GEOLOGY OF THE UPPER TICK CANYON AREA
LOS ANGELES COUNTY, CALIFORNIA

Thesis

by

Carel Otte, Jr.

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ABSTRACT

The upper Tick Canyon area, approximately seven square miles in extent, lies between Agua Dulce Canyon and Mint Canyon in the easternmost part of the Ventura Basin in southern California. This area was mapped in detail on a scale of 1000 feet to one inch and the stratigraphic and structural relationships of the exposed rocks were established.

The oldest rocks in the area are of highly metamorphosed metasedimentary and metavolcanic types, which are intruded by igneous bodies of presumed pre-Cretaceous age. This crystalline complex is in fault contact with the rocks of the Vasquez series, the oldest unit in a thick section of Tertiary sedimentary and volcanic rocks.

The Vasquez series is perhaps Oligocene in age and was deposited under nonmarine conditions in an elongate trough of fault-block origin. The rocks are mainly fine-to coarse-grained clastic sediments. Interlayered with them are basaltic and andesitic flows and shallow intrusive masses, that form with the sediments a total section of about 4500 feet. This section thickens rapidly east of the area mapped.

Overlying the Vasquez strata with a distinct angular unconformity is a series of conglomerates and siltstones of the late Lower Miocene Tick Canyon formation. This unit is approximately 900 feet thick, but thins rapidly to the west within the area under consideration. The Upper Miocene Mint Canyon formation, which also consists of nonmarine clastic

sedimentary rocks overlies the Tick Canyon formation throughout the area. These two formations probably are separated by an unconformity, along which there may be local angular discordance of a few degrees.

Almost flat-lying, Pleistocene stream deposits occur throughout the area at an elevation of several hundred feet above the present, newly alluviated valley bottoms.

Some strike-slip faulting with northeasterly trend took place after Mint Canyon time, perhaps during the Pliocene epoch. This may be related to the San Andreas fault, which lies ten miles to the northeast.

All folds and faults that involve the sedimentary beds probably can be related to adjustments taking place in the underlying crystalline rocks. The forces causing these adjustments probably were active throughout much of Tertiary and Quaternary time, and activities do not appear to have ceased as yet.

INTRODUCTION

Nature of study and previous work

An attempt was made during the present investigation to obtain a clearer understanding of the stratigraphic and structural relationships of some of the formations that crop out in the easternmost part of the Ventura Basin. Previous work in this general area was done by Hershey[1], who measured a detailed section in upper Tick Canyon in 1902. He called the formation Escondido series. Kew[2], who mapped this area in reconnaissance in the early nineteen twenties, referred to the same beds as Sespe formation. Sharp[3] suggested the name Vasquez series in 1935, inasmuch as Escondido was preoccupied. Maxson and others undertook principally the dating of the Mint Canyon formation in the early thirties. The purpose of Miller's[4] work, published in 1934, was primarily a study of the rock types and areal extent of the pre-Cretaceous and Tertiary crystalline rocks of the western San Gabriel Mountains.

The first detailed stratigraphic investigation was started in 1938 by R. H. Jahns[5], who mapped an area approximately five miles west and southwest of the area of present study. The

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[1] O. H. Hershey Amer. Geologist, Vol. 29, pp. 349-372, 1902.

[2] W.S.W.Kew U.S.Geol.Surv.Bull., No. 753, 1924.

[3] R.P.Sharp Pan Amer.Geologist, Vol. 63, p.314, 1935.

[4] W.J.Miller Univ.of Calif.at Los Angeles publication, March 31, 1934.

[5] R.H.Jahns Carnegie Institution of Washington publication No. 514, June 1940.

aim of that work was to determine the relations of the marine and nonmarine Tertiary beds in the eastern portion of the Ventura Basin. Repeated reference will be made to this work by Jahns, inasmuch as this report will be, to a certain extent, a continuation of that investigation. With respect to the ages of the formations involved, the author relies heavily on work of other students and follows, for the purpose of this report, the age classification made by Jahns.[6]

The upper Tick Canyon area, mapped during the present investigation, is approximately seven square miles in extent and includes within its boundaries three of the key formations in this general part of the Ventura Basin. They are key formations inasmuch as they are important in determining the early Tertiary history of this area.

