

Sulphur River Formation and the Pleistocene Mammals of the Ben Franklin Local Fauna

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ABSTRACT

An extensive alluvial deposit in northeastern Texas is here described and named the Sulphur River Formation. Twenty-one mammals from these deposits are identified and grouped under the name Ben Franklin local fauna. Fossils and radiocarbon dates indicate that the age of the fauna is Late Wisconsin.

INTRODUCTION

In 1929 most of the snake-like meanders of the North Sulphur River of Delta County, Texas, were isolated by a series of cross-cutting channels, excavated to reclaim the surrounding bottoms from flood damage. This halving of the distance traversed by the river steepened the gradient of the stream. Subsequently the width of the channel has grown from 30 to 195 feet, and the depth from 10 to 30 feet. As a result, Pleistocene alluvium is exposed throughout the length of the new channel, from western Fannin County to the extreme eastern portion of Delta County and perhaps farther—a distance of over forty miles. Snail faunas sampled along the new exposures have proved to be essentially the same, and the lithological sequence is almost identical at all points. Such an extensive deposit, though representing a relatively short period of time, deserves the rank of formation. The name Sulphur River,² is here proposed. The type locality is at the Highway 38 bridge on the North Sulphur River immediately north of the town of Ben Franklin. Other artificial channels at the crossing of Highway 1531 over the Middle Sulphur River, and Highway 513 over the South Sulphur River expose similar deposits.

¹ Shuler Museum of Paleontology, Southern Methodist University. We should like to express our appreciation to Dr. Ernest L. Lundelius, University of Texas, for arranging comparisons of *Mylobyus* material. Drs. E. R. Hall and J. Knox Jones, University of Kansas, and Dr. Paul W. Parmalee, Illinois State Museum, loaned comparative material. Frank Schneider assisted in making the collections, and Kathleen Crow, Kathleen Gilmore, Norma Hoffrichter, and Lorrain McGraw helped in the sorting of concentrates. Mackey Coker prepared the photographic plates.

² The Sulphur River Alluvial Terrace, as described by Frye and Leonard (1963, Univ. of Texas, Bureau of Economic Geology, Rept. Invest. no. 49) was found in this investigation to consist of two, not three, units. The lowermost ranges in age from 12,000 to 9,000 years B.P., and the upper unit is younger than 2,000 B.P.

The name, Sulphur River Formation, is here restricted to the lower unit. Frye and Leonard assigned this unit partly to the Kansan and partly to the early Wisconsin, on the basis of the molluscan fauna.

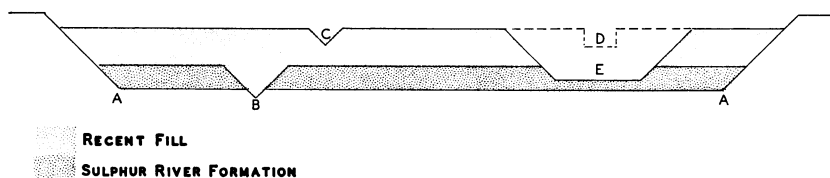


Figure 1.—Schematic section of the Sulphur River near Ben Franklin showing the sequence of cutting and filling. (A) Bedrock cut made prior to deposition of Sulphur River Formation. (B) Erosion of the Sulphur River Formation made between approximately 9,000 BP and 2,000 BP. (C) Natural river channel in 1929. (D) Artificial channel excavated in 1929. (E) Present channel showing the amount of downcutting since 1929.

Several tons of matrix, removed from five quarry sites within six hundred yards of the Highway 38 bridge, was washed for microvertebrate remains. A modified version of Hibbard's (1949) technique was used.

THE BEN FRANKLIN AREA

The area of the Ben Franklin local fauna lies at the western boundary of the post oak belt, which separates piny woodlands to the east from the Black Prairie to the west. Although there is some post oak on the divides, most of the timber is in the valleys. Lesser amounts of elm and blackjack also grow here. The mean annual temperature is 64 degrees and rainfall averages some 40 inches annually. Ben Franklin is at the eastern edge of the Texan biotic province (Blair, 1950). The living fauna is more like that found twenty to thirty miles to the west than that a similar distance to the east.

Although the North Sulphur River almost never floods, since the excessive downcutting of its channel, the natural floodplain is over half a mile wide.

