THE PLEISTOCENE FAUNA OF THE MANIX BEDS
IN THE MOJAVE DESERT, CALIFORNIA

Thesis by

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Figure 1

Kodachrome Photograph of the Manix Beds.

View looking northeast near sublocality W25, C. I. T. locality 540 (pl. II). Essentially a complete section of beds of Lakes nos. 1 and 2 is shown in the foreground and middleground. The darker colored, pebbly sediments at the base are the finer fanglomerates, Unit 17 of the stratigraphic section. Above this unit is about two feet of grayish-green lake clays. The corrugated ledge-maker above these clays is the two to three feet thick Iron Oxide Zone, Unit 16.

Mojave River channel is in the middleground beyond the light colored beds, running from right (south) to left (north). Southeast base of Alvord Mountains in the background.

Photograph courtesy of Dr. Theodore Downs, Los Angeles County Museum.

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ABSTRACT

The Manix Beds were deposited in a Pleistocene lake basin that occupied 200 to 300 square miles of the Mojave Desert, near the center of San Bernardino County, California. Three stages of lake deposition are recognized. Arenaceous clays and argillaceous sands, light grayish-green in color, are the predominant lithologies. The first and second lake stages are separated by interpluvial sediments; erosion occurred between the second and third stages. The total thickness of lake and interpluvial deposition in the center of the basin probably exceeded 250 feet. Except for minor faulting, which has affected even the youngest layers, the Manix Beds are essentially undeformed.

When Lake Manix first formed, the mammalian fauna included a sabre-tooth cat apparently close to *Machairodus*, *Equus* sp. cf. *E. scotti*, *Camelops* sp. cf. *C. kansanus*, a giant camel, and possibly a primitive species of *Tremarctotherium*. Therefore, an Illinoian age is suggested for the first lake stage. Tortoise and fish remains tend

to corroborate this dating. This pluvial stage may be younger, but hardly older, than Illinoian as is indicated by fragmentary remains of what appears to be a small or medium-sized Bison. The Avifauna indicates a late Pleistocene, possibly Tahoe, age for the second lake stage. The molluscan fauna from this lake is possibly of Tahoe times. No vertebrate fossils have been recovered from beds of the third lake stage, but, sequentially, deposition probably took place during the Tioga subage of the Wisconsin.

Conformable beneath the Manix Beds are 300 to 400 feet of fanglomerates that are considered to be interpluvial sediments of probable Yarmouthian age. The fanglomerates overlie, with an angular unconformity, Tertiary volcanics that have been highly sheared and deformed, probably by Pasadenan orogenic movements. The extreme coarseness, angularity, and lack of decomposition or sorting of the fanglomerates suggest their deposition during the late phases of the Pasadenan Orogeny in the Yarmouthian interglacial age.

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INTRODUCTION

Pleistocene lake beds and their contained fossils in the Basin and Range Province have long been of considerable interest to geologists and paleontologists because of: (1) Their relationship to glaciation in the higher mountains of the west and the concurrent climatic changes; (2) possible faunal correlations with the glaciated regions of the midwest; and, (3) the possibility of dating the late Cenozoic Orogeny of the west coast. This last possibility has been largely overlooked or was inapplicable in most of the lake studies, but Buwalda (1914, p. 443) stressed the idea that the lacustrine Manix Beds in southeastern California were apparently " - - - deposited in the latest period of deformation in that region."

Hoping to closely date the Manix Beds, John Cagle, Emanuel Vardas, and the writer collected fossils for 12 days during early 1952. This work was undertaken as a part of the Mojave Project under Dr. D. F. Hewett of the United States Geological Survey. The mammalian fossils are in the California Institute of Technology (C. I. T.) collection, localities 540-542 (pl. II). Most of the remains were found at Locality 540. The fossils collected by Dr. Buwalda (1914) are in the University of California (U. C. M. P.) collection, locality 676. Two bones, U. C. M. P. locality 791, were found by Will Fzakes along Mojave River, presumably in the Manix Beds.

All fossil measurements are in millimeters.

Acknowledgments

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Location and Physical Setting (pls. I-II)

Manix, formerly called Manly, is a siding on the Union Pacific Railroad in Sec. 7, T. 10 N., R. 4 E., San Bernardino base and meridian, San Bernardino County, Southeastern California. It lies approximately 28 miles E. N. E. of Barstow along U. S. Highway 91, between Barstow and Baker, at an elevation of 1760 feet.

The Pleistocene Manix Lake Basin occupied a northwest-southeast elongated area of 200 to 300 square miles in the vicinity of Manix, including the present Troy and Coyote Dry Lakes, the Manix area and Afton or Cave Canyon. The ephemeral Mojave River crosses the central part of this basin in a general west-east direction. The Manix Beds are exposed in the river banks and in tributary gulleys. Camp Cady, an abandoned U. S. Army post, is located in Sec. 19, T. 10 N., R 4 E., near springs which emerge along the river banks. Approximately two miles east of Camp Cady Mojave River turns southward and then bends abruptly northward. This bend is herein referred to as the "Big Bend", and is well illustrated by Thompson (1929, pl. 26A). The Old Spanish Trail crosses the narrow spur of the undercut slope. Most of the fossils were found just north of the Big Bend.

A relief map of this part of the Mojave Desert is presented by Thompson (1929, pl. 11). Topographic Quadrangles 65 and 66 (pl. I) of The Metropolitan Water District of Southern California are the most detailed maps of the area that are available. United States Geological survey air photos (pl. II) were furnished by Dr. D. F. Hewett.

Geological Setting

Pre-Cenozoic igneous and metamorphic rocks (Thompson, pl. 8) apparently form the cores of the rather low-lying Alvord, Cave, Cady, Newberry, Kane, and Calico Mountains which enclose Manix Basin. Isolated outcrops of limestone and marble, probably of Paleozoic age, occur on the flanks of the mountains. At the southeast end of Cave Mountain Mojave River has cut a channel into this marble (Thompson, p. 510). There are several hills of limestone (pls. I-II) on the south side of Mojave River near Camp Cady.

The Calico and Newberry Mountains are composed mainly of Tertiary volcanics and sediments, as are the west flank of Cady Mountains and many of the lower areas throughout this portion of the Mojave Desert. The Tertiary volcanics in the Cady Mountains are highly sheared (Thompson, p. 443).

Lying angularly unconformable on the Tertiary volcanics in Manix Basin are fanglomerates which in places attain a thickness of 300 to 400 feet (Thompson, pp. 510-511). East of Afton this contact " - - - is one of erosion and often has considerable relief" (Buwalda, p. 448). Buwalda (p. 451, etc.) interpreted these relationships and the extreme coarseness, lack of wear, decomposition, or sorting in the fanglomerates as being indicative of concurrent or recent strong deformation.

Broad valleys in the Cady, Ord, San Bernardino, and other mountains of the southwestern Mojave Desert suggested to Thompson (pp. 440-441) " - - - an erosion cycle - - - which may have been interrupted by the uplifting of the mountain mass." Vaughn (1922, pp. 337, 384) believes that an early Quaternary basalt flow in the San Bernardino Mountains is equivalent to a basalt in the Mojave Desert, a few miles to the north, which now lies approximately 500 feet lower in elevation. This indicates " - - - that the desert and the present mountains were at one time a continuous surface of low relief" (p. 343) and that later in the Pleistocene the San Bernardino Mountains were uplifted and divided into several blocks (p. 396). Fairbanks and Carey (1910, p. 33) observed that the sediments in the lowest moraine in the San Bernardino Mountains are very fine " - - - as though when the first ice tongue came down it found the surface soft and deeply disintegrated." They assume that the range, shortly before being glaciated, was " - - -topographically a portion of the Mohave Desert." Hinds (1952, p. 71) suggests that the erosion surface in the San Bernardino Mountains may correlate with a similar surface of late Pliocene or early Pleistocene age in the Sierra Nevadas, Coso Mountains, Argus and Panamint Ranges, and ranges in southwestern Nevada. English (1926, p. 64) correlates the San Bernardino Mountains surface with the Perris Peneplain to the south. It seems probable that the erosional surfaces in Manix Basin and in the nearby mountains are of the same age and that the fanglomerates were deposited during and shortly after the Pleistocene deformation in southeastern California.

Stille (1936, p. 867) has applied the name "Pasadenan" to the middle Pleistocene orogeny in which the San Bernardino, San Gabriel, Santa Monica, and Santa Ynez Mountains acquired their present heights. Mann (1952, p. 1338), Reed and Hollister (1936, p. 1595), and Woodring (1952, p. 402) contend that the major late Cenozoic deformation in southern California occurred during the middle or late Pleistocene. A similar dating is proposed for uplift in the Sierra Nevadas by Dibblee and Chesterman (1953, p. 53); for the Coast Ranges by Bailey (1943, p. 1566), and Eaton (1941, p. 206). Grant and Gale (1931, p. 63), and Reed and Hollister (1936, p. 1595) assume that the main period of folding and faulting was contemporaneous throughout California. Pleistocene lake deposits in Nevada and California have yielded remains of fishes which are now limited to lowlands and coastal waters. Hubbs and Miller (1948, p. 26) interpret this as denoting " - - - a recent elevation of the Great Basin as well as the Sierras - - -."

Lying conformably on the Manix Basin fanglomerates are the lacustrine argillaceous sands and arenaceous to relatively pure clays which Buwalda (p. 444) has termed the Manix Beds. Towards the basin borders the lake beds grade into coarser sediments that he (pl. 24, figs. 1 and 2) calls "fine fanglomerates."

The origin of the basin which held the body of water has not been determined. Buwalda (p. 455) considered the irregular anticline of fanglomerates east of Afton to have been a possible barrier. Later, he (and Richter, 1948, p. 1367) concluded that fault displacements near Afton " - - - apparently created the depression in which the Mohave River was confined and in which it cut Afton Canyon." Thompson (1929, p. 511) and Dr. D. F. Hewett (personal communication) believe that the fanglomerates near Afton formed an alluvial dam. Miller (1946, p. 51) postulates a diversion of the Mojave River from a more southerly course into a pre-existing Manix Basin (see also Buwalda, p. 455). The depression southwest of the Cady Mountains that is now occupied by Bagdad, Bristol, and Cadiz Dry Lakes, is considered by Darton (1915, p. 153) as probably resulting from tilting of a main stream channel. Gale (1951, p. 5) thinks this depression " - - - might have been part of a former channel of overflow from the Mojave River - - - into the Colorada River drainage." The distribution of Pleistocene and Recent fish suggests a former connection between Mojave and Colorado Rivers (Miller, 1946, pp. 50-52, and Hubbs and Miller, 1948, p. 90).

Near Manix, Buwalda (1914, p. 449) recognized two sets of lake beds that are usually separated by a coarser, oxidized sand layer which in the present report is termed "Iron oxide zone" (Unit 16, p.12). Blackwelder and Ellsworth (1936) found evidence for three lake stages in Afton Basin, a nearly closed bay forming the eastern extension of Manix Basin. The last lake was confined to Afton Basin.

According to Blackwelder and Ellsworth (1936, p. 461) the first lake dried up due to lack of inflow, and Afton Basin became a playa. The second lake stage attained a higher level, about 1815 feet above sea level (pp. 459, 462) and probably eventually overflowed and dissected the dam at the east end of the basin. Stream erosion then cut a channel to a depth of at least 150 feet below the level of the ensuing third lake which reached a maximum elevation of approximately 1637 feet.

STRATIGRAPHIC PALEONTOLOGY

Stratigraphic Section (pl. II, A-A')

The following section was taken along a west-east line, perpendicular to Mojave River, about one and one eighth miles north of the Big Bend, probably in Sec. 17, T. 10 N., R. 4 E. Most of the streams draining the northwestern side of the Cady Mountains emptied into this edge of the lake. It should be noted that the top of Unit 1 is approximately 1400 feet west of the base of Unit 17 and therefore farther from the source of sediments. Probably Unit 17 grades westward into true lake beds. Unit 18 is not part of the Manix Beds.

Wind blown sand and residual, pebbly, mainly volcanic, fragments form the present surface. Beds of Lake no. 3 are not included.

Unit	Lithology	Thickness (in feet)	Contained Fauna *
1	Arkosic sand, fine to coarse, rounded, brownish-gray, containing whitish zones of calcium carbonate, semi-consolidated.	16	** Two to four inches thick clamshell (p.26) bed about four feet below surface. ?Aechmophorus occidentalis, Phalacrocorax auritus ?, Ursus ? sp., Mammuthus sp., Equus sp., Camelops sp., Tanupolama sp., Antilocapra ? sp.
2	Clay, silty, light grayish-green, non-calcareous.	1	
3	Arkosic sand, silty to granular, subrounded.	3	
	INTERPLUVIAL BETWEEN LAKES NO. 1 AND NO. 2		
4	Clay, light greenish-gray, weathering to medium-brown, micaceous in places, contains large, usually pentagonal, mud cracks with arkosic wedges extending at least four inches down between the polygons.	3	** Aechmophorus occidentalis, Phoenicopterus copei ? Grus ? sp.
5	Clay, arenaceous, light grayish-green, calcareous.	4	
6	Arkosic sand, fine, argillaceous, rounded, light greenish-brown.	1.5	

7	Clay, silty, light grayish-green calcareous, micaceous.	4	
8	Arkosic sand, fine, argillaceous, light grayish-green with reddish-brown iron stain in upper inch.	0.5	
9	Clay, light grayish-green weathering to light gray, brown iron staining in places.	4	
10	Clay and arkosic sand inter-bedded, stained brownish-red at top.	4	_Siphateles_ _mohavensis_
11	Clay, medium brownish-gray, calcareous, local lenses of fine to medium arkosic sand.	14	
12	Volcanic ash, very fine, white, forms benches.	0.25	No fossils found.
13	Clay, shaly, arenaceous in places, light grayish-green, micaceous, calcareous.	3	
14	Arkosic sand, silty to pebbly, subrounded, light greenish-brown, calcareous, many volcanic fragments. Cross-bedded and channeled in places.	8	
15	Clay, shaly, local lenses of coarse arkosic sand, light grayish-green to medium-brown near top, calcareous.	15	_Siphateles_ _mohavensis_

16	"Iron Oxide Zone." Arkosic sand, fine to medium, medium reddish-brown to yellowish-brown, interbedded with light grayish-green clay. In places contains lenses of mica up to two inches thick.	4	75-90 percent of remains of *S. mohavensis* and majority of bird bones- *Aechmophorus occidentalis*, *Pelecanus erythrorhynchos*, *Ciconia maltha*, *Phoenicopterus* sp., *Phoenicopterus minutus*, *Nyroca valisineria*, Phalaropodidae; Machairodontinae, *Equus* sp. cf. *E. scotti*, *Equus* sp. cf. *E. tau*, **Giant camel, *Camelops* sp. cf. *C. kansanus*, *Tanupolama* sp., *Ovis* sp.
17	Arkosic sand, pebbly, subangular to subrounded, light brown, contains layers of light greenish-gray, micaceous clay. Poorly exposed.	26	Tenebrionid beetle; *Gopherus* sp. aff. *G. agassizii*; ?*Pelecanus erythrorhynchos*, ***Phoenicopterus minutus*; *Mammuthus* sp., *Equus* sp. cf. *E. scotti*, *Equus* sp. cf. *E. tau*, *Tanupolama* sp., cf. *Bison* sp.
Total thickness of measured section		111.25	
18	Bouldery fanglomerates, mainly red to purple volcanic fragments, medium-grained arkosic matrix. Volcanic fragments may or may not be continuous below Unit 17.	Thickness unknown, Recent wind blown sand covers beds below.	*Camelops* sp. cf. *C. kansanus*

* Many of the fossils were not collected stratigraphically and therefore are not listed in this column. Most of the specifically referable remains are from Units 16 and 17; it seems unwise to extend the ranges of these forms into the upper beds.

