TERTIARY MAMMAL BEARING BEDS IN THE UPPER CUYAMA DRAINAGE BASIN, CALIFORNIA

Thesis

by

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TERTIARY MAMMAL BEARING BEDS IN THE UPPER CUYAMA DRAINAGE BASIN, CALIFORNIA

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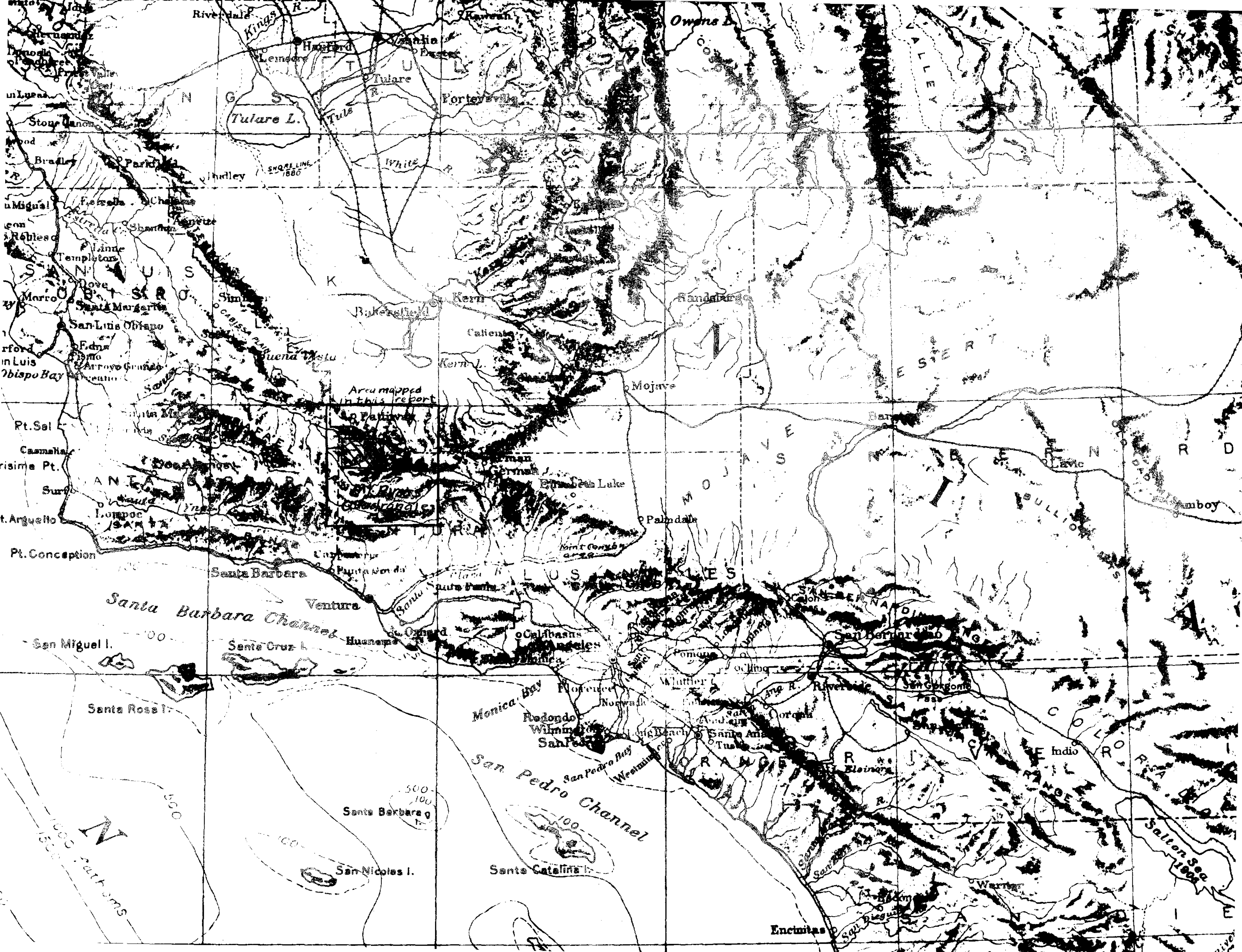
INTRODUCTION

The discovery of Tertiary mammalian remains in the vicinity of Apache Canyon, in the upper Cuyama drainage basin, Ventura county, California, was made by Mr. John B. Stevens, Geologist of the Associated Oil Company. Further collecting in this region has furnished a fauna of considerable stratigraphic and biologic significance. A study of the geologic features of the area and of the mammalian collection was undertaken primerily with a view to establishing the position and relationships of the assemblage in the sequence of Tertiary faunas known from the Pacific Coast and Great Basin provinces. Investigation of the problem was conducted under the direction of Dr. Chester Stock.

LOCATION

The region investigated, as shown in the accompanying figure, lies in the Santa Ynez Mountains west of Mount Pinos and includes a portion of the eastern part of the Cuyama Valley system. Latitude 34^{o} 50' N. and longitude 119^{o} 20' W. pass through the center of the area, which lies just within the northern boundary of Ventura County. The city of Ventura lies 37 miles due south, Maricopa is 17 miles north, and Tejon



Riverdale
Kings R.
Hanford
Visalia
Lemoore
Exeter
Tulare
Porterville
Tulare L.
Tule R.
Owens L.
VALLEY
Stone Canon
Bradley
Parkfield
White R.
SHORE LINE 1880
Estrella
Shandon
Linne
Templeton
Dove
Morro
Santa Margarita
San Luis Obispo
Edna
Arroyo Grande
Obispo Bay
Bakersfield
Kern
Caliente
Kern L.
Buena Vista
CABISSA PLAIN
Randsburg
Mojave
MOJAVE
DESERT
Area mapped in this report
Pt. Sal
Casmalia
Surf
Lompoc
Pt. Arguello
Pt. Concepcion
Santa Barbara
Ventura
Santa Barbara Channel
Hueneme
Oxnard
San Miguel I.
Santa Cruz I.
Santa Rosa I.
Santa Barbara I.
San Nicolas I.
Santa Catalina I.
San Pedro Channel
San Pedro Bay
Monica Bay
Redondo
San Pedro
Florence
Norwalk
Long Beach
Santa Ana
Calabasas
Los Angeles
Pomona
Riverside
San Bernardino
San Gorgonio Pass
Palmdale
Elizabeth Lake
Lavic
Amboy
BULLION
Barstow
Indio
Salton Sea 1906
Encinitas
Warner
Elsinore
ORANGE
LOS ANGELES
SAN BERNARDINO
COLORADO
fathoms
N

Pass on the Ridge Route is 25 miles due east. Approximately 40 square miles were covered in the geologic mapping. The topographic map employed is that of the Mount Pinos Quadrangle, U. S. Geological Survey; the map being enlarged for field purposes from 2 miles to the inch to 2000 feet to the inch.

PREVIOUS WORK

Very little has been published concerning the geology of the region under consideration. During the period 1854-55 the Cuyama Valley was visited by one of the Pacific Railroad survey parties and the geological features were described by Thomas Antisell (Ref. 1857, pp. 53-57). Fairbanks (1895, pp. 273-300) described an analcite diabase on the north side of Cuyama Valley. Lawson (1908, pp. 22, 42) reported on the California earthquake of 1906, which included a consideration of the principal physiographic features of the region. In the same volume Fairbanks described the features of the San Andreas Rift which passes through to the north of this area. W. A. English (1916, pp. 191-215) published a detailed description of the geology of Cuyama Valley which included a map of the formations involved in the structure of a part of both sides of the valley to the west of the area considered in this report. Later, C. M. Wagner and K. H. Schilling (1923, pp. 235-276) described the region northeast of San Emigdio mountain which, however, lies to the north of the San Andreas

Rift and hence is somewhat removed from the present district. Two other papers, one by W. S. W. Kew (1919, pp. 1-21) and the other by R. N. Nelson (1925, pp. 327-396), have been published on the upper portion of the Santa Ynez drainage basin to the southwest.

GEOGRAPHY

Topography.- The region for the most part is very rugged and mountainous. The topography appears to have reached a youthful stage in the cycle of erosion as indicated by the partially dissected mesas and by the steepness of the canyon walls. The valley floors are, however, often very broad. The elevations range from 2800 feet on the floor of the Cuyama Valley near the mouth of Quatal Canyon to approximately 8800 feet, the height of Mount Pinos, indicating an extensive high-lying country having a maximum relief of approximately 6000 feet north of the principal drainage divide which lies in the southern part of the Mount Pinos Quadrangle. In the limited area investigated the valleys range in elevation from 3500 feet to about 4500 feet; the mesa-topped ridges vary from 4400 to 5500 feet in height. The direction of slope of these ridges is in general the same and the mesa level on the ridges is approximately 500 feet higher than the adjacent valleys.

The area has rather a unique position with regard to the drainage systems of this part of the State. Immediately to the east the combined Mount Pinos and Sawmill Mountain mass forms the apex of a four-way drainage pattern. The west side is drained by the Cuyama system which enters the ocean near Santa Maria, while the drainage of the south side reaches the ocean near Ventura by way of the Santa Clara Valley to the south. The latter is the trunk drainage for the south slopes of the Santa Ynez range east of Ventura. To the north of the Mount Pinos block the streams enter the enclosed basin of the southern end of the San Joaquin Valley, and the east side drains through Cuddy Valley along the San Andreas Rift to Castac Lake which has no outlet.

Climate.- The climate of the region, as in most parts of the coast ranges of southern California, is semi-arid. The area is subject to frequent rains in winter as well as light snow storms, and most of the higher peaks, as for example Mount Pinos, carry a small snow cap on their north sides during this season. In summer, as is often the case in the more mountainous districts, occasional cloudbursts occur which have a very pronounced effect on the finer details of the topography. All of the stream beds of the Cuyama Valley system in the quadrangle are dry except after rains. During periods of precipitation broad shallow streams of muddy water are formed, making travel in the region difficult. Springs are rather scarce except near the heads of canyons originating in the mesas flanking the higher projecting masses.

Flora.- Cuyama Valley is for the most part but sparcely covered with vegetation other than sage brush. In the tributary canyons to the east and towards the southeastern end of Cuyama Valley itself the vegetation changes to a fairly profuse growth of sage brush, manzanita, scrub oak, juniper, and pine. This flora is found at the higher elevations and is particularly well represented on the mesa remnants, as for example those near the slopes of Mount Pinos.

Culture.- Cuyama Valley appears to have been fairly well settled judging from the number of farm houses in the vicinity, but most of these have been abandoned. Agriculture has apparently not thrived in the valley, due probably to seasons of draught which have brought about failure of crops. Cattle raising is now being undertaken on a moderate scale.