Approximately seven miles upstream from Ben Franklin, the Taylor formation of Upper Cretaceous age is exposed in the bed as hillocks and ridges covered by the Sulphur River alluvium. At Ben Franklin the Cretaceous bedrock is buried and the river flows on the Pleistocene alluvium. Downstream one mile, channels filled with Recent sediment are entrenched in the Sulphur River Formation. These are easily recognized by differences in color and by the abundance of the snails, *Mesodon* and *Bulimulus*, which are not present in the Sulphur River formation. Artifacts, and bones of *Odocoileus virginianus* and *Bison bison* have been found in this younger alluvium.

At Ben Franklin, where the Sulphur River formation is least eroded, the section is as follows. Mottled blue-yellow clay four feet thick in the bed is overlain by three feet of gravel and sandier clay just above stream grade. This is in turn covered by mottled clay, grading darker toward the top until it is almost black at the contact with the overlying Recent sediments, ten feet above the river bed. The Recent material is also black, but the two fills are separated by a few inches of sediment sparsely charged with calcareous nodules, either caliche or freshwater marl.

Quarries.—Quarry No. 1 is on the south bank, 1,958 feet east of the center of the highway bridge, four feet below the contact with the Recent material. This site was the most productive of fish remains. The only mammals recovered here were *Castoroides*, *Sorex*, and *Ondatra*.

Quarry No. 2 is on the north bank, 242 feet east of the center of the bridge and two or three feet below the Pleistocene-Recent contact. This site was the most productive of mammal remains and molluscan species. Some fish and herpetological material was also recovered here.

Quarry No. 3 is on the south bank, 315 feet west of the center of the bridge, and four to five feet below the Pleistocene-Recent contact. This site produced fish, herpetological material, and numerous aquatic snails.

Quarry No. 4 is in the river bed, 813 feet west of the center of the bridge. The fossil material recovered here is about the same as that of Quarry No. 3. The mussel shells used in radiocarbon test no. SM 533 were collected here.

Quarry No. 5 is on both the north and south banks, 1885 feet west of the center of the bridge and just two feet above the bed. Here, a dark area 200 feet across indicates either a floodplain pond or bog. The color grades from black in the center to the yellow-blue typical of the formation at the edge. The dark color is attributed to organic material in the sediments. Samples taken from the darkest areas produced nothing but clams and aquatic snails. Coyote jaws were collected near the northern edge of the dark area, and the charcoal used in radiocarbon test no. SM 532 was recovered from a burned area approximately seven feet in diameter at the western edge of the "pond fill."

MAMMALS OF THE BEN FRANKLIN FAUNA

Check List

Order INSECTIVORA
Sorex cinereus Kerr
Blarina sp.

Order EDENTATA
Dasybus bellus (Simpson)

Order RODENTIA
Spermophilus franklini (Sabine)
Geomys sp.
Castoroides ohioensis Foster
Sigmodon hispidus (Say and Ord)
 ?*Reithrodontomys* sp.
Neotoma sp.
Ondatra zibethicus (Linnaeus)
Microtus pennsylvanicus (Ord)
Microtus ochrogaster (Wagner)
 or
M. pinetorum (Le Conte)
Synaptomys cf. *S. cooperi* Baird

Order CARNIVORA
Canis latrans Say

Order PROBOSCIDEA
Elephas cf. *E. columbi* Falconer
Mammut americanus (Kerr)

Order LAGOMORPHA
 leporid

Order ARTIODACTYLA
Mylobyus sp.
Odocoilus virginianus Zimmerman
 ?*Antilocapra americana* (Ord)
Bison sp.

Order PERISSODACTYLA
Equus sp.

Notes on Species

Sorex cinereus Kerr

Plate 1, fig. B

Referred specimens.—Right lower jaw containing m1-m3; SMUMP 60815. Right lower jaw containing m1; SMUMP 60617. Right lower jaw containing m2; SMUMP 60618. Left lower jaw containing m1-m2; SMUMP 60619.

Discussion.—The small Ben Franklin shrew material was compared with recent jaws of *S. cinereus* and was found to be identical in every detail. *S. cinereus* ranges today at somewhat higher latitudes and/or elevations and its habitat requirements are quite different from those currently available in Delta County. It is interesting to note how closely the southern range limit of this species, as well as that of *Microtus pennsylvanicus*, follows the line representing the 72° mean summer temperature (fig. 3).

Blarina sp.

Plate 1, fig. A

Referred specimen.—Right lower jaw containing p4, m1, m2, m3; SMUMP 60694.

Discussion.—The Delta county fossil compared with specimens of *Blarina brevicauda bulophaga*, *B. b. kirtlandi*, and *B. b. talpoides* was found to match the latter more closely than the others. The size of the fossil is greater than any of these and very nearly like that of the holotype of *B. fossilis* Hibbard. The diagnosis of *B. fossilis*, as given by Hibbard (1943, p. 240), cites this as the "largest of known forms of *Blarina*; m3 possesses a heavier developed cingulum." All three molars on the Texan jaw have better developed cingula than those of the subspecies of *B. brevicauda*. There is one slight difference between our specimen and Hibbard's type. Hibbard states (Op.