**Probable stratigraphic location.

Interpretation of Sediments and Contained Fossils

Most of the field time was used in searching for fossils, therefore the foregoing section and the following interpretation are of little more than reconnaissance value.

Unit 1 is the uppermost portion of the Manix Beds in the vicinity of Manix, and presumably was deposited in Lake no. 2 of Blackwelder and Ellsworth (1936, p. 462). This lake probably overflowed the dam at the east end of the basin. A well developed alluvial bench is present around several of the limestone hills (pls. I, II) between Camp Cady and the Big Bend. Its elevation is somewhat above 1800 feet; Lake no. 2 rose to 1815 feet in Afton Basin. An examination of the air photos suggests a narrower bench cut a few feet lower on the alluvial deposits. The clamshell bed is of forms (p.26) that, according to D. W. Taylor (personal communication), indicate permanent quiet water. Most of the vertebrates from this unit were found in the lower part. Aechmophorus occidentalis and the cormorant, Phalacrocorax auritus ? suggest a shallow pond. The mammalian remains are of little consequence except for five joined vertebrae of Tanupolama sp. that would seem to indicate fairly shallow, quiet water. This unit must be a near shore facies of the lake beds.

Manix Basin was probably a dry type playa following the deposition of Unit 4. Unit 3 was probably wind blown and flood transported onto the playa surface. The birds in Unit 4 are waders in shallow ponds, and the presence of the flamingo Phoenicopterus copei ? intimates brackish water. This unit seemingly represents the last phase of Lake no. 1, which was followed by an interpluvial period.

The volcanic ash, Unit 12, very likely correlates with the "volcanic ash (glass), light gray" found in Bristol Dry Lake at depths ranging from 38 to 75 feet (Gale, 1951, pp. 15-17). Test hole no. 12 (Gale, p. 17) showed three distinct beds of rock salt above the ash, but rock salt was absent in some of the adjacent wells. Possibly the lava underlying Lanfair Valley (Thompson, 1929, p. 665) is of the same age. The Manix Beds ash is undoubtedly older than the Bagdad (Gale, 1951, p. 3), Pisgah, and other Recent lavas that lie upon the present playa surfaces southeast of Manix Basin. The ash is relatively pure and probably settled directly into the lake. North of Manix Wash it caps vertical bluffs 25 to 30 feet high.

According to Buwalda (p. 449), Unit 16, the Iron Oxide Zone, represents " - - - a short period of contraction or dessication of the lake and fluviatile deposition of coarser, more highly oxidized yellowish material." Where the section was taken, Unit 17, immediately below the Iron Oxide Zone, is coarser material, but near the Big Bend the Iron Oxide Zone separates lake clays. About three-fourths of a mile north of the Big Bend are two knobs that still retain the upper surface of the Lake no. 2 beds even though the adjacent areas are highly eroded. Perhaps these knobs are underlain at shallow depth by resistant outliers of the Cady Mountains. Unit 17 is seemingly only a few feet thick on the south side of these knobs and is overlain by lake clays. The Iron Oxide Zone therefore lies between lake clays, and contained a large quantity of bones. Apparently the oxidized sand pinches out to the west of these knobs. The presence of resistant rock beneath the two knobs would perhaps explain the Big Bend in Mojave River. Russell (1885, pp. 141, 143) describes a ferruginous sandy bed, containing detached mammal bones, between the clays of the "upper lacustral clays" in Lake Lahontan. Antevs (1925, pp. 96-97) mentions eight inches of brown sand between clay layers in a profile on Mill Creek, near the shore of the Pleistocene Mono Lake. Neither of these authors attaches any long range climatic significance to the oxidized sand zone. Shrock and Hunzicker (1935, p. 30) interpret sandy bands in Great Basin lake sediments as probably being " - - - deposits made at times of cloudbursts." Unit 16 maintains approximately the same thickness for almost a mile in a north-south direction. To the north it grades into wind blown (?) sands that grade into gravels (John Cagle, personal communication). The chub, Siphateles mohavensis, shows lake adaptations (Hubbs and Miller, 1948, p. 87). The birds are shallow pond forms, many of them being waders. The flamingo has affinities for brackish water. Many of the mammal bones are in an excellent state of preservation, showing little abrasion or cracking due to exposure. The bones were disarticulated, but three Camelops incisors were found together. In places the major portions of Siphateles mohavensis skeletons were closely associated. As the sand is interbedded with light grayish-green clay, possibly seasonal fluctuations in the lake level are indicated. The lenses of mica were probably deposited in shallow channels along the edges of the lake. Unit 16 was very likely deposited in a shallow pond, or around the lake border. It seems possible that a rising lake level is represented, rather than temporary dessication, because this unit here overlies coarser, apparently terrestrial, material and is overlain by 15 feet of clay.

Most of the fossils in Unit 17 came from the coarser layers. Gopherus sp. aff. G. agassizii may be an ancestral form of the Recent desert tortoise. The Tenebrionidae are land beetles that are abundant today in the Great Basin and elsewhere (F. S. Truxal, personal communication). The pelican resides in shallow water. The mammals are plains types; the bones are fragmentary and usually abraded. This unit likely denotes the early, fluctuating, stage of Lake Manix and the closing stage of the long arid or semiarid period that preceded the lake. Possibly the coarser layers were deposited at times of heavier runoff.

Unit 18 is considered to be Buwalda's (p. 446) "Pleistocene Fanglomerates," the oldest deposits in Manix Basin, and not part of the Manix Beds. This unit was deposited during the interpluvial preceding Manix Lake and immediately after the faulting in this area.

GEOMORPHOLOGY OF MANIX BASIN

Field observations plus information obtained from reports by Blackwelder and Ellsworth (1936), Buwalda (1914), and Thompson (1929), and others suggest the following geomorphic history for the Manix Basin and the lower Mojave River.

During the late Pliocene and early Pleistocene times much of the Mojave Desert and many of the present day mountains in southeastern California, including the San Bernardinos, were reduced to a surface of low relief. It is questionable whether the then existing drainage channels would be preserved after the Pasadenan Orogeny, but Darton (1915, p. 153) thinks the depression occupied by Bagdad, Bristol, and Cadiz Dry Lakes, about 65 miles southeast of Manix, " - - - resulted from tilting of a portion of an old stream channel." Gale (1951, p. 5) believes this stream channel might have been occupied by Mojave River. Thompson (pp. 657-658) discusses evidence for a continuous trough between

Barstow and Bristol that may have existed as recently as early Pleistocene. The presence of a fossil Cyprinodon fish in the Death Valley System, which includes Mojave River, " - - - demands a connection with the basin of the Colorado River" (Miller, 1946, p. 52) possibly during the late Pliocene or early Pleistocene. Buwalda (p. 454) suggests that Mojave River did not flow through Manix Basin in pre-Lake Manix times. Conceivably it did occupy the Barstow-Bristol trough prior to the Pasadenan Orogeny.

During the Pasadenan Orogeny (Stille, 1936, p. 867), in middle or late Pleistocene times, the formerly continuous erosion surface was broken into a series of fault block mountains and troughs. Soda Lake Basin, east of Manix Basin, is probably a graben (Thompson, p. 558) formed at that time. Presumably the Ord Mountains and others on the south side of the Barstow-Bristol trough were contemporaneously uplifted. The Cave Mountains appear to be due to block faulting (Thompson, p. 517). In 1947, strike-slip movement occurred along a pre-existing fault trending east-northeast to west-southwest (pl. I) along Mojave River, south of Manix (Buwalda and Richter, 1948, p. 1367). These authors propose that movement along this fault " - - - apparently created the depression in which the Mohave River was confined and in which it cut Afton Canyon." It is likely that the north side of the Cady Mountains is also a fault scarp.

The thick fanglomerates lying with an angular unconformity atop the upturned Tertiary volcanics in Manix Basin were deposited during and immediately after the deformative movements. Fanglomerates are deposits of arid or semiarid regions, so an interglacial age for the orogeny is intimated. It is probable that Mojave River at that time was an ephemeral stream. Buwalda (pp. 454-455) suggests that Mojave River might have been turned into Manix Basin as a result of orogenic movements, or that it lengthened its lower course due to increased water supply. The anticline of fanglomerates (Buwalda, p. 455) at the east end of the basin may have dammed the river.

During the succeeding pluvial the basin was filled to an elevation of 1795 feet, making a lake 200 feet deep in Afton Basin (Blackwelder and Ellsworth, p. 459). Information obtained by Thompson (p. 451) from water wells indicates that the lake was approximately the same depth southwestward to the vicinity of Newberry. The maximum extent of the lake is not known. About 200 feet of relatively pure blue clay, drying green, and coarser clastics were deposited in the deeper parts of the lake. North of the Big Bend this lake stage is represented by approximately 90 feet of interbedded argillaceous sands and arenaceous clays. Miller (1946, p. 47) postulates a connection between Mojave and Amargosa Rivers during this stage, but Blackwelder and Ellsworth (p. 459) believe " - - - that the lake entirely dried up without being drained - - - " and (p. 461) that it could not have overflowed. They (p. 459) report bones of Siphateles mohavensis from a Lake no. 1 gravel bar. It seems likely that the mud-cracked zone at the top of Unit 4 (p. 10) at an elevation of about 1750-1775 feet, represents the dessication of Lake no. 1. Fish remains from Units 10 and 16 are of the genus Siphateles, probably S. mohavensis (R. R. Miller, personal communication). This species is considered to have evolved from a common stock with a species of Siphateles found fossil and living in Owens Valley. The two species differ in several respects. It seems that differentiation and perhaps isolation of the Mojave River species had already occurred and the possibility arises that the Owens Valley - Amargosa - Mojave River connection antedates Lake no. 1. Miller (personal communication) reasons

" - - - that the differentiation, if not the isolation, - - - is of pre-Wisconsin age."

Four species of mollusks and the chub, Siphateles mohavensis, establish the existence of a fresh water lake that must have been of considerable duration judging from the thickness of the lake clays. The clays near Afton and west of the Big Bend contain salt crystals, and numerous large crystals are in the light brown clays below the volcanic ash north of the mouth of Manix Wash. These light brown clays contain less than one percent of sand grains, and were probably deposited in a deep portion of the lake. Salt layers are absent from the surface of Unit 4, a condition to be expected on a dry type playa in which the water table lies more than 10 feet below the surface (Thompson, p. 125). Clay dunes, derived from dried mud cracks of the playa, are found on the northeast side of Afton Basin (Blackwelder and Ellsworth, p. 459). The volcanic ash, Unit 12, can be traced from slightly north of the Big Bend to the place where it is covered by later beds, about 1000 feet south of Manix Wash. It is present in the hills bordering the north side of Manix Wash. Erosion probably did not cut below the ash until the present day channels were excavated.

Silty to granular arkosic sand, similar to present day deposits on the lower portions of fans, buried the playa surface above Unit 4. Unit 3 is only three feet thick and is overlain by the lake-type silty clays. At least 20 feet of fan gravels was laid down in the center of Afton Basin (Blackwelder and Ellsworth, p. 459), and the Lake no. 1 gravel bars were breached (p. 461). Thompson (p. 510) observed about 100 feet of fanglomerates above the lake beds east of Dunn. No evidence of stream erosion of the playa surface was found, but the alluvial (?) dam at the east end of the basin was still forming a temporary base level. The available evidence is insufficient for determining the length of this interpluvial, but it must have been somewhat shorter than the preceding one.

With the reappearance of a more moist and/or cooler climate, the basin gradually refilled to a depth approximating 50 feet, with a maximum level of about 1815 feet. A prominent alluvial bench lies at about that elevation around the limestone hills between Camp Cady and the Big Bend. Green clay, blue when wet, is considered to be the typical deposit of the more remote portions of the lake. However, the light brown clay of Lake no. 1 near Manix Wash also seems to be a deep water deposit. Green clay of Lake no. 2 is of limited extent, possibly due to the shallowness of the lake. It is found in wells near Manix and Newberry (Thompson, p. 451), and in the bluffs and badlands east and northeast of Camp Cady. Wells between Newberry and Manix produced no blue clay above depths of 150 feet. Thompson (p. 450) observed a seemingly anomalous occurrence of greenish clay on the bedrock hill southwest of Harvard, where it lies in a horizontal position on the east side, about 25 feet above the plain which is herein considered to be the original upper surface of Lake no. 2 beds. One possible explanation is that the upper Miocene Barstow formation contains greenish clays similar to the Manix Lake clays. Thin beds of greenish clay are present at elevations of about 1800 feet on the upper alluvial slopes east of the Big Bend.

In Afton Basin the second lake stage is represented by 20 feet of lake gravel near the eastern edge of the lake, but there are no traces of lacustrine sands or clays. It is presumed that they were completely removed during the dissection that postdated Lake no. 2 (Blackwelder and Ellsworth, pp. 459-460). It seems that such extreme dissection in Afton Basin would be reflected in the beds near Manix, but a possible explanation for their apparent lack of dissection is discussed under the history of Mojave River.