The only improved road permitting access to the valley connects Maricopa in the southwestern extremity of the San Joaquin Valley with Santa Maria on the coast. This road enters from the east at the northeastern corner of the widest part of Cuyama Valley and follows the drainage to the coast highway. Another road connecting with the above facilitates travel into the southern part of the valley. This road, however, does not reach Lockwood Valley in the eastern part of the quadrangle as shown on the map, the divide being crossed only on foot or on horseback.

GEOLOGY

General Statement.- The formations involved in the structure of the region lying to the west of the area studied have been identified by W. A. English as (1) pre-Franciscan(?) gneissoid granite, (2) a series of pre-Monterey shales, (3) the Monterey group, (4) the Santa Marguerita sandstones and shales, (5) the Cuyama Pliocene(?), (6) the Pleistocene terrace sands and gravels, and (7) Recent or Quaternary alluvium. The geological record in the restricted area of this report includes a large block of the granite along the eastern boundary, an extensive series of highly colored beds considered by English as being approximately the equivalent of the Monterey, the Santa Marguerita(?), and lastly terrace and Quaternary alluvial deposits.

The pre-Monterey shales and the Cuyama (Pliocene?) formation mapped by English in the adjacent region are absent in the area investigated.

Stratigraphy

Granite Basement.- There are two exposures of granite within the mapped area, one being the small block faulted up in the northwest section and exposed by erosion, and the other being the extreme westerly end of a very large mass extending to the east. The outcrops examined near the contact with the terrace deposits are well weathered and show a decidedly schistose character. The minerals are essentially quartz, feldspar, muscovite, biotite, and hornblende, with alterations to kaolinite, chlorite, and sericite. As a whole the rock has a highly micaceous appearance with a composition close to that of binary granite. The schistose structure of the granite is also evident from the character of the material scattered over the mesa to the west.

Monterey(?).- In the region west of the area examined this group lies unconformably on a pre-Monterey series of shales of Eocene or Cretaceous age, but in the area mapped in this report there are probably no sediments older than Monterey exposed. In view of factors to be discussed later it is highly probable that the upper horizons in the group are well up in the Miocene.

The formation outcrops along the south side of the San Andreas Rift in a band from four to six miles wide in the vicinity of Quatal (Fig. 1) and Ballinger Canyons. These beds reappear in the southern part of Apache Canyon on the south flank of an east-west trending syncline. The beds are highly colored and in distant cliff-sections present a very striking banded pattern.

The lower members of the series are green, grayish green, white and deep red in color on weathered surfaces, the bands being alternations of poorly sorted, coarse grained, green or red mudstone and somewhat finer grained gray sandstone. Very thick beds of grayish green material are characteristic of the lower horizon and somewhat higher up thick beds of a deep red color are prominent.

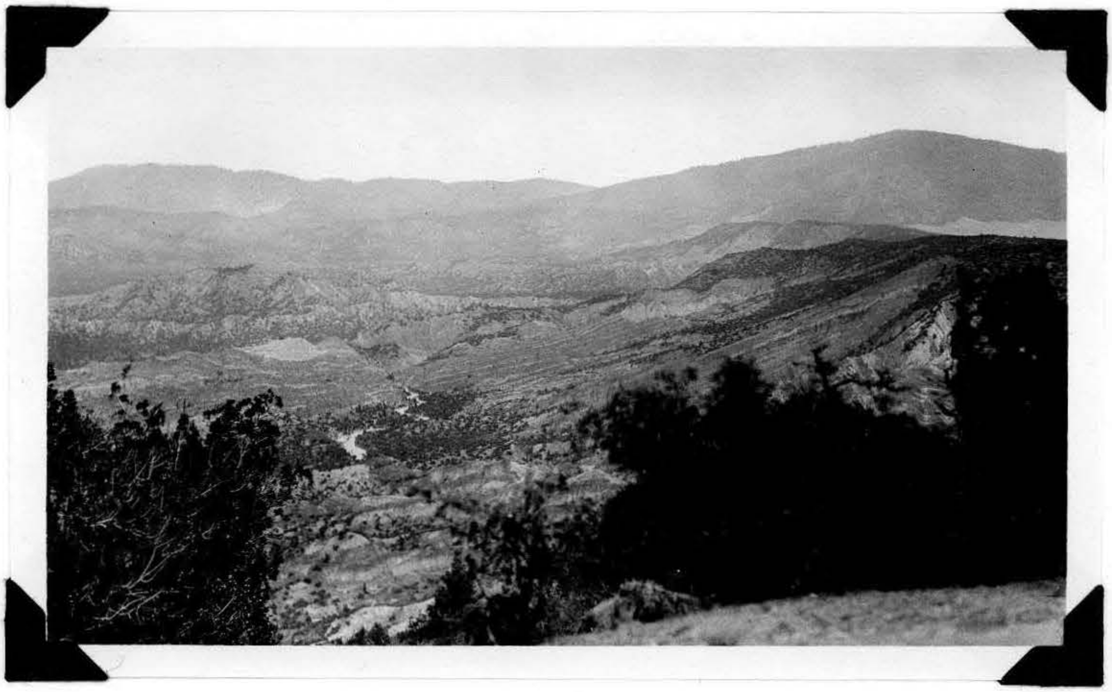


Figure 1

Highly colored fossiliferous badland features of the Monterey(?) in Quatal Canyon. Mount Pinos is to the east in the right background and the San Andreas Rift is indicated on the left.

The lower portion of the so-called Monterey is considered by English, in his paper on the geology and oil prospects of Cuyama Valley, as being of marine origin. English also states that the upper portion may be in part of non-marine origin. The higher horizons of alternating coarse white sandstone and ocher-colored sandy clays very probably are land-laid as shown by the occurrence of a vertebrate fauna, the heterogeneity and arkosic nature of the sediments, their coloration, and possibly also by the peculiar type of erosion which has resulted in the formation of a typical badland topography (Figs. 2 and 3).

In general the coarse white sand of the upper horizon is composed of grains, pebbles, and boulders, unsorted and exhibiting considerable variation in size. The grains are angular and non-uniform and are made up of a large variety of minerals, quartz being the most common. In detail the boulders are well rounded and consist of a large variety of rock types, as for example quartzites, granites, diorites, andesites, diabase, basalts, and metamorphic gneisses and schists. The ocher-colored beds are massive, thick-bedded to unstratified, uniform sandy clays, the sand grains being angular and verying in size with a low upper limit. The composition of the mass is essentially quartz, feldspar, mica, and kaolin, colored by iron oxides. The thickness of the white beds varies from a few feet to twenty or thirty feet, ten feet being an average. The brownish beds are generally thicker and range from five or six feet to thirty or more feet.

Figure 2

Looking west along a rain washed outcrop of Monterey(?) at the Apache Canyon vertebrate locality. At the distant mesa horizon can be seen the Pleistocene accumulation resting unconformably on the colored beds.

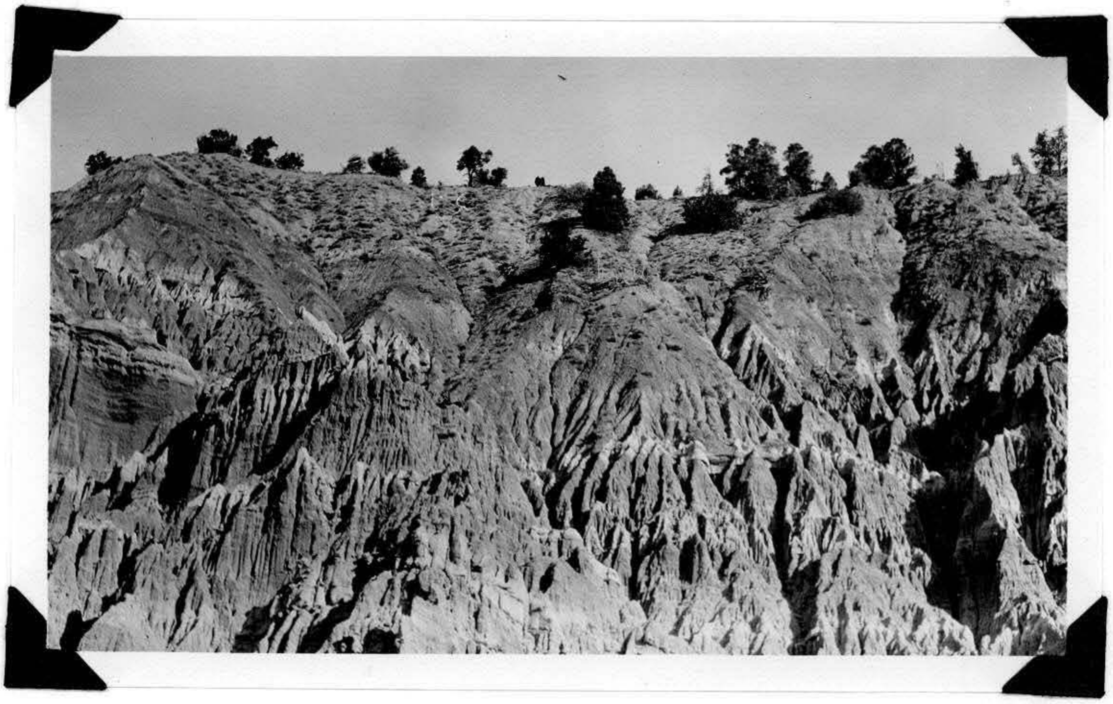


Figure 3

A north view at the same locality as Figure 2, also showing the Pleistocene overlying the Monterey(?).

Thicknesses of approximately twenty feet are rather common. The thickness of the formation as a whole is approximately 7500 feet (English) as measured from the lowest levels exposed to the bottom of the overlying Santa Marguerita(?).

Interbedded with the uppermost part of the series is a small basalt flow which is exposed in the northwestern portion of the mapped area and is found also in the region discussed in English's report.

Santa Marguerita(?).- This formation overlies the non-marine Miocene with apparent conformity in this district, and the contact between the two is defined on a rather arbitrary basis. In the region to the west English has found that the two are in places locally unconformable and at other localities the lower formation is absent. Furthermore, the overlying member contains a plentiful supply of basalt boulders which are not as commonly found in the Monterey, indicating that a period of erosion separates the two.

As defined for the particular area under discussion the Santa Marguerita has as its basalt portion a bed of brown gypsum-bearing clay of approximately five hundred feet in thickness (Fig. 4). Above this there is a series of coarse, rather well sorted and thin bedded sandstones, shales, and gravels, reaching a thickness of perhaps 4000 feet (Figs. 5 and 6). The color on weathered surfaces varies from gray to white and cream.