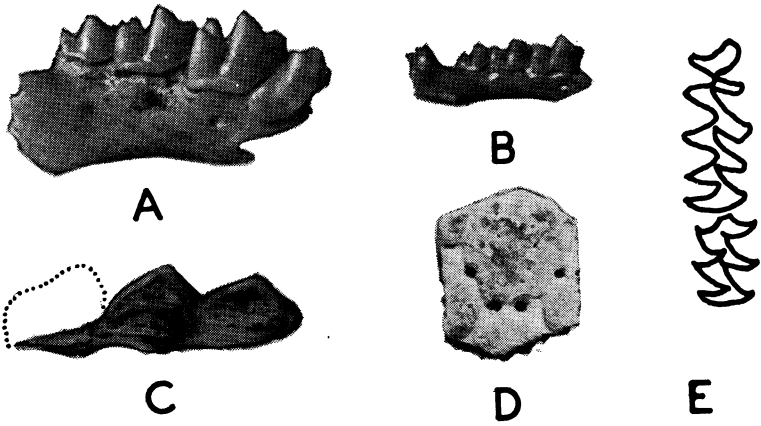


Plate 1

- Figure A — *Blarina* sp. Right lower jaw; SMUMP 60694. Approximately x5.
 B — *Sorex cinereus*. Right lower jaw; SMUMP 60815. Approximately x5.
 C — ?*Antilocapra americana*. Right m3; SMUMP 60728. Approximately x 1.5.
 D — *Dasyypus bellus*. Buckler scute; SMUMP 60689. x2.
 E — *Microtus pennsylvanicus*. Pattern of m1 and m2; SMUMP 60691. x7.

cit., p. 240) that the separation between the paraconid and the protoconid of m3 is "more pronounced." This feature is the same in the fossil as it is in our Recent specimens. The angle of the mandible below m3 is fairly strong, developed about the same as it is in *B. b. talpoides*, whereas the same angle is said to be less well developed in the fossil race *B. b. ozarkensis* Brown. Cope (1899) placed some significance on the lack of the V-form of p4 in *B. simplicidens*. Hibbard (1955, p. 332) states, "The oval outline of p4 in *B. simplicidens* is due chiefly to wear. The V-form of p4 is an unworn character of *Blarina brevicauda*." The V-form in the new fossil is well developed, and although the tooth is essentially unworn, one can follow the contour well down the crown. This sculpturing makes it evident that wear would not greatly affect the shape. While all of the teeth in this fossil are larger than those of our Recent material, p4 relatively is even larger. Three well developed external styles lend the tooth a decidedly more functional appearance.

As the Ben Franklin specimen is intermediate in character and size between *B. fossilis* and specimens of *B. brevicauda* that we have examined, a reference to species is not made. Perhaps when additional material of *Blarina* is recovered from this locality and the consistency of size and character is established, it will be possible to refer our material to one or the other species.

	<i>Blarina</i> sp. Ben Franklin local fauna cm	<i>B. fossilis</i> holotype cm	<i>B. brevicauda</i> <i>talpoides</i> cm
Antero-posterior diameter of p4	1.12		.75
Transverse diameter of p4	1.2		1.0
Antero-posterior diameter of m1	2.23		2.0
Transverse diameter of m1	1.5		1.3
Antero-posterior diameter of m2	1.8		1.8
Transverse diameter of m2	1.3		1.2
Antero-posterior diameter of m3	1.42	1.55	1.25
Transverse diameter of m3	1.0	.9	.8
Transverse diameter of m3 trigonid above cingulum	.9	.8	.6
Transverse diameter of m3 talonid above cingulum	.7	.6	.5
Antero-posterior diameter of p4-m3	6.8		5.9
Depth of mandible below m3	2.4	2.1	2.0

Dasybus bellus (Simpson)

Plate 1, fig. D

Referred specimens.—Two buckler scutes; SMUMP 60689.

Discussion.—Slaughter (1961a) suggested that *D. bellus* probably shared *D. novemcinctus*' inability to withstand long periods of low temperatures. The greater weight of *D. bellus* might allow that species to stand slightly colder temperatures, but the same greater weight would require greater quantities of insects for food, and as numbers of available insects diminish towards the north, any discrepancies in temperature-tolerance based on weight would probably be offset.

