Plains region from central Saskatchewan south to the Gulf of Mexico; western Montana eastward to Michigan and Ohio; eastern Arizona to eastern Texas and Oklahoma (Burt and Grossenheider, 1964, p. 109).

Habitat. - Chiefly in dry, open grassland prairies and secondarily in sandy river bottoms and the brushy borders of timber tracts (Howell, 1938, p. 18).

Occurrence. - Cragin Quarry local fauna (UM-K4-59); Robert local fauna (UM-K1-57).

Material. - UM-K4-59 locality: no. 45995, a right $M^{\frac{1}{-}}$ or $M^{\frac{2}{-}}$; UM-K1-57 locality: no. 46025, part of a left jaw with P_4 - M_3 and two isolated lower molars.

Remarks. - The left jaw (Fig. 5G) is that of a young individual as shown by the little tooth wear. The occlusal length of P_4 - M_3 is 6.6 mm. C. tridecemlineatus is found living in Meade County, Kansas, at the present time.

Family Geomyidae

Thomomys cf. T. talpoides (Richardson)
(Fig. 5H)

Occurrence. - Robert local fauna.

Material. - UM-K1-57 locality: no. 46031, fragment of right jaw containing M_1 - M_2 and the alveolus of P_4; no. 46226, isolated cheek teeth.

Remarks. - The teeth are the size of a small individual of the species T. talpoides. Better material is needed to confirm the presence of the northern pocket gopher in the fauna.

Geomys sp.

Occurrence. - Cragin Quarry local fauna (UM-K3-59 and UM-K4-59) and Robert local fauna (UM-K1-57).

Material. - UM-K3-59 locality: no. 41553, isolated teeth; UM-K4-59 locality: no. 45985, part of an upper incisor; UM-K1-57 locality: no. 41465, an upper right incisor and several isolated cheek teeth.

Remarks. - The material is too fragmentary to permit species determination.

Family Heteromyidae

Perognathus hispidus Baird

Geologic Range. - Illinoian to Recent.

Distribution. - Central Arizona southeast into Mexico, northeast along the Gulf Coast to western Louisiana; northwest to the southwestern corner of North Dakota; south through the Great Plains to northeastern New Mexico and southwest into Arizona. Absent from extreme eastern Kansas (Burt and Grossenheider, 1964, p. 147).

Habitat. - The hispid pocket mouse, chiefly a grassland form, lives in both the short grass and the long grass prairies.

Occurrence. - Cragin Quarry local fauna (UM-K3-59).

Material. - UM-K3-59 locality: no. 41559, part of left jaw with M_1 - M_2 and part of a right jaw with incisor and M_2; no. 41560, parts of three maxillaries.

Remarks. - The hispid pocket mouse was reported by Hibbard and Taylor (1960, p. 157) from Cragin Quarry Locality 1, Big Springs Ranch, and is also found living in Meade County at the present time.

Perognathus sp.
(Fig. 5F)

Occurrence. - Cragin Quarry local fauna (UM-K3-59 and UM-K4-59).

Material. - UM-K3-59 locality: no. 41561, parts of four maxillaries; no. 41562, five lower jaws; no. 41563, a right jaw with M_1 - M_3; UM-K4-59 locality: no. 45991, upper and lower incisor and a lower molar.

Remarks. - The maxillaries and lower jaws belong to a small pocket mouse the size of *Perognathus flavescens* Merriam. The occlusal length of M_1 - M_3 in the right jaw, no. 41563, is 2.2 mm. (Fig. 5F). The specimens are similar to the small *Perognathus* reported from Cragin Quarry Locality 1 (Hibbard and Taylor, 1960, p. 168). Again no characters were found that would separate the lower jaws and fragmentary maxillaries of *P. flavescens*, *P. merriami* Allen, and *P. flavus* Baird.

Family Castoridae

Castor canadensis Kuhl
(Fig. 5E)

Geologic Range. - Late Pleistocene (Illinoian?) to Recent.

Distribution. - The Canadian beaver is found throughout North America where a favorable habitat exists from Alaska south to Mexico. Absent in Florida, southern California and southern Nevada and most of Mexico (Burt and Grossenheider, 1964, p. 158).

Habitat. - The Canadian beaver lives in or beside lakes, streams, and ponds. Most of the present day beavers in Kansas

live in burrows in the banks of lakes or streams rather than in houses.

Occurrence. - Cragin Quarry local fauna (UM-K2-62).

Material. - UM-K2-62 locality: University of Kansas (KU) nos. 4727 and 5628, a right M_I and a right P^4.

Remarks. - The M_I, KU 4727, was reported and figured by Hibbard (1939, p. 470). The P^4, KU 5628, is figured here (Fig. 5E) and is indistinguishable from that of the Recent species. Both teeth were found near the top of the red silts just below the caliche horizon.

Family Cricetidae

Onychomys cf. O. leucogaster (Wied-Neuwied)

Occurrence. - Cragin Quarry local fauna (UM-K3-59 and UM-K4-59).

Material. - UM-K3-59 locality: no. 41567, a left M^1; UM-K4-59 locality: no. 45983, a right M_I.

Remarks. - The upper molar is that of a young adult and consists of crown only with unworn cusps; length is 2.2 mm. and width is 1.3 mm. The lower molar, complete, is that of an older adult; length, 1.9 mm. and width, 1.1 mm.

Reithrodontomys megalotis Baird
(Fig. 6C)

Geologic Range. - Illinoian to Recent.

Distribution. - British Columbia south to southern Mexico; California, east to Texas Panhandle, from central Kansas east to

the Mississippi River, just entering northern Illinois and southwestern Wisconsin (Burt and Grossenheider, 1964, p. 160).

Habitat. - The western harvest mouse lives in tall grass and weeds and is confined to more moist areas in the western part of its range.

Occurrence. - Cragin Quarry local fauna (UM-K3-59 and UM-K4-59).

Material. - UM-K3-59 locality: nos. 41568-41574, parts of 5 lower jaws and 4 maxillaries; UM-K4-59 locality: no. 45994, a left jaw.

Remarks. - Parts of 3 right lower jaws, 3 right maxillaries, 3 left lower jaws and 1 left maxillary of young adult to mature adult individuals were recovered. The teeth were compared with those of Recent specimens of Reithrodontomys megalotis, and R. montanus and with those of R. cf. megalotis from Cragin Quarry Locality 1 (Hibbard and Taylor, 1960, p. 170) and R. cf. montanus from the late Sangamon Jinglebob local fauna (Hibbard, 1955, p. 209) of Meade County. They are very similar to those of R. megalotis.

Three lower jaws have M_1 - M_2 present and no. 41571, a right jaw with M_1 - M_3, has a tooth row length of 3.2 mm. (Fig. 6C). The anteroconid of M_1 in these jaws is not divided by an anterior groove as in R. m. aztecus from Meade County. Two M_1s and one M_2 possess a small ectostylid; stylids and lophids are absent on the remaining lower teeth. Three maxillaries contain M^1 - M^3 and the length of the tooth row in each is 3.3 mm. No styles or lophs are present.

Explanation of Figure 6

A, Peromyscus progressus: UMMP 41564, left lower jaw, M_1 - M_3: lateral and occlusal views

B, Reithrodontomys sp.: UMMP 46026, left lower jaw, I - M_2: lateral and occlusal views

C, Reithrodontomys megalotis: UMMP 41571, right lower jaw, I - M_3: lateral and occlusal views

D, Microtus (Pedomys) ochrogaster: UMMP 41469, right lower jaw, M_1 - M_2: lateral and occlusal views.

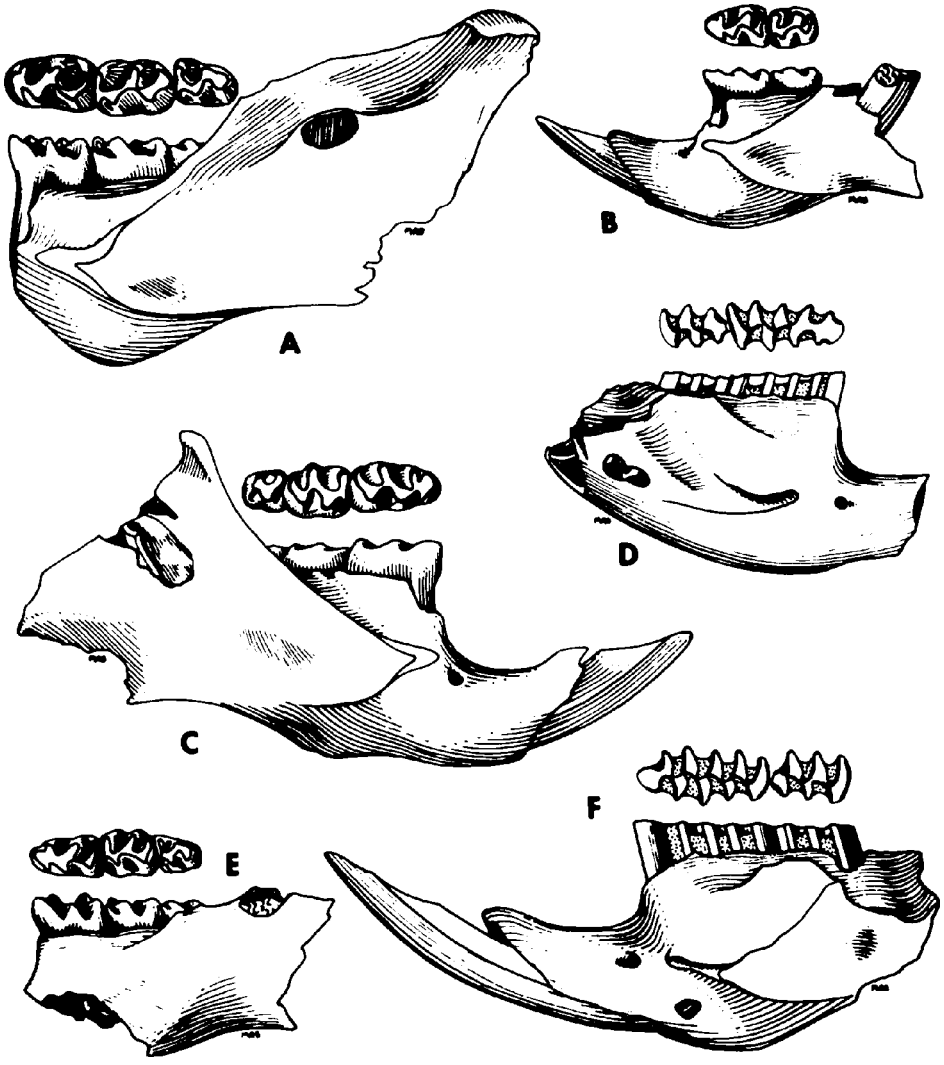
E, Peromyscus cf. P. maniculatus: UMMP 46023, left lower jaw, M_1 - M_3: lateral and occlusal views

F, Microtus pennsylvanicus: UMMP 46024, left lower jaw, I - M_2: lateral and occlusal views

A, C, Cragin Quarry local fauna; B, D-F, Robert local fauna.