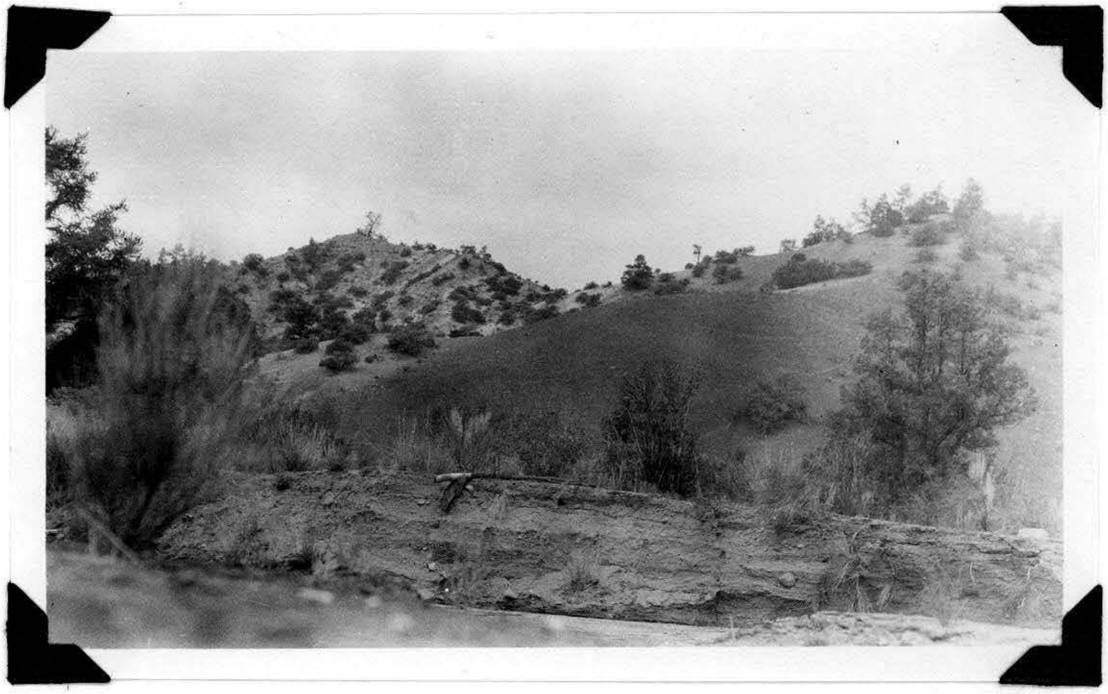


Figure 4. Basal member of Santa Marguerita(?) in center as exposed in a tributary valley to Apache Canyon.

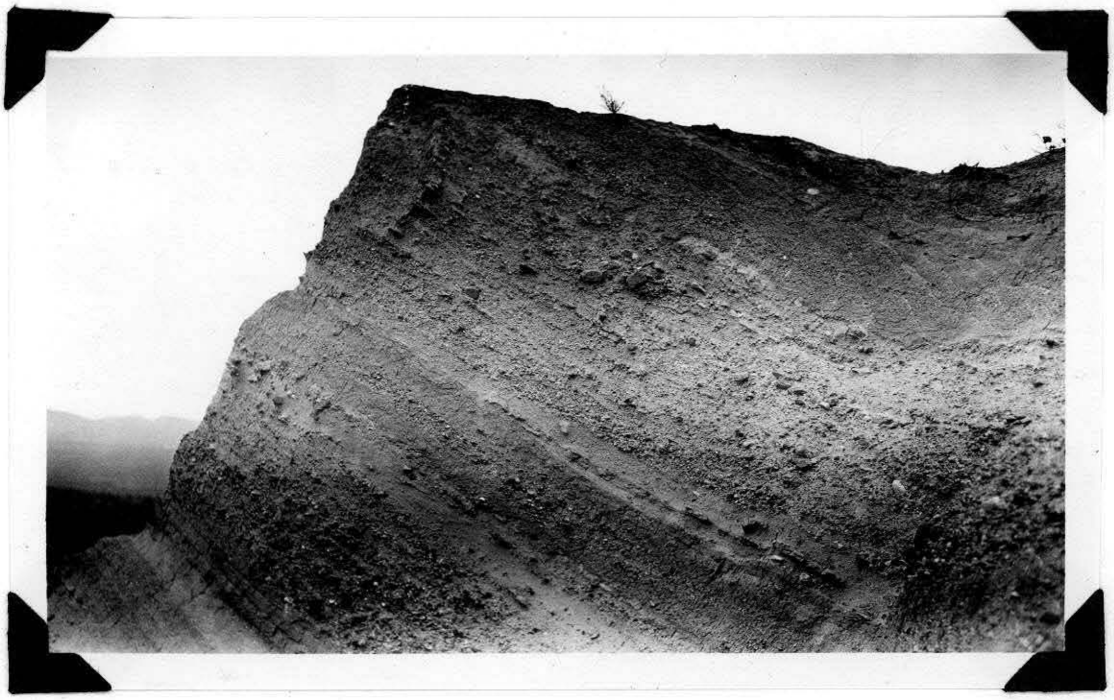


Figure 5. Close view of a very coarse sandstone or conglomerate horizon in the Santa Marguerita(?).

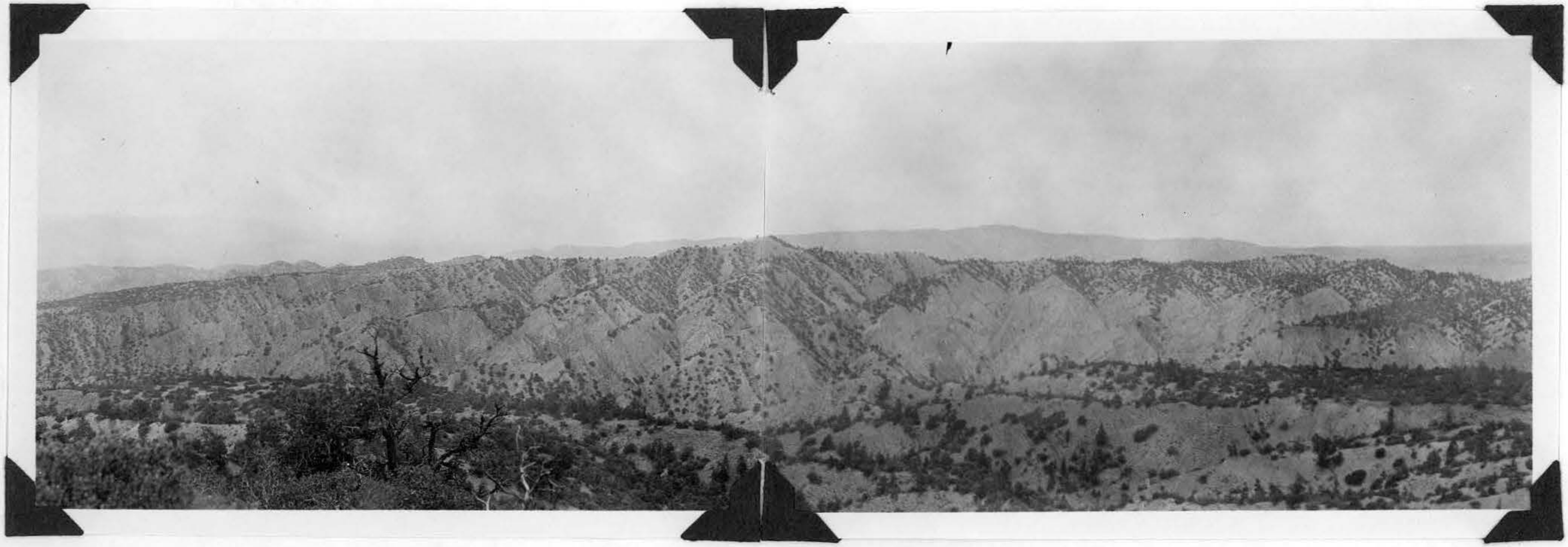


Figure 6

Panorama view of the north flank of the Santa Marguerita(?) syncline, exposed along the northwest side of Berges Canyon. Terrace remnants are in the foreground.

Without much doubt this series is marine although unfossiliferous in the region east of Cuyama Valley. The origin of the deposits is evidenced by the good sorting and fine bedding of the material, in spite of its fair coarseness at a number of horizons. The formation for the most part represents a near shore accumulation occurring during a period of fair land relief when frequent or diastrophic changes were taking place causing the variation in lithology.

<u>Pleistocene Terrace Sands and Gravels.</u>- The Pleistocene materials occurring in scattered patches over the area are found in association with the old mesa surface and the terraces. The best exposures and those which have been examined more closely lie on the ridge between Apache and Quatal Canyons (Figs. 2 and 3). Here the deposits range in thickness from a few feet to fifty or more feet. For the most part the materials consist of reworked sediments derived from the underlying formations. The sands are poorly stratified, contain a little coarse material, and in the above mentioned section are clearly derived from the Monterey(?) beds which they bevel. It is to be noted also at this locality that only the surface layers near the eastern end of the ridge contain material which may be considered as having come from the crystalline mass to the east.

The large, practically undissected mesa at the head of Apache Canyon (Fig. 7) probably carries an indefinite thickness of these terrace sands, all of which have been obscured by the extensive detrital

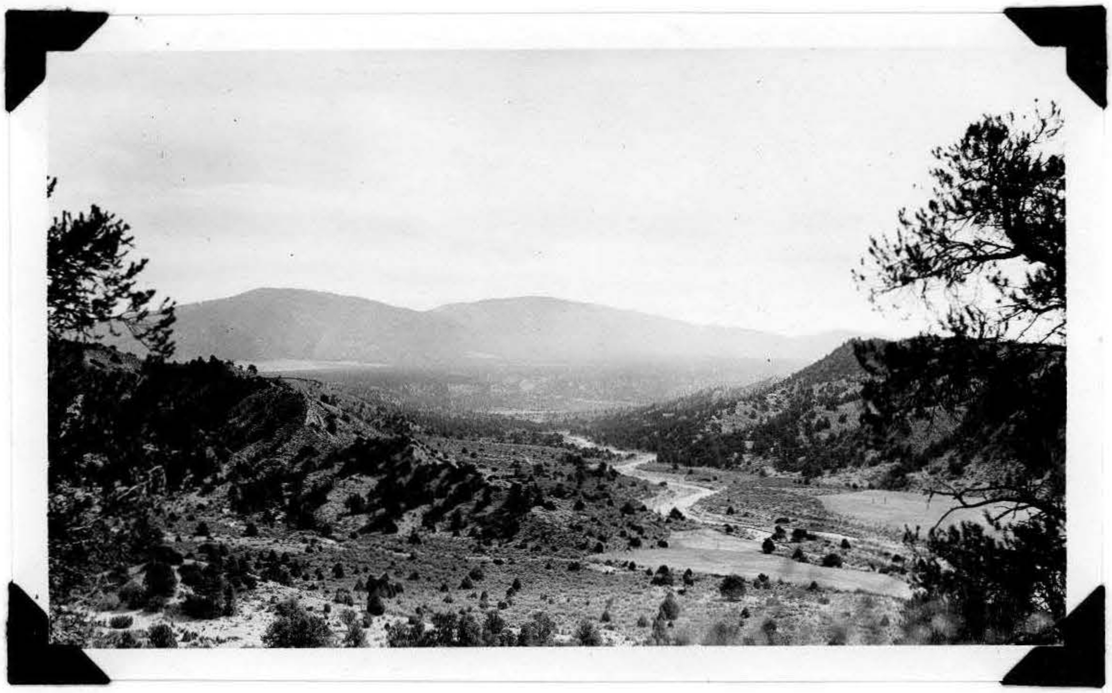


Figure 7

View east up Apache Canyon. The hills in the foreground are of Santa Marguerita(?). The Mount Pinos and Sawmill group form the mass in the background, and at its foot, stretching across the head of the canyon, is an extensive mesa.

deposit of Recent and probably late Pleistocene age derived from the easterly block. This overlying detritus is composed of boulders and gravels of granite and gneiss with an abundance of schist flakes, all in a coarse sand matrix.