The nature of the outcrops was good, which facilitated the work considerably. The brush cover was not very disturbing. A total of about 35 days was spent in actual field mapping during the period August-December, 1949. No detailed laboratory investigation was done. Mapping was done on a scale of one inch to 1000 feet, both on enlargements of the U.S.Geological Survey Lang Quadrangle and on aerial photographs obtained from Fairchild Aerial Surveys.

Acknowledgments

The studies were carried out under the supervision of Professor Richard H. Jahns of the California Institute of

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[6] R.H.Jahns Carnegie Institution of Washington publication, No. 514, June 1940, pp. 169-172.

Technology, to whom the writer wishes to express his sincere gratitude for guidance and valuable criticism offered through all phases of the problem. Thanks also are extended to W. Porter Irwin, teaching assistant at the California Institute of Technology, with whom many of the problems encountered during the actual field mapping were discussed. The writer also wants to express his gratitude to Joseph H. Birman, with whom the sections were measured.

Geographic features

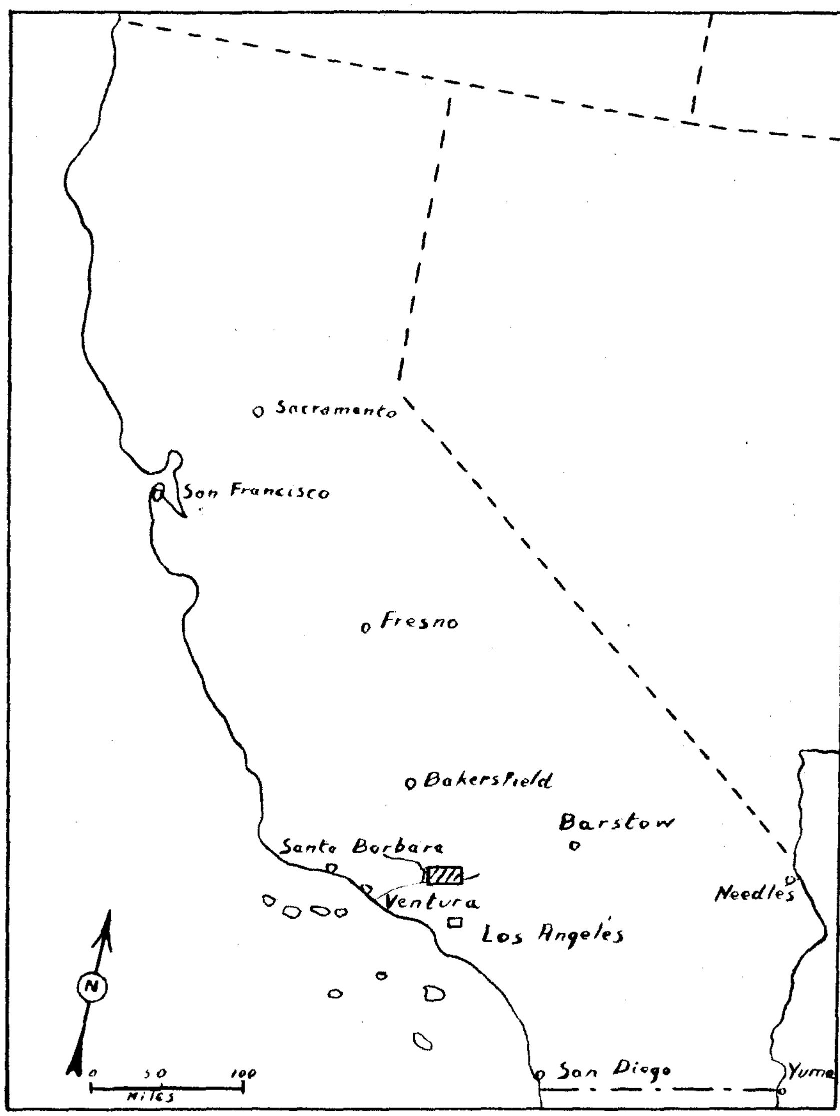
The area under consideration is approximately 30 miles northwest of Los Angeles, in the easternmost part of the Ventura Basin (fig. 1) and in the northwestern part of Los Angeles County, California. It is drained by Tick Canyon, and is bounded on the west by Mint Canyon and on the east by Agua Dulce Canyon. All these canyons drain southward into the Santa Clara River Valley and Soledad Canyon, which form the main drainage channel for this region.