A, C, x8; B, D-F, x6. All drawings by Margaret (Skeels) Stevens (M.A.S.).

Figure 6



Reithrodontomys sp.
(Fig. 6B)

Occurrence. - Robert local fauna.

Material. - UM-K1-57 locality: nos. 45999, 46008-46012, 46026, parts of 4 lower jaws and 3 maxillaries.

Remarks. - Parts of 3 left lower jaws, 2 left maxillaries, 1 right lower jaw and 1 right maxillary of young adult to mature adult individuals were recovered. The dentitions were compared with both R. megalotis and R. montanus but can not be assigned with certainty to either species.

The occlusal length of M_1 - M_2 in the left jaw, no. 46026 (Fig. 6B), is 2.5 mm.; the remaining jaws contain either M_1 or M_2. A mesostylid and mesolophid are present on one of the M_1s but no ectostylids are present on any of the teeth. Of possible importance is the presence in several of the lower jaws of a faint enamel ridge along the labial side of M_1 and M_2 which blocks the reentrant valley between the protoconid and the hypoconid and also extends anterior to the protoconid as a shelf in M_2. According to Hooper (1952, p. 41) this ridge is well-developed in R. burti and exists as a trace in R. montanus.

Two of the maxillaries contain M^1 - M^3. The anteroposterior tooth row measurements are 3.0 and 3.1 mm. The left maxillary contains an anterostyle on M^1 and M^2. The right maxillary lacks both styles and lophs. Both specimens possess rather broad U-shaped enamel folds on the labial sides of M^1 and M^2 which makes the cusps appear farther apart. Hooper (1952, p. 37) considers this

characteristic of R. montanus. However, a third maxillary containing M^1 does not exhibit this feature. More and better material is needed to determine if one or two species of harvest mouse were present in the fauna.

Peromyscus progressus Hibbard (Fig. 6A)

Occurrence. - Cragin Quarry local fauna (UM-K3-59).

Material. - UM-K3-59 locality: nos. 41564-41566, three lower jaws.

Remarks. - The teeth are those of young adults and are very similar to those of P. progressus from Cragin Quarry Locality 1 (Hibbard and Taylor, 1960, p. 171). No. 41564 is a left jaw with M_1 - M_3 (Fig. 6A). The anteroposterior length of the tooth row is 3.8 mm. A rudimentary ectostylid is present on M_1 and M_2, but mesostylids and lophids are absent. No. 41565 is a left jaw with M_1 - M_3 (anteroposterior length 3.9 mm.). Ectostylid and mesostylid are well developed on M_1 and M_2, but lophids are lacking except for a moderate mesolophid on M_1. No. 41566 is a right jaw with M_2; no stylids or lophids are present.

Peromyscus cf. P. leucopus (Rafinesque)

Occurrence. - Robert local fauna.

Material. - UM-K1-57 locality: nos. 41463, 46000, and 46032, three right maxillaries.

Remarks. - The dental characters appear as advanced as in the Recent P. leucopus noveboracensis from Meade County and the

teeth agree in size and shape with those of the Recent form. All three maxillaries contain M^1 - M^2 and vary from mature adult to old age. Well-developed mesostyles and mesolophs are present on all of the M^1s and M^2s. In addition a rudimentary enterostyle is present on M^1 and M^2 of one of the specimens. In the M^1s the anteromedian groove is absent and the anteroloph joins the style at the mouth of the reentrant between anterocone and paracone.

These teeth appear to be more advanced than either P. progressus from the Cragin Quarry local fauna (Hibbard and Taylor, 1960, p. 171) or P. cochrani from the late Sangamon Jinglebob local fauna (Hibbard, 1955, p. 210). If so, the present grade of dental development observed in the Recent P. leucopus was probably attained during the Wisconsin (Hibbard and Taylor, 1960, p. 175).

Peromyscus cf. P. maniculatus Wagner
(Fig. 6E)

Occurrence. - Robert local fauna.

Material. - UM-Kl-57 locality: no. 46023, a left jaw with M_1 - M_3.

Remarks. - The teeth are like those of P. maniculatus nebrascensis. They are narrower and smaller than any of P. leucopus with which it was compared. The anteroposterior length of M_1 - M_3 is 3.7 mm. An ectostylid is present on M_2 but all other stylids and lophids are absent. Better material is needed to determine whether P. maniculatus is actually present in the fauna.

Microtus pennsylvanicus (Ord)
(Figs. 6F and 7G)

Geologic Range. - Illinoian to Recent.

Distribution. - Boreal region of North America from southern Alaska to Colorado and central New Mexico; east across extreme northern Kansas and southern Nebraska to Missouri; southeast through Kentucky to Georgia; Atlantic Coast to Labrador and west to Alaska (Burt and Grossenheider, 1964, p. 192; Fleharty and Andersen, 1964, p. 129).

Habitat. - The meadow vole lives chiefly in moist, low grassy areas but is also found in high grasslands and areas near lakes, swamps, and streams.

Occurrence. - Cragin Quarry local fauna (UM-K3-59); upper Sangamon red beds; Robert local fauna (UM-K1-57).

Material. - UM-K3-59 locality: no. 41554, a palate with right and left dentition; upper Sangamon beds: no. 46044, a left jaw with M_1; UM-K1-57 locality: nos. 41468, 46015, 46017-46019, 46024, 46027-46028 and 46030, parts of 9 lower jaws; no. 41471, isolated cheek teeth.

Remarks. - The remains of meadow voles are common in the Robert local fauna. Parts of 5 right and 4 left jaws were recovered. Three of the jaws contain M_1 - M_2; the anteroposterior occlusal lengths are 4.7 (Fig. 6F), 4.9, and 5.2 mm. The remaining jaws contain M_1 only. In addition, there are numerous isolated teeth including 26 left M_1s and 23 right M_1s. At least 30 individuals are represented by the jaws and isolated teeth.

Explanation of Figure 7

A, Odocoileus sp.: UMMP 47805, right M_3: lateral and occlusal views

B, Zapus cf. Z. hudsonius: UMMP 41464, left lower jaw, M_2: lateral and occlusal views

C, Vulpes velox: UMMP 46048, right lower jaw, C - P_3: lateral view

D, Panthera atrox: UMMP 47823, right patella: anterior view

E, Mustela cf. M. frenata: UMMP 41592, right lower jaw, P_4 - M_2: lateral and occlusal views

F, Canis (Aenocyon) dirus: UMMP 42622, left calcaneum: dorsal view

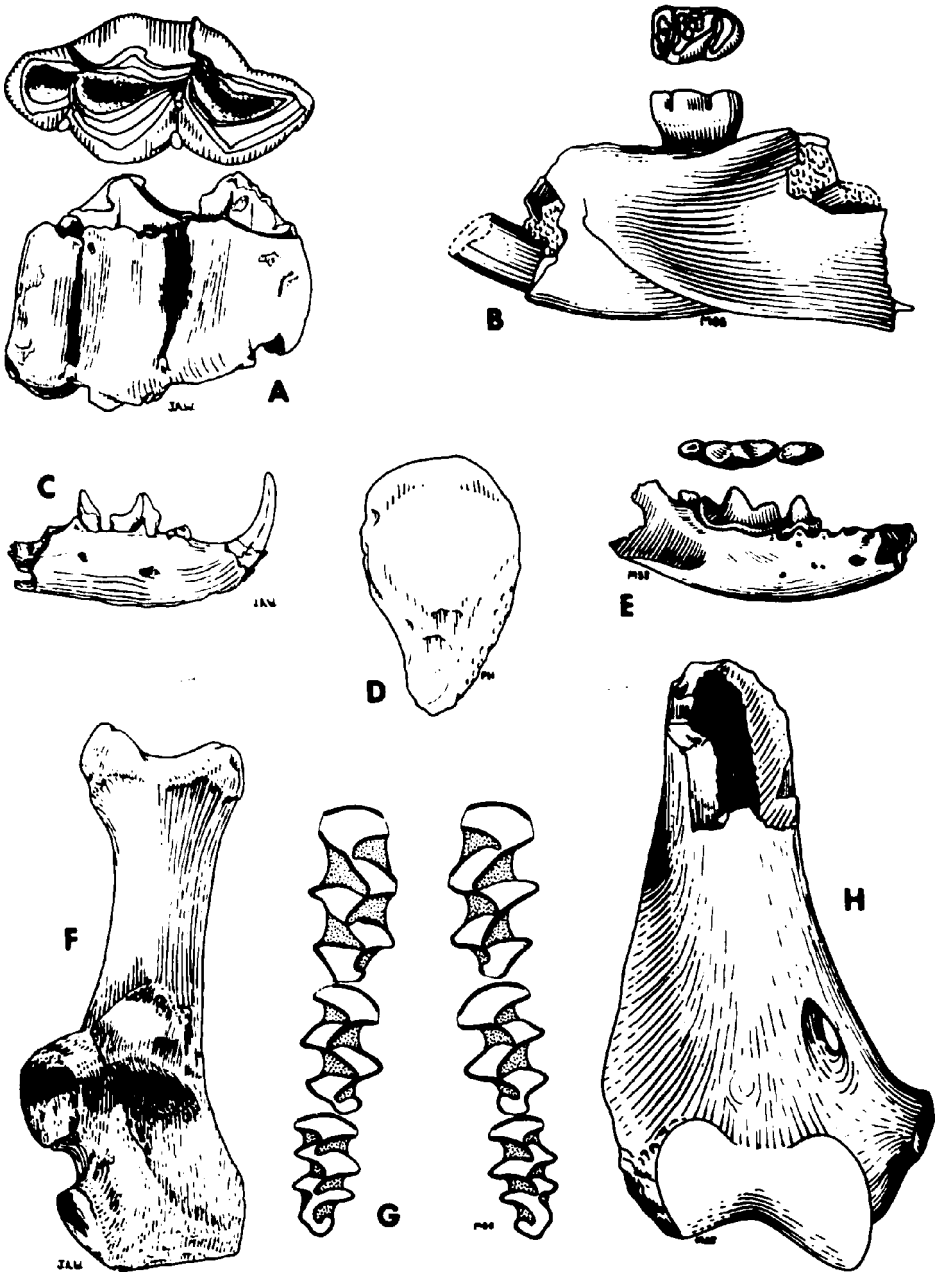
G, Microtus pennsylvanicus: UMMP 41554, upper M^1 - M^3: occlusal view

H, Panthera atrox: UMMP 29023, distal end of right humerus: anterior view

B, Robert local fauna; all others, Cragin Quarry local fauna.