The terraces in Berges Canyon are covered with only a thin veneer of reworked, and in part merely weathered, Santa Marguerita(?) material. However, there has been a certain amount of transportation and deposition inasmuch as it has been noted that the terraces near the head of the canyon present a striking reddish color in contrast to the gray and white beds of the underlying material. This is accounted for by the fact that the divide at the head of the canyon consists in part of the brown-clay basal member of the Santa Marguerita(?), which has contributed sediments to the terraces.

North of Quatal Canyon the mesa level has been outlined on the map, but the nature and extent of the material that is probably associated with it have not been closely examined.

Structure

Regional.- The area lies on a block to the southwest of the San Andreas Rift and in the northern part of the Santa Ynez and San Rafael mountain system. These ranges are essentially large anticlinoriums with accessory folding extending well out on the flanks. This major aspect of the Santa Ynez range is noticeable in an extensive section well exposed in Gaviota Pass near the coast to the west.

The Cuyama Valley region represents a small section of the folded portion of the northern flank of the San Rafael anticlinorium, which has been affected by movements resulting from its proximity to the San Andreas Rift. The rift at this point has a strike of approximately N. 65° W. and the neighboring structures to the south have arranged themselves to an orientation which approaches parallelism with the fault. In this vicinity the rift is changing its direction from N. 75° W. in Cuddy Valley to approximately N. 55° W. near the south end of the Carriso Plain north of the Caliente range.

<u>Local</u>.- The Tertiary sedimentary formations in the area mapped are folded up into broad anticlines and synclines. Faulting has occurred in the region of igneous masses. The Santa Marguerita(?) on the east side of Cuyama Valley is exposed along the core of a rather broad and simple syncline which persists for a considerable distance without appreciable plunge along its strike. According to English, the northwestward extension of the syncline forms the broad portion of the Cuyama Valley which has been modified by faulting and subsequent erosion. This syncline extends in a direction strikingly parallel to the rift, having along with the latter a more nearly east and west trend toward the south.

To the northeast are a series of smaller and somewhat more acute folds (Fig. 8) all trending nearly parallel except for minor deformation near the Mount Pinos igneous mass. In the vicinity of this block the strikes are not constant and the beds rapidly become

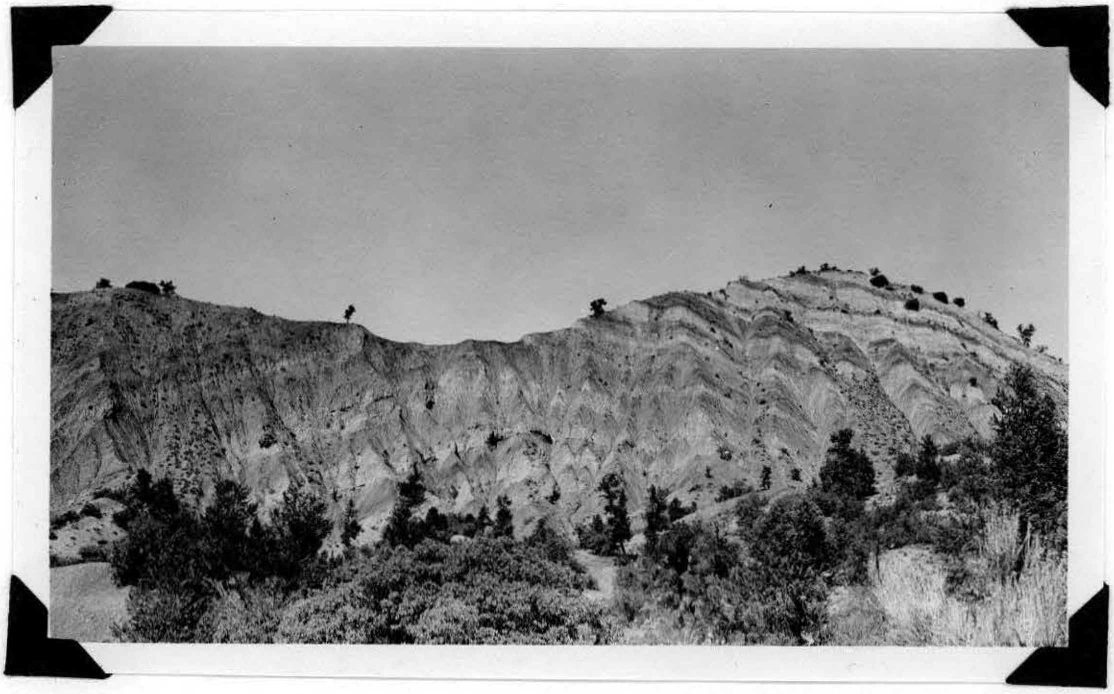


Figure 8

A cliff section of Monterey(?) showing the anticlinal structure a little north of the Santa Marguerita(?) contact in the vicinity of the Apache Canyon vertebrate locality.

nearly vertical in their dip. This has been noted particularly in Section 29, T 9 N, R 22 W, where the Monterey(?) deposits last appear before being obscured by the mesa detritus. The disturbed condition of the strata furnishes the only evidence for the existence of a fault presumably responsible for the uplift of this mass.

Another fault of more local extent has causes a small granite block to be exposed on the north side of Quatal Canyon near the basalt flow. This fault and the resulting igneous exposure have been noted by English in the Cuyama Valley report. A continuation of the fault on the south side of Quatal Canyon has not been observed, the deformation being recorded perhaps in one of the folds. Apparently the fault also disappears to the northwest in Ballinger Canyon.

Geologic History

The history of the area may be considered as having commenced with the deposition of the Monterey(?) series, inasmuch as this is the lowest formation exposed. During this period of sedimentation there occurred frequent alternations in the coarseness and in the type of materials deposited. The variation appears to have been almost periodic giving an effect which one might expect to find produced on a much smaller scale as a result of seasonal change. The thickness of the sediments recorded in the alternating periods is frequently, however, quite large. This alternation of thickness may have resulted from periodic climatic changes where the duration of any one cycle would represent a considerable length of time. The deposits apparently accumulated on a broad flood plain, possibly similar in size to that of the Colorado River. The waters of this stream may have contributed a part of the load to the extensive shale facies of the period.

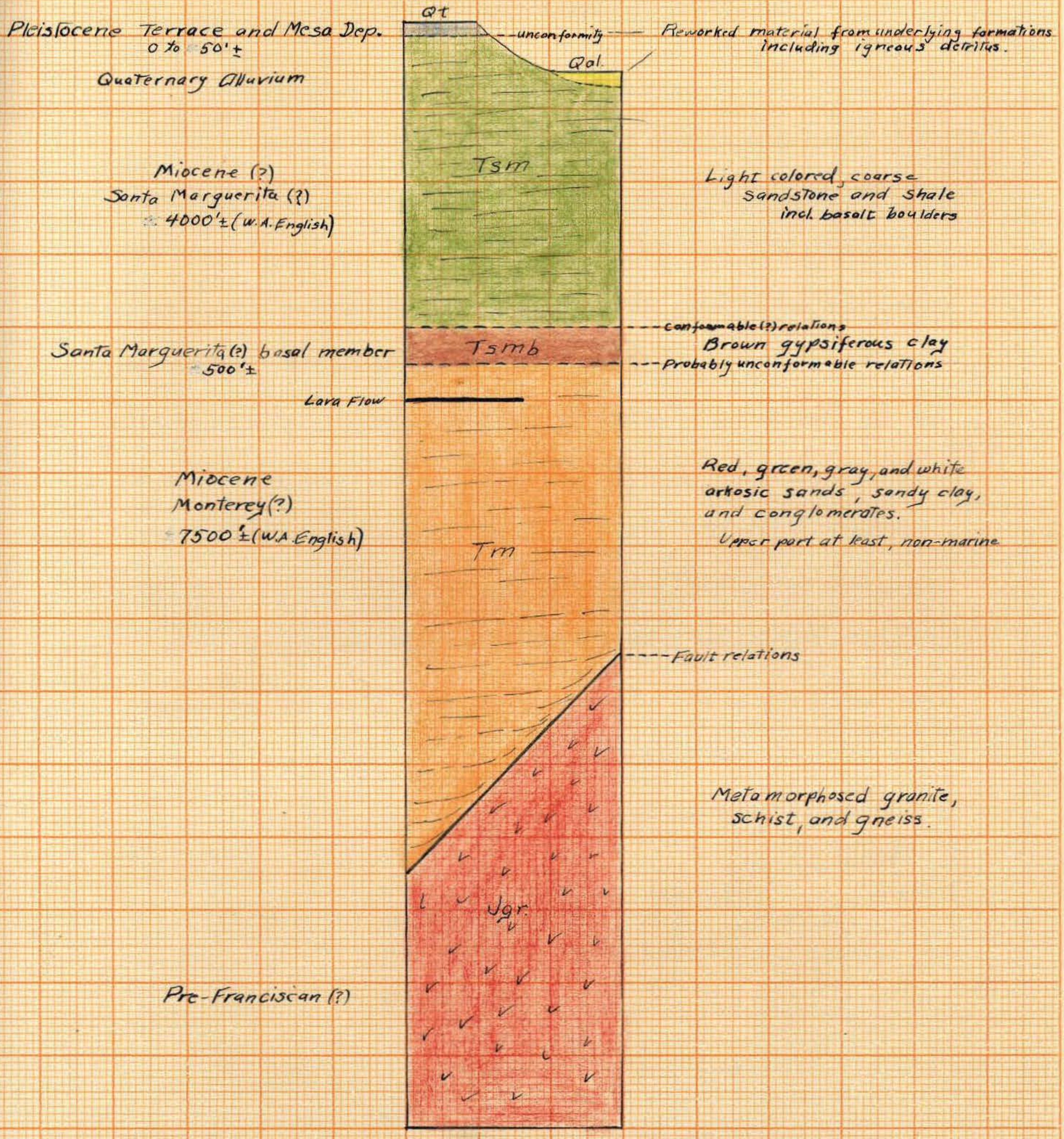
At the close of Monterey(?) time the entire region was subjected to a brief period of erosion, possibly unaccompanied by uplift at this locality. Following erosion the region was definitely lowered below sea-level and a thick series of marine sandstones and shales deposited. The subsidence was probably not rapid as sedimentation seems to have kept pace with it in maintaining an alternating series of rather constantly coarse materials.