North of the Big Bend the deposits of this stage consist of about 17 feet of silty clay and arkosic sand. The fresh water mollusks in the four inch shell layer near the top of Unit 1 are inhabitants of permanent, quiet water. Valvata and Helisoma subcrenatum are now found in southern California only in the San Bernardino Mountains, and Carinifex lives in the northern California-Oregon region. D. W. Taylor interprets these distributions as indicating cooler summers at the time of Lake no. 2. This lake was of much shorter duration than the first stage.

About three miles southeast of Afton vertical bluffs rise from the rather narrow channel of the river. The arched fanglomerates, which supposedly dammed Lake Manix, form the southern bluffs and the northern cliffs are mainly the older, resistant rocks of the Cave Mountains which rise 700 feet in about one-tenth of a mile. Lake no. 2 probably rose over the fanglomerates, which were rapidly removed, and flowed northeastward to Baxter and presumably into Soda Lake. According to Blackwelder and Ellsworth (pp. 460-462), Afton Basin was excavated to a depth of at least 1500 feet above sea level.

They believe that this eroded basin was occupied by a third lake of much shorter duration than the others. Lake gravel rests on wave cut benches at an elevation of 1560 feet and is overlain by two feet of greenish clay containing Anodonta californiensis. Terrace remnants at 1619 and 1637 feet above sea level are referred to this lake stage, which must have been confined to the arm of Manix Basin lying east of the mouth of Manix Wash. These authors assume that a new dam was built subsequent to the deep excavation of the basin, but no trace of such a barrier was found. Movement on the Manix Fault (pl. I) has occurred during pre- and post-lacustral times (Buwalda, p. 453) and may have played a part in forming a new dam.

Mojave River has cut at least 75 feet into the resistant rocks beneath the arched fanglomerates (Buwalda, p. 455). Using this figure and extrapolating from the present elevation of the channel, the top of the hard rock was at an elevation of at least 1425 to 1450 feet above sea level. The fanglomerates, therefore, must have been about 365 to 390 feet thick. Thompson (p. 511) cites a well near Afton, on the west flank of the anticline, that penetrated 423 feet of alluvium before striking rock. This places the hard rock at about 200 feet below the channel at Afton. Possibly the resistant rock east of Afton halted the downcutting after Lake no. 2 at 1500 feet above sea level. Buwalda (p. 455) observed " - - - that the lake beds were deposited approximately up to the level of the top of the older rocks where these underlying formations are exposed in the section along the Mohave just east of Afton." If these older rocks were exposed by removal of the overlying fanglomerates, the lake beds postdate the overflow and dissection of the fanglomerate dam and may be deposits of the third lake stage. Perhaps additional work in this area would show that Lake no. 2 cut down only to the resistant rock which then formed a barrier for Lake no. 3.

The dirt road from Manix to C. I. T. Locality 540 (pl. II) crosses a fairly shallow north-south depression that is several hundred feet wide. It can be traced northeastward to Manix Wash, about one mile northwest of the mouth of the wash. On air photos this depression can be traced southwestward, along a meandering course, to at least a mile and a half west of Camp Cady and three-fourths of a mile north of Mojave River channel. Thompson (pp. 443-444) noted apparently similar depressions, at places separated by low alluvial divides, southward from the river along the west base of the Cady Mountains, into Troy Dry Lake, then westward to a mile west of Newberry. The topographic map (pl. I) indicates a similar trough near Minneola. Thompson interpreted these depressions as " - - - an old channel of the river, now separated from the river by wind-blown sand or alluvium washed in from the Cady Mountains." A somewhat similar possibility is that after the draining of Lake no. 2, ancestral Mojave River occupied a channel from Barstow to Troy Dry Lake, thence north and northeast to the present location of Manix Wash. This proposed channel is along the assumed main axis of the basin occupied by Lake Manix. The area around Manix is, and seemingly was during the second lake stage, the lowest part of the basin west of the mouth of Manix Wash. A study of air photos of the area will undoubtedly furnish additional information. Thompson (p. 652) states that Lavic Valley, southeast of Troy Dry Lake " - - - appears to have been a part of a large valley that drained northwestward to the Lower Mohave Valley, near Newberry Spring - - -, but the (Pisgah) lava flow cut off the upper part of the valley and formed a closed basin."

This channel may correlate with Lake no. 3 or the erosional interval after Lake no. 2, assuming that these two phases are separated by a significant time interval. If the post-Lake no. 2 erosion did cut down to 1500 feet near Afton, the stream gradient between Manix Wash and Afton would have been perhaps 20 feet per mile. This is about the average gradient of the present stream which is apparently aggrading. Actually the stream gradient might have been less than 20 feet per mile because, near Manix, the upper surface of the lake beds has been tilted ten to twelve feet per mile to the east (Buwalda, p. 453). Therefore, the erosion of Afton Canyon would not necessarily have affected the Manix area.

At a somewhat later time Mojave River adopted its present course. Possibly the elongated depressions between Newberry and the present channel, and south of Camp Cady (Thompson, p. 444) represent interim channels. At Daggett the river debouches from a rather narrow valley onto a gently sloping alluvial fan. From time to time the stream undoubtedly has occupied different distributaries. A greater quantity of alluvium has been washed down from the Ord Mountains on the south, than from the Calico Mountains on the north (Thompson, p. 441). There is a distinct northwardly convex bulge in the 2000 foot contour line southeast of Daggett. These factors suggest that the river has been forced northward by the excess alluvium from the south.

If Mojave River did at one time flow from Troy Dry Lake to Manix Wash, the present channel must cross the earlier channel west of Camp Cady. How this was accomplished might be determined from air photos. The Manix fault should intersect the river west of Camp Cady; perhaps part of the channel occupies the fault trough.

Isolated meanders, probably tens of feet above the flood plain, are present near Camp Cady. Thompson (pp. 443-444) describes river terraces near Manix Wash, south of the river near Camp Cady, and farther upstream. Buwalda (p. 454) mentions three terraces cut on the fanglomerates near Field. These terraces are ascribed to temporary halts in downcutting caused by the encountering of rock barriers. The present writer suggests that the formation of the Big Bend is due to the existence of rock outliers of the Cady Mountains lying beneath the knobs north of the Big Bend. Rock probably lies close to the surface at several places in Manix

Basin, judging from the fact that the river is forced to the surface at such places as Camp Cady and Afton.

After the terraces were formed, Mojave River again eroded its channel to total depths of 75 feet near Camp Cady and approximately 200 feet near Afton. This erosion cycle postdates Lake no. 3. On the north flank of the Cady Mountains, near Afton, about 75 feet of coarse fanglomerates overlie the Manix Beds (Buwalda, p. 451). Mojave River is ephemeral and only in times of flood does it reach Baxter where it emerges from Afton or Cave Canyon and flows over a gently sloping alluvial surface into Soda and/or Cronise Dry Lake. In early 1952 it emptied into Cronise Dry Lake. Precipitation in the Camp Cady area for 1869-70 was 1.28 inches (Thompson, p. 80).

THE MANIX FAUNA

Faunal List

The following list includes essentially all invertebrates and vertebrates that have been found in the Manix Beds. As has been pointed out in the faunal column of the Stratigraphic Section (pp. 9-12), most of the specifically referable mammalian remains are from deposits of Lake no. 1. For the purposes of simplicity, if a genus is present in the lower beds, a separate designation such as _Equus_ sp., etc., is not listed for the later remains which may or may not represent _Equus_ sp. cf. _E. scotti_, etc.

The Mollusca are those from the clamshell layer of Unit 1 that were collected and identified by D. W. Taylor (personal communication), plus the list, slightly revised, of Blackwelder and Ellsworth (p. 459).

Dr. F. S. Truxal of the Los Angeles County Museum studied the tenebrionid beetle. Siphateles mohavensis remains were examined by Dr. R. R. Miller of the University of Michigan. B. H. Brattstrom of the University of California at Los Angeles identified the tortoise remains. The avian forms are those identified by Dr. Hildegarde Howard as of April, 1954. The Mammalia are classified according to Simpson (1945).

The fragmentary nature of many of the remains and the fact that some forms are represented by only one element suggest that this is somewhat less than a complete consensus of the animals living in the Mojave Desert during middle and late Pleistocene times.

Phylum Mollusca:

(1,2,3)	Anodonta californiensis Lea
(1,2)	Pisidium sp.
(2)	Valvata humeralis californica Pilsbry
(2)	Lymnea modicella Say
(2)	Gyraulus vermicularis (Gould)
(1?,2)	Helisoma ammon (Gould)
(1?,2)	H. subcrenatum (Carpenter)
(2)	Carinifex newberryi (Lea)
(2)	Physa sp.
(1)	Parapholyx effusa Lea

Phylum Arthropoda:
  Class Crustacea:
    Subclass Ostracoda
  Class Insecta:
      Tenebrionidae

Phylum Chordata:
  Class Osteichthyes:

(1,2?)	Siphateles mohavensis Snyder

  Class Reptilia:

(1)	Gopherus sp. aff. G. agassizii (Cooper)

  Class Aves:

(1,2?)	Aechmophorus occidentalis (Lawrence)
(1)	Pelecanus erythrorhynchos Gmelin
(2)	Phalacrocorax auritus (Lesson)?
(1)	Ciconia maltha Miller
(1)	Phoenicopterus copei Shufeldt?
(1)	P. minutus Howard
*	Branta canadensis (Linnaeus)
(1)	Nyroca valisineria (Wilson)?
*	Erismatura jamaicensis (Gmelin)
*	Aquila chrysaetos (Linnaeus)
(1)	Grus? sp.

(1) Phalaropodidae

Class Mammalia:

Order Carnivora:

Canidae:

* Canis sp.

Ursidae:

* Tremarctotherium? sp.

(2) cf. Ursus sp.

Felidae:

(1) Machairodontinae

Order Proboscidea: at least two forms.

(1,2) Mammuthus sp.

Order Perissodactyla:

(1) Equus sp. cf. E. scotti Gidley

(1) Equus sp. cf. E. tau Owen

Order Artiodactyla:

Camelidae:

(1) Giant camel

(1) Camelops sp. cf. C. kansanus Leidy

(1,2) Tanupolama sp.

Antilocapridae:

(2?) cf. Antilocapra sp.

Bovidae:

(1) cf. Bison sp.

(1) Ovis sp.

(3) From Lake beds no. 3.
(2) " " " " 2.
(1) " " " " 1.
(1?,2?) Questionably found in that series of beds.
* Not stratigraphically collected.

Environment of the Fauna

The Mojave Desert today lies in the Lower Sonoran Life Zone. Of those mammalian types still existing in California, the only Manix representatives that one would not expect to find in this life zone are the bears. One is from Lake no. 2 and the other was not stratigraphically collected. Approximately 125, or 83 percent of the mammalian elements found are of Equidae and Camelidae. Eleven, or almost one-half of the remainder, are of Proboscideans, and these may all be of mammoths.

In many morphological characters Camelops resembled the llamas, but was somewhat like Recent camels. Camels would seem to be indigenous to Central Asia, including the Gobi Desert. Tanupolama was a long-legged long-necked form and probably a plains dweller. Long-necked guanacos are (or were) abundant on the semiarid plains of Patagonia (Flower, 1891, p. 302). The larger horse possessed a medium-sized body but rather large head and feet. Troxell (1915, p. 617) suggests that Equus scotti lived in a region of abundant vegetation. An intensive search in the Manix Beds uncovered no fossil plants. Equus przevalskii, the wild horse of the desert of Central Asia, is a relatively broad-hoofed form (Flower, 1891, p. 383). The scarcity of remains of the smaller Manix horse suggests that it was less abundant in the lowlands than the larger form, and may have been an inhabitant of the mountainous areas. Judging from the limb bones, at least one of the Proboscideans was thin-limbed and rather short. The complete lack of sloth remains is rather puzzling, but none were found at Lake Cochise, Arizona (Bryan and Gidley, 1926). A large majority of the herbivore remains came from Unit 16 or below. Only four bones could be identified as being of carnivores and apparently none were found below Unit 16.

Vardas appropriately termed the Pleistocene Manix Basin a "Haven for herbivores." The lack of carnivores is most easily explained by the supposition that they were excluded by a hot, dry climate prior to the deposition of Unit 16. The tortoise, similar to the existing desert species, and perhaps the tenebrionid beetle are further evidence for such a desert type climate preceding Lake no. 1. Very likely there were small shrubs and short grasses, but the vegetation was probably little different from today's.

The pelican bone from Unit 17 was only slightly below Unit 16, and the flamingo - Phoenicopterus copei ? was not in situ and may have washed out of Unit 16 which contained many bird bones.

Most of the birds live in the Great Basin today and are possibly indicative of a slightly cooler climate than today's during their accumulation in Unit 16 and other lake beds. They are mainly forms that inhabit or feed in shallow waters of a pond or lake. Fossil locality 540 is near the edge of Manix Basin.

The best climatic indicators for the pluvial periods are the mollusks Valvata, Helisoma subcrenatum and Carinifex. Their present distribution intimates cooler summers during the second lake stage (D. W. Taylor, personal communication). The clamshell layer in Lake no. 2 beds evidences quiet water and, as do the mollusks from Lakes no. 1 and no. 3, the presence of a fresh water lake.

Faunal Correlations

Except for Lymnaea, D. W. Taylor (personal communication) has collected all of the Lake no. 2 invertebrate species from the Salt Wells Valley, California Pleistocene deposits. During the Tahoe (?) glacial subage a lake occupied Salt Wells Valley, but in the Tioga (?) subage the valley contained only a stream connecting Lakes China and Searles (Hubbs and Miller, 1948, p. 81). The mollusks inhabit quiet water and therefore are probably from the Tahoe (?) phase. Taylor believes that the Manix and Salt Wells Valley faunas may be contemporaneous, but that most of the Manix mollusks probably ranged through the three stages of Lake Manix unless there were saline low levels with no outlet. The playa that developed after the first lake stage probably indicates complete dessication of Manix Basin. It seems that the mollusks must have migrated in during the second lake stage, either from the headwaters of Mojave River or through a hydrographic connection that no longer exists.