The maximum relief in the area is about 1000 feet. The maximum elevation above sea level is approximately 3000 feet. These heights were only attained by the very resistant volcanic beds, like the flowbreccia, in the northeast part of the area. In general, the resistant volcanic or conglomerate beds produce cliffy slopes. The subdued, gentle slopes are underlain by soft friable siltstones.

The climate is arid, the annual rainfall being slightly more than ten inches. Most of the precipitation falls during December, January and February. During the summer months, daytime temperatures not infrequently rise above 100°F, although the nights are always cool. There are no perennial streams in the immediate vicinity and only parts of the Santa Clara River to the south carry water during most of the year.

In general, the vegetation is scant and of the typical southern California chaparral variety. Yucca, sage, creosote bush, etc. are present. Junipers form dense growths on the northern slopes of many hills.

The area, which is sparsely settled, can be reached from Los Angeles over U. S. Highway 6 (Sierra Route), which follows Mint Canyon. Davenport Road, which branches off this highway, extends through the entire area in east-west direction, and ends near Agua Dulce Canyon. A great many secondary roads and trails make almost every point in the mapped area easily accessible.


Sacramento
San Francisco
Fresno
Bakersfield
Barstow
Santa Barbara
Ventura
Los Angeles
Needles
San Diego
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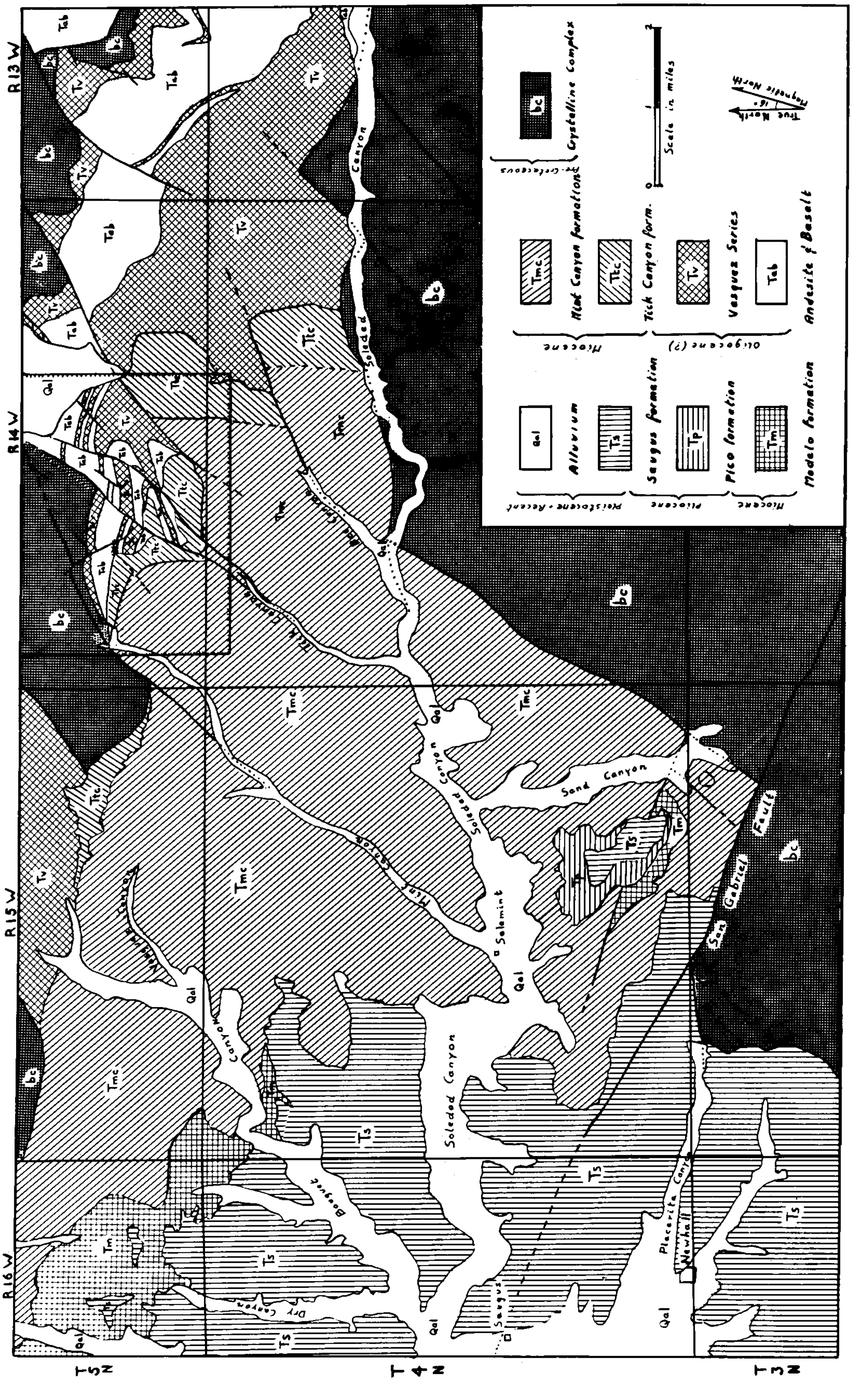
STRATIGRAPHY