Following the accumulation of the Santa Marguerita(?) the area emerged from the sea for the last time, and the Tertiary deposits were subjected to intense deformation resulting in the folding exhibited in the present structure. During the period preceding the deposition of the Cuyama formation, presumably of Pliocene age, orogenic movements initiated the formation of mountains.

During the deposition of the non-marine Cuyama formation over the beveled edges of the earlier strata, and subsequent to that time, the diastrophic forces affecting the crust altered the level of the land without regional crumpling. As indicated by the distribution of the upper-Pliocene(?) formation the Cuyama Valley was probably then in existence and controlled the accumulation of the material. At that time the valley appears to have been much wider and shallower than it is at present, permitting deposition to take place on a broad surface. Succeeding uplift has entrenched the stream and has restricted the area of deposition to the limits now observable. The area still remains, however, of generous proportions.

The most effective uplift occurred in late geologic time, as indicated by the very broad mesa-level which carries the Pleistocene sands and gravels. The resulting incision of the drainage pattern has given deep wide valleys and canyons separated by mesa remnants or sharp edged ridges which have been reduced somewhat below the table-level. The nature of the dissected material has played a very large part in the development of the type of erosional features now seen. Due to softness the materials have yielded readily to rain wash, producing large wide canyons with steep walls. The Santa Marguerita(?) deposits are weathered into pyramidal or conical shaped hills having generally a side slope in accordance with the angle of repose of fairly loose materials, and also sharp cliff faces where cutting has proceeded too rapidly for surface weathering. The smaller and narrower canyons are strikingly smooth and V-shaped, in contrast to the characteristic badland erosional features developed in the neighboring Monterey(?) sediments. In the latter series the hetrogeneous mixture of fine and coarse sediments, cemented with a soluble material probably in part gypsum, has yielded even more rapidly to rain wash, producing caverns and pinnacles like those often found associated with arid erosion.

During the period of terrestrial accumulation in post-Santa Marguerita time faulting elevated the Mount Pinos block high above the surrounding region. The overlying sediments were then subjected to erosion and contributed largely to the formation of the earlier land-laid beds of this interval. Later erosion of the granite and schist furnished the materials for the more recent accumulations. The faulting may have taken place during a large part of the Pleistocene and may have continued into the Recent period.



Columnar Section

C.L. Gozin

VERTEBRATE FAUNA

Occurrence

The zone in which the vertebrate fossils were found lies near the top of the formation tentatively recognized as the Monterey. The material is scattered through these upper beds from a point approximately one hundred feet below the brown gypsiferous clay member of the Santa Marguerita(?) to a level at least several hundred feet lower. The occurrence of the fossil remains is not sharply limited to a definite horizon, but apparently thins out gradually near its upper limits and is more concentrated in the upper parts of the formation. The material is very scattered in the lowest levels exposed in the ravines adjacent to the northern portion of Apache Canyon, but the still lower horizons represented on the north side of Quatal Canyon have not as yet been investigated.

The following is a faunal list of the types represented in this collection:

See later revised fauna as published

Perissodactyla
    Protohippus, sp.

Artiodactyla
    Merycodus, sp.
    Procamelus ?
    Oreodon ?

Rodentia
    Otospermophilus stocki, n. sp.
    Perognathus furlongi, n. sp.
    Hypolagus apachensis, n. sp.

Proboscidea
    Tetrabelodon ?

Testudinata

Evidence of Age of Fossil Bearing Strata

Physical.- The age of the faunal horizon may be determined on the basis of two types of evidence, (1) the correlation of the series with the known Tertiary record by the stratigraphic method, and (2) the stage of development and relationships of the vertebrate fauna.

The correlation of the deposits on the basis of physical evidence involving the areal mapping of the formations can be established through the intervening region between that in which the vertebrates occur and the area studied by English (1916, pp. 191-215). On this basis the formations have been identified in the foregoing work. English has correlated the formations on the two sides of Cuyama Valley on the basis of the regional structure. In the determination of the formation as Monterey(?) difficulty arises as a result of dissimilarity in lithology between the two sides and the apparent absence of an invertebrate fauna in the deposits exposed on the east side of the valley to check with. The supporting evidence lies in the careful study of the structure and the occurrence of a basalt flow in the upper part of the Monterey(?). These basalt flows, according to English, are rather characteristic of this horizon at a number of other places, particularly in the Caliente Range to the north of Cuyama Valley where they are associated with the upper beds of the Maricopa Shales.

Biological.- The presence of Protohippus in the fauna suggests an upper Miocene or lower Pliocene age. The stage represented by the teeth found in the Cuyama deposits is at least well up toward the top of the Miocene, and in view of this occurrence it is possible that the thick section of strata referred to as Santa Marguerita(?) is in part at least lower Pliocene rather than upper Miocene in age. A more complete collection may ultimately demonstrate the presence of such forms as Merychippus or Hypohippus on the one hand, or of Hipparion or Pliohippus on the other. Were the presence of the genus Merychippus determined as a result of further work the time relationships of the deposits in which the vertebrates occur as at present recognized would be approximately correct.

The presence of a large number of specimens belonging to Merycodus does not aid materially in the finer age distinctions because the group as a whole has not changed appreciably within the limits of the period designated by Protohippus. Furthermore, the absence of sufficiently complete horn-core material makes a specific determination of the form difficult, if not impossible, especially in referring to other forms which have been described on horn-structure.

The validity of making an age determination on the basis of evolutionary features of the Leporidae has not been established, but a consideration of the characters presented by Hypolagus apachensis with regard to forms described from other mammal horizons adds to the evidence in favor of considering the age as perhaps late Miocene.

The presence of mastodon material places the stage above the middle of the Miocene, this being in accordance with the view that the Proboscidea did not reach North America from the Old World until the middle of this period.

Correlation of Fauna

In a comparison of the vertebrate fauna from the Cuyama region with assemblages known from other Tertiary deposits of the Great Basin and Pacific Coast provinces, it is noticed that there is a rather small amount of protohippine material recorded. In several of these cases the form is doubtful, but in all, the genus tends to fall close to the Miocene-Pliocene transition. The presence of Protohippus and the apparent absence of Merychippus suggests a stage close to the upper limits of the Miocene. The Cedar Mountain (J.C. Merriam, 1916, pp. 161-198) and Barstow (J.C. Merriam, 1919, pp. 473-585) faunas contain a questionable Protohippus associated with Merychippus and Hypohippus, and both assemblages have been regarded as upper, if not uppermost, Miocene in age. Protohippus tehonensis is also recorded in association with Hipparion from the Chanac (J.C. Merriam, 1916, pp. 111-127). This assemblage has been regarded as lower Pliocene in age.

The Cuyama faunal horizon seemingly corresponds stratigraphically to the "Big Blue" or "Rainbow beds" of the North Coalinga region (J.C. Merriam, 1915) in its relation to the overlying Santa Marguerita(?), but in this area Protohippus(?) is recorded from beds determined as the lower Etchegoin or Jacalitos and lying above the Santa Marguerita. Protohippus(?) at this locality occurs above Neohipparion and below, or in association with, Pliohippus coalingensis.

The Mint Canyon series has yielded Parahippus, Merychippus, and a protohippine form and is of middle or upper Miocene age. The close proximity of the latter occurrence to the Cuyama Valley region will undoubtedly furnish in further work an interesting correlation problem in both geology and paleontology. At present it would appear that the Mint Canyon horizon is somewhat older, this relationship being based on the occurrence of Merychippus, Parahippus, and Miolabis in the Mint Canyon fauna.

The Great Plains (H.F. Osborn, 1918, p. 128) region has contributed a considerable number of individuals and species belonging to the genus Protohippus, particularly in Nebraska. The Republican River localities have furnished three distinct species in the Pliauchenia-Peraceras zone, which is probably lowermost Pliocene. In the Snake Creek group Protohippus has been recorded from one of the upper zones apparently in association with Hipparion and possibly Pliohippus. In the following deposits of the Great Plains regarded as lower Pliocene (or upper Miocene) in age Protohippus has been found in association with Procamelus and Hipparion: (1) Upper Pawnee Creek beds, Colorado, (2) Clarendon formation, Texas, (3) Little White River formation, South Dakota, and (4) the Niobrara River formation in Nebraska.

Should additional field work in the Cuyama area result in the discovery of more and better preserved equid material the age and relationships of the occurrence would perhaps be confined within narrower limits. The presence of Hipparion would tend to bring the fauna into close time relation with the Ricardo, or the presence of Merychippus would suggest an age close to that of the Barstow, inasmuch as the remaining forms, when comparison can be made, are common to both stages.

Description of Material

Protohippus, sp.

Remains of members of the family Equidae include a number of upper and lower teeth and several elements, for the most part incomplete, of the skeleton.

In most of the upper teeth only a portion of the crown is preserved, making a specific determination rather difficult. These teeth appear to belong to the genus Protohippus as suggested by the size, shape, and enamel pattern. The size of the limb fragments suggests a type intermediate between the merychippine forms of the middle Miocene and the equif species of the Pleistocene.

The Cuyama form resembles somewhat the P. perditus group of the Great Plains region except for the cross-section of the upper teeth which is somewhat larger in the former than in the latter. A rather advanced stage in the development of the protohippine horses of the Cuyama may be indicated by the size of the teeth, in which respect an approach is made to the genus Pliohippus.

Measurements.-

		Transverse width	Ant.-posterior width	Heighth
Left upper molar	No.19	2.7 cm.	3.1 cm.	3.5 cm.
Left upper molar	No.20	2.5 (approx)	2.6	3.3
Left upper molar or premolar	No.21	2.7 (?)	2.9	4.3
Left P2 (?)	No.22	2.2 (approx)	2.8	4.3
Right upper molar	No.23	2.9	2.7	3.1
Right M3 (?)	No.24	2.3	?	2.0
Right upper premolar	No.25	2.6 (approx)	2.9	5.3
Left lower tooth	No.26	1.8	2.6	3.3
Right lower tooth	No.27	1.4	2.6	4.8
Right lower tooth	No.28	1.5	2.6	3.6

Merycodus, sp.