Siphateles mohavensis exists in the present Mojave River. It supposedly evolved from a common stock, of northern Great Basin origin, with a fossil and Recent species of Owens River (R. R. Miller, personal communication). If, as seems probable, the fish remains from Unit 16 are of S. mohavensis, this species must have already differentiated from the Owens River species and/or the common ancestor. Yet the Owens River and Mojave River species have never been reported together, Recent or fossil. A possible assumption is that the Owens-Mojave Rivers connection through Death Valley antedates Lake no. 1 and that no later connection permitted the mingling of the two species. Under this hypothesis the invertebrates in Manix Basin must have migrated in before the first lake stage and became established in the headwaters of Mojave River.

Desert tortoise remains from McKittrick, California (Miller, 1942, p. 439) and from Rampart Cave, Arizona (Wilson, 1942, p. 176) are indistinguishable from the Recent Gopherus agassizii whereas the Manix tortoise is possibly an extinct species.

Two of the avian species are probably the same as Fossil Lake or Rancho La Brea forms. Most are still living, but slightly less than a third are extinct (Howard, in press).

Most of the Manix mammalian remains were closely compared with elements from Rancho La Brea, McKittrick, Irvington, Bautista Creek, etc., west of the mountains bordering the Mojave Desert. Seemingly these faunas are not closely related to the Manix fauna.

Camelops kansanus and Equus scotti suggest equivalence with the late Kansan or early Yarmouthian Tule formation (Rock Creek Beds) of Texas, Grand Island formation (Hay Springs or Sheridan Beds) of Nebraska, and Crooked Creek formation (at Arkalon gravel quarry) of Kansas. The machairodontine humerus is somewhat like one from Hay Springs and, as does the Tremarctotherium? atlas, intimates some antiquuty. However, Bison has not been found in any of those formations. The American Falls, Idaho, Camelops may well be the same as the Manix and Sheridan Beds C. kansanus, and that fauna (Gazin, 1935) includes two Bison - one of them small, cf. Antilocapra americana, and a large ursid that may be a tremarctothere. The American Falls fauna must be somewhat younger than early Yarmouthian and Gazin suggests a glacial age.

Ovis is normally considered to be a late Pleistocene form, but Schultz, Lueninghoener, and Frankforter (1951, Table 1) list Ovis canadensis from Yarmouthian deposits of Nebraska. The Ovis sp. cervical vertebra from Manix does differ somewhat from those of Recent and late Pleistocene bighorn sheep. Frick (1937, p. 554) concludes that the scarcity of fossil sheep remains may be due to their mountainous habitat.

The Borchers fauna (Hibbard, 1949, p. 1424) and an assemblage from gravels in South Dakota (Warren, 1952, p. 1148), of probable Yarmouthian age, contain a camel as large as Gigantocamelus. Small horses, about the size of Equus tau, apparently range throughout the Pleistocene.

It seems that the Manix fauna would be somewhat similar to faunas of the same age from other parts of the Basin and Range Province. Equus pacificus, the Fossil Lake horse is considerably larger than the Manix horse. Simpson (1933, p. 3) identifies the Clark County, Nevada horse as E. pacificus. Merriam (1918, p. 520) considers one of the Lake Lahontan horses to be near that species. Gidley (Bryan and Gidley, 1926, P. 482) found Equus sp. cf. E. pacificus in the Lake Cochise, Arizona fauna. Camelops hesternus is the camel usually associated with this horse.

Elftman (1931, p. 2) mentions arrow heads that were discovered with the Fossil Lake fauna which occurs in place near the top of the Pleistocene lake sediments (Allison, 1941, p. 1979). A probable obsidian artifact and charcoal were found in the Clark County, Nevada, deposits (Simpson, 1933, p. 9). Except for one Proboscidean, all the Lake Lahontan fossils are probably from the youngest beds (Merriam, 1918, pp. 517-518) which also contained a spearhead that was undoubtedly associated with the mammals (Russell, 1885, p. 247). On physiographic evidence Bryan (and Gidley, 1926, p. 482) consider the Lake Cochise sediments to be late Pleistocene. At the time of the Fossil Lake and Lake Lahontan artifact discoveries it was considered most improbable that man could have inhabited North America at the same time as the mammals then considered to be "early Pleistocene." It is now recognized that any artifact made as recently as 8,000 (Hibbard, 1949, p. 1419; Libby, 1954, p. 138) and possibly 6,000 years ago (Camp, Welles and Green, 1953, p. 4) could be legitimately associated with many of the extinct "Pleistocene" mammals.

Negative evidence is of little value, but despite the intensive searching in Manix Beds of Lakes no. 1 and no. 2, no artifacts have been found. The Manix horse and camel are almost certainly specifically different from *Equus pacificus* and *Camelops hesternus*.

AGE OF THE MANIX BEDS

In speaking of the Pleistocene it is necessary to have an understanding of what the epoch includes. According to Woodring (1952, p. 408) the San Joaquin formation, which contains the Blancan horse *Equus (Plesippus) proversus*, correlates with the Pico and other late Pliocene marine formations in California. For purposes of this report, the Blancan provincial age is therefore considered to be late Pliocene.

The Holdredge-Fullerton (Broadwater) formation in Nebraska (Frye, Swineford, and Leonard, 1948, p. 521) and the Blanco formation, Holdredge and Fullerton members, in Kansas (Moore et al., 1951, p. 15) are of Nebraskan and early Aftonian age. A necessary corollary is that the Nebraskan glacial stage, in this report, is of late Pliocene age. The terms early and middle Pleistocene therefore become very confusing, so glacial and interglacial stage names are herein used, where practicable.

From the Manix remains he recovered, Dr. Buwalda (1914, p. 451) identified " - - - one or more species of birds, four species of fresh-water mollusks, and one or more species of fish - - - a large horse quite certainly _Equus_, a somewhat smaller horse, a large camel, a smaller camel, a mastodon or an elephant, and an antelope." He suggested " - - - an early stage of the Pleistocene" for the age of the Manix Beds, under " - - - the supposition that camels became extinct in North America before Glacial time." Compton (1934, p. 167), Hay (1927, pp. 160-161), Merriam (1915B, p. 262), and Wood et al. (1941, pl. I) arrive at estimates of late Pliocene to late Pleistocene for the age of the remains collected by Buwalda.

Blackwelder and Ellsworth (1936), on physiographic evidence, tentatively correlate Lake no. 1 with the Tahoe and Lake no. 2 with the Tioga glacial substages. Lake no. 3 is considered to have existed during Recent times or at the close of the last glacial age and may or may not be of climatic significance.

Camp sites and artifacts, about 9,000-10,000 years old, were found at the overflow level of Lake Mohave, a Pleistocene lake in the basin of Soda Dry Lake (see Campbell and Campbell, 1937; Campbell, 1949, p.340; and Antevs, 1952, p. 26). The maximum rise of that lake is considered to be of the Tioga glacial substage and to equate with the stage of Lake Manix, no. 2, which Blackwelder and Ellsworth had called Tiogan.

A short discussion of other Basin and Range Pleistocene lakes and of the glacial and diastrophic history of the Sierra Nevadas is necessary for an attempted correlation of the Manix Beds with those phases of Pleistocene developments.

Lake Lahontan evidently experienced three distinct moist substages during the Wisconsin with complete dessication between substages 1 and 2, but with the clays of substages 2 and 3 being conformable (Morrison, 1952B, p. 1367). There were two pre-Wisconsin stages and four Wisconsin substages of Lake Bonneville (Bissell, 1952, p. 1358; Richmond, Morrison, and Bissell, 1952, p. 1369) with probably complete dessication between Wisconsin substages 2 (Bonneville shoreline) and 3 (Provo shoreline). Substage 4 is the Stansbury level. Two radiocarbon dates of slightly more than 11,000 years (Libby, 1952, p. 86) from Danger Cave on the old beach of Lake Stansbury show that substage 4 equals the Mankato glacial substage (Allison, 1952, p. 908). Richmond, Morrison, and Bissell (1952, p. 1369) consider Lake Stansbury to be the counterpart of Lake Lahontan substage 3. One might therefore infer a Mankato age for the Lake Lahontan vertebrates. A radiocarbon date of 6,453 ± 250 years for the Mount Mazama (Crater Lake) pumice leads to a Mankato age for the 4,325 foot bench at Upper Chewaucan Marsh (and Summer Lake), Oregon (Allison, 1952, p. 907), and possibly for the youngest, vertebrate-bearing beds at Fossil Lake. The uppermost levels of Summer Lake are assumed to be pre-Wisconsin (p. 907).

A radiocarbon date of at least 16,000 years (Libby, 1952, p. 85) for the presumably glacial mud seam between the upper and lower salt deposits at Searles Lake suggests a Cary or earlier glacial substage (see Antevs, 1954, p. 183) for the rise of Searles Lake that was assumed to be Tiogan (see Blackwelder, 1941, p. 1943). If beds of rock salt are indicative of the disappearance of a lake (see Nolan, 1927, p. 41), it is interesting to note that one of the test holes in Bristol Dry Lake, about 65 miles southeast of Manix, showed five distinct beds of rock salt down to a depth of 152 feet.

Putnam (1949, p. 1295) observed that the highest bench in the Mono Lake area is cut in the Tahoe moraine and a lower one is cut in the Tioga moraine, but considers his correlations to be only tentative. About 30 benches lie below the Tioga shoreline.

Blackwelder (1931) found evidence of four glacial advances on the eastern slopes of the Sierra Nevadas. The earliest, McGee, stage is presumed to be of Nebraskan age and antedates the present eastern front of the range (p. 904). The second, Sherwin, stage is dated as Kansan. This advance postdates the Sierran uplift (Gilbert, 1938, p. 1832). Blackwelder (p. 919) considers it possible that glacial deposits of Illinoian age are present, but not differentiated from the Sherwin till. Howevever, Putnam (1952, pp. 1291-1292) found only three glacial tills in sections along Owens Gorge and in Los Angeles aqueduct tunnels, the oldest being the Sherwin.

The last two advances in Blackwelder's (1931) terminology are the Tahoe and Tioga, early and late Wisconsin, substages. Possibly the Tahoe substage correlates with the Iowan-Tazewell substages of the Wisconsin, which seem to be closely related (Flint, 1950, p. 1461; Antevs, 1954, p. 183; Frye and Leonard, 1952, pp. 132-135). R. P. Sharp (personal communication) believes the field evidence in the Sierras indicates the Tioga and Mankato substages are probably correlative. Antevs (1954,

p. 183) considers the Cary substage to be the late Wisconsin pluvial maximum in New Mexico.

West of the Sierran divide the first, Glacier Point, stage is assumed by Matthes (1930, pp. 73-74) to be Kansan or Nebraskan. The second advance, apparently correlative with the Sherwin, is Illinoian or Kansan, probably Illinoian. Grant and Gale (1931, p. 62) agree that the Sierra Nevada uplift began after the first glaciation was over and (p. 75) consider the second glaciation to be Illinoian in age.

Eliminating the remains above Unit 16, the Manix Beds mammalian fauna shows some definite and some probable relationships to late Kansan and Yarmouthian faunas from the Great Plains. The dry period preceding Lake no. 1 must have been of considerable duration judging from the 300 to 400 feet of fanglomerates that were deposited. It is probable that this dry episode was the Yarmouth interglacial age, which would also seem to be the time of the Pasadenan Orogeny.

Lake no. 1 probably existed during and shortly after the Illinoian glacial age. If the uplift of the Sierras and the Mojave Desert ranges was contemporaneous, this lake may represent the Sherwin stage of Blackwelder's (1931) Sierran glacial sequence, which he considers, on physiographic evidence, to be Kansan in age. However, Matthes (1930, pp. 73-74) considers the apparently correlative second glacial stage on the west side of the Sierras to be probably Illinoian. The three glacial tills, including the Sherwin, in Owens Gorge (Putnam, 1952, pp. 1291-1292) could, conceivably, time equate with the three high cycles of Lake Manix. The distance between these areas is about 150 miles. Assuming that the diastrophic and sedimentary history of Manix Basin is correctly stated in the Geological Setting (pp. 5-9), there is some evidence that the

Sherwin glacial stage may be Illinoian rather than Kansan.

The shorter interpluvial, after Lake no. 1, would be of Sangamon Interglacial times.

It follows that the second lake stage rose during Tahoe (Iowan-Tazewell ?) times. There is no concrete evidence for an interpluvial between Lakes nos. 2 and 3, but apparently there was considerable erosion in the interval between the two. Lake no. 3 might not have been precipitated by a pluvial age, but the dating of the first lake stage suggests that it existed during the Tioga subage.

It is interesting to note that Soda, Silver, and Manix Lake Basins were dry (Albright, 1921, p. 116; Williamson, 1855, p. 33) during the culmination of the little ice age in the 1850's. Mojave River was apparently little different then than it is today. Lake no. 3 might date from the Recent Cochrane glacial advance, but it is more probable that it preceded the thermal maximum and was late Wisconsin in age.

SYSTEMATIC DESCRIPTION OF THE MAMMALIA

CARNIVORA

Canidae

Canis sp.

Referred Specimen: Third cervical vertebra, U. C. M. P. locality 791, unnumbered specimen.

Compared with the third cervical of a female *Canis latrans* of about the same age, the main difference is the presence of only a very low ridge for a neural spine. The overall sizes of the two are approximately the same, but the individual parts differ quantitatively and qualitatively.

Ursidae

Tremarctotherium? sp.

Referred Specimen: Portion of an atlas, no locality number, C. I. T. 5091.