A, E, x2; B, G, x8; C, F, x1; D, H, x½. Drawings by Janet A. Walerstein (J.A.W.); Florence Hodge (F.H.); and Margaret (Skeels) Stevens (M.A.S. and M.S.S.).

Figure 7



Examination of the M_1s showed 21 with 5 alternating closed triangles, 36 with 6 closed triangles and 1 with 7 closed triangles.

In the Cragin Quarry local fauna an upper palate with both right and left complete dentitions was recovered from the UM-K3-59 Locality (Fig. 7G). The anteroposterior occlusal length of M^1 - M^3 is 7.2 mm.

The meadow vole is a northern form and does not live in Meade County today. It is found about 220 miles to the north in Jewell County, Kansas, (Fleharty and Andersen, 1964, p. 129) and about 200 miles to the west in eastern Colorado and northcentral New Mexico. Although its presence in the Robert local fauna (late Wisconsin) can be explained on the basis of generally cooler summers, its occurrence in the Cragin Quarry local fauna (early Sangamon) can probably be explained on the basis of the survival from late Illinoian time of a small population in a locally favorable moist habitat.

Microtus (Pedomys) ochrogaster (Wagner)
(Fig. 6D)

Geologic Range. - Illinoian to Recent.

Distribution. - Central Oklahoma northwest to southeastern Alberta; southeast through Minnesota and Wisconsin to Ohio and West Virginia; southwest through Kentucky to the Mississippi River and west across northern Arkansas (Burt and Grossenheider, 1964, p. 199).

Habitat. - The prairie vole lives in open grasslands and is seldom found in wooded areas.

Occurrence. - Cragin Quarry local fauna (UM-K4-59). Upper Sangamon or Wisconsin beds; Robert local fauna (UM-K1-57).

Material. - UM-K4-59 locality: no. 45984, a right M_1; latest Sangamon or Wisconsin beds; KU no. 5971, a left jaw with M_1 - M_2; UM-K1-57 locality: no. 46016, 41469, two right jaws; no. 41470, isolated cheek teeth.

Remarks. - Parts of 2 right jaws and isolated teeth representing 4 individuals were recovered from the Robert local fauna. No. 41469 is a right jaw with M_1 - M_2 (Fig. 6D). The anteroposterior occlusal length of the teeth is 4.0 mm.

Hibbard (1943, p. 190) reported a left jaw, KU 5971, collected by Tihen in 1940 from a sand horizon which lies just below the Robert local fauna horizon. The jaw contains M_1 - M_2 which have an anteroposterior length of 5.2 mm. The beds from which this jaw was taken are Wisconsin or latest Sangamon in age.

Synaptomys cooperi Baird

Geologic Range. - Wisconsin to Recent.

Distribution. - Western Ontario southwest through Plains region to Meade County, Kansas; east through northern Arkansas, Kentucky, and Virginia, north to Quebec and west across Ontario (Burt and Grossenheider, 1964, p. 184).

Habitat. - The southern bog lemming lives in low damp bogs or meadows with a heavy grass cover which are generally small local areas.

Occurrence. - Robert local fauna.

Material. - UM-K1-57 locality: no. 46029, three upper and two lower molar teeth; no. 46033, part of left maxillary with M^1.

Remarks. - The left M^1, no. 46033, and three of the isolated teeth are the size of those of the Recent Synaptomys cooperi cooperi which is the more northern subspecies. Two of the teeth are somewhat larger. At the present time there is a small population of bog lemming in Meade County State Park which are of larger body size than S. c. cooperi. This local population constitutes the subspecies S. c. paludis.

Family Zapodidae

Zapus cf. Z. hudsonius (Zimmermann)
(Fig. 7B)

Occurrence. - Robert local fauna.

Material. - UM-K1-57 locality: no. 41464, a left jaw with M_2.

Remarks. - The M_2 is that of an adult and compares in size and shape with that of Z. hudsonius; the anteroposterior length of the M_2 is 1.4 mm. and the width is 0.9 mm.

Order Carnivora

Family Canidae

Canis (Aenocyon) dirus (Leidy)
(Fig. 7F)

Geologic Range. - Late Pleistocene.

Distribution. - The dire wolf is known from California east to the Atlantic Coast and Wisconsin south to Mexico. The southern limits of its range are unknown.

Habitat. - Open plains country.

Occurrence. - Cragin Quarry local fauna (KU Locality 7); upper Sangamon beds.

Material. - KU Locality 7: KU no. 4613, a left lower jaw with associated upper canine and both $I\frac{3}{-}$; no. 42622, a left calcaneum; upper Sangamon beds: no. 29028, a proximal toe bone.

Remarks. - Hibbard (1939, p. 464) reported the left lower jaw of an old individual, KU 4613, which he collected in 1937 along with an associated upper canine and two upper third incisors from "an old stream channel now well above the flood plain of the present Cimarron river."

The measurements of the calcaneum (Fig. 7F) are: greatest length 65.5 mm.; greatest width across the posterior astragalar facets, 25.0 mm.; greatest width across cuboid surface, 20.0 mm.; greatest width of outer face measured normal to plantar border and to edge of outer astragalar facet, 30.0 mm.

The calcaneum and the toe bone are the size of those bones in the mounted skeleton, no. 3479, of the dire wolf from the Rancho La Brea deposits.

Hibbard and Taylor (1960, p. 178) reported Canis (Aenocyon) dirus from Cragin Quarry Locality 1.

Vulpes velox (Say)
(Fig. 7C)

Geologic Range. - Late Pleistocene (Sangamon) to Recent.

Distribution. - Southern Alberta south to New Mexico and west Texas, north through the eastern Plains region to southern Manitoba and west to Alberta (Burt and Grossenheider, 1964, p. 78).

Habitat. - Open grassland prairies.

Occurrence. - Cragin Quarry local fauna (UM-K2-62).

Material. - UM-K2-62 locality: no. 46048, part of a right lower jaw, with canine, P_1, P_2, and part of P_3.

Remarks. - The jaw is weathered but is indistinguishable from that of the Recent swift fox now living in Meade County, Kansas. The posterior portion of the jaw is missing (Fig. 7C), also the molar series, P_4, and the incisors.

Hibbard and Taylor (1960, p. 179) reported the right and left lower jaws of a swift fox from Cragin Quarry Locality 1.

Vulpes sp.

Occurrence. - Cragin Quarry local fauna (UM-K4-59).

Material. - UM-K4-59 locality: no. 45990, five deciduous cheek teeth including a right DP^3 and DP^4, a left DP^4, a left DP_3 and DP_4.

Remarks. - The teeth, which show no wear, are those of a young animal of the genus *Vulpes*. They may represent the species *V. velox*, however, better material is needed before positive identification can be made.

Family Mustelidae

Mustela cf. *M. frenata* Lichtenstein
(Fig. 7E)

Geologic Range. - Late Pleistocene (Sangamon) to Recent.

Distribution. - The longtail weasel is found throughout southern Canada, the United States except extreme southwestern corner, and most of Mexico (Burt and Grossenheider, 1964, p. 63).

Habitat. - Forests, prairies and brushlands near water.

Occurrence. - Cragin Quarry local fauna (UM-K4-59).

Material. - UM-K4-59 locality: no. 41592, a right jaw with P_4 - M_2.

Remarks. - The jaw (Fig. 7E) compares favorably in size and form with that of a female *M. frenata* and is smaller than those of the male of this species with which it was compared. The jaw is larger than those of most males of the species *M. erminea*. The P_4 is slightly shorter and broader than that of most specimens of both species but this may be due to individual variation. The anteroposterior length of P_4 - M_2 is 8.8 mm.

Mephitis sp.

Occurrence. - Cragin Quarry local fauna (UM-K4-59).

Material. - UM-K4-59 locality: no. 45989, a fragment of left maxillary containing part of the left P^4 and the infraorbital foramen.

Remarks. - The size and shape of the infraorbital foramen is identical to that of the Recent striped skunk, *Mephitis mephitis*,

now living in Meade County. Better material is needed for positive species identification.

Family Felidae

Panthera atrox (Leidy)
(Figs. 7D, H)

Geologic Range. - Illinoian? to late Wisconsin.

Distribution. - Scattered records of this extinct giant jaguar are reported from Natchez, Mississippi, westward and from Alaska south to the valley of Mexico (see map by Simpson, 1941, p. 21).

Habitat. - The habitat of this large cat in southwest Kansas is probably similar to that suggested by Merriam and Stock (1932, p. 26), from their study of the Rancho La Brea material: "An open plain or a rolling country, probably grass-covered and supporting here and there a growth of trees and shrubs, presented in the vicinity of Rancho La Brea during Pleistocene time an environment in which one might reasonably expect to find such carnivores as the great cat."

Occurrence. - Cragin Quarry local fauna (KU Locality 7).

Material. - KU Locality 7: no. 29023, distal end of right humerus; no. 47823, a right patella.

Remarks. - The humerus (Fig. 7H) is like that of the Rancho La Brea material described by Merriam and Stock (1932, p. 111-115). The supracondylar ridge is abraded and part of the lateral condyle is missing. The entepicondylar foramen is present and

the medial condyle is well developed. The least anteroposterior diameter of the articulating surface for the ulna is 27.5 mm.

Measurements of the patella (Fig. 7D) are: proximo-distal length, 63.5 mm.; greatest width, 41.0 mm.; anteroposterior diameter through middle of articulating surface, 21.8 mm.

Hibbard and Taylor (1960, p. 180) reported P. atrox from Cragin Quarry Locality 1.

Order Proboscidea

Family Elephantidae

Mammuthus sp.

Occurrence. - Cragin Quarry local fauna and upper Sangamon beds.