Although the mean annual temperature of Delta County was lower during "Sulphur River" deposition than at present, indications are that most of the difference was in the summer temperature.

Spermophilus franklini (Sabine)*Referred specimen.*—Right m1; SMUMP 60737.

Discussion.—Franklin's ground squirrel is the only species that matches the fossil exactly both in size and form. The West Coast species of similar large size were not examined and may not be separable. Considering the sympatry of *S. franklini* with the other faunal elements of the Ben Franklin local fauna today, however, reference is made to that species with some confidence. The current southern limit of the species is some four hundred miles to the north.

Geomys sp.*Referred specimens.*—Isolated teeth; SMUMP 60620.

Discussion.—This material is indistinguishable from teeth of the eastern pocket gopher (*G. bursarius*), which still lives in the area today.

Castoroides ohioensis Foster

Plate 2, fig. B; Text fig. 2

Referred specimens.—Left upper incisor, LP4, LM1, LM2, LM3, Lp4 and ?Lm1 of the same individual; SMUMP 60732.

Discussion.—The Ben Franklin *Castoroides* specimens are among the

largest reported. The first cheek tooth (P4) has the largest transverse diameter and each successive tooth is progressively smaller. Only minor differences were noted between the enamel patterns of these teeth and those of teeth from other localities.

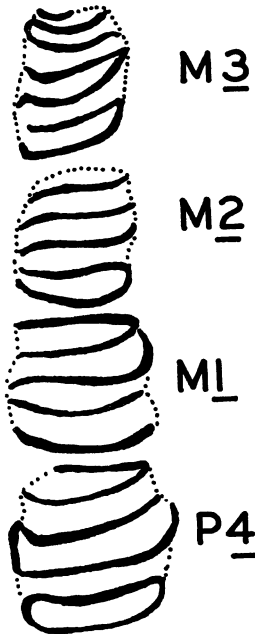


Figure 2.—Cheek tooth patterns of *Castoroides ohioensis*; SMUMP 60732. x1.

Martin (1913, p. 393), in proposing the species, *C. kansasensis*, placed some significance upon the width and spacing of flutes and ridges on the enamel of the incisor. Twenty-four flutes were counted on the enameled surface of his specimen, compared with eighteen on specimens of *C. ohioensis*. The flutes on the buccal side of the Ben Franklin incisor are narrow, closely spaced, and continue throughout the length of the tooth. The flutes on the anterior surface, on the other hand, are widely spaced and often merge with neighboring flutes. Twenty-four flutes were counted on one part of the tooth and but seventeen at another, lending further support to the current feeling that only *C. ohioensis* is valid.

Although the giant beaver is extinct, there is little doubt that it was a marsh dweller. As the vast majority of *Castoroides* are reported from the Great Lakes area, its occurrence this far south is almost certain evidence of cooler temperatures during deposition of the Sulphur River Formation.

Sigmodon hispidus (Say and Ord)

Referred specimen.—Isolated M2; SMUMP 60721.

Discussion.—The northern range limit of the cotton rat apparently coincides with that of *Dasyopus novemcinctus*. Therefore its presence in

the Ben Franklin fauna strengthens the supposition that the winters were not much cooler than those of the present time.

?Reithrodontomys sp.

Referred specimen.—Two toothless jaws; SMUMP 60722.

Discussion.—These specimens are of the size of *R. fulvescens*.

Neotoma sp.

Referred specimens.—Isolated teeth; SMUMP 60693.

Discussion.—Only M1 is helpful in identification beyond genus, and none of these teeth has been recovered.

Ondatra zibethicus (Linnaeus)

Referred specimens.—Fragmentary lower jaw containing the incisor and m1; SMUMP 60692.

Discussion.—No climatic inference may be drawn from the presence of this wide-ranging animal. Like many of the other faunal elements, it is indicative of swamp or marsh conditions.

Microtus pennsylvanicus (Ord)

Plate 1, fig. E

Referred specimens.—Right lower jaw containing m1 and m2; SMUMP 60691. Fifteen isolated m1's; SMUMP 60734.

Discussion.—The meadow vole is typically northern, ranging mostly north of the 72-degree mean summer isotherm.

The diagnostic m1 in this species contains a posterior loop, in front of which are five or six closed triangles and the anterior loop. It is interesting to note that of the numerous specimens reported by Dalquest (1962) from the Good Creek fauna (Sangamon), the large majority had but five closed triangles. Likewise, two thirds of those reported by Hibbard (1955) from the Jinglebob local fauna (Sangamon) displayed but five. All sixteen of the m1's in the Ben Franklin collection are of the six-triangle variety.