General statement

The formations exposed in upper Tick Canyon area consist of a pre-Cretaceous crystalline complex and a nonmarine series of Tertiary sedimentary and volcanic rocks. In early Tertiary time, the older pre-Cretaceous rocks of this part of the Ventura Basin formed probably an elongate basin with a general eastward trend. Later deposition of sediments in this trough, contemporaneous with and followed by several periods of folding, caused a structural offlap of the younger sediments both from north to south and east to west. This offlap becomes evident from the generalized geologic map of this part of the Basin (Fig. 2).

The oldest Tertiary rocks represented in this area compose the Vasquez series; conglomerates, sandstones and siltstones interlayered with a considerable thickness of basalt and andesite flows. Their age has been tentatively determined as Oligocene. These beds are separated from the overlying Lower Miocene Tick Canyon formation by a marked angular unconformity. The general attitude of the Tick Canyon formation is east, dipping southward. Overlying with roughly the same attitude are the beds of the Upper Miocene Mint Canyon formation (Plate 1). The last two formations consist of interbedded conglomerates, sandstones, and fine-grained siltstones.

Farther to the southwest, beyond the limits of the mapped


R13W
R14W
R15W
R16W
T5N
T4N
T3N
Qal
Alluvium
Ts
Saugus formation
Tp
Pico formation
Tm
Modelo formation
Pleistocene + Recent
Pliocene
Miocene
Tmc
Mint Canyon formation
Ttc
Tick Canyon form.
Miocene
Tv
Vasquez Series
Tab
Andesite & Basalt
Oligocene (?)
bc
Crystalline Complex
pre-Cretaceous
Scale in miles
True North
Magnetic North
16°
Soledad Canyon
Sand Canyon
San Gabriel Fault
Solemint
Saugus
Newhall
Placerita Canyon
Bouquet Canyon
Dry Canyon
Mint Canyon
Tick Canyon

area, the continental beds of the Mint Canyon formation are unconformably overlain by marine Modelo beds of Miocene age and the Pliocene Pico and Saugus formations, separated from one another by angular unconformities (Fig. 2). This easternmost part of the Ventura Basin received sediments subaerially from positive areas to the north, east and south during large parts of the Tertiary period. In late Miocene and Pliocene time, the sinking of the trough relative to sea level, was sufficient to allow transgression of the sea from the west with deposition of marine strata. Locally, Pleistocene terrace gravels are present at elevations of 250 to 500 feet above the present canyon bottoms.