Material and Remarks. - Enamel tooth plates and fragments of limb bones of mammoths have been observed in several Sangamon horizons, but none of these fragments was saved.

Order Lagomorpha

Family Leporidae

Lepus sp.

Occurrence. - Cragin Quarry local fauna (KU Locality 7).

Material. - KU Locality 7: KU no. 6855, a right calcaneum and assorted metatarsals and toe bones.

Sylvilagus sp.

Occurrence. - Cragin Quarry local fauna (UM-K4-59); Robert local fauna (UM-K1-57).

Material. - UM-K4-59 locality: no. 45982, a right P^2; UM-K1-57 locality: no. 46013, part of an upper tooth.

Order Artiodactyla

Family Tayassuidae

Platygonus cf. P. compressus Le Conte
(Figs. 8D, E)

Geologic Range. - Middle Pleistocene to late Wisconsin.

Distribution. - New York to California, Michigan south to Florida and Texas.

Habitat. - Western grasslands; meadows and open woodland in eastern part of range.

Occurrence. - Cragin Quarry local fauna (KU Locality 7).

Material. - KU Locality 7: no. 35672, a left lower jaw with P_2 - M_3; no. 42626, a left metatarsal.

Remarks. - The left jaw (Fig. 8E) is that of a young adult; all of the cheek teeth are present in the series and the M_1 is but slightly worn. The jaw is broken ventral to the premolar series and the symphyseal region is missing; the condyle is present but the coronoid process is lacking. The total length of the cheek tooth series, P_2 - M_3, is 90.8 mm. which agrees closely with that of a paratype, U.S.N.M. no. 8200 (female), of P. cumberlandensis Gidley (see Gidley, 1920, p. 668; Gidley and Gazin, 1938, p. 81) but is smaller than that of the male specimens described therein.

The jaw has been compared with 2 right jaws of P. cf. P. cumberlandensis from the late Kansan Seymour Fm. of Texas (see

Explanation of Figure 8

A, Capromeryx furcifer: UMMP 46050, left horn core: lateral view

B, Capromeryx furcifer: UMMP 46049, left lower jaw, P_4 - M_3: lateral and occlusal views

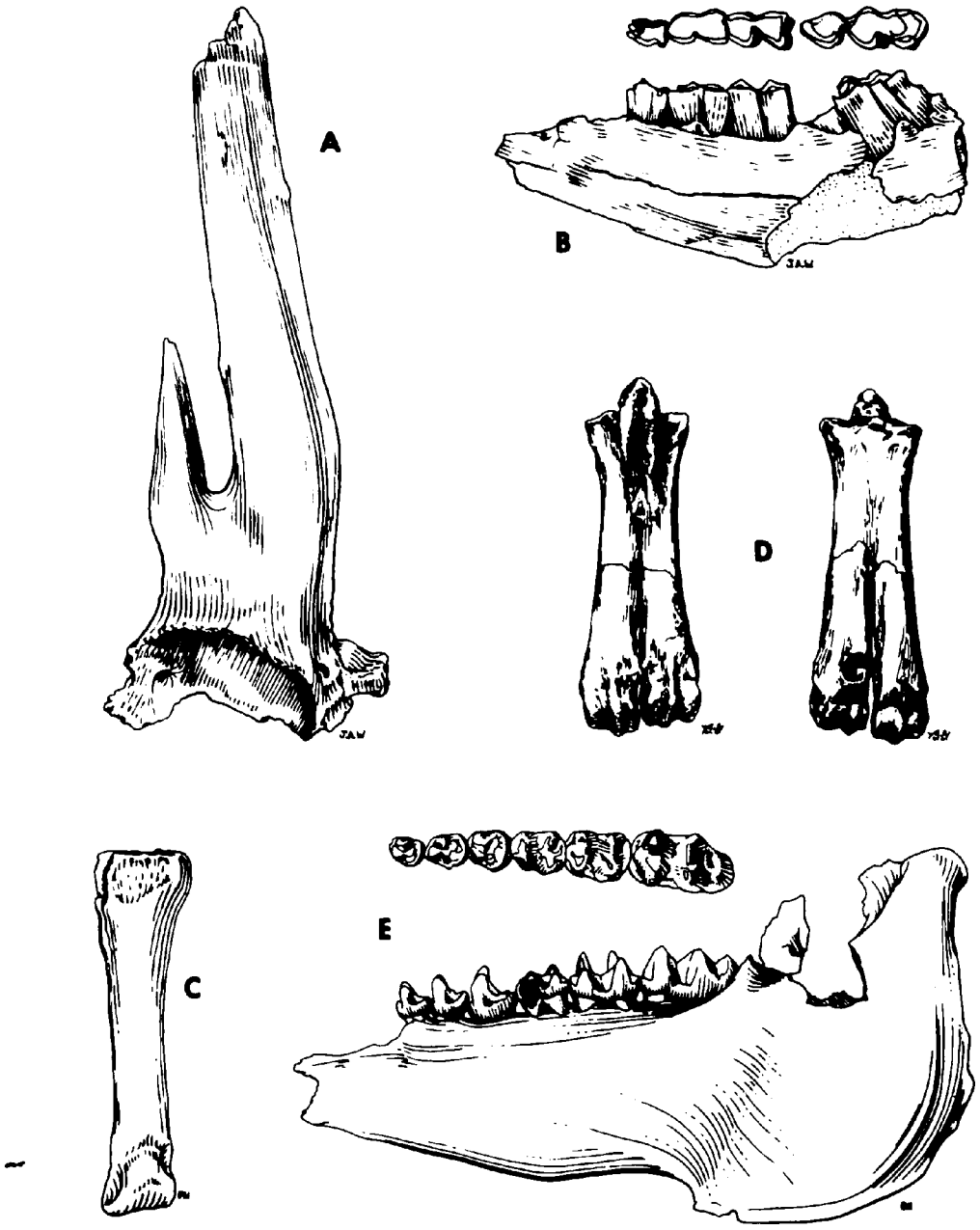
C, Tanupolama: UMMP 46095, proximal toe bone: anterior view

D, Platygonus cf. P. compressus: UMMP 42626, left metatarsal: anterior (right) and posterior (left) views

E, Platygonus cf. P. compressus: UMMP 35672, left lower jaw, P_2 - M_3: lateral and occlusal views

A, Middle or late Sangamon; C, Surface find (Sangamon?); B, D, E, Cragin Quarry local fauna. A, B, x1; C-E, x½. Drawings by Barbara Gagnon (B.G.), Bonnie Hall (B.H.), Janet A. Walerstein (J.A.W.), and Florence Hodge (F.H.).

Figure 8



Hibbard and Dalquest, 1962) and the teeth agree generally in size and proportion. In the Texas specimens, the jaw tends to be somewhat larger and heavier, with the condyle placed approximately in line with the tooth row, whereas in the Kansas specimen here described, the region between the third molar and the condyle is foreshortened while the condyle is placed considerably above the axis of the tooth row.

Simpson (1949) described a population of P. compressus from a Pleistocene deposit in Cherokee Cave, St. Louis. Unfortunately he gave no jaw or tooth row measurements, but only the size range and mean dimensions of the molars and premolars themselves. Each of the teeth of the Kansas specimen falls within the upper size limits of the corresponding teeth of the St. Louis specimens.

Hibbard and Taylor (1960, p. 183) referred part of a left maxillary from Cragin Quarry Locality 1 to P. compressus, but stated that the M^3 is slightly larger than most teeth assigned to this species.

Measurements of the metatarsal (Fig. 8D) are: greatest length, 95.0 mm.; proximal width, 25.0 mm.; distal width, 29.0 mm.; minimum transverse width, 18.5 mm. Because of the considerable variation in size, as Simpson has shown in the case of P. compressus, it is impossible to determine species on the basis of the metatarsal alone.

In view of the above discussion and the lack of better comparative material, it would seem that a conservative treatment at present is to refer the Kansas specimen to P. compressus. Future

examination of more complete skulls or skeletons may confirm or invalidate this conclusion.

Family Camelidae

Camelid indeterminate

Occurrence. - Upper Sangamon red silts above the caliche.

Material. - No. 46087, proximal end of a right radius-ulna; no. 46088, distal end of a metapodial of a large camel.

Remarks. - The enormous size of these specimens indicates that they may belong to a genus larger than Camelops, perhaps Gigantocamelus. The greatest proximal width of the radius (articular surface) is 104.0 mm. and the greatest anteroposterior depth of the olecranon process is 95.0 mm. The width of the articular surface of the metapodial is 48.0 mm.

Camelops kansanus Leidy
(Fig. 9E)

Geologic Range. - Middle Pleistocene to late Wisconsin.

Distribution. - Fossil records are from the Mississippi River west to the Pacific Coast with the southern limits of the range unknown.

Habitat. - Open shrub and grassland country.

Occurrence. - Cragin Quarry local fauna (Localities: KU 7, UM-K4-59 and UM-K2-62) and upper Sangamon gray beds.