Microtus ochrogaster (Wagner)

or

M. pinetorum (Le Conte)

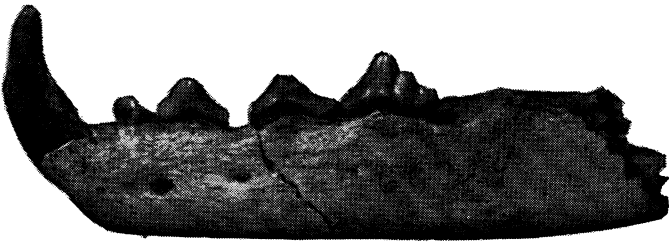
Referred specimens.—Seven isolated m1's; SMUMP 60733.

Discussion.—Both the pine vole and the prairie vole share the characters of the first lower molar, posterior loop, three closed triangles, two anterior triangles confluent with each other, and the anterior loop. Only seven such specimens were recovered at Ben Franklin. The smaller number of these teeth compared to m1's of *M. pennsylvanicus* is no doubt due to the micro-environment of the collecting localities. One would not expect many prairie voles in a swamp or marsh, such as suggested for the Sulphur River Formation. As both the pine vole and the prairie vole share ranges with the other Ben Franklin mammals today, it is possible that both are represented in the fossil fauna.

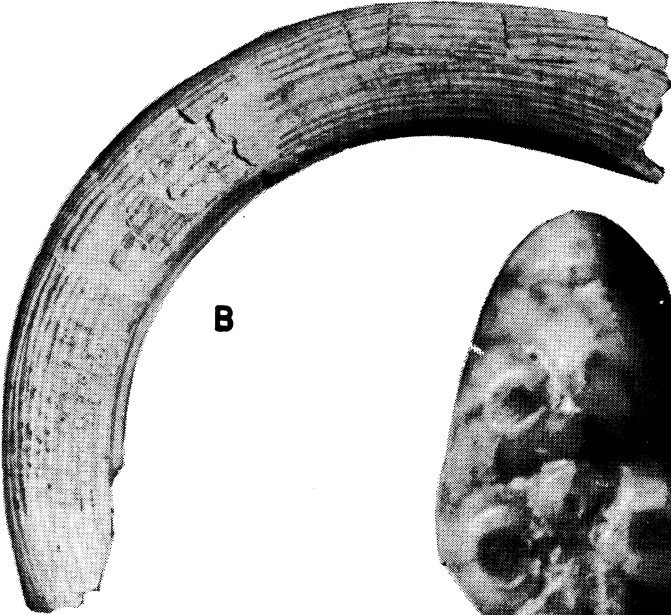
Synaptomys cf. *S. cooperi* Baird

Referred specimens.—Isolated teeth; SMUMP 60733.

Discussion.—As the larger size of *S. australis* seems to be the only feature distinguishing it from *S. cooperi*, there is no assurance that these specimens



A



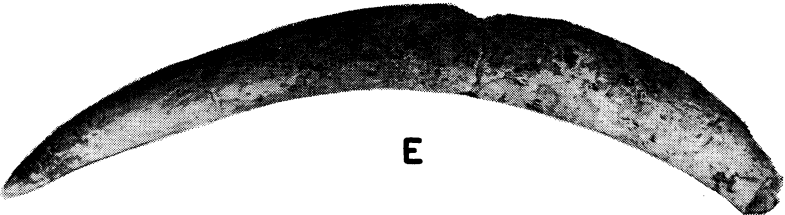
B



C



D



E

do not represent immature individuals of the extinct species. However, the presence of *S. australus* in the Clear Creek local fauna (Slaughter and Ritchie, this issue) suggests the preferences of the extinct form may not be the same as those of the living species. Therefore, this material is referred provisionally to *S. cooperi*, whose current range coincides with that of *M. pennsylvanicus*, *Sorex cinereus*, and other Ben Franklin faunal elements.

Canis latrans Say

Plate 2, fig. A

Referred specimens.—Left lower jaw fragment containing C, p1, p2, p3, and p4; right lower jaw fragment containing c, p1, p2, and p3; SMUMP 60724.