The merycodont antelopes are among the more common types represented in the fauna. The material consists of numerous scattered teeth in jaw fragments, parts of limb bones, carpal and tarsal elements, vertebrae, and many small fragments of horn-cores. There is also one partially preserved skull with lower jaw and several associated parts of the skeleton belonging to one individual and collected at a locality in Apache Canyon. The skull of this individual is small, although it does not represent a particularly young animal since the sutures are all indistinct. In addition it is without horns, and there is no evidence of its ever having possessed any.

It is difficult to compare this material with that which has been described from other late middle Tertiary occurrences inasmuch as the proportions and attitude of the horns has played a large part in distinguishing the various species, and the most complete specimen from the present occurrence is the individual without horns. Pieces of horn which have been found are too fragmentary to be of value.

In size, a character of doubtful value, the form seems closer to _M._ _necatus_ of the Barstow than to _M._ _furcatus_ of the Ricardo (E.L. Furlong, 1927, pp. 145-186).

Procamelus(?), sp.

A portion of the symphasis of a lower jaw, two astragali, and several small fragments of limb elements represent the occurrence of camel. At present the nature of the material does not permit of a definite generic identification.

Oreodont(?), sp.

The presence of oreodons in the fauna is suggested by a portion of the mandible near the ascending ramus with only roots of the teeth showing, also by a few teeth, and possibly by a number of limb fragments which have been assigned to this group.

Order Rodentia *Revised later*

Family Sciuridae

In describing the fossil sciurid material from the Cuyama an attempt has been made to determine the structural characters of the skull and dentition distinguishing the recent squirrels, Sciurus, Otospermophilus, and Citellus. The recognition of these types by modern mammalogists is frequently based on characters other than those available to the paleontologist, and question may be raised as to the validity of the reference of fossil forms to Otospermophilus unless the structural features which ally the former with the modern type can also be employed in distinguishing Otospermophilus from other living sciurids. In the following description an attempt is made to determine the structural relationships of the three living genera.

Skull.- The ratio of dorso-ventral depth of the rostral region to lateral width is much greater in the case of Sciurus than in either Citellus or Otospermophilus. A pair of fossae posterior to the incisors, but anterior and somewhat lateral to the anterior palatine foramina are conspicuous in Citellus and Otospermophilus, but are indistinct in Sciurus. The infra-orbital foramina in Sciurus are considerably anterior in position with reference to P3 and have a rather smooth unprotruding lateral margin, whereas in Otospermophilus the foramina are less advanced in position and the outer margin protrudes laterally and downward. In Citellus the foramina are still less advanced in position, more rounded and show a very pronounced lateral development of the external margin. Moreover, there is a greater antero-posterior inflation of the bullae in _Sciurus_ and _Otospermophilus_ than in Citellus. In addition there are a number of other skull characters of lesser importance which assist in discriminating the three forms.

Mandible.- In the lower jaw the depth of the ramus is much greater proportionately in _Sciurus_ than in either _Otospermophilus_ or _Citellus_. Excepting size, no noticeable character distinguishes the lower jaw of _Otospermophilus_ from that of _Citellus_.

Upper Dentition.- P3 is simple and rudimentary in _Sciurus_, but larger and stronger in _Otospermophilus_ and _Citellus_, having a very pronounced bifid cross-section in the latter. The upper molars and P4 of _Sciurus_ are somewhat quadrate in form, particularly M1, with low cusps and shallow basins. In _Otospermophilus_ the teeth are somewhat less quadrate than in _Sciurus_ with cusps more pronounced, whereas in _Citellus_ these teeth are decidedly triangular with the internal apex angle more sharply formed. The cusps and ridges of the teeth in _Citellus_ are very well defined and the valleys are more deeply impressed than in the other forms.

Lower Dentition.- In _Otospermophilus_ the teeth approach _Sciurus_ in their shallowness, with the two outer cusps protoconid and hypoconid, of equal height in practically all stages of wear, whereas in *Citellus* the internal basin is deeper and the protoconid is better developed than the hypoconid unless the tooth has been subjected to considerable attrition. This tendency on the part of the protoconid to increase in size aids in the formation of a high transverse ridge connecting with the paraconid. This ridge is not well developed in *Otospermophilus*, nor is the paraconid as conspicuous as in *Citellus* when teeth of equivalent stages of wear are compared. Furthermore, the two anterior cusps in $\overline{P4}$ of *Otospermophilus* are closer together than in *Citellus*. In the latter genus the two cusps are spread out to form a ridge giving this premolar a shape similar to that of the succeeding molars.

To recapitulate, the following characters distinguish *Otospermophilus* from *Citellus* and from *Sciurus*:

A. *Otospermophilus* from *Citellus*

I. Infra-orbital foramina are more advanced in position with opening not as circular.

II. Greater antero-posterior inflation of bullae.

III. Dentition:

1. $P\underline{3}$ not bifid in cross-section.

2. Molariform teeth more quadrate, less triangular in shape.

3. Cusps of teeth less pronounced and have shallower basins.

4. Protoconid not large and equal in height to hypoconid.

5. Paraconid less developed.

6. Protoconid and paraconid do not form an anterior transverse ridge.

7. $\overline{P4}$ has anterior cusps closely appressed rather than spread apart to form a ridge.

B. Otospermophilus from Sciurus

I. Less depth of rostral region in proportion to width.

II. Prominence of fossae posterior to superior incisors.

III. Infra-orbital foramina not as anterior in position and outer margin has a lateral and downward development.

IV. Less relative depth of mandible.

V. Dentition:

1. $P\underline{3}$ less rudimentary.

2. Molariform teeth less quadrate.

3. Cusps of teeth more pronounced and basins deeper.

4. Paraconid more developed.

Citellus (Protospermophilus) quatalensis n. subgen. and sp.

Otospermophilus stocki, n. sp.

Type specimen.- No. 30 C.I.T. Coll. Vert. Pale., a skull including superior dentition and lower jaw from locality 48 in Quatal Canyon eight miles east of Cuyama Valley.

Co-types.- Nos. 31, 32, 33, & 34.

Specific characters.- Broad muzzle with strong dorso-lateral ridges parallel to incisors and lower jaw having a short diastema with curve of superior surface shallow. Molariform teeth quadrate, low cusped, and shallow basined with the internal cusp on superior teeth partially divided, and lower teeth having ridge with entoconid disconnected from paraconid.

Material.- This form is represented in the collection of the California Institute by a series of eight specimens which may be listed as follows:

Upper jaw No. 30 consists of the anterior part of the skull with the larger portion of the superior dentition. Nos. 30 and 30 are right and left ramii, respectively, of the lower jaw which were found in association with No. 30 and probably belong to the same individual. No. 34 is a more fragmentary upper jaw without teeth. Nos. 31 to 33 are lower jaw fragments carrying from two to four teeth apiece.

Description.- The skull is characterized by an extremely broad muzzle with the premaxillaries forming a considerable part of the dorsal surface well towards the anterior end. A strong dorso-lateral ridge extends parallel to the incisors from the zygoma to the nasal opening. In the living forms this ridge is only faintly demarcated. The width of the ventral surface of the skull is also very pronounced in the vicinity of the anterior palatine foramina.

The fossae posterior to the incisors and antero-lateral to the foramina are large as in many ground squirrels. The ventro-lateral margins of the infra-orbital foramina are developed as in Otospermophilus.

The lower jaw has a rather short diastema which is shallow in that it does not drop much below the level of the base of the teeth. The depth of the mandible below the grinding teeth is small, this being a common characteristic among ground squirrels. The masseteric fossa terminates anteriorly below the middle of $\overline{M1}$.

$P\underline{3}$ is very small and simple, much as in Sciurus. The superior grinding teeth are quadrate in shape, rather low cusped and shallow basined as in both Sciurus and Otospermophilus, and differ somewhat in these characters from the comparable teeth in Citellus. The posterior ridge running transversely inward from the postero-lateral cusp (metacone) in teeth present in No. 30 is slightly concave anteriorly as in Sciurus. Also it is noticeable that one or two intermediate cusps are present on the outer rim between the paracone and the metacone in several of the teeth. The most characteristic feature in the upper dentition, however, is the division of the internal cusp in each tooth into two equal and closely appressed cusps, adding to the rectangular appearance of the teeth. These cusps are completely united in all Recent genera. The division of the cusps is a primitive character and is commonly present in the Eocene and early Oligocene Ischyromydiae, which family is regarded by W. D. Matthew (1910, p. 64) as ancestral to the Sciuridae.

The lower teeth increase in size from $\overline{P4}$ to $\overline{M2}$ and are rudely rectangular in shape, except $\overline{P4}$ which is somewhat triangular due to the appressed position of the two anterior cusps. In this respect No. corresponds closely to *Otospermophilus* and *Sciurus*, but is removed from *Citellus*. The teeth have low well defined cusps and rather shallow basins. The postero-internal ridge is sharply disconnected from the paraconid and carries a rather well developed entoconid which is more like that in *Sciurus* than like that in either of the ground squirrels discussed. The paraconid is slightly higher than the remaining, equally elevated cusps, and in this respect approaches both *Sciurus* and *Otospermophilus*. The paraconid does not tend to form an anterior ridge as it does in *Citellus*.

Relationships.- On the basis of the material available *Otospermophilus stocki* appears to represent a stage in or near the line of descent of the ground squirrels. Moreover, it appears that the form resembles the Recent genus *Otospermophilus* more nearly than it does any of the other sciurids. On the other hand, *Otospermophilus* presents characters midway between *Sciurus* and *Citellus*, and inasmuch as the Cuyama specimen possesses features in which *O. stocki* makes an even closer approach to *Sciurus* and its ancestors than do the Recent species of the genus to which the fossil was referred, one may be warranted in assuming that *Otospermophilus* branched from the *Sciurus* group in post-Eocene time and presumably prior to the upper Miocene. *Citellus* with its close relationships to *Otospermophilus* among the Recent forms may have diverged from *Otospermophilus* somewhat later, developing to a larger extent those characters which separate the latter genus from *Sciurus*.

The present fossil differs from *O. gidleyi*, recorded by J. C. Merriam, Chester Stock, and C. L. Moody (1925, pp. 68-69) from the Rattlesnake Pliocene, in much shallower depth of mandible in proportion to the length, in greater development of the entoconid, and in a lesser elevation of the paraconid. In the proportions of the ramus *O. gidleyi* resembles more closely *Sciurus* than the form under discussion, but in dentition it is more advanced than the latter and shows characters closer to the Citellid group.