Material. - KU Locality 7: no. 29985, a right M_3; no. 29024, a left calcaneum; no. 42240 and no. 42627, two right carpals; UM-K4-59 locality: no. 44688, a right calcaneum; no 44684 and

Explanation of Figure 9

A, Equus cf. E. (Hemionus) calobatus: UMMP 46034, left hind phalange: anterior view

B, Equus cf. E. scotti: UMMP 44686, left P_4: medial and occlusal views

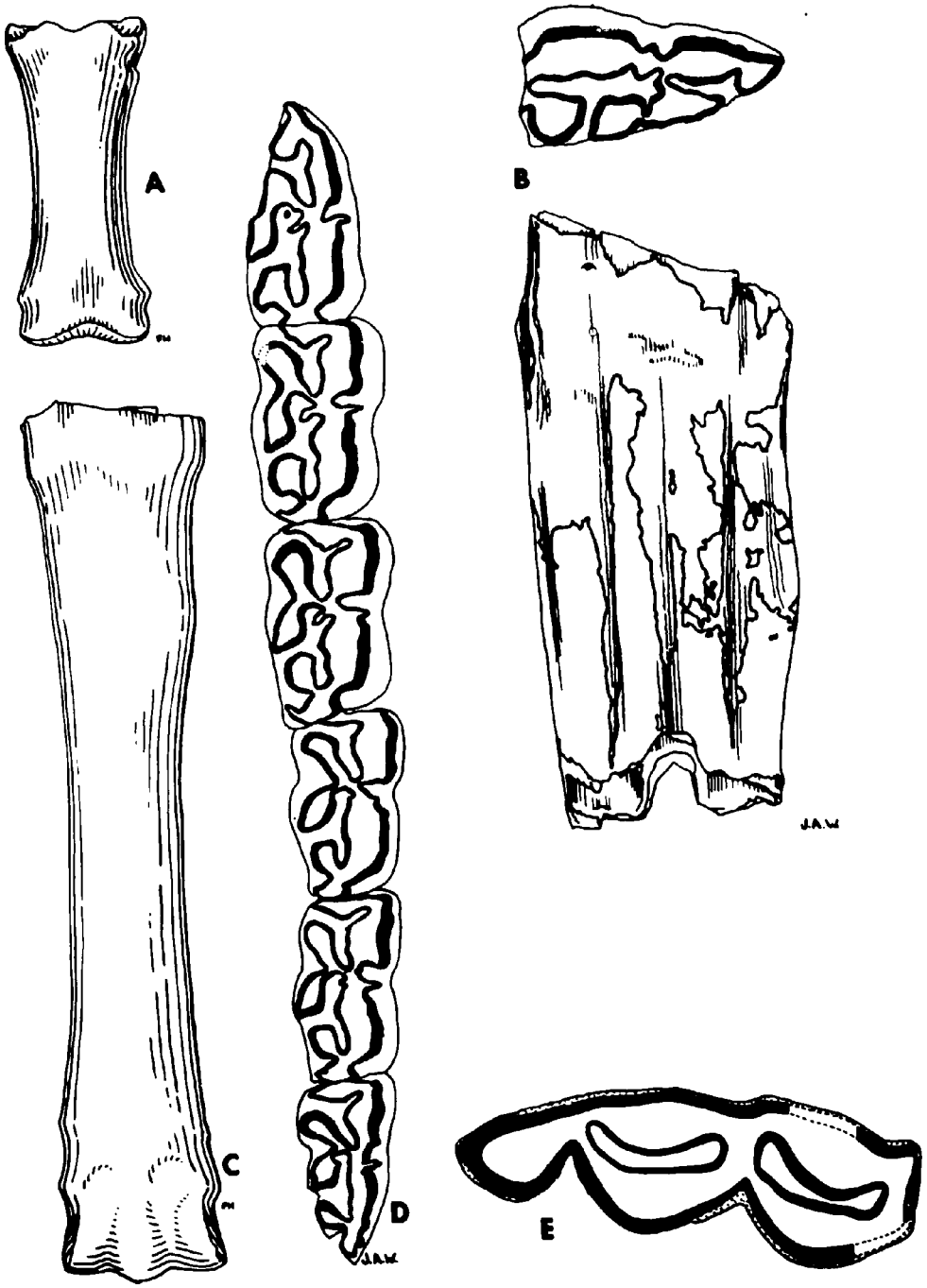
C, Equus sp.: UMMP 29029, right metacarpal: anterior view

D, Equus cf. E. (Hemionus): UMMP 46066, right lower P_2 - M_3: occlusal view

E, Camelops kansanus: UMMP 29985, right M_3: occlusal view

A, C-E, Cragin Quarry local fauna; B, Late Sangamon. A, C, x½; B, D, E, x1. Drawings by Florence Hodge (F. H.) and Janet A. Walerstein (J.A.W.).

Figure 9



no. 44691, two proximal phalanges; no. 46056, a right tarsal; UM-K2-62 locality: no. 29982, a proximal phalange; no. 42623, a right tarsal. Upper Sangamon gray beds: no. 32444, distal part of right tibia, right astragalus, and two tarsals in association; no. 46059, a right carpal; no. 35704, a proximal phalange.

Remarks. - The anteroposterior length of the M_3 (Fig. 9E) is 62.0 mm. and the greatest width is 21.0 mm. These measurements agree with those of a M_3 in a lower jaw from Cragin Quarry Locality 1 which Hibbard (1939, p. 468) identified as of this species. The length of the left calcaneum, no. 29024, is 141.0 mm. and that of the right calcaneum, no. 44688, is 156.0 mm. The phalanges vary from 101.0 mm. to 122.0 mm. in length while the greatest proximal width varies from 35.5 mm. to 39.5 mm. The length of the astragalus, no. 32444, is 87.0 mm. and the width is 61.0 mm.

Camelops sp.

Occurrence. - Cragin Quarry local fauna (UM-K3-62).

Material. - UM-K3-62 locality: no. 46041, a right carpal; no. 46065, a left astragalus.

Remarks. - These elements belong to a species somewhat smaller than *C. kansanus* Leidy. The astragalus measures 61.0 mm. in total length and 42.0 mm. in width.

Tanupolama macrocephala (Cope)
(Plate 3 and Fig. 8C)

Geologic Range. - Middle Pleistocene to Wisconsin.

Distribution. - Fossil records are from the Great Plains region and California.

Habitat. - Open shrub and grassland country.

Occurrence. - Cragin Quarry local fauna (KU Locality 7).

Material. - KU Locality 7: no. 46086, a left maxillary with P^4 - M^3; surface find: no. 46095, a proximal phalange.

Remarks. - The maxillary (Pl. 3) is like that of an adult specimen of Tanupolama stevensi (Merriam and Stock) from McKittrick, California (Stock, 1928). Hibbard and Dalquest (1962, p. 88) synonymized this species with Tanupolama macrocephalus (Cope) from Texas and T. americanus (Wortman) from Hay Springs, Nebraska.

The occlusal length of P^4 - M^3 is 86.5 mm. Though P^3 is missing, the alveolus shows that it was two-rooted. The alveolar length of P^3 - M^3 is 96.0 mm. and the occlusal length of the molar series is 74.0 mm. The posterior lobes of the molars have well-developed anteroexternal styles or folds.

The maxillary is broken above the infraorbital foramen and across the lachrymal vacuity below the position of the lachrymal foramen. A portion of the jugal is present forming the floor of the orbit which is placed directly above M^3. The infraorbital foramen is placed just above P^4.

The posterior palatine foramen is opposite the front end of P^3. The palatine border of the posterior nares forms a V-shaped notch which terminates anteriorly at a point opposite the middle of M^2.

Since the proximal phalange (Fig. 8C) was recovered in the bed of Butler Spring Arroyo downstream from the coalescence of all tributaries draining the basin, it is impossible to assign it with certainty to any horizon or bed. It is probably of Sangamon age and I refer it to the same species as that of the maxillary. The length of the phalange is 95.5 mm. and the greatest proximal width is 25.0 mm.

The fragmentary material from Cragin Quarry Locality 1 (Hibbard and Taylor, 1960, p. 184) may also be referrable to this species.

Family Cervidae

Odocoileus sp.
(Fig. 7A)

Occurrence. - Cragin Quarry local fauna (UM-K2-62).

Material. - UM-K2-62 locality: no. 47805, a right M_3.

Remarks. - The tooth (Fig. 7A) is like that of one of the smaller races of O. virginianus. It compares favorably in size with that of O. v. couesi from Arizona and O. v. thomasi from Guatemala (greatest length, 19.5 mm.; greatest width, 9.5 mm.). An external style is present between the first and second columns and another between the second and third. Since the tooth is broken at the base of the crown, the roots are absent.

Because of inadequate knowledge of Pleistocene fossil material and the wide range in variation in the Recent species, it is impossible to assign this tooth to a species.

Family Antilocapridae

Capromeryx furcifer Matthew
(Figs. 8A, B)

Geologic Range. - Late Pleistocene.

Distribution. - Fossil records are from Nebraska, Kansas, and Texas.

Habitat. - Open grassy uplands.

Occurrence. - Cragin Quarry local fauna (UM-K3-62); upper Sangamon gray beds.

Material. - UM-K3-62 locality: no. 46049, left jaw with P_4 - M_3; upper Sangamon gray beds: no. 46050, a left horn core.

Remarks. - The left jaw (Fig. 8B) contains P_4 - M_3 and the alveoli of P_2 and P_3. It is broken anterior to and beneath the alveolus of P_2 and also posterior to and beneath M_3. P_4 has two lingual inflections separated by a shallow indentation. Parts of the crown of M_3 as well as the entire posterior part of the jaw are missing; the depth of the jaw beneath M_3 is indeterminate. The occlusal length of P_4 - M_3 is approximately 38.0 mm. The teeth are those of an adult individual.

The left horn core (Fig. 8A) is small and well preserved except for the tip of the posterior prong. The two prongs arise from a common laterally constricted base (greatest width is 24.0 mm.). The anterior prong is triangular in cross section with the posterior face deeply concave and is approximately 24.0 mm. long; the greatest width of the base is approximately 6.0 mm. The posterior prong is approximately 70.0 mm. long and bears a deep

groove along the posterior face which runs ventrally to terminate at the margin of a broad deep sulcus at the base of the horn core. The greatest width of this prong is 16.0 mm. and its transverse width, 15.0 mm. The posterior prong is somewhat longer and more slender than that of C. minor Taylor and the forward inclination is not as pronounced as in C. mexicana Furlong.

The horn core and lower dentition compare with those of C. minimus Meade (1942) from the Slaton local fauna of Texas. Hibbard and Taylor (1960, pp. 186-189) described several lower jaws, a horn core and other skeletal elements from Cragin Quarry Locality 1 which also compare with Meade's C. minimus specimens. Hibbard assigned the Cragin Quarry specimens to C. furcifer Matthew and stated that the differences between the holotype of C. furcifer and Meade's specimens of C. minimus do not appear to be as great as the individual variation noted by Skinner (1942) in Recent specimens of Antilocapra americana (Ord).

Antilocaprid indeterminate

A right calcaneum, no. 46099, and a left fibula, no. 46046, were recovered from the upper Sangamon red silts above the caliche. The length of the calcaneum is 79.0 mm. This is greater than that of either Capromeryx or Antilocapra but falls within the range of 136 specimens of left calcanea of Stockoceros conklingi (Stock) reported by Furlong (1943, p. 7) from San Josecito Cave, Mexico. The fibula is the size of that of Antilocapra americana. Better material is needed to determine generic relationships of these specimens.

Order Perissodactyla

Family Equidae

Equus cf. *E.* (*Hemionus*) *calobatus* Troxell (Fig. 9A)

Occurrence. - Cragin Quarry local fauna (KU Locality 7).

Material. - KU Locality 7: no. 46034, a first phalange; no. 46037, a first phalange; no. 47752, a second phalange.