Measurements:	*Tremarctotherium?* sp. C.I.T. 5091	*Tremarctotherium simum* U.C.M.P. 3035
Greatest distance between lateral borders of anterior and posterior articulating facets	78	68
Greatest dorso-ventral diameter of anterior articulating facet	39	32.4
Greatest dorso-ventral diameter of posterior articulating facet	33	32.5

Merriam and Stock (1925, p. 4) divide the Recent and Pleistocene bears of the western hemisphere into two groups, one containing *Ursus* and allied genera, the other including *Tremarctos* and *Tremarctotherium*. One of the distinguishing characteristics of the *Tremarctotherium* group is (p. 4) "(8) Atlas with posterior opening of vertebrarterial canal on upper side of transverse process in advance of posterior edge." Although the transverse process is broken on C. I. T. 5091, the posterior medial border of the vertebrarterial canal is clearly turned upward. Since the posterior articulating facet is complete, there can be no doubt that the posterior opening was on the upper side of the transverse process. The atlas of *Tremarctotherium simum* from Potter Creek Cave, California, U. C. M. P. 3035, is appreciably smaller and the posterior opening is apparently farther anterior on the dorsal surface of the transverse process. In *Agriotherium schneideri* (U.C.M.P. 30557) from Coffee Ranch, Texas, and *Indarctos? oregonensis* (U.C.M.P. 22362) from the Rattlesnake Beds, the posterior opening is ventral to the lateral border of the posterior articulating facet. Merriam and Stock (1925, p. 5) believe the Recent and Pleistocene

Tremarctinae " - - - represent a line passing through or very close to the Hyaenarctos (Agriotherium) group." The overall size, the position of the posterior opening of the vertebrarterial canal, the shape and size of the groove connecting the alar and intervertebral foramina, and other characters of the Manix atlas suggest that this ursid is specialized in the direction of Tremarctotherium simum but retains some characters of the Hyaenarctos group. The possibility arises that the atlas might represent T. californicum, but Rinker (1949, p. 109) and Schultz (1938, p. 174) believe, as had been suggested by Merriam and Stock (1925, p. 9) that T. simum and T. californicum may be conspecific.

cf. Ursus sp.

Referred Specimen: Median phalanx, C. I. T. 5092.

A mature median phalanx of an ursid is too small to represent Tremarctotherium.

Felidae

Machairodontinae

Referred Specimen: Humerus shaft, including entepicondylar foramen, C. I. T. 5093 (pl. III).

Measurements:

Greatest length	e305
Least width of shaft	24.6
Least fore and aft diameter at entepicondylar foramen	25.8
Greatest inner length of entepicondylar foramen	7.4

The distinguishing characteristics of this machairodont humerus are the extreme transverse flattening of the shaft and the small size of the entepicondylar foramen. The shaft is considerably smaller than that of Smilodon californicus. Although specimen 5093 is longer and possesses a somewhat dissimilar entepicondylar foramen, it is strikingly similar to humeri (U.C.M.P. 30191 and 30192) of Machairodus catocopis from Coffee Ranch, Texas (Burt, 1931). Loren Toohey, who compared the Manix element with machairodontine humeri at the American Museum, also reaches this conclusion regarding M. catocopis, and adds that an unnamed humerus from Hay Springs, Nebraska " - - - agrees in some respects to the Manix specimen." Until Machairodus is definitely identified from the Pleistocene, it seems inadvisable to refer this bone to that genus. Glen Evans (personal communication) asserts that the humeri of Dinobastis in the Texas Memorial Museum are not transversely flattened.

PROBOSCIDEA

Referred Specimens: Portion of distal end of tusk, C. I. T. 5094; immature supraoccipital, U. C. M. P. 29770; immature exoccipital, C. I. T. 5095; fragments of enamel tooth plates; portion of a vertebra; proximal two-thirds of right radius, C. I. T. 5096; third metacarpal, U. C. M. P. 23821; incomplete proximal phalanx, U. C. M. P. 29768; phalangeal sesamoid, C. I. T. 5090 (pl. III).

Measurements:	Radius C.I.T.5096	Third metacarpal U.C.M.P. 23821
Greatest length	e825	180
Proximal width	a105	75
" depth	a 57	a 85
Least width at mid-shaft	e 55	58
" depth " " "	50	43
Distal depth	-	a 66

Probably at least two species of Proboscidea are represented. There are several fragments of enamel tooth plates of Mammuthus. The above measurements of the radius and metacarpal intimate a fairly short, thin-limbed form, apparently exceeding in size only Mammuthus exilis. The radius seems more like that of Mammuthus. A peculiarity of the immature supraoccipital is the shallowness, as contrasted with a young Elephas indicus of the pit for the attachment of the ligamentum nuchae. The phalangeal sesamoid (pl. III) closely resembles phalanx 1, digit 5, of the manus of *Mylodon*, but examination of a modern elephant manus in the National Museum left no doubt of its true identity. Several sesamoids of *Mammuthus columbi*, U. S. N. M. 10196, from Washington are similar to, but smaller than, the Manix specimen.

Mammuthus sp.

The *Mammuthus* tooth plates are too fragmentary to permit a species reference.

PERISSODACTYLA

Equus sp. cf. *E. scotti* Gidley

Referred Specimens: Occipital condyle and portion of basisphenoid, C. I. T. 5097; portion of mandible, C. I. T. 5098, including ascending ramus, nearly complete M/3 (pl. IV), portion of M/2 and alveoli of M/1-M/3; portion of ascending ramus, U. C. M. P. 23815; portion of horizontal ramus, U. C. M. P. 23816 and 23817, including alveoli for P/3-M/2; incomplete P2/, C. I. T. 5099 (pl. IV); incomplete M/2(?), C. I. T. 5100 (pl. IV); portion of a lower tooth showing the metastylid column, C. I. T. 5101 (pl. IV); atlas, C. I. T. 5102; third metacarpal, C. I. T. 5103 (pl. III); four calcanei, U. C. M. P. 23818 and 23819, C. I. T. 5104 and 5105; astragalus, U. C. M. P. 23812; proximal phalanx, U. C. M. P. 23809; incomplete ungual phalanx, C. I. T. 5106 (pl. III); vertebrae; other tooth and skeletal fragments.

Measurements: Compared with those of *Equus scotti*.

Teeth:	C.I.T. 5099	(1914)	(1901)
P2/ length	a38.5	42	43
" width.	e28	31	30.5

	C.I.T. 5100	(1914)	
M/1 length	e30.6	29.5	-
" width.	a15.6	17	-

	C.I.T. 5098*	(1914)	
M/3 length	a38	34	-
" width.	a14	15	-

Mandibles:	U.C.M.P. 23815 - 23817**, and C.I.T. 5098	(1914)	(1953)
Length of P/2-M/3 alveoli . .	e175, a195	-	-
Length of molar-premolar series.	-	203	189,194
Labial depth between P/2 and P/3	a84	-	92,104.5
Labial depth between P/4 and M/1	a109	105	108,119
Labial depth at posterior border M/3.	a137	-	138,141.5

Skeletal elements: Atlas:	C.I.T. 5102	***	
Greatest width anterior articulating facets . .	a92.5	87	-
Greatest width posterior articulating facets . .	91	91.5	-
Greatest antero-posterior length on outer edge of articulating facets .	a99	99.5	-

Third metacarpal:	C.I.T. 5103	(1914)	(1953)
Greatest length	237	236	230
Width proximal articulating surface	51.6	57	56
Depth proximal articulating surface	33	35	-
Width at mid-shaft	35	38	-
Depth " " "	28	29	-

Width distal articulating surface	a47	54	55.5
Depth of keel	39.2	40	-
First phalanx:	U.C.M.P. 23809	(1914)	(1953)
Greatest length	83	88,94	89
Proximal width	52	63,60	62
Distal width	45	-	48
Posterior ungual phalanx:	C.I.T. 5106	(1914)	----
Greatest width	e81	86	-
Length on front slope . . .	58	64	-
Calcanei:	C.I.T. 5104, 5105	U.C.M.P. 23818, 23819	(1914)
Length.	115,120	118,117	123
Astragalus:	U.C.M.P 23812	(1914)	----
Greatest length	67	67	-
Width of articulation for navicular	51.5	57	-

(1901) -Gidley, p. 136.
(1914) -Hay, pp. 183-186.
(1953) -Hibbard, pp. 123-124.
* Tooth somewhat flattened transversely and elongated antero-posteriorly by compression of overlying sediments.
** Ramus of old individual.
*** Equus caballus, Florida Geol. Survey V4717.

With the exception of three bones referred to Equus sp. cf. E. Tau, all the equine skeletal elements suggest a short-legged horse of medium build. All the jaws and teeth, however, indicate a heavy-jawed animal with very high-crowned teeth. It is possible that one species is represented by the skeletal elements and a larger species by the skull material. A more probable answer is that the larger Manix horse is the " - - - huge-skulled, medium-build - - -" (Savage, 1951, p. 251) Equus scotti. The tooth measurements of the Manix horse are not exact because the teeth are incomplete or were somewhat compressed by the overlying sediments, but they approximate those of E. scotti. P2/ is of an old individual and both diameters decrease with age. Hay (1914, p. 183) figures a P2/ of E. scotti with a similar enamel pattern and the pattern on the lower teeth is uncomplicated, as in the Manix teeth. A lower cheek tooth fragment, C.I.T. 5101 (pl. IV), has a metastylid column that is convex inward and the gutter seems to have a moderately sharp apex, as do P/3s of Equus scotti (Hay, 1914, p. 183; Hibbard, 1953, p. 122). The isolated M/1 (?) is very high crowned.

As in E. scotti, the mandibles are heavy and have a distinct convexity on the inferior border below M/1. These characters are also common to the plesippines and to Equus occidentalis (Schultz, 1938, p. 197) - the Rancho La Brea-McKittrick horse. However, the ungual phalanx and atlas are too large to represent those horses. The metacarpal is significantly shorter and not as heavy as those of E. occidentalis from Rancho La Brea.

The metacarpal, ungual phalanx, atlas, and other bones are considerably smaller than those of Equus pacificus - the Fossil Lake horse. The atlas was compared with one of E. caballus; apparently there are no published measurements of an E. scotti atlas. A horse is indicated that has a wider occiput than E. caballus, but a slightly narrower axis. The Manix atlas is slightly shorter, but much more massive. These factors suggest a horse with a large skull and do not contradict the possibility of a short neck as in E. scotti (Gidley, 1900, p. 113).

The metacarpal, calcaneum, astragalus, and ungual phalanx are narrower than those of E. scotti, but the differences might be attributable to sexual or geographic variations. The fact that the limb elements from Manix have the same relative variation is perhaps an indication that all are of one species.

The limb elements are of a form adapted to life in the basins and low-lying hills that are found in much of the Mojave Desert today. Troxell (1915, p. 617) considers E. scotti of the Rock Creek beds as having lived " - - - in a region surrounded by luxuriant vegetation with plenty of food and water - - -." Despite an intensive search in the Manix Beds, no trace of fossil plants could be found, and it seems doubtful that vegetation was much more plentiful during the Pleistocene than it is now.

Equus sp. cf. E. tau Owen

Referred Specimens: Proximal end of third metacarpal, U. C. M. P. 23813; distal end of metapodial; astragalus, U. C. M. P. 23811.

Measurements:

Width of proximal articulating surface of metacarpal	42
Depth of proximal articulating surface of metacarpal	27.5
Width of distal articulating surface of metapodial	[a]39
Depth of inner portion of distal articulating surface	26.3
Depth of keel of metapodial	30.6
Length of astragalus on inner side . .	50.4
Width of astragalus across tuberosites.	49
Width of articulating surface for navicular	[a]39

These three elements indicate a very small horse of the size of Equus hemionus or E. tau. No skeletal material was found with the E. tau teeth from Mexico, but Savage (1951, pp. 244-245) refers E. francisi Hay to that species. The skeletal material of Hay's (1915, pp. 545-549) species from the Lissie formation of Texas is, in general, somewhat smaller than E. hemionus. Skinner (1942, pp. 170-171)refers a phalanx from Papago Springs Cave, Arizona to E. tau. Remains of small horses are in the Gypsum Cave and other late Pleistocene faunas in the C. I. T.

collection. Perhaps more than one species of small horse lived in the west during the Pleistocene. Mainly in order to indicate the small size of the smaller Manix horse, it is compared with E. tau.

ARTIODACTYLA

Camelidae

Giant camel

Referred Specimen: M2/(?), C. I. T. 5107 (pl. IV)

Measurements of M2/:	C.I.T. 5107	Gigantocamelus spatula (Meade, 1945, p. 533)
Length	e47	53.7, 54, 49.5
Width.	e32	35, 35, 37.6

The large size, sharpness of the mesostyle, and apparent presence of labial ridges between the styles indicates that this tooth represents a camel larger than Camelops. Comparisons were made with the teeth of Gigantocamelus fricki (equals G. spatula, see Meade, 1945, p. 531) Nebraska State Museum specimen 18559-39 from Garden City, Nebraska, which Dr. C. B. Schultz kindly loaned for study. An occlusal view of M2/ of G. spatula is shown in Plate IV, along with two occlusal sections of the Manix tooth. Teeth of G. spatula are only slightly larger. The posterior fossette of the Manix tooth has a deep inflexion or fold in the anterior border. This inflexion is also present on many upper cheek teeth of G. spatula and also of Camelops hesternus (see Elftman, 1931, fig. 5B, p. 14; Merriam, 1913, pp. 308, 312). The fossettes are extremely wide transversely, but this characteristic is also seen in M3/ of G. spatula from Nebraska and in C. hesternus teeth from Rancho La Brea (Merriam, 1913, pp. 308, 312). The tooth is 42 mm high, measured from the junction of the roots on the labial side, and this height was exceeded by at least 10 mm before the tooth was ground down in order to show the enamel pattern.

It is, therefore, not of Titanotylopus which Barbour and Schultz (1934, p. 1) describe as having distinctly brachyodont cheek teeth. A comparison with Megacamelus blicki Frick (1929) was not possible, but Frick examined the tooth and did not suggest correlation with the Arizona genus. The large camelid teeth from Curtis Ranch, Arizona, U. S. N. M. 12870 (Gazin, 1942, pp. 513-514) possess a sharper mesostyle, much narrower fossettes, and other characters distinguishing them from the Manix tooth.

In a preliminary draft of this paper, the tooth was questionably referred to Gigantocamelus, a genus that is apparently limited to the Blancan provincial age (Meade, 1945, p. 517). Giant camels, as yet unnamed, have been found in middle or late Pleistocene deposits in Mexico (de Terra, 1953, p. 748), South Dakota (Warren, 1952, p. 1148), and Kansas (Hibbard, 1951, p. 233). Even though the Manix tooth resembles those of Gigantocamelus, it seems unwise to extend the range of that genus into the definitely post-Blancan Manix Beds until these later giant camels are identified.

Camelops sp. cf. C. kansanus

Referred Specimens: Three incisors, C. I. T. 5108 (pl. V); cheek teeth fragments; portions of a skull, C. I. T. 5109 (pl. V), including incomplete supraoccipital and parts of the temporal, auditory and occipital regions; many skeletal elements.