Discussion.—Slaughter (1961b) reported that all Texas Late Pleistocene coyote jaws examined appeared to represent a form distinct from the living subspecies and proposed the name *C. l. harriscrooki*. Perhaps the most distinctive feature is a well developed posterior accessory cusp on p2. Only three of almost a hundred modern specimens contained this cusp. These were not as well developed as in the fossils and all were from Mexico and Central America. In closing Slaughter said (*Op. cit.*, p. 509), "As the recognized subspecies have not been found in the Late Pleistocene deposits of Texas, it will prove important to watch for the oldest specimen referable to one of these races. Whether the living coyote proves to be a product of late or post-Sangamon evolution, or a replacement of an older form by a new immigrant, it could become a useful stage indicator. Coyote jaws from Late Wisconsin deposits are needed to settle the point". Although the Ben Franklin specimen does not settle the point, it is apparently the first Late Pleistocene coyote from Texas that is typical of the living subspecies. It is slightly smaller than the average *C. l. texanus*, but does not display the extra cusp on either p2 or p3. Whether the living forms are products of, or replacements for, *C. l. harriscrooki*, the change apparently took place between the Upper Shuler fauna (approximately 40,000 B.P.) and the deposition of the Sulphur River Formation (11,000 B.P.).

Elephas cf. E. columbi Falconer

Referred specimens.—Fragmentary enamel plates of cheek teeth; SMUMP 60725.

Discussion.—All plates recovered were separate, and therefore the number occurring in a hundred-millimeter line cannot be determined. However, the plates are quite thin and otherwise similar to complete specimens of *E. columbi* from other localities.

Mammut americanus (Kerr)

Referred specimens.—Cheek tooth fragments; SMUMP 60726.

Discussion.—Although these fragments can be duplicated in the teeth

Plate 2

Figure A — *Canis latrans*. Left lower jaw. SMUMP 60724. x1.

B — *Castoroides ohioensis*. Left superior incisor; SMUMP 60732. Approximately x 3/4.

C — *Mylohyus* sp. Occlusal view of Dp2; SMUMP 60690. x6.

D — Possible antler artifact; SMUMP 60736. Not to scale.

of other mastodons, these are referred to *M. americanus* in view of the age of the Sulphur River Formation.

It is interesting to note that mastodon tooth fragments by far outnumber those of elephants, whereas elephant teeth are generally in the majority in interglacial deposits of this region.

Leporid

Referred specimens.—Isolated teeth; SMUMP 60727.

Discussion.—Reference to genus is not suggested but the material is the size of *Sylvalagus floridanus*, which lives in the area today.

Mylohyus sp.

Plate 2, fig. C

Referred specimen.—Deciduous p2; SMUMP 60690.

Discussion.—The Ben Franklin specimen contains seven cusps, four posterior and three anterior. The two best developed posterior cusps, the metaconid and the hypoconid are separated by the metaconulid and the hypoconulid. Anteriorly, the protoconid and the paraconid are equally well developed, and there is a distinct cingular cusp. The specimen was compared with *Mylohyus* from the Friesenhahn Cave, Bexar County, Texas, deposited in the collection of the Bureau of Economic Geology, University of Texas. This material was referred to *M. nasutus* by Lundelius (1960). Measurements of the Ben Franklin Dp2 are slightly greater than those of the Friesenhahn specimens, particularly the transverse diameter. Another striking difference lies in the number of anterior cusps. There are but two on both deciduous and permanent p2s from Friesenhahn and three on our specimen. Leidy (1887) used this "extra" cusp in distinguishing *M. pennsylvanicus*, but Lundelius (*Op. cit.*) proved this feature to be quite variable, noting that both types occur in the Conrad Fissure collection, as well as in a sample from Florida. Therefore it seems best not to make specific reference of this peccary until more complete material is recovered.

Slaughter (1961a) noted that generally *Platygonus* is the peccary present in southern interglacial deposits, while *Mylohyus* occurs in deposits referred to glacial stages. This occurrence seems to strengthen that observation.

A radiocarbon date recently reported in *RADIOCARBON* (vol. 3, 1961, p. 107) indicates an age of 9540 ± 500 for the fauna of Lloyd's Rock Hole in Pennsylvania. This was considered "a minimum terminal date for the Pleistocene peccary, *Mylohyus*." It is interesting to note how closely this compares with the youngest date from the Sulphur River Formation ($9,550 \pm 375$). The Texas specimen of *Mylohyus* was collected from a horizon slightly above this radiocarbon sample.

?*Antilocapra americana* (Ord)

Plate 1, fig. C

Referred specimen.—Right m1; SMUMP 60728.

Discussion.—The fossil m3 is somewhat larger than those of Recent specimens that we have examined, but within the maximum as given by Skinner (1942, p. 205) for *Antilocapra*. Individuals of *A. americana* are said to average larger in the northern portion of their range. Those specimens available to us were collected in Texas. Skinner (*Op. cit.*, p. 204-

208) states that 106 of 130 m3's of *Stockoceros onusrosagris* contain fourth lobes and some of the remaining 24 have slight indications of this feature. He goes on to say that when the extra lobe is not present, the third lobe is reduced. This is not the case in *Antilocapra*. There are but three lobes present in the Delta County m3 and the third lobe is well developed, being more than one third of the tooth's total length. This feature in addition to the Texas fossil's greater size would seem to negate the possibility of its representing *Stockoceros*.