Remarks. - The first phalange, no. 46034, appears to be from the left hind foot (Fig. 9A). Its length is 88.0 mm. The width of the proximal end is 39.5 mm.; the least width of the shaft is 25.0 mm. and the width of the distal end is 34.0 mm.

In the collection of the University of Michigan is a nearly complete left hind limb of *E. calobatus* which includes the tarsals, metatarsal, and the first and second phalange; the third phalange is missing. This specimen, no. 29071, was taken from the Arkalon gravel pit in Seward County, Kansas, and is considered to be latest Kansan in age (Hibbard, 1953). The length of the first phalange is 87.0 mm. The width of the proximal end is 41.5 mm.; the least width of the shaft is 24.0 mm. and the width of the distal end is 33.0 mm. This phalange is identical to the one here reported from KU Locality 7.

Another first phalange from KU Locality 7, no. 46037, is somewhat smaller, but probably represents a smaller individual of the same species. Though badly weathered it appears to be from a right limb. A second phalange, no. 47752, fits the figured first phalange, no. 46034, but is smaller than the

corresponding bone of the Arkalon specimen. Its length is 40.0 mm.; proximal width, 36.5 mm.; and distal width, 30.0 mm.

The distal end of a narrow metapodial, no. 46096, from the same horizon but taken one-half mile east of KU Locality 7, fits the figured first phalange and may belong to a stilt-legged horse, but its original length is unknown.

It is possible that E. calobatus is a synonym of E. semiplicatus Cope since the type of the former is a metatarsal and the type of the latter is a second upper molar from the same area; Antonius (1919, p. 280, fide Hay, 1930, p. 703), Abel (1926, p. 433, fide Hay, 1930, p. 703), and Quinn (1957, p. 12) have considered this to be the case. The use of E. calobatus is retained here, however, since the materials reported are limb bones without any associated teeth.

Equus cf. E. scotti Gidley
(Fig. 9B)

Occurrence. - Cragin Quarry local fauna; upper Sangamon beds.

Material. - Cragin Quarry local fauna: KU Locality 7: KU no. 6839, associated left radius, ulna, carpals, and metacarpal and no. 46035, a left tarsal; UM-K4-59 locality: no. 29030, a right astragalus; no. 44687, a cervical vertebra; no. 44690, a first phalange; UM-K3-62 locality: no. 29980, a left P^{4} and M^{1}; no. 46064, a right calcaneum and two second phalanges; no. 46090, a right calcaneum; no. 46091, a left astragalus; other localities: nos. 46057 and 46058, two second phalanges. Upper Sangamon beds:

no. 44686, a left P_2; no. 46060, a left tarsal; no. 46094, a lower right molar.

Remarks. - Most of the equine specimens recovered from the Cragin Quarry local fauna represent a large horse. Material of this size from Cragin Quarry Locality 1 (KU Locality 6) and the Horse Quarry (KU Locality 8) was originally assigned by Hibbard (1939, p. 467) to E. niobrarensis Hay. It now appears that E. niobrarensis is similar in dental characteristics to E. scotti which was found associated with E. calobatus in late Kansan deposits at the Arkalon gravel pit, Seward County, Kansas (Hibbard, 1953). It differs only slightly in size and may therefore represent a later and slightly smaller variant of E. scotti at the subspecies level (Hibbard, personal communication). I have therefore followed Hibbard and Taylor (1960, p. 193) in the use of E. scotti for the large horse remains found at both Cragin Quarry Locality 1 and the equivalent beds on the XI Ranch since this name has priority over E. niobrarensis.

The left P^4 and M^1, no. 29980, are similar to those from the Horse Quarry (KU Locality 8). The left P_2, no. 44686, (Fig. 9B) has a length of 37.0 mm., a width of 17.0 mm., and the metaconid-metastylid length is 19.5 mm.

The left metacarpal, KU 6839, has a length of 242.0 mm. The width of the distal end is 49.0 mm., the least width across the shaft is 36.0 mm., and the width of the distal end is 46.0 mm.

Equus cf. *E.* (*Hemionus*)
(Fig. 9D)

Occurrence. - Cragin Quarry local fauna.

Material. - Qpk_2l bed: no. 46092, left P_2 - M_3; UM-K3-62 locality: no. 46066, right P_2 - M_3; KU Locality 7: no. 29986, three left lower molars or premolars.

Remarks. - A portion of the right jaw, no. 46066, of a young adult horse containing P_2 - M_3 was taken from the red silts of the UM-K3-62 locality (Fig. 9D). The teeth are those of a medium-sized horse which is smaller than *E. scotti* but larger than *E. conversidens* Owen from Cragin Quarry Locality 1. The teeth are extremely hypsodont and show little wear. A pli caballinid fold is present on the last two premolars and the molars while the external median valley is shallow and does not reach the flexids except on M_1. A broad V-shaped groove is present between the metaconid and the metastylid of P_4 and the three molars. The enamel ridges forming the base of the metaconid are nearly parallel and the metaconid terminates in a rounded loop; the metastylid is truncated posteriorly. Measurements of the teeth in mm. are given below. All occlusal measurements are exclusive of the cement.

The extreme hypsodonty and other dental characters suggest affinities with *Hemionus* rather than with *Asinus* and these teeth may belong to the same species of stilt-legged horse to which the slender phalanges described above were assigned. The teeth are smaller than those referred to this species by Quinn (1957, p. 12).

Tooth	(approximate) Crown Length	Occlusal Length	Width	M-M*
P_2	65.0	31.0	13.0	14.5
P_3	80.0	27.0	13.0	15.5
P_4	87.0	28.0	14.0	15.0
M_1	83.0	25.0	13.0	14.5
M_2	80.0	26.0	12.0	13.0
M_3	78.0	25.0	10.0	11.0

*Metaconid-metastylid length

Three lower left teeth, no. 29986, of approximately the same size taken from KU Locality 7 are more worn than those just described but appear to represent an older individual of the same species.

Following the publication of the Cragin Quarry local fauna by Hibbard and Taylor (1960), several lower teeth of a medium-sized horse including 5 teeth from a left jaw, no. 42223, were recovered from Cragin Quarry Locality 1. These lower teeth are nearly identical in size to the lower teeth, no. 46066, from UM-K3-62. They are in the size range of the upper teeth nos. 38778-38779, reported from Cragin Quarry Locality 1 by Hibbard and Taylor (1960, p. 195).

Equus sp.
(Fig. 9C)

Occurrence. - Cragin Quarry local fauna.

Material. - UM-K4-59 locality: no. 29029, a right metacarpal with associated splint bones and carpals; no. 44685, a first

phalange; UM-K3-62 locality: no. 31391, a first and second phalange; KU Locality 7: no. 46038, a second phalange; KU no. 6493, a third phalange.

Remarks. - The right metacarpal, no. 29029, is narrower (Fig. 9C) than the left metacarpal, KU 6839, which was assigned above to E. cf. E. scotti. The length is 236.0 mm., the width of the proximal end is 49.0 mm., the least width across the shaft is 32.0 mm., and the width of the distal end is 43.0 mm. The phalange, no. 44685, from the same locality is somewhat narrow and fits the right metacarpal.

The phalanges, no. 31391 and no. 46038, belong to a medium-sized horse but were not found associated with any teeth. University of Kansas no. 6493 is a small third phalange taken at Locality 7 in the area of the first phalange, no. 46034, assigned to E. cf. E. calobatus. There is a shallow excavation on the ventral surface where the tendo perforans attaches but the dome-shaped enlargement of bone characteristic of some Hemionus is absent. Measurements of this phalange are: greatest proximal width, 50.0 mm.; greatest width of articular surface, 35.0 mm.; greatest dorsal-ventral height, 32.0 mm.; medium length, 46.0 mm.

Interpretation of Faunas

Age and Correlation. - The Adams and Butler Spring local faunas are considered to have lived during part of maximum Illinoian and late Illinoian time, respectively (Schultz, 1965).

The fauna from localities UM-K3-59, UM-K4-59, UM-K2-62, UM-K3-62, and KU Locality 7 occurs in beds which lie stratigraphically above the Butler Spring local fauna and below a massive caliche layer similar to the caliche which overlies the Cragin Quarry local fauna on the Big Springs Ranch, Meade County, Kansas. This fauna, moreover, is similar in composition to the Cragin Quarry local fauna as evidenced by the presence in both of such species as Capromeryx furcifer, Canis (Aenocyon) dirus, Vulpes velox, Panthera atrox, Platygonus cf. P. compressus, Peromyscus progressus and others (see Table 1). Remains of the large land tortoises, Gopherus and Geochelone, from locality UM-K3-59 indicate a warm, interglacial climate for the time in which this fauna lived. Although there is no floral (pollen) evidence from these beds, it seems justified, on the basis of the stratigraphic and faunal evidence, to assign this new fauna from the Butler Spring area to the Sangamon interglacial and to include it within the term Cragin Quarry local fauna.

The Robert local fauna, on the other hand, is a cool fauna as evidenced by the presence of more northerly species such as Sorex cinereus, Sorex palustris, Blarina b. brevicauda, Citellus cf. C. richardsoni, Thomomys cf. T. talpoides, Microtus pennsylvanicus, and Zapus cf. Z. hudsonius, which do not range as far

south as Meade County, Kansas, at the present time. It occurs stratigraphically above the caliche that overlies the Cragin Quarry local fauna, and appears to represent a late phase of the Wisconsin glacial. Of special interest is the first appearance of the ostracod Eucypris meadensis Gutentag and Benson which lives today in an artesian spring-fed stream in Meade County State Park (Gutentag and Benson, 1962, p. 25). This would indicate a link between the late Wisconsin and the present. The Robert local fauna can not at present be correlated with any other known faunas of the region. A radio-carbon date of 11,100 ± 390 years B.P. was recently obtained by dating shells of Succinea ovalis Say from this bed. A comparison with the Jones Ranch local fauna, the only other Wisconsin age fauna from Meade County, Kansas, is shown in Table 1. A radio-carbon date of > 30,000 years B.P. was obtained for the Jones Ranch local fauna (Crane and Griffin, 1961, Sample M-1103).

Environment. - Inferences about the environment in which the Cragin Quarry and Robert local faunas lived can be made from a study of the present-day habitats of the species represented as fossils or of their closest living relatives. The local habitat at Cragin Quarry Locality 1 on the Big Springs Ranch has been discussed by Hibbard and Taylor (1960, p. 33). The local habitats of equivalent age faunal sites on the XI Ranch can be determined partly on the basis of vertebrate remains. The mollusks from these sites have not been studied and no floral (pollen) evidence is available.