S. E. Helprin of the Frick Laboratory compared the incisors, cheek teeth fragments, skull parts, and measurements of the skeletal elements with material available to him. His conclusion was that the Manix remains are " - - - practically indistinguishable from specimens collected at quarries in Sheridan County, Nebraska" which Schultz and Stout (1948, p. 566) identify as Camelops kansanus. Careful examination of the material at the Los Angeles Museum and the University of California leaves little doubt that the Manix camel does not represent either *C. hesternus* from Rancho La Brea (Merriam, 1913) or *C. minidokae* from Irvington, California (Savage, 1951, pp. 253-259).

If incisors are diagnostic, the Manix camel is closely related to the American Falls camel which Gazin (1935, pp. 300-301) calls "*Camelops* cf. *hesternus*. - - - However, no important differences in teeth and foot material were observed when comparisons were made with *Camelops kansanus* from Hay Springs, Nebraska." The incisors from Manix and American Falls are very long, fairly thin labio-lingually especially in the distal portions, overlap rather strongly, are concave to only slightly convex upward on the lingual surfaces, and the roots are apparently only slightly curved upward. Some Nebraska incisors referred to *Camelops niobrarensis* are similar though somewhat smaller; possibly these teeth would now be referred to *C. kansanus*. Cope's (1893, p. 72) description of those of *Holomeniscus* (=*Camelops*) *hesternus* from Austin, Texas, fits the Manix teeth in their overlapping and being strongly procumbent. Merriam (1913, pp. 320-321) questions the species reference of the Texas camel; Hay (1914B, p. 275) considers it as probably being *Camelops huerfanensis*.

The Manix camel was of a size intermediate between *C. minidokae* and *C. hesternus*. Skeletal elements and teeth from Isleta Cave, New Mexico, of a camel slightly larger than the Manix form, have been referred by the writer (unpublished manuscript) to *C. sulcatus* (Cope). Savage (1951, p. 263) considers this species to be a smaller *Camelops* but the New Mexico material and a careful study of Cope's (1893, p. 85) type jaw indicate that it is only slightly smaller than *C. hesternus*. M/1 of *C. sulcatus* is about 10 mm shorter than an M/1 of *C. hesternus*, making the overall cheek teeth measurements less, but the other teeth are of almost equal size or even larger.

Tanupolama sp.

Referred Specimens: Five lumbar vertebrae; portion of ulna-radius, C. I. T. 5110; proximal end of metacarpal, C. I. T. 5111; five proximal phalanges, U. C. M. P. 23841 and 23842, and C. I. T. 5112; two median phalanges, U. C. M. P. 23843 and 23844; distal ends of two tibias, U. C. M. P. 23831 and C. I. T. 5113; portions of four metatarsals, U. C. M. P. 23814 and C. I. T. 5114; calcaneum, U. C. M. P. 23827; portions of pelvis, U. C. M. P. 29772.

Measurements:

	Metacarpal C.I.T. 5111	Proximal phalanges (5)	Median phalanges (2)	Tibias (2)	Metatarsals (4)	Calcaneum
Greatest length...	-	92.6-107.1	45, 49.5	-	-	131.3
Proximal width ...	54	25.1- 31	23, 25	-	44-[a]53	-
" depth ...	-	25.7- 29.9	20, 23	-	[a]38- 42	-
Distal width	-	19 - 24	19, 21	62, 64	[a]60	45
" depth	-	19 - 23	17, 20	43.4, 45	[a]33	-

Major axis of acetabulum of pelvis .. 53
Minor " " " " " ..[a]45

The skeletal elements indicate a camelid about the size of Tanupolama stevensi (Stock, 1928, p. 36) or of smaller specimens of Tanupolama blancoensis (Hibbard and Riggs, 1949, p. 858). Some undescribed metapodials and phalanges of T. stevensi in the C. I. T. collection are as large as the Manix elements. Tanupolama longurio (Hay), from Anita, Arizona, is probably a smaller species as indicated by the type (see Gazin, 1942, p. 516), although Hibbard and Riggs (1949, p. 855) consider an anterior first phalanx, referred by Hay, as indicating a very large species.

Tanupolama seems to be the one genus of long-legged llamas inhabiting North America during Blancan and later times. Though no teeth or skull parts were recovered, the Manix llama is almost certainly of that genus.

Antilocapridae

cf. Antilocapra sp.

Referred Specimen: Last thoracic vertebra, U. C. M. P. unnumbered specimen, locality 676.

Measurements:

	U.C.M.P.	Antilocapra U.S.N.M. 49688	americana U.S.N.M. 270598 ♀
Greatest length of body. . .	34.6	31	32.4
Depth of body at middle of anterior face. . . .	17.3	18.4	17.3
Depth of body at middle of posterior face . . .	17.3	17.6	18.0
Width of posterior face of body	23.7	23.2	24.7

A last thoracic vertebra is indistinguishable from those of Antilocapra americana. Vertebrae of Antilocapra americana were found on the surface of the upper beds and may represent Recent pronghorns.

Bovidae

cf. Bison sp.

Referred Specimen: Distal half of scapula, C. I. T. 5116.

A distal half of an apparently immature scapula is very similar to that of a Bison in the following respects: (1) the spine is very thin, bent backward in its middle, merges into the blade somewhat below the suprascapular border and forms a broad, low ridge; midway between the acromion and the suprascapular border the base of the spine is narrow, and the upper edge of the spine is rounded off, not rugose; (2) the prescapular fossa is very narrow, or conversely the spine is near the anterior border of the blade and the postscapular fossa is very wide; (3) the blade itself is very thin; (4) a rounded ridge is present on the posterior ventral edge; and (5) it compares closely in size with that of a mature Bison bison.

The suprascapular border is relatively thick and pitted, suggesting an immature scapula. Perhaps some of the above characteristics would change somewhat with age. The scapulae of Cervus and some bovids are similar to a Bison's, but apparently are never as large. Nearly every other large Pleistocene mammal was eliminated as a possibility. The size similarity to Bison bison is perhaps due to the immaturity of the Manix scapula which probably represents a somewhat larger species. If the scapula is of a small or medium-sized Bison, a fairly late phase of the Pleistocene is indicated.

Ovis sp.

Referred Specimens: Third cervical vertebra, C. I. T. 5115 (pl. V); proximal phalanx, U. C. M. P. 23846.

Measurements:	C.I.T. 5115	Ovis canadensis ♀ from S.E. California U.S.N.M. 155622
Length of body on dorsal surface	51	46
Anterior width of body on ventral border	27	25.5
Anterior depth of middle of body	19	17
Posterior width of body	32	29
" depth " "	25	23.7

The third cervical vertebra of a female Ovis canadensis is so unlike that of any other form examined that there is little hesitation in referring a similar Manix vertebra to that genus: (1) the anterior face of the body is rectangular, almost square; (2) the posterior face is heart shaped; (3) both openings of the vertebrarterial canal are visible from a side view; and (4) in the neural canal there is no ridge or bridge over the nerve foramina entering the dorsal surface of the body.

The Manix sheep is probably the mountain or desert species O. canadensis, but if sufficient material were available, might prove to be an ancestral form. On the lateral surface, C. I. T. 5115 has a ridge running ventro-posteriorly from the anterior opening of the vertebr-arterial canal to the dorsal surface of the transverse process. This ridge was not found on any of the *O. canadensis* vertebrae examined. The larger size of the Manix vertebra may suggest a cooler climate, or might be due to individual variations.

The proximal phalanx is apparently the digital element that Buwalda (1914, p. 451) considered to be of an antelope. However, comparisons with *Antilocapra*, *Tetrameryx*, *Odocoileus*, and *Ovis* leave little doubt that it belongs to *Ovis*.

REFERENCES

Albright, G. L., 1921, Official Explorations for Pacific Railroads, 1853-1855, California Univ. Press, Berkeley, California, 187 pp.

Allison, I. S., 1941, Stratigraphic setting of the Fossil Lake fauna, Geol. Soc. America Bull., vol. 52, p. 1979.

-------------- 1952, Dating of pluvial lakes in the Great Basin, Am. Jour. Sci., vol. 250, pp. 907-909.

Antevs, Ernst, 1925, On the Pleistocene history of the Great Basin, Carnegie Inst. Washington Pub. 352, art. 2, pp. 53-114.

------------- 1948, Climatic changes and pre-white man, (in), The Great Basin with emphasis on glacial and post glacial times, Utah Univ. Bull., vol. 38, no. 20, pp. 168-184.

------------- 1952, Climatic history and the antiquuty of man in California, (in), Symposium on the antiquuty of man in California, California Univ. Archeol. Survey, Rept. no. 16, pp. 23-29.

------------- 1954, Climate of New Mexico during the last glacio-pluvial, Jour. Geology, vol. 62, no. 2, pp. 182-191.

Bailey, T. L., 1943, Late Pleistocene Coast Range orogenesis in southern California, Geol. Soc. America Bull., vol. 54, pp. 1549-1568.

Barbour, E. H., and Schultz, C. B., 1934, A new giant camel, Titanotylopus nebraskensis, gen. et sp. nov., Nebraska State Mus. Bull. 36, vol. 1, pp. 291-294.

Bissell, H. J., 1952, Stratigraphy of Lake Bonneville and associated Quaternary deposits in Utah Valley, Utah, Geol. Soc. America Bull., vol. 63, p. 1358.

Blackwelder, Eliot, 1931, Pleistocene glaciation in the Sierra Nevada and basin ranges, Geol. Soc. America Bull., vol. 42, pp. 865-922.

------------- 1941, Lakes of two ages in Searles Basin, California, Geol. Soc. America Bull., vol. 52, pp. 1943-1944.

------------- and Ellsworth, E. W., 1936, Pleistocene lakes of the Afton Basin, California, Am. Jour. Sci., 5th ser., vol. 31, no. 186, pp. 453-463.

Bryan, Kirk, and Gidley, J. W., 1926, Vertebrate fossils and their enclosing deposits from the shores of Pleistocene Lake Cochise, Arizona, Am. Jour. Sci. 5th ser., vol. 11, no. 66, pp. 477-488.

Burt, W. H., 1931, Machaerodus catocopis from the Pliocene of Texas, California Univ., Dept. Geol. Sci., Bull., vol. 20, no. 7, pp. 261-277.

Buwalda, J. P., 1914, Pleistocene beds at Manix in the eastern Mohave Desert region, California Univ. Dept. Geol. Sci., Bull., vol. 7, no. 24, pp. 443-464.

------------- and Richter, C. F., 1948, Movement on the Manix (Calif.) fault on April 10, 1947, Geol. Soc. America Bull., vol. 59, no. 12, pt. 2, p. 1367.

Camp, C. L., Welles, S.P., and Green, Morton, 1953, Bibliography of fossil vertebrates, 1944-1948, Geol. Soc. America Mem. 57, 465 pp.

Campbell, E. W. C., 1949, Two ancient archeological sites in the Great Basin, Science, new ser., vol. 109, no. 2831, p. 340.

-------------- and Campbell, W. H., 1937, The Lake Mohave site, (in), The archeology of Pleistocene Lake Mohave, Southwest Mus. Paper 11, pp. 9-44.

Compton, L. V., 1934, Fossil bird remains from the Manix Lake deposits of California, Condor, vol. 36, pp. 166-168.

Cope, E. D., 1893, A preliminary report on the vertebrate paleontology of the Llano Estacado, Texas Geol. Survey Fourth Ann. Rept., pp. 1-136.

Darton, N. H., and others, 1915, Guide book of the western United States, Part C, The Santa Fe route, U. S. Geol. Survey Bull. 613, 194 pp.

de Terra, Helmut, 1953, A strange Pleistocene fossil locality in Mexico, Science, new ser., vol. 118, no. 3077, pp. 748-749.

Dibblee, T. W., Jr., and Chesterman, C. W., 1953, Geology of the Breckenridge Mountain Quadrangle, California, California Div. Mines Bull. 168, pp. 1-56.

Eaton, J. E., 1941, The Pleistocene in California, California Div. Mines Bull. 118, pt. 2, pp. 203-207.

Elftman, H. O., 1931, Pleistocene mammals of Fossil Lake, Oregon, Am. Mus. Novitates 481, 21 pp.

English, W. A., 1926, Geology and oil resources of the Puente Hills region, southern California, U. S. Geol. Survey Bull. 768, 110 pp.

Evans, G. L., and Meade, C. E., 1945, Quaternary of the Texas High Plains, Texas Univ. Pub. 4401, pp. 485-507.

Fairbanks, H. W., and Carey, E. P., 1910, Glaciation in the San Bernardino Range, California, Science, new ser., vol. 31, pp. 32-33.

Flint, R. F., 1950, Pleistocene stratigraphy of eastern South Dakota, Geol. Soc. America Bull., vol. 61, no. 12, pt. 2, pp. 1460-1461.

Flower, W. H., 1891, An introduction to the study of mammals living and extinct, London, 763 pp.

Frick, Childs, 1929, History of the Earth (Childs Frick Tertiary - Quaternary Explorations, 1928), Nat. History, vol. 24 (1), pp. 106-108.

--------------- 1937, Horned ruminants of North America, American Mus. Nat. History Bull., vol. 69, 669 pp.

Frye, J. C., Swineford, Ada, and Leonard, A. B., 1948, Correlation of Pleistocene deposits of the central Great Plains with the glacial section, Jour. Geology, vol. 56, no. 6, pp. 501-525.

--------------- and Leonard, A. B., 1952, Pleistocene geology of Kansas, Kansas Geol. Survey Bull. 99, 230 pp.

Gale, H. S., 1951, The saline deposits of Bristol Dry Lake, San Bernardino County, California Div. Mines, Special Rept. 13, 21 pp.

Gazin, C. L., 1935, Annotated list of Pleistocene mammals from American Falls, Idaho, Washington Acad. Sci. Jour., vol. 25, no. 7, pp. 297-302.

--------------- 1942, The late Cenozoic vertebrate faunas from the San Pedro Valley, Arizona, U. S. Nat. Mus. Proc., vol. 92, no. 3155, pp. 475-518.

Gidley, J. W., 1900, A new species of Pleistocene horse from the Staked Plains of Texas, Am. Mus. Nat. History Bull., vol. 13, art. 13, pp. 111-116.

--------------- 1901, Tooth characters and revision of the North American species of the genus Equus, Am. Mus. Nat. History Bull., vol. 14, art. 9, pp. 91-142.