As the inferior dentition of *Tetrameryx* is unknown, it is still possible that this is the genus represented. The probable size of the m3 in *Tetrameryx* would be as large and perhaps larger than the maximum for *Antilocapra*, and our specimen is very near the maximum for the living species. However, considering the closer relationship between *Tetrameryx* and *Stockoceros*, and the relatively recent age of the Ben Franklin local fauna, this specimen is referred provisionally to the living form.

	<i>Antilocapra americana</i>	<i>Antilocapra americana</i>		
	SMUMP 60728 Ben Franklin local fauna	Minimum	Average	Maximum
Antero-posterior diameter of m3	26.3mm	19.4mm	22.9mm	26.8mm

Odocoilus sp.

Referred specimens.—Antler fragments and an astragalus; SMUMP 60735.

Discussion.—The deer material cannot be distinguished from the same elements of the larger sized white-tailed deer found in the area today.

Bison sp.

Referred specimen.—Buccal enamel of superior molar; SMUMP 60730.

Discussion.—Specific assignment cannot be given to such a specimen but the size is not unlike that of a large *B. bison*. Considering the age of the deposit, however, it more likely represents one of the extinct species, *B. antiquus* or *B. occidentalis*.

Equus sp.

Referred specimen.—Buccal one half of a superior molar; SMUMP 60731.

Discussion.—The size of the fragmentary specimen indicates a horse the size of *A. conversidens*. The enamel pattern is quite complex, but inadequate for specific identification.

ENVIRONMENT

Sorex cinereus and *Microtus pennsylvanicus*, with the southern limit of their present ranges some three hundred miles north of Delta County, most certainly are to be considered northern types. Likewise, if the *Synaptomys* material represents *S. cooperi* rather than immature individuals of *S. australis*, it too would suggest considerably cooler weather. On the other hand, the northernmost ranges of *Sigmodon hispidus* and *Dasyus novemcinctus*, the modern counter-

part of *D. bellus*, currently are south of the southern limits of the species mentioned above. The paradox is resolved if one remembers that it is the blistering summers, *not the lack of bitter winters*, that restrict the northern types, and that it is the presence of prolonged extreme winter temperatures, *not the lack of hot summers*, that limit the range of southern species. The current allopatry in the ranges of these species could become sympatric in a climate having summer temperatures similar to those of the southern Great Lakes area and winter weather no more severe than found in Oklahoma today. If one subscribes to the idea that glacial and pluvial stages go together, persistent cloud covers would tend to equate extremes of weather, insulating the ground from the summer sun and retarding loss of heat by radiation in the winter.

There is some evidence that rainfall may have been slightly greater during Sulphur River time than at present. Prior to the excavation of the artificial channel, the river valley was intermittently flooded, but was not marshy. Although snails are found throughout the formation, many of the sampling localities produced nothing but aquatic species, indicating that parts of the old floodplain were covered by water perennially. Unless swamps or marshes were created by the activities of *Castoroides*, one might assume that formerly the water table stood at a higher level. Here again there is the alternative that cooler summers merely lessened the rate of evaporation.

AGE

Mammals and mollusks of the Ben Franklin local fauna indicate cooler summer temperatures than now prevail in this area. The alluvium containing these animals underlies Recent sediments. Radiocarbon dates place the age of this alluvium around 9,000-11,000 years B.P. These lines of evidence converge to indicate that the local fauna belongs to the late Wisconsin glacial stage.

Two samples were submitted to Dr. E. E. Bray, of the Socony Mobil Field Research Laboratory, for radiocarbon testing. Sample SM-532, charcoal collected from a possible human hearth near Quarry No. 5, was dated as $9,550 \pm 375$ B.P.

The other sample, SM-533, collection of articulated shells of the fresh water mussel, *Amblema plicata*, from Quarry No. 4, has a radiocarbon date of $11,135 \pm 450$ B.P.

All mammals the size of *Castoroides* or smaller that have been recovered from the Berends, Doby Springs, and Butler Springs local faunas, are also present in the Ben Franklin assemblage. These three faunas are considered Illinoian by Hibbard and Taylor (1960).

Thus the reference of an assemblage of mammals to either Illinoian or Wisconsin may be difficult unless the fauna is quite diversified.