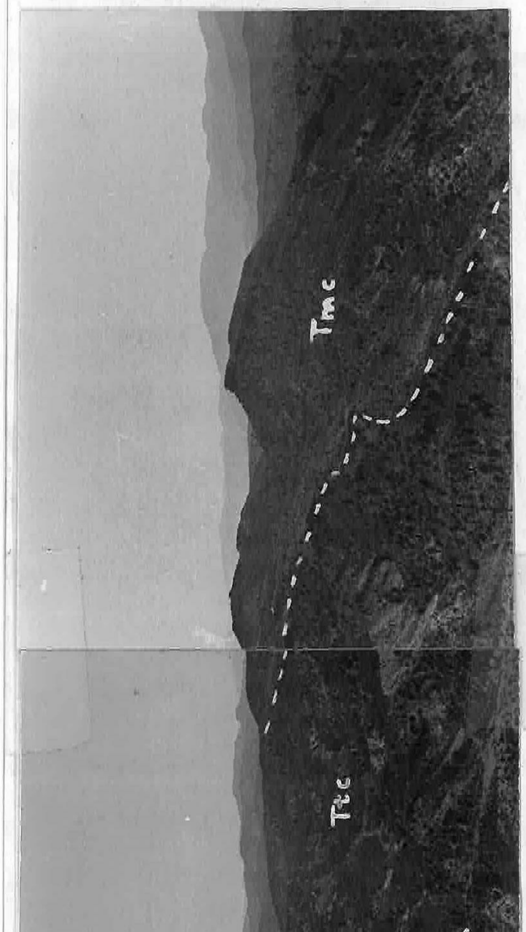
Crystalline complex

A highly complex series of metamorphic and igneous rocks compose the series that has been mapped as crystalline complex. Lack of time, the character of exposures and the scale on which mapping was done, did not warrant detailed investigation of the different rock types involved. Henceforth, no effort was made to distinguish the various rocks as map units. This crystalline complex is present along the northern part of the mapped area and is in what appears to be a fault contact with the younger sedimentary rocks. Predominant in the crystalline rocks are such metamorphic types as strongly foliated, biotite-rich schist, quartzites and augengneiss. Many migmatitic rock types are also present. Locally, granitic to granodioritic intrusive rocks occur which

Plate 1

Panoramic view looking east from the section east of Tick Canyon, south of Davenport Road.

Note the gently southward dipping Tick Canyon and Mint Canyon formations with cliff-forming conglomerate members.


Tmc
Ttc
Tv

could represent correlatives of the Sierra Nevada intrusives of late Jurassic age. For the purpose of this report, this entire unit will be listed as pre-Cretaceous in age. The rocks are severely sheared and shattered, and show evidence of strong deformation.

Vasquez series

Within the boundaries of the area under discussion, the rocks of the Vasquez series are present between Agua Dulce Canyon and Mint Canyon south of the crystalline complex. This formation comprises about half of the entire area investigated, and disappears to the west and southwest beneath the younger Tick Canyon and Mint Canyon formations.

The rocks of this formation were already measured and described in more detail by Hershey[7], who proposed the name Escondido series. Sharp mapped the same formation in the Ravenna Quadrangle in an area farther to the east, north of Soledad Canyon. Sharp apparently measured a complete section of rocks that are in depositional contact with the Jurassic intrusive rocks. Sharp[8] suggested the name Vasquez series for this series of rocks, replacing the preoccupied name Escondido earlier proposed by Hershey.

Within the area of present study, the contact between the Vasquez series and the older crystalline rocks has been

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[7] O. H. Hershey <u>American Geologist</u>, Vol. 29, 1902.

[8] R. P. Sharp <u>Pan American Geologist</u>, p. 314.

interpreted by the author as a fault. This will be discussed critically later in the report in the section dealing with structure.