Gilbert, C. M., 1938, Welded tuff in eastern California, Geol. Soc. America Bull., vol. 49, pp. 1829-1862.

Gilbert, G. K., 1890, Lake Bonneville, U. S. Geol. Survey Mon. 1, 438 pp.

Grant, U. S., IV, and Gale, H. R., 1931, Catalogue of the marine Pliocene and Pleistocene Mollusca of California and adjacent regions, San Diego Soc. Nat. History Mem., vol. 1, 1036 pp.

Hay, O. P., 1914, The Pleistocene mammals of Iowa, Iowa Geol. Survey Ann. Rept., 1912, vol. 23, 662 pp.

--------------- 1914B, Camels of the fossil genus Camelops, U. S. Nat. Mus. Proc., vol. 46, pp. 267-277.

--------------- 1915, Contributions to the knowledge of the mammals of the Pleistocene of North America, U. S. Nat. Mus. Proc., vol. 48, pp. 515-575.

--------------- 1927, The Pleistocene of the western region of North America and its vertebrated animals, Carnegie Inst. Washington Pub. 322B, 346 pp.

Hazzard, J. C., 1933, Notes on the Cambrian rocks of the eastern Mohave Desert, California, California Univ., Dept. Geol. Sci., Bull., vol. 23, no. 2, pp. 57-80.

Hibbard, C. W., 1949, Pleistocene vertebrate paleontology in North America, (in), Pleistocene research, Geol. Soc. America Bull., vol. 60, pp. 1417-1428.

--------------- 1951, Vertebrate fossils from the Stump Arroyo member, Meade County, Kansas, Michigan Univ. Mus. Paleontology, Contr., vol. 9, no. 7, pp. 227-245.

--------------- 1953, Equus (Asinus) calobatus and associated vertebrates from the Pleistocene of Kansas, Kansas Acad. Sci. Trans., vol. 56, no. 1, pp. 111-126.

--------------- and Riggs, E. S., 1949, Upper Pliocene vertebrates from Keefe Canyon, Meade County, Kansas, Geol. Soc. America Bull., vol. 60, pp. 829-860.

Hinds, N. E. A., 1952, Evolution of the California landscape, California Div. Mines Bull. 158, 240 pp.

Hubbs, C. L., and Miller, R. R., 1948, The Great Basin with emphasis on glacial and postglacial times, II, The geological evidence, Utah Univ. Bull., vol. 38, no. 20, pp. 21-166.

Libby, W. F., 1952, Radiocarbon dating, Chicago, Chicago Univ. Press, 124 pp.

------------- 1954, Chicago radiocarbon dates, 4, Science, new ser., vol. 119, no. 2083, pp. 135-140.

Mann, J. F., Jr., 1952, Late Cenozoic geologic history of the Temecula region, southern California, Geol. Soc. America Bull., vol. 63, p. 1338.

Mansfield, G. R., 1920, Geography, geology, and mineral resources of the Fort Hall Indian Reservation, Idaho, U. S. Geol. Survey Bull. 713, 152 pp.

Matthes, F. E., 1930, Geologic history of the Yosemite Valley, U. S. Geol. Survey Prof. Paper 160, 137 pp.

--------------- 1949, Glaciers, (in), Hydrology, Physics of the Earth - IX, New York, pp. 149-219.

Meade, G. E., 1945, The Blanco fauna, Texas Univ. Pub. 4401, pp. 509-540.

Merriam, J. C., 1913, The skull and dentition of a camel from the Pleistocene of Rancho La Brea, California Univ, Dept. Geol. Sci., Bull., vol. 7, no. 14, pp. 305-323.

-------------- 1915, An occurrence of mammalian remains in a Pleistocene lake deposit at Astor Pass, near Pyramid Lake, Nevada, California Univ., Dept. Geol. Sci. Bull., vol. 8, no. 21, pp. 377-384.

-------------- 1915B, Extinct faunas of the Mohave Desert, their significance in a study of the origin and evolution of life in North America, Pop. Sci. Monthly, vol. 86, no. 18, pp. 245-264.

--------------1918, Evidence of mammalian paleontology relating to the age of Lake Lahontan, California Univ., Dept. Geol. Sci., Bull., vol. 10, no. 25, pp. 517-521.

------------- and Stock, Chester, 1925, Relationships and structure of the short-faced bear, Arctotherium, from the Pleistocene of California, Carnegie Inst. Washington Pub. 347, paper 1, 35 pp.

Miller, Loye, 1932, Notes on the desert tortoise (Testudo agassizii), San Diego Soc. Nat. History Trans., vol. 7, no. 18, pp. 187-208.

------------- 1942, A Pleistocene tortoise from the McKittrick asphalt, San Diego Soc. Nat. History Trans., vol. 9, pp. 439-442.

Miller, R. R., 1946, Correlation between fish distribution and Pleistocene hydrography in eastern California and southwestern Nevada, with a map of the Pleistocene waters, Jour. Geology, vol. 54, no. 1, pp. 43-53.

Moore, R. C., et al., 1951, The Kansas rock column, Kansas Geol. Survey Bull. 89, 132 pp.

Morrison, R. B., 1952A, Late Quaternary climatic history of the northern Great Basin, Geol. Soc. America Bull., vol. 63, p. 1367.

---------------- 1952B, Stratigraphy of Lake Lahontan and associated Quaternary deposits in the Carson Desert area, near Fallon, Nevada, Geol. Soc. America Bull., vol. 63, p. 1367.

Nolan, T. B., 1927, Potash brines in the Great Salt Lake Desert, Utah, U. S. Geol. Survey Bull. 795, pp. 25-44.

Putnam, W. C., 1949, Quaternary geology of the June Lake district, California, Geol. Soc. America Bull., vol. 60, pp. 1281-1302.

-------------- 1952, Origin of Rock Creek and Owens River Gorges, California, Geol. Soc. America Bull., vol. 63, pp. 1291-1292.

Reed, R. D., and Hollister, J. S., 1936, Structural evolution of southern California, Am. Assoc. Petroleum Geologists Bull. 20, pp. 1529-1692.

Richmond, G. M., Morrison, R. B., and Bissell, H. J., 1952, Correlation of the late Quaternary deposits of the La Sal Mountains, Utah, and of Lakes Bonneville and Lahontan by means of interstadial soils, Geol. Soc. America Bull., vol. 63, p. 1369.

Rinker, G. C., 1949, Tremarctotherium from the Pleistocene of Meade County, Kansas, Michigan Univ., Mus. Paleontology, Contr., vol. 7, no. 6, pp. 107-112.

Russell, I. C., 1885, Geological history of Lake Lahontan, a Quaternary lake of northwestern Nevada, U. S. Geol. Survey Mon. 11, 288 pp.

Savage, D. E., 1951, Late Cenozoic vertebrates of the San Francisco Bay region, California Univ., Dept. Geol. Sci., Pub., vol. 28, no. 10.

Schultz, C. B., and Stout, T. M., 1948, Pleistocene mammals and terraces in the Great Plains, Geol. Soc. America Bull., vol. 59, no. 6, pp. 553-588.

-------------- Lueninghoener, G. C., and Frankforter, W. D., 1951, A graphic resumé of the Pleistocene of Nebraska (with notes on the fossil mammalian remains), Nebraska Univ. State Mus. Bull., vol. 3, no. 6, 41 pp.

Schultz, J. R., 1938, A late Quarternary mammal fauna from the tar seeps of McKittrick, California, Carnegie Inst. Washington Pub. 487, pp. 111-215.

Schrock, R. R., and Hunzicker, A. A., 1935, A study of some Great Basin lake sediments of California, Nevada, and Oregon, Jour. Sedimentary Petrology, vol. 5, no. 1, pp. 9-30.

Simpson, G. G., 1933, A Nevada fauna of Pleistocene type and its probable association with man, Am. Mus. Novitates 667, 10 pp.

-------------- 1945, The principles of classification and a classification of mammals, Am. Mus. Nat. History Bull., vol. 85, 350 pp.

Skinner, M. F., 1942, The fauna of Papago Springs Cave, Arizona, Am. Mus. Nat. History Bull., vol. 80, art. 6, pp. 143-220.

Stearns, H. T., Crandall, Lynn, and Steward, W. G., 1938, Geology and ground-water resources of the Snake River Plain in southeastern Idaho, U. S. Geol. Survey Water-Supply Paper 774, 139 pp.

Stille, Hans, 1936, Present tectonic state of the Earth, Am. Assoc. Petroleum Geologists Bull., vol. 20, no. 7, pp. 849-880.

Stock, Chester, 1928, Tanupolama, a new genus of llama from the Pleistocene of California, Carnegie Inst. Washington Pub. 393, pp. 29-37.

--------------January, 1931, Problems of antiquuty presented in Gypsum Cave, Nevada, Sci. Monthly, vol. 32, pp. 22-32.

Thompson, D. G., 1929, The Mohave Desert region, California, U. S. Geol. Survey Water-Supply Paper 578, 759 pp.

Troxell, E. L., 1915, The vertebrate fossils of Rock Creek, Texas, Am. Jour. Sci., 4th ser., vol. 39, pp. 613-638.

Vaughan, F. E., 1922, Geology of San Bernardino Mountains north of San Gorgonio Pass, California Univ., Dept. Geol. Sci., Bull., vol. 13, no. 9, pp. 319-411.

Warren, C. R., 1952, Probable Illinoian age of part of the Missouri River, South Dakota, Geol. Soc. America Bull., vol. 63, no. 11, pp. 1143-1156.

Williamson, R. S., and others, Report of explorations in California for Railroad routes to connect with the routes near the 35th and 32nd parallels of latitude, U. S. Pacific Railroad Explorations, vol. 5.

Wilson, R. W., 1942, Preliminary study of the fauna of Rampart Cave, Arizona, Carnegie Inst. Washington Pub. 530, pp. 169-185.

Wood, H. E., et al., 1941, Nomenclature and correlation of the North American continental Tertiary, Geol. Soc. America Bull., vol. 52, pp. 1-48.

Woodring, W. P., 1952, Pliocene-Pleistocene boundary in California Coast Ranges, Am. Jour. Sci., 5th ser., vol. 250, no. 6, pp. 401-410.

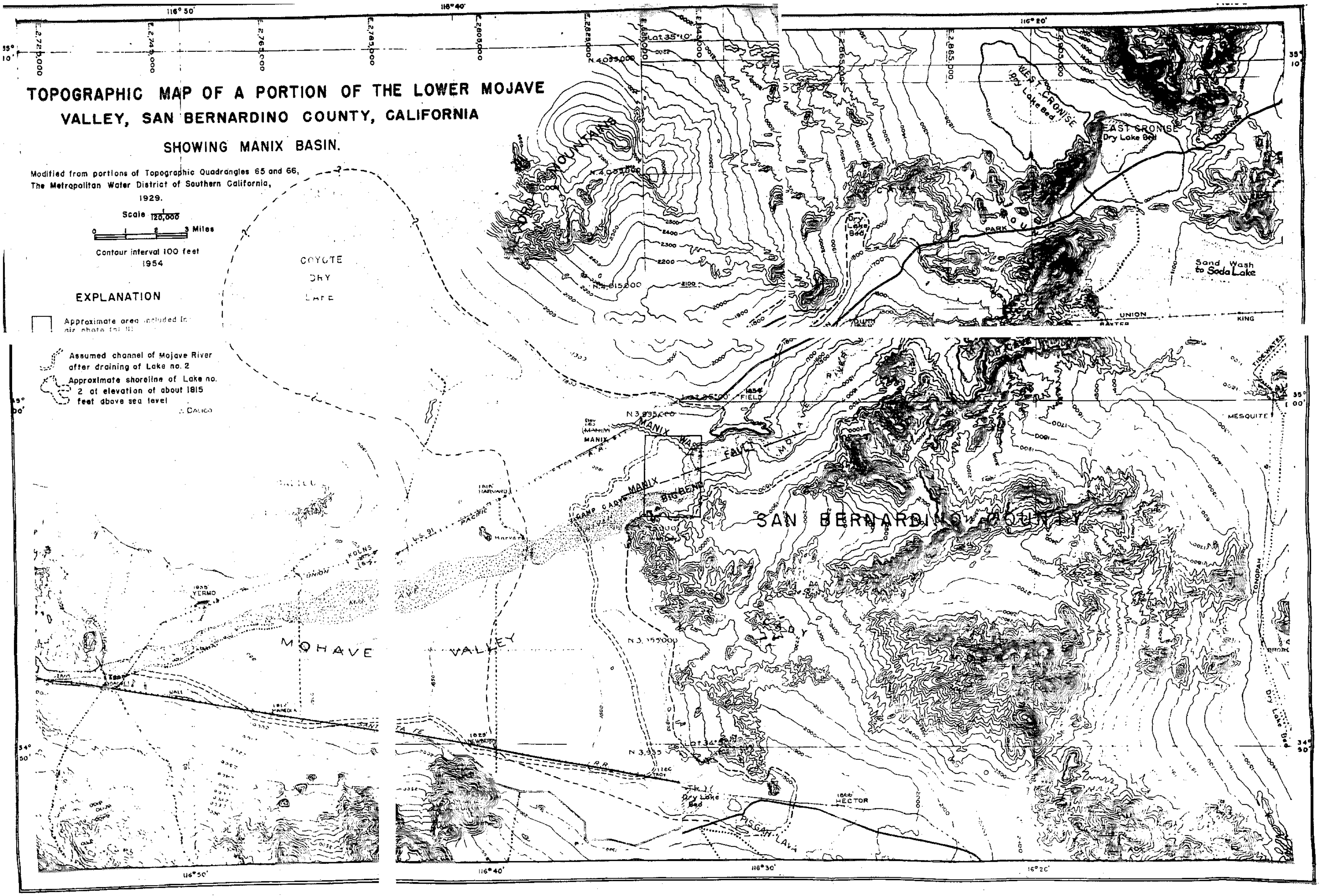

TOPOGRAPHIC MAP OF A PORTION OF THE LOWER MOJAVE VALLEY, SAN BERNARDINO COUNTY, CALIFORNIA
SHOWING MANIX BASIN.
Modified from portions of Topographic Quadrangles 65 and 66, The Metropolitan Water District of Southern California, 1929.
Scale 1/120,000
0 1 2 3 Miles
Contour interval 100 feet
1954
EXPLANATION
Assumed channel of Mojave River after draining of Lake no. 2
Approximate shoreline of Lake no. 2 at elevation of about 1815 feet above sea level
COYOTE DRY LAKE
MOHAVE VALLEY
SAN BERNARDINO COUNTY
MANIX
BIG BEND
CAMP CADY
YERMO
HECTOR
MESQUITE
UNION
PACIFIC
SANTA FE
U.S. 91
WEST CRONISE Dry Lake Bed
EAST CRONISE Dry Lake Bed
Sand Wash to Soda Lake
Dry Lake Bed
KING
TONOPAH
TIDEWATER
116°50'
116°40'
116°30'
116°20'
35° 10'
35° 00'
34° 50'

Plate II

Portion of U. S. Geological Survey air photo 16 Ps. 5N672 D (5) LV 132, showing fossil localities. Scale one inch = approximately 1880 feet.