Localities KU 7, UM-K3-59, UM-K2-62, and UM-K3-62 are all situated in the reddish buff silts below the caliche near the west edge of the Butler Spring Basin. Nearly all of the mammals recovered from these sites are characteristic of upland habitats. The presence of Canis (Aenocyon) dirus, Vulpes velox, Panthera atrox, Platygonus, Camelops, Tanupolama, Capromeryx furcifer, Equus, Mammuthus, Lepus, and Cynomys ludovicianus suggest that the local habitat was a grassy upland with occasional trees and shrubs. Mammals of lowland or marshy habitats are rare or absent from the fauna. Two teeth of the beaver, Castor canadensis, taken from locality UM-K2-62 indicate the presence of perennial waters. No remains of muskrats, water rats, cotton rats, or rice rats were recovered, however.

At UM-K3-59, the presence of a few frog and salamander remains suggests the presence nearby of a small spring or stream. The abundance of Peromyscus progressus and Reithrodontomys megalotis suggests that the habitat at this locality was primarily a moist one with tall grass and weeds. Perognathus hispidus can live in both tall and short grass. The single specimen of Microtus pennsylvanicus can be explained by the survival from late Illinoian time of a small population in a locally favorable moist habitat. No ostracodes were recovered at this locality.

At the UM-K4-59 locality near the top of the lake beds below the caliche both aquatic and land mollusks as well as ostracodes are present. The vertebrates are few and fragmentary and consist

primarily of isolated teeth of several upland prairie forms (Cynomys ludovicianus, Citellus tridecemlineatus, and Microtus (Pedomys) ochrogaster) which have been washed into the lake by stream action or slope wash.

The Robert local fauna is confined to locality UM-K1-57 near Butler Spring. The presence of Sorex cinereus, Sorex palustris, Blarina brevicauda, Synaptomys cooperi, Thomomys cf. T. talpoides, Zapus cf. Z. hudsonius and numerous remains of the meadow vole, Microtus pennsylvanicus, indicate a marshy habitat surrounded by a moist, low meadow with a good grass cover. Nearby wooded or brushy areas are inferred from the occurrence of Peromyscus cf. P. leucopus as well as by Sorex palustris and Blarina brevicauda.

A dry upland prairie grassland not far from the immediate environment of deposition is indicated by Peromyscus cf. P. maniculatus, Citellus tridecemlineatus and fragmentary isolated teeth of Citellus cf. C. richardsoni, Cynomys ludovicianus and Sylvilagus. Microtus (Pedomys) ochrogaster probably inhabited the drier grassy slopes as well as the nearby upland surface.

Climate and Present Distribution. - Conclusions about the climate in which the Cragin Quarry local fauna lived are derived partly from the physical features of the deposits and partly from the fossils themselves. The presence of caliche above the faunal sites at Cragin Quarry Locality 1 and the Butler Spring area indicates that a semiarid period with good drainage existed after deposition of the sediments containing the fauna. During Cragin Quarry time, a trend toward this drier climate was probably noticeable.

All of the extant species of vertebrates from the Butler Spring localities may be found living in Meade County today. Remains of more southern or southwestern forms such as the lizards and the desert shrew, Notiosorex crawfordi, which have been found at Cragin Quarry Locality 1 on the Big Springs Ranch have not yet been reported from any of the localities in the Butler Spring area. The absence of conspicuously northern forms (except Microtus pennsylvanicus) and the presence of the land tortoises Gopherus and Geochelone suggest a rather mild climate (Hibbard, 1960, p. 22).

Conclusions about the climate in which the Robert local fauna lived are derived largely from the present distribution of living species represented in the fauna. Seven of the extant species do not live in Meade County, Kansas, today. Four of these species, Sorex cinereus, Sorex palustris, Citellus cf. C. richardsoni, and Thomomys cf. T. talpoides, are conspicuously northern forms which do not range into Kansas today. Two species, Zapus cf. Z. hudsonius and Microtus pennsylvanicus, are northern forms which are present in eastern and northern Kansas respectively while the seventh species, Blarina brevicauda, is an eastern form extending as far west as eastern Kansas (see Burt and Grossenheider, 1964, maps). In addition, while Synaptomys cooperi may be found living in Meade County today, the fossil material from this fauna represents the northern subspecies S. c. cooperi rather than the local subspecies S. c. paludis, which appears

to have lived farther south during the Wisconsin (Patton, 1963, p. 28).

The climate in Meade County at the time the Robert local fauna lived may be compared with the climate of the area in which nearly all of the extant forms are living today. Although there is no area where all of the species now occur sympatrically, eleven of them are found in a small area in the extreme northeastern corner of South Dakota and an adjacent portion of Minnesota (Fig. 10). The limits of this area are determined by the southwestern border of the range of Sorex palustris, the western border of the range of Synaptomys cooperi and the eastern border of the range of Citellus cf. C. richardsoni. The eastern limit of Thomomys cf. T. talpoides appears to be just outside this area by a few miles while Cynomys ludovicianus is absent altogether, its eastern limit having been restricted by cultivation.

The mean annual temperature in northeastern South Dakota is 42° F. while in southwestern Kansas it is 55° F. (Visher, 1954, map 3). In South Dakota the average difference between January and July mean temperatures is about 62° F. whereas it is about 45° F. in Kansas for the same period (Visher, 1954, map 328). The precipitation in both areas (Visher, 1954, map 492) is about 22 inches per year with 75-80% occurring in the period of April through September. Because of the lower temperatures in South Dakota, however, there is less evaporation there than in southwestern Kansas.

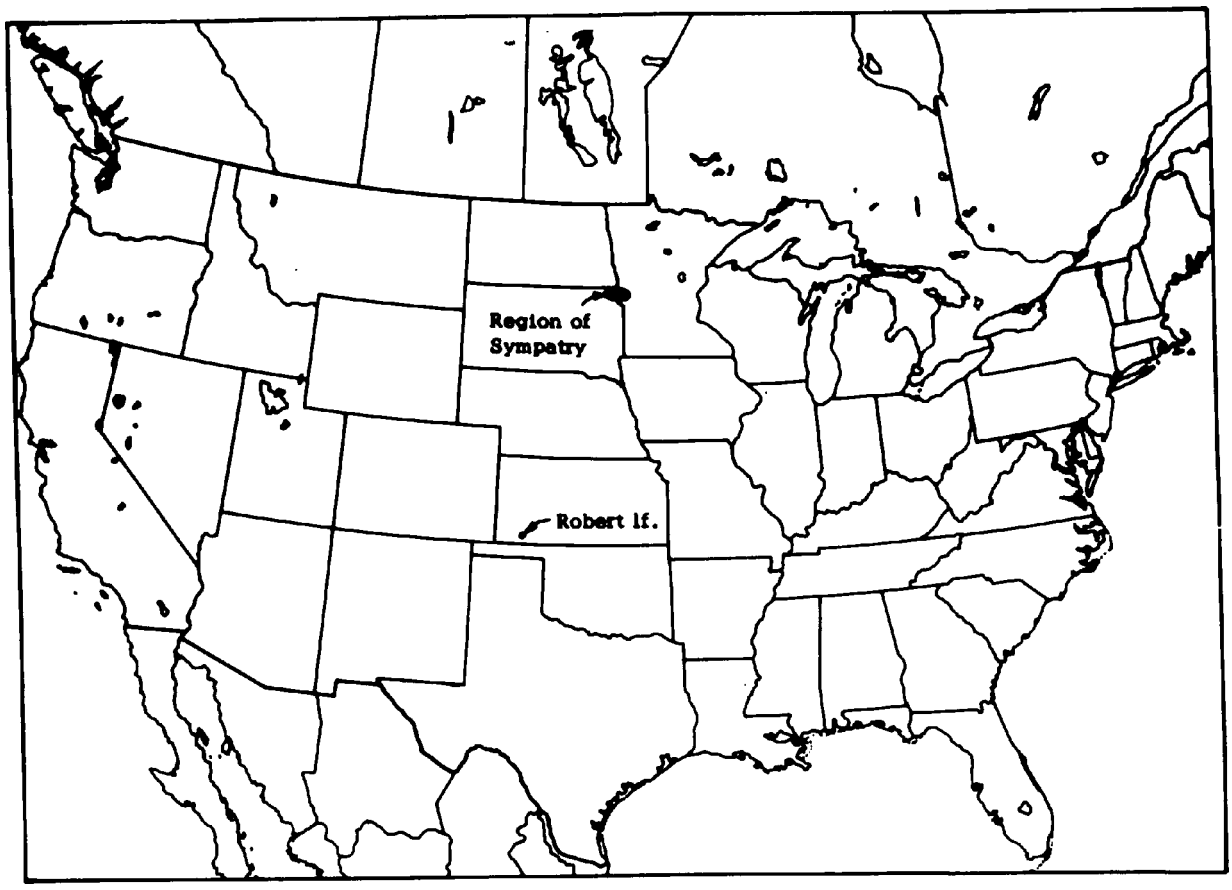


Fig. 10. Map showing present region of sympatry (shaded zone) of eleven extant mammalian species represented in the Robert local fauna (late Wisconsin).

The Robert local fauna lived in Meade County, Kansas, during the late Wisconsin glacial time in a climate which appears to have had a summer climate similar to that of extreme northeastern South Dakota today. The fauna lived in and around a marsh surrounded by a moist lowland meadow. A grassy upland prairie occurred in the neighborhood. The average annual temperature was probably about 42° F. Precipitation averaged about 25 inches per year with at least 75% falling during the summer and with less evaporation in the area than there is today.