The Vasquez series, approximately 4500 feet thick in the upper Tick Canyon area, consists of coarse and fine clastic sediments interlayered with basaltic and andesitic flows and sills. About half the section consists of sedimentary rocks. The predominant rock types in this sedimentary series are purplish to white, coarse to medium grained, arkosic sandstones. The shales and siltstones often have a more greenish or lavender cast and contain many thin borate beds. Greenish white, resistant tuffaceous beds serve as good horizon markers because of their wide areal extent, good outcrops and occurence as "time" horizons. A 440 foot thick boulder conglomerate occurs along the contact of the Vasquez series and crystalline complex. Many workers in this area called this bed a "basal" conglomerate, a quite erroneous expression if the contact is interpreted as a fault contact. Slightly over half the section, (2400 feet), is made up of volcanic rocks of basic or intermediate composition. In general, the olivine basalts predominate, are thicker and occur more in the basal part of the section, in the northern part of the area. The younger rock types are more andesitic in composition. This is only a broad generalization and in the upper parts of the section occur also olivine basalts.

For the purpose of bringing out the structure and determining the stratigraphic relations within this series of rocks, the Vasquez series was divided into 18 members, all of which are described in detail at the end of this report. A section of the series, extending along line XX^1 was measured in a south-southwesterly direction immediately west of Tick Canyon. The upper two members were measured along the line YY^1, south of Davenport Road, slightly east of Tick Canyon, inasmuch as they were incompletely or not at all exposed along the line XX^1. Thicknesses were measured by tape, except for member 4, which was measured from the map. Two members, a volcanic flow, primarily consisting of andesite (Tv 8) and a white sandstone member (Tv 9), occur east of the zone XX^1 where the Vasquez series were measured. These two members pinched out to the west. In other beds of the Vasquez series also a general thickening to the east has been noticed. This feature of thickening and the coarser character of some sandstone members and of the conglomerate bed Tv 14 in the eastern part of the area, suggests in general an eastern source for the Vasquez sediments. This holds true only in two dimensions, inasmuch as the beds trend east-west. Owing to the fact that the Vasquez series is in fault contact with the crystalline rocks in the north and is covered by younger formations in the south, the change in coarseness and thickness of the individual members cannot be established in north-south direction. An elongate east-trending trough, bounded by faults from the surrounding high-standing metamorphic and igneous terranes, represents most likely the type of basin in which the Vasquez series was laid down.

The arkosic sandstones with locally conglomerate facies show in places such primary structures as scour-and-fill structure and cross-bedding. Presumably, some stream transportation took place over not too large a distance. The very coarse deposits show alluvial fan characteristics. The more fine grained clastic sediments, like the sandstones and siltstones, could represent either floodplain deposits or were laid down in a closed basin such as the type of environment represented by a playa lake. The occurrence of borate beds interbedded with the shaly members of the Vasquez series support the idea of local deposition in a playa lake type of environment. Many views are held by the different investigators as to the origin of the borate in shale beds. The author favors here the volcanic origin of the boron, on account of the close association of the borate beds and the volcanic flows and sills[9]. The boron may have been brought to the surface by volcanic gases or waters. The uppermost unit (Tv 18) shows at its base a breccia of volcanic material, strictly monolithologic in character. Fragments are very angular and about two inches in size. They consist of olivine basalt very similar to the one of which member 16 (Tv 16) is made up. This breccia is overlain by a thin bed of ande-

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[9] Hoyt S. Gale Calif. Jour. Mines and Geology Report of the State Mineralogist, pp. 325-378, Oct. 1946.

site and is therefore still considered a part of the Vasquez series. This Vasquez member should not be confused with the basal member of the Tick Canyon formation that occurs in the embayment near the intersection of Davenport Road and Tick Canyon. Both beds show a great deal of similarity in texture and composition, but have entirely different attitudes. The breccia-like beds show no indication of being tectonic in origin. Probably a mudflow mechanism, as discussed by Blackwelder[10] for semi-arid regions or a mudflow associated with volcanic eruptions can explain these deposits better.

Such features as discussed in the previous paragraphs and the general purplish color of the sediments in the Vasquez series, suggest a semi-arid type of climate for the environment of deposition.

In view of the fact that so far no diagnostic fossil remains have been found in the Vasquez series, the age of the beds is still doubtful. Jahns[11] disproved the Middle Miocene age suggested by Miller[