T-13
C.I.T LOC. 541
W30
T-7
C.I.T LOC. 540
W31
MANIX
2 miles
T-3
T-4
T-6
W12
A
W1
W11
A'
T-14
T-8
W13
W4
W5
W27
C.I.T.
LOC.
540
W10
W19
T-5
T-10
T-9
W9
W17
W20
T-11
W15
W6
T-12
W26
W18
W23
W24
W25
W28
W29
C.I.T. LOC. 542
W21

Plate III

All views approximately natural **size**.

Fig. 1 - Machairodontinae humerus (C. I. T. 5093), anterior view.

Fig. 2 - Equus sp. cf. E. scotti Gidley metacarpal (C. I. T. 5103), anterior and proximal views.

Fig. 3 - Equus sp. cf. E. scotti Gidley posterior (?) ungual phalanx (C. I. T. 5106).

Fig. 4 - Proboscidean phalangeal sesamoid (C.I.T. 5090) lateral view.

Plate III

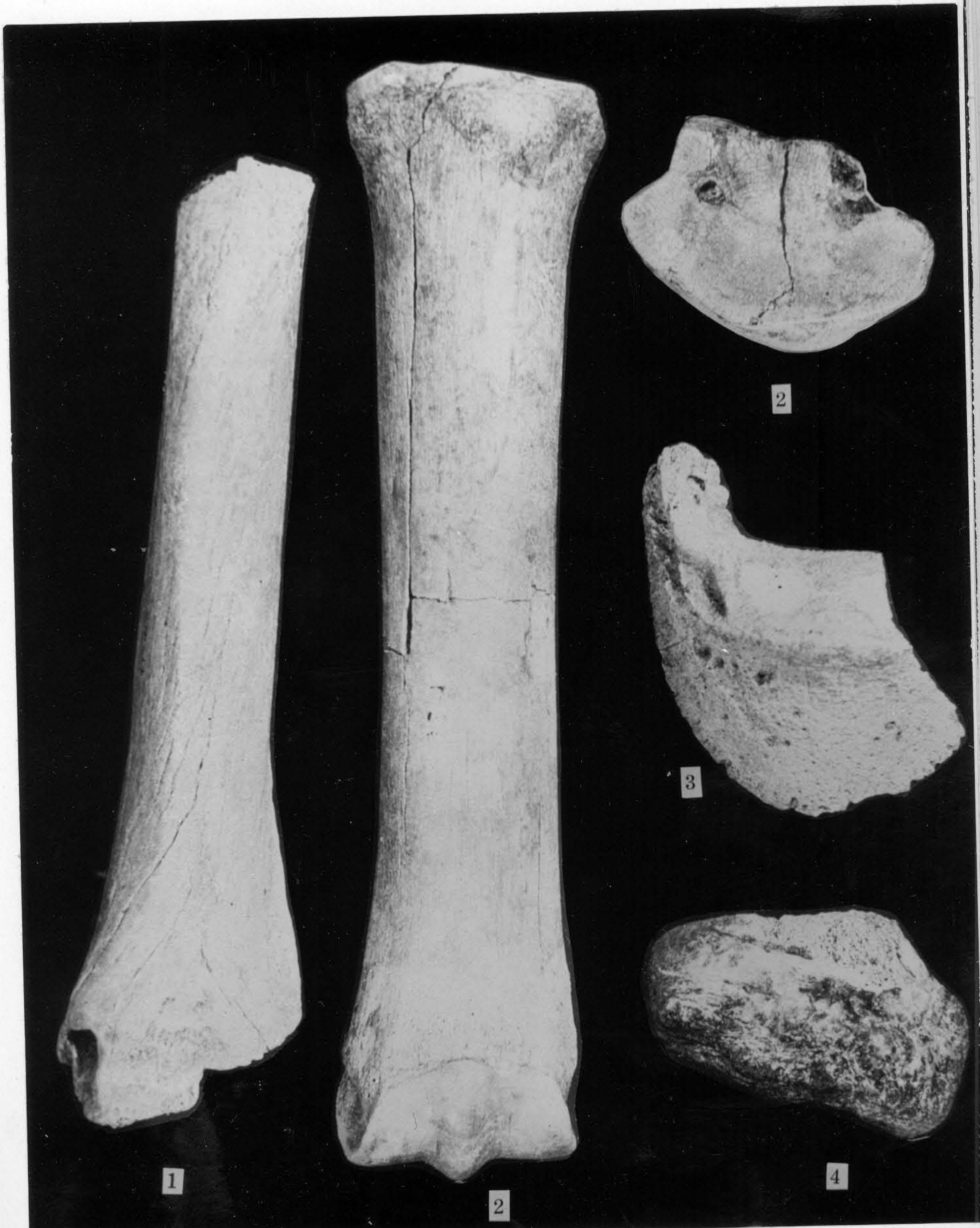


Plate IV

All views approximately natural size

Figs. 1 and 2. Giant camel M/2(?) (C. I. T. 5107); dashed lines indicate hypothetical reconstruction. 1, occlusal surface slightly ground down to show enamel pattern; 2, sectioned view 17 mm below surface in Fig. 1 and 25 mm above junction of roots.

Fig. 3. Gigantocamelus spatula M/2 from Nebraska State Museum specimen 18559-39.

Figs. 4-7. Equus sp. cf. E. scotti Gidley teeth: 4, incomplete P2/ (C. I. T. 5099); 5, M/3 (C. I. T. 5098); 6, incomplete M1/(?) (C. I. T. 5100); 7, portion of lower cheek tooth showing internally convex metastylid column (C. I. T. 5101).

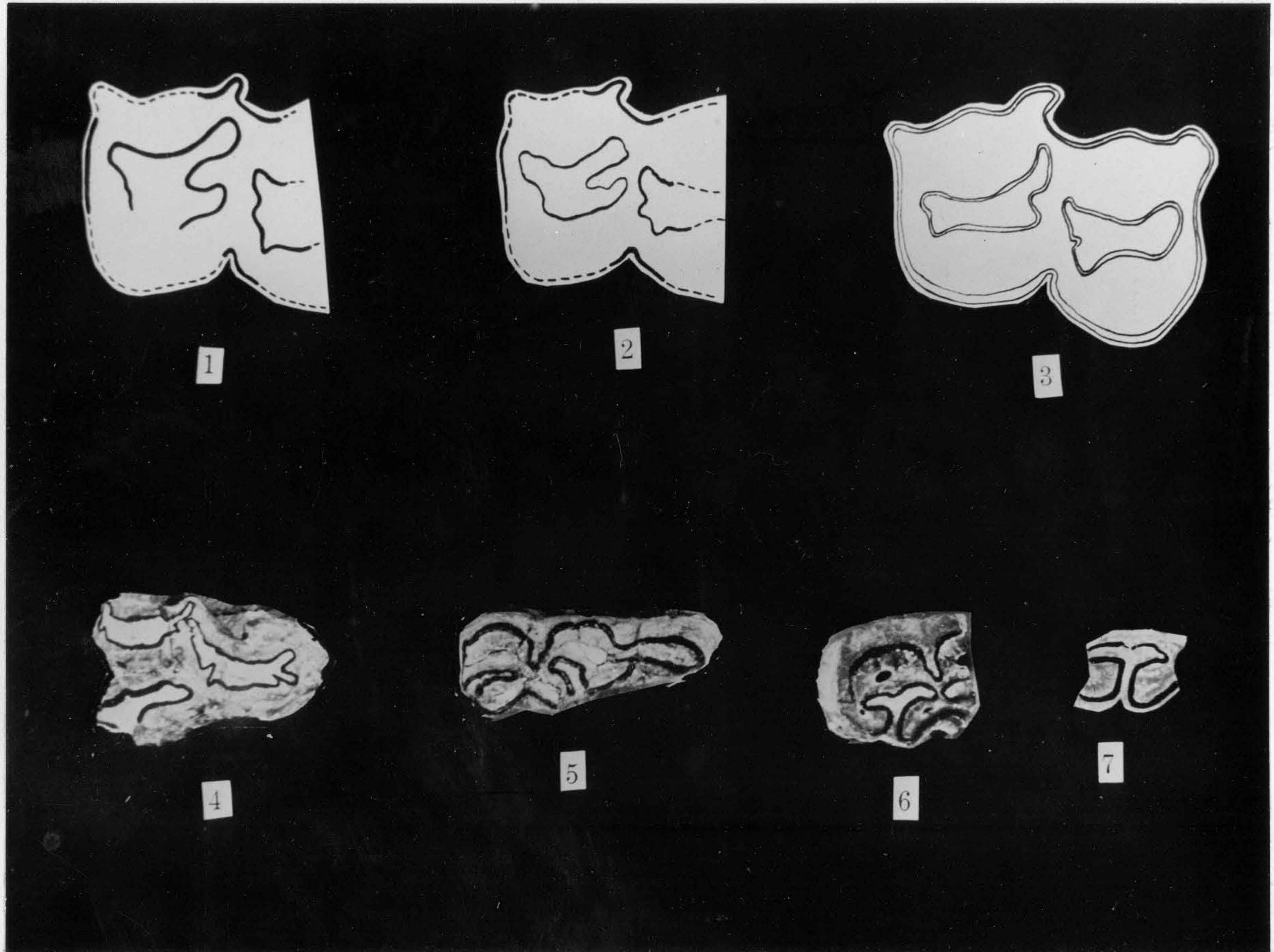

1
2
3
4
5
6
7

Plate V

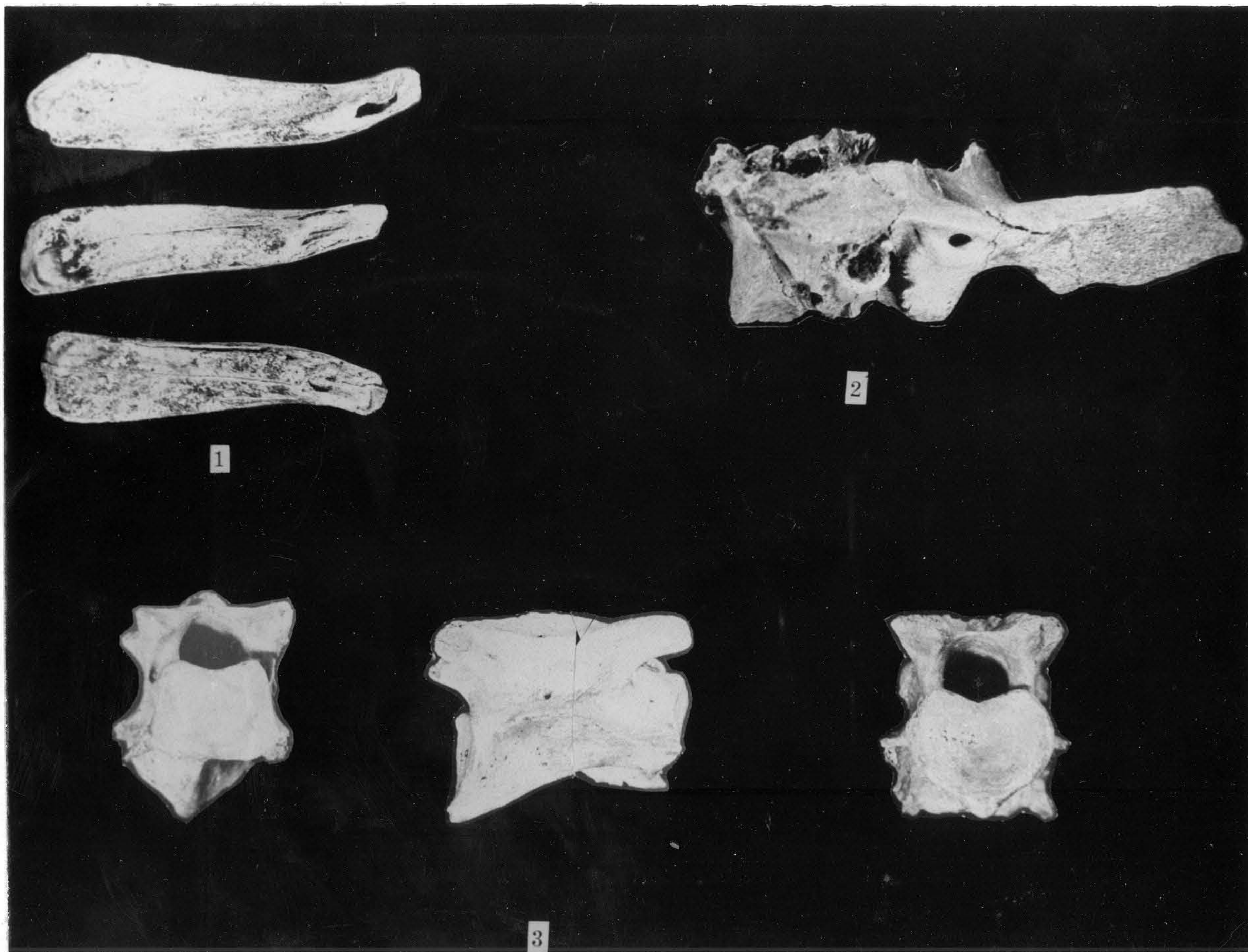
All views approximately X 3/4.

Figs. 1 and 2. *Camelops* sp. cf. *C. kansanus*:

1, incisors (C. I. T. 5108), lingual views;

2, portions of temporal, auditory, and occipital regions of skull (C. I. T. 5109), lateral view.

Fig. 3 - *Ovis* sp. third cervical vertebra (C. I. T. 5115), anterior, lateral and posterior views.



1

2

3