The most likely Wisconsin indicators seem to be *Dasyypus bellus* and *Sigmodon hispidus*, provided these are accompanied by typically northern forms. Both of these species apparently arrived in the United States during the Sangamon, probably in post-Jinglebob time. The usefulness of these species may be limited geographically, as their northern advance during the Pleistocene is unknown. The Bar M local fauna of Harper County, Oklahoma, has a suggested climate much like that indicated by the Ben Franklin mammals, and this assemblage includes *D. bellus*. The Bar M was considered as glacial, either Illinoian or Wisconsin by Hibbard and Taylor (1960), and Wisconsin by Slaughter (1961a).

POSSIBLE OCCURRENCE OF EARLY MAN IN THE SULPHUR RIVER FORMATION

About thirty feet from the western edge of the fossil "pond" at Quarry No. 5 is a lens of ash and charcoal seven feet in diameter and 18 inches thick. Three superimposed layers of ash, charcoal, and burned red clay suggest that there may have been several fires in the same spot at different times. It was here that radiocarbon sample SM-532 was collected.

About fifty feet away, near the northern edge of the "pond," an antler fragment was collected *in situ*. The specimen is 180 mm long. Half of the fragment has the natural taper of a deer antler. Midway of its length, however, the tine tapers symmetrically in the opposite direction. The proximal portion is broken away; presumably it was pointed. The proximal tapering was most certainly post-mortem, as the porous interior of the antler is visible. If the specimen was in fact pointed at both ends, the maximum diameter of 24 mm would be at the exact center. At this point, also centered transversely, is a hole 8 mm in diameter running through the specimen. The shoulders of this hole are square and sharp. Obviously this specimen is an artifact, but its use is not known.

Several chips and fragments of quartzite were removed from the three tons of Quarry No. 2 material that was washed. One displays a series of flakes all of which originate on one end and one side. It seems unlikely that these specimens could have been chipped by impact with other stones tumbling in the stream, and it is difficult to imagine how pieces of quartzite could be deposited in fine silt containing no other pebbles. At other quarries in the forma-

tion, where gravels occur, quartzite pebbles are in the minority and all pebbles are concentrated and graded by size.

As inconclusive as these specimens and observations may be, the Sulphur River Formation certainly deserves the attention of archeologists.

EROSION AND BURIAL OF THE SULPHUR RIVER FORMATION

A mile downstream from Ben Franklin a number of channels eroded into the Pleistocene deposits and filled with Recent sediments are transected by the present river. The larger of these had almost cut through the older formation before being filled (B, fig 1.) Without exception, the bottoms of these fills display two-foot lenses of gravel made mostly of the calcereous nodules that separate the Pleistocene from the Recent sediments where channels are not present. Above the gravels the fills are made of gray sandy clay becoming darker toward the top and merging, without disconformity, with an almost black sediment that has completely buried the Sulphur River Formation. A radiocarbon date (SM-599) determined from articulated clam shells collected from the base of the gray sand indicates that the channels began to fill shortly before 1833 ± 144 B.P. Another date on charcoal (SM-598) from the same fill, at about the same level as the top of the Pleistocene alluvium, indicates that the channels were full but that the Pleistocene formation was not yet buried by 1123 ± 366 B.P. Thus the ten feet of black sediment that now covers the older valley fill has been deposited in the last 1,000 years. A third test (SM-600), which was determined on a well preserved piece of oak from another fill some two hundred yards upstream, produced a date of 1170 ± 157 , reinforcing the supposition that all of the channels were filled at about the same time.

SUMMARY

Immediately before the deposition of the Sulphur River Formation, the valley of North Sulphur River was characterized by steep hillocks and ravines developed upon the Taylor Formation of Upper Cretaceous age. When the valley began to fill with sediments, probably about 12,000 B.P., numerous large marshes bordered shallow streams of cool water. Summer temperatures were mild. Winters may have been little different from those of the present. Rainfall may have not been much different from the present annual average of forty inches, but there may have been less evaporation due to the cooler summers. Doering has suggested that the aggrading of the valley paralleled the rapid aggrading of the Red River, which de-

posited sediment across the mouth of the Sulphur River. This in turn may reflect a rising sea level. Sometime shortly after 9,500 B.P., deposition ceased, and the river was either stable or cutting down slowly until deposition was resumed approximately 2,000 B.P. By this time the essentially modern fauna had replaced the strikingly different fauna of the Sulphur River Formation. The floodplain and river bed itself continued to aggrade until 1929, when the artificial channel reduced the length of the river and caused a rapid down-cutting through the entire sequence.

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