<u>Measurements</u>.-

	O. stocki	S. griseus	O. beecheyi	C. richardsonii
Skull:				
Depth of muzzle immediately in front of maxillaries	10.3 mm.	15.6 mm.	11.3 mm.	10.0 mm.
Width of muzzle	14.7	12.7	11.6	9.9
Length of diastema	11.4	15.7	15.3	12.5
Width of palate between M1	8.2	8.1	8.2	7.6
Dentition:				
P3-M3	10.5 (approx)	11.6	11.2	10.6
Antero-posterior diam.				
I	3.4 (approx)	3.6	2.8	2.0
P4	2.0	2.3	2.0	1.9
M1	2.2	2.9	2.3	2.0
M2	2.3	3.1	2.5	2.0
M3		3.3	2.7	2.7
Lateral diameter				
I	1.9	2.0	1.8	1.6
P4	2.5	2.7	2.7	2.7
M1	2.6	3.3	3.2	3.0
M2	2.7	3.6	3.2	3.0
M3		3.3	3.0	2.8
Length of palate from incisors to post-palatal notch	24.9	30.7	28.3	25.2
Mandible:				
Depth of ramus under M1	7.3	10.5	8.0	7.5
Length of diastema	6.6	8.2	9.6	8.0
Dentition:				
P4-M3	10.0	12.0	11.0	9.5
Antero-posterior diam.				
I	3.1	3.8	2.6	2.2
P4	1.9	2.2	2.1	1.9
M1	2.0	2.8	2.3	2.0
M2	2.4	3.0	2.8	2.2
M3	3.2	3.6	3.4	3.3
Lateral diameter				
I	1.6	1.4	1.6	1.5
P4	1.8	2.4	2.5	2.4
M1	2.5	3.3	3.1	2.6
M2	2.7	3.5	3.3	3.0
M3	2.7	3.2	3.1	2.8

Perognathus furlongi, n. sp.

Type specimen.- No. 35 C.I.T. Coll. Vert. Pale., a fragmentary skull including superior dentition, from Locality in a ravine adjacent to Apache Canyon eight miles from the Cuyama Valley.

Specific characters.- The dorsal surface of the muzzle is broad with the naso-frontal suture anterior to the suture between premaxillary and frontal. The maxillary is broad between the teeth and the diastema is rather long. The tooth line is not straight but tends to be convex outward. Teeth have external convex surfaces and deeply infolded enamel.

Comparison.- Compared with Recent species the teeth of this form are somewhat less prismatic, each having a strongly convex external surface. The infolding of the enamel in M1 and M2 is deeper in No. than in Recent species, allowing for differences arising from the inequality of wear in these teeth. The fold in each of these two teeth is impressed well through the convexity of the outer side, giving the very base of the tooth an indented outline.

The paleontological record of the pocket mice is very incompletely known. Dr. L. R. Dice (1925, p. 125) notes the occurrence of forms referable to the Recent subspecies P. californicus californicus Merriam at Rancho La Brea. Matthew (1924, p. 85) has described the type Peridiomys rusticus from the lower Snake Creek beds of Nebraska and places the genus in the family Heteromyidae. Peridiomys appears to be closely related to Perognathus but unfortunately no comparison can be made with the Cuyama specimen inasmuch as Matthew's description was based on a lower jaw.

Perognathus furlongi is surprisingly similar to living species of the genus, considering the wide separation in time. Although the form is more primitive in a number of characters there is notable correspondence in many points. This type furnishes apparently another example of the stability of structural characters exhibited by groups of rodents in their evolution during the later Cenozoic.

Measurements.-

Width of muzzle dorsally	4.9 mm.
Width of palate at anterior palatine foramina	2.7
Length of diastema	7.1
Depth of muzzle midway above median point in diastema	6.2
Width of palate between M1	2.8
Dentition:	
P4-M3	4.1
Antero-posterior widths of	
I	1.4
P4	1.6
M1	0.9
M2	0.8
M3	0.7
Lateral widths of	
I	0.9
P4	1.2
M1	1.3
M2	1.2
M3	0.9

Hypolagus? apachensis, n. sp.

Type specimen.- No. 36 C.I.T. Coll. Vert. Pale., a left ramus of the mandible including inferior dentition without incisor, from Locality   in a ravine adjacent to Apache Canyon eight miles from the Cuyama Valley.

Co-types.- Nos. 37, 38, + 39

Specific characters.- Size smaller than in other species referred to Hypolagus. The antero-posterior and transverse diameters of lower molariform teeth are nearly equal. $\overline{P3}$ is well rounded with postero-external re-entrant fold simple and extending nearly half way to internal margin, and antero-external re-entrant fold shallow and V-shaped. External surface of $\overline{P3}$ shows longitudinal groove throughout tooth length.

Material.- The form is represented by approximately fifteen lower jaw fragments retaining from one tooth to a full set of grinding teeth. One fragment, No. —— , consists of the diastemal region with the base of the incisor and $\overline{P3}$. There is also a cheek fragment, No. 37 , with parts of $\underline{P2}$, $\underline{P3}$, $\underline{P4}$ and $\underline{M1}$.

Description.- The form compares favorably in dimensions of lower jaw, as far as known, with living species of Sylvilagus. $\overline{P4}$ to $\overline{M2}$ inclusive have a fairly simple external fold extending practically to the internal margin, dividing each tooth into two joining columns. $\overline{P3}$ is a well rounded tooth with postero-external re-entrant fold simple and extending nearly half way to the internal margin. The antero-external re-entrant fold is shallower and V-shaped. The internal surface of the tooth is not evenly rounded but has a slight yet definite concavity or groove throughout the length of the tooth. In one of the jaw fragments, No. 38 , $\overline{P3}$ is more elongated antero-posteriorly and shows two such concavities. This specimen may be specifically different from the rest but a separation does not appear to be justifiable on the basis of the limited material available. $\overline{M3}$ is a double-columned tooth with the division taking place as a result of the extension of the re-entrant folds from both the internal and external surfaces towards the middle of the tooth.

The upper tooth row is fragmentary, but P$\underline{2}$, which is somewhat broken, is elongated laterally and shows a pronounced anterior fold with another incipient fold external to it. P$\underline{3}$ and M$\underline{1}$ inclusive are simple teeth with an internal, slightly flexed fold extending a little past the middle of each tooth. The external surfaces of these teeth are folded inward but not deeply.

<u>Comparison</u>.- The Cuyama form differs from the type species, <u>Hypolagus</u> <u>vetus</u> (Kellogg) (1910, pp. 436-437, and see also L.R. Dice, 1917, pp. 181-182) from the Virgin Valley Miocene of Nevada in smaller size and in the character of the teeth. $\overline{P3}$ has a less triangular shape, a more convex posterior surface, and a slightly sharper and deeper

antero-external re-entrant angle. _H. vetus_ does not have the concavity or groove on the inner surface of this tooth. $\overline{P4}$ to $\overline{M2}$ are broader antero-posteriorly in proportion to their transverse width than they are in _H. vetus_. Also, the upper teeth have a simpler, less serate internal fold than in the type species.

The species differs from _H. edensis_ Frick (1921, p. 348) of the lower Pliocene Eden beds, in having a considerably shallower antero-external re-entrant angle of $\overline{P3}$, and a more posterior position of this infolding. In _H. edensis_ the fold is more nearly on the anterior surface of the tooth, and has changed materially the whole appearance of the tooth, giving it an appearance like that in modern forms.

The Cuyama form also differs from _Lepus macrocephalus_ Matthew (1907, pp. 214-216) from the Upper Rosebud of South Dakota in much shorter length of diastema in proportion to depth of jaw and in length of lower tooth row. Also, _L. macrocephalus_ is a distinctly larger form, although not much larger than _H. vetus_. Dr. Matthew in a later paper (1924, pp. 85-87) refers this species and _L. primigeneous_ presumably to the genus _Archeolagus_.

Measurements.-

	H. apachensis	H. vetus	H. edensis	L. macrocephalus
Depth of lower jaw below P4	9.6 mm.			13.0 mm.
Length of diastema	12.2	14.1 mm.		15.0
Dentition:				
P2-M1	8.0			
P3-M3	11.0			15.7
Antero-posterior diam.				
P2	1.1			
P3 (superior	1.5			
P4 dentition)	1.7			
M1	1.7			
Transverse diameter				
P2	1.9			
P3 (superior	2.9			
P4 dentition)	2.8			
M1	2.6 (?)			
Antero-posterior diam.				
I	1.5	1.9		
P3 (inferior	2.3	2.9	2.4 mm.	
P4 dentition)	2.1	2.7		
M1	2.0	2.4	2.0	
M2	2.0	2.6	2.1	
M3	1.5			
Transverse diameter				
I	2.0	2.5		
P3 (inferior	2.0	2.8	2.1	
P4 dentition)	2.2	3.2		
M1	2.1	3.1	2.2	
M2	2.1	2.8	2.2	
M3	1.4			

Tetrabelodon(?), sp.

Several tooth fragments have been collected which undoubtedly belong to the mastodon group. The material probably represents the _Tetrabelodon_ or _Trilophodon_ stage, although nothing of the jaw structure can be inferred from these fragments.

Testudinate Remains

Tortoises are represented by a nearly complete limb bone and a large number of carapace and plastron fragments.