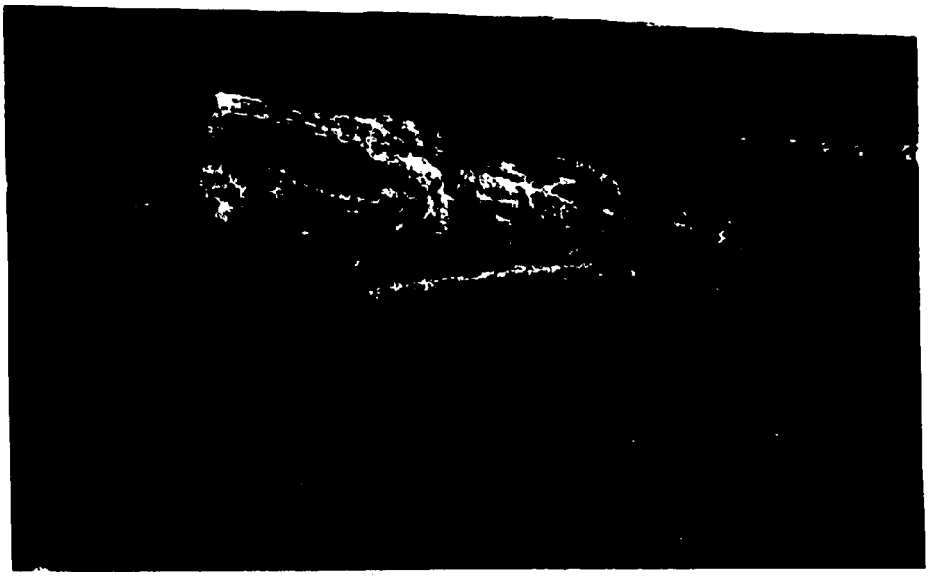


Plate 2. **Butler Spring Area, Meade County, Kansas.** (Top: view south toward Cimarron River; beds dip east. Bottom: KU Locality 7; beds dip southeast.)



Plate 3. Left maxillary of Tanupolama macrocephala (Cope). UMMP 46086, P^{4} - M^{3}: lateral and occlusal views. Cragin Quarry local fauna, KU Locality 7. Note scale.

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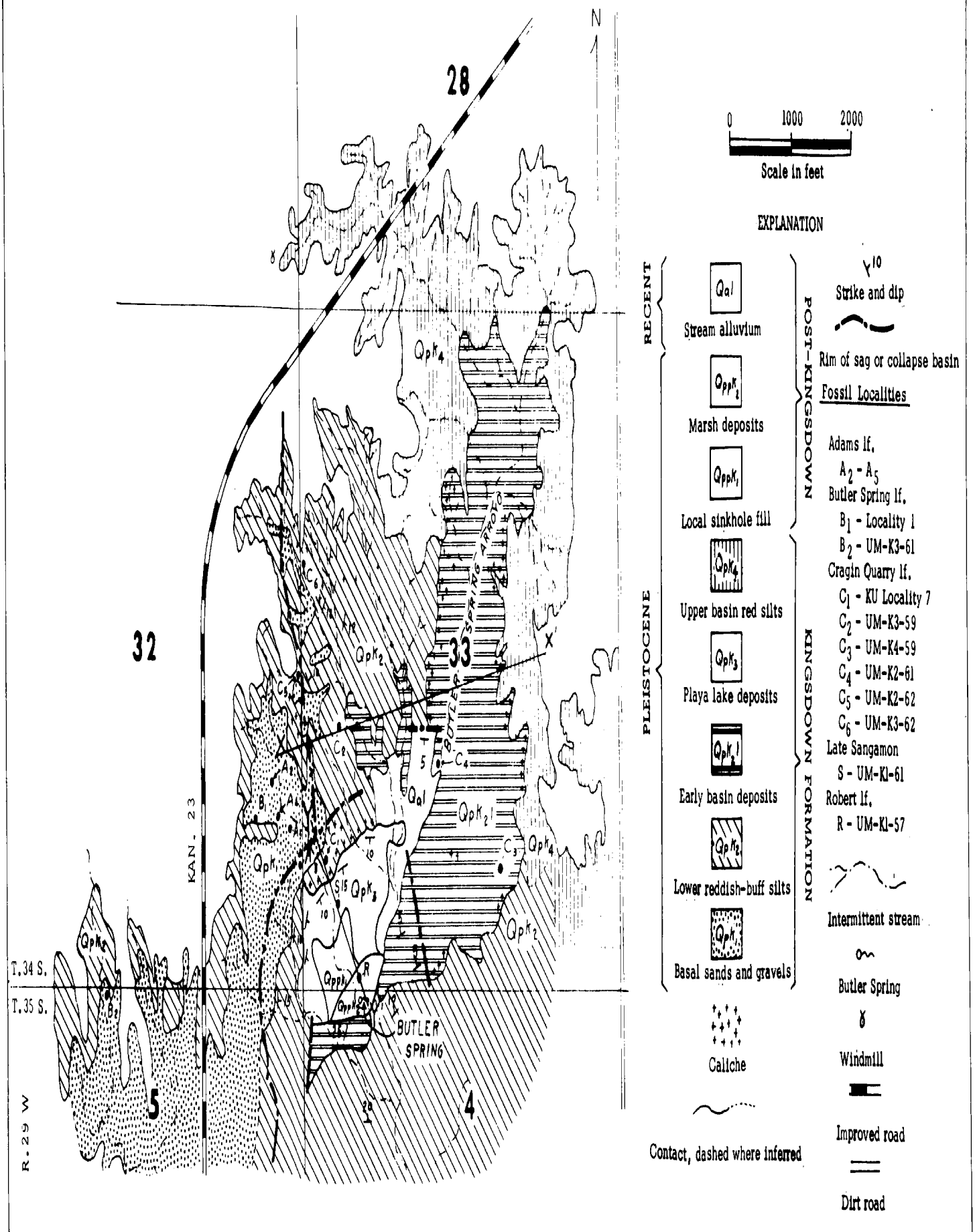
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N
28
32
33
5
4
KAN. 23
R. 29 W
T. 34 S.
T. 35 S.
BUTLER SPRING
0 1000 2000
Scale in feet
EXPLANATION
RECENT
PLEISTOCENE
POST-KINGSDOWN
KINGSDOWN FORMATION
Qal Stream alluvium
QppK4 Marsh deposits
QppK1 Local sinkhole fill
QpK4 Upper basin red silts
QpK3 Playa lake deposits
QpK2 1 Early basin deposits
QpK2 Lower reddish-buff silts
QpK1 Basal sands and gravels
Caliche
Contact, dashed where inferred
Strike and dip
Rim of sag or collapse basin
Fossil Localities
Adams lf.
A2 - A5
Butler Spring lf.
B1 - Locality 1
B2 - UM-K3-61
Cragin Quarry lf.
C1 - KU Locality 7
C2 - UM-K3-59
C3 - UM-K4-59
C4 - UM-K2-61
C5 - UM-K2-62
C6 - UM-K3-62
Late Sangamon
S - UM-K1-61
Robert lf.
R - UM-K1-57
Intermittent stream
Butler Spring
Windmill
Improved road
Dirt road

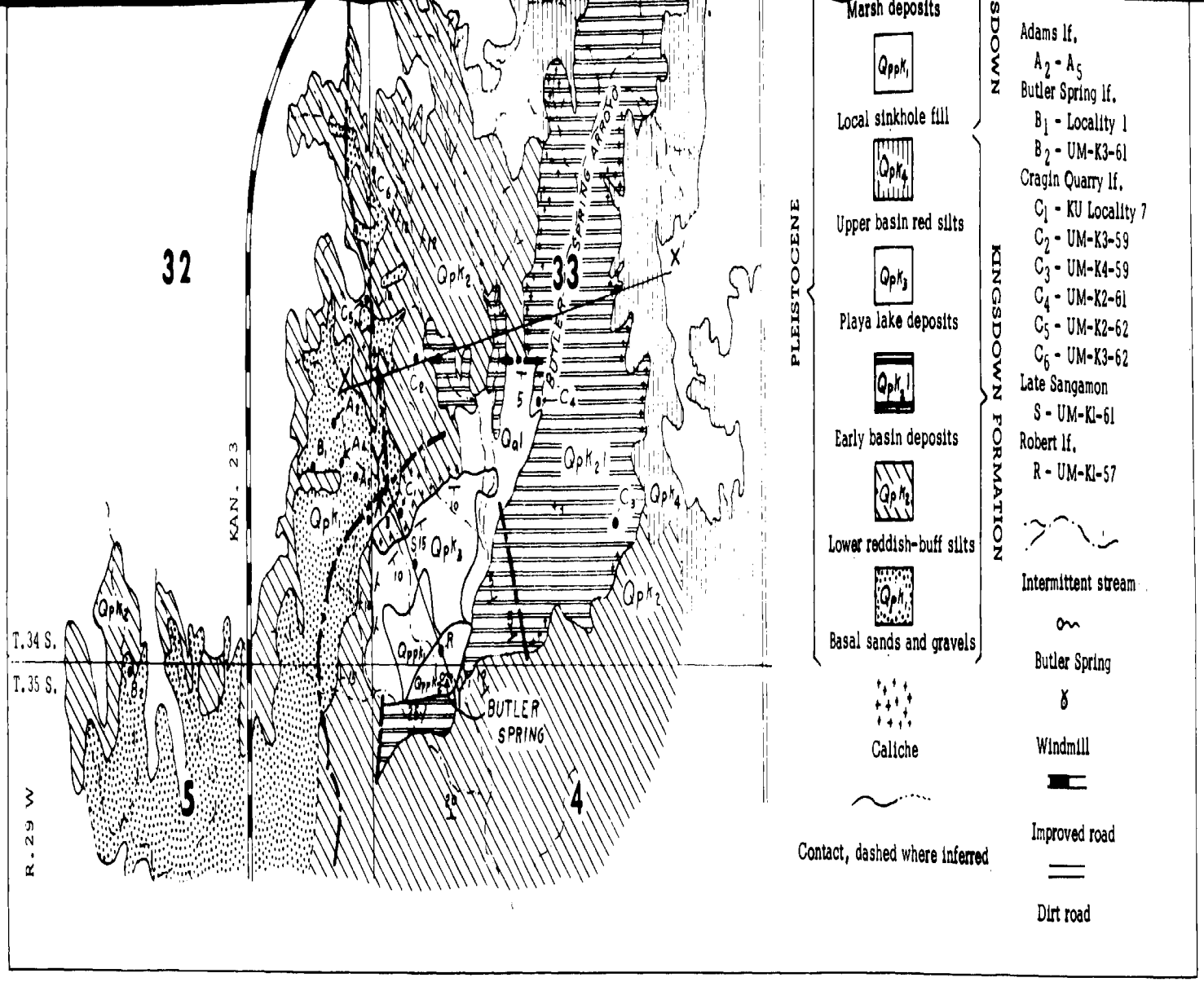


PLATE 1. GEOLOGIC MAP, BUTLER SPRING AREA, MEADE COUNTY, KANSAS