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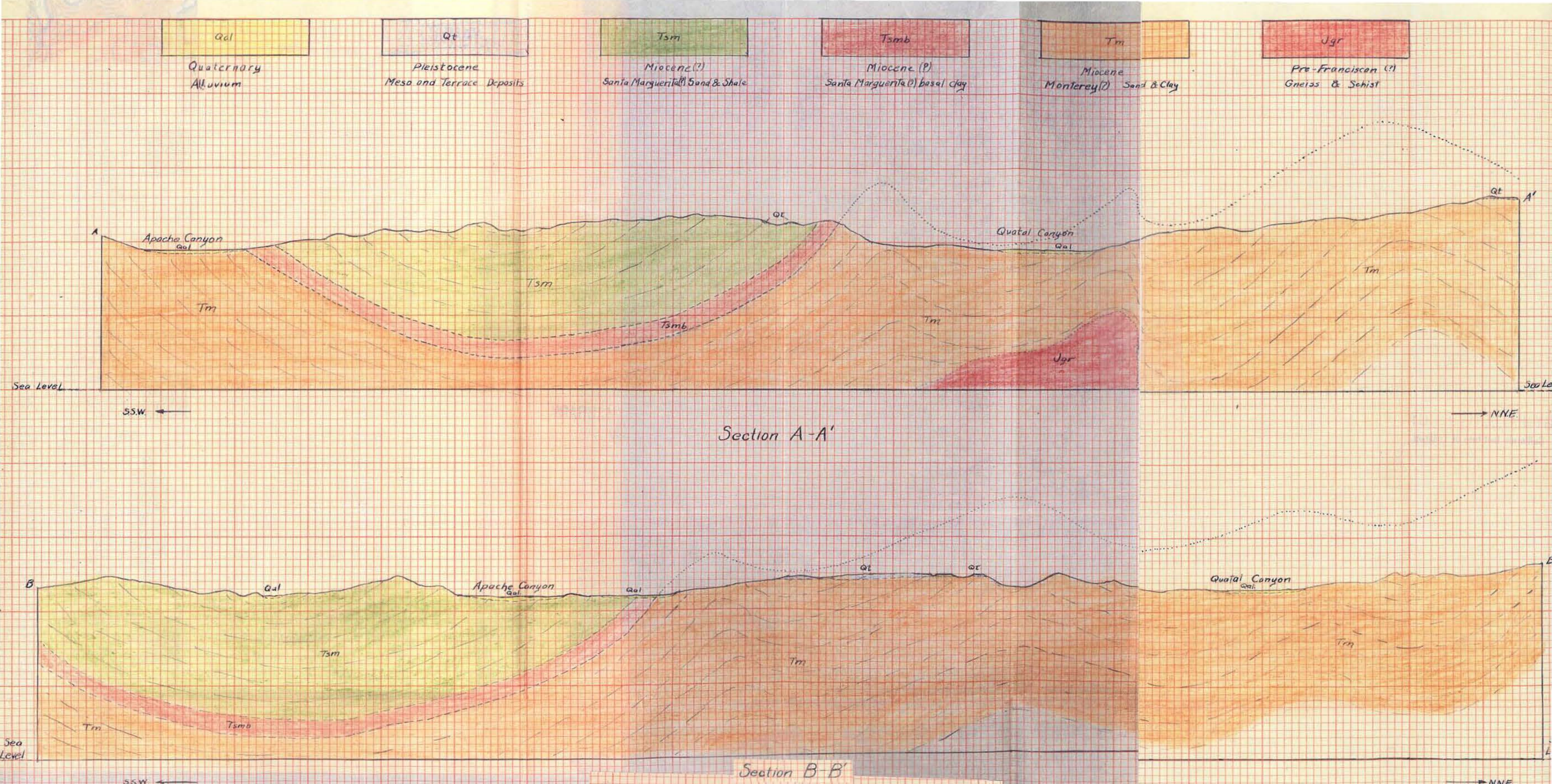
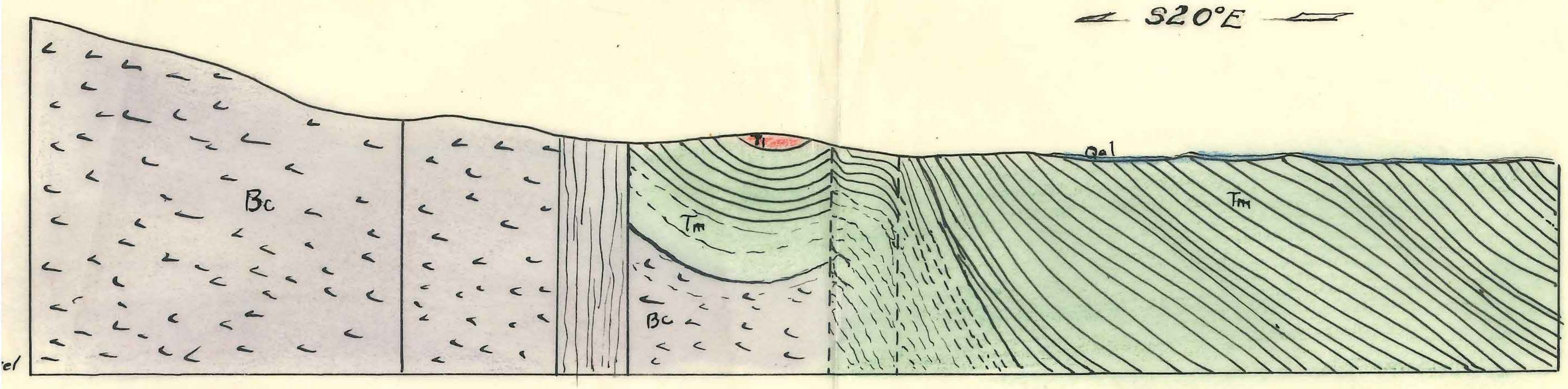


Geologic Sections across Apache and Quatal Canyons

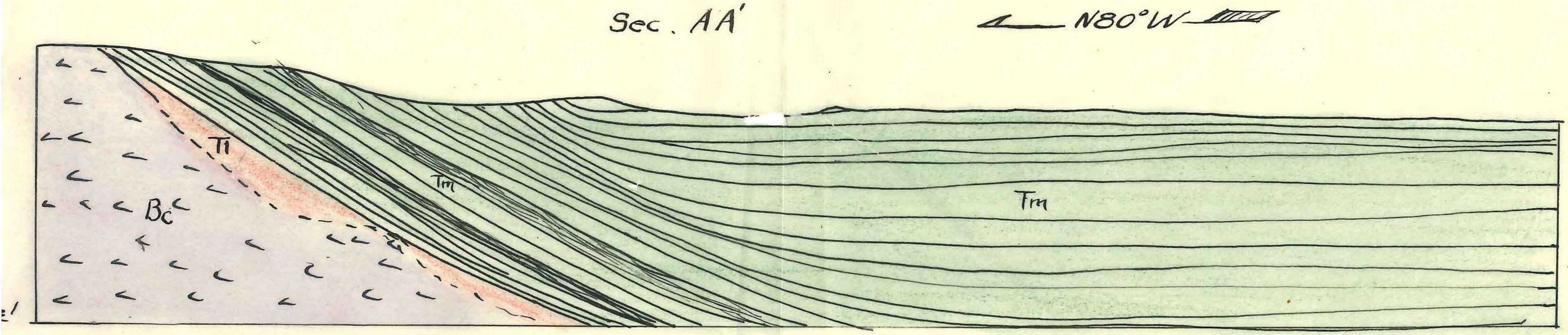
Scale 2000' = 1' (approx.) Normal Profile

GAZIN 1928

Sec. AA'

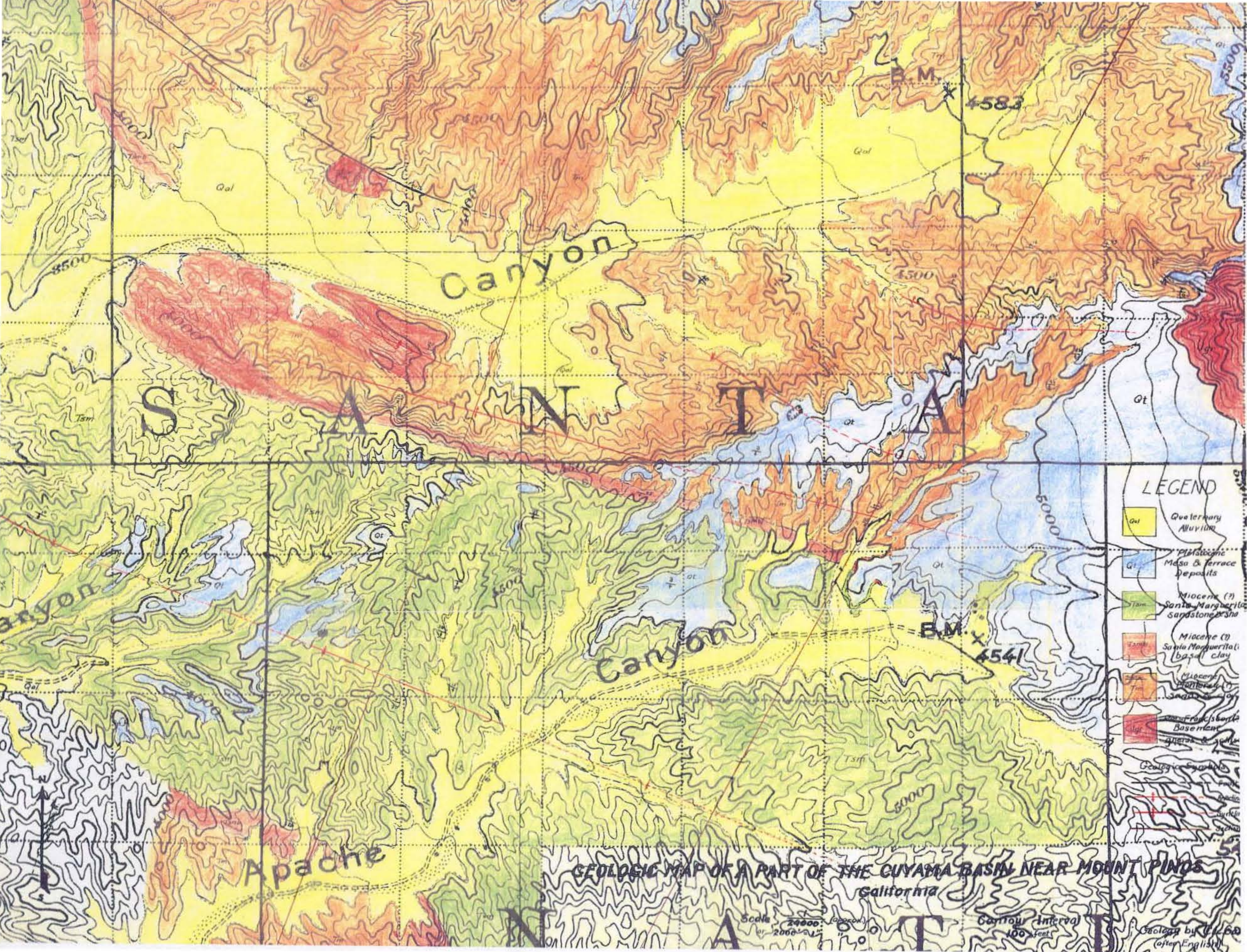


Sec. AA'



Qal --- Pleistocene alluvium
Tm --- Miocene s.s. etc.
Ti --- Miocene volcanics
Bc --- Basement complex

Note - sections generalized
Natural Scale



GEOLOGIC MAP OF A PART OF THE CUYAMA BASIN NEAR MOUNT PINOS
California
LEGEND
Quaternary Alluvium
Pleistocene Mesa & Terrace Deposits
Miocene (?) Santa Margarita Sandstone & Shale
Miocene (?) Santa Margarita basal clay
Santa Fe Basement
Geologic Symbols
Canyon
Canyon
Apache
S A N T A
B.M. 4583
B.M. 4541
5000
4500
Qal
Qt
Tsm
Contour Interval 100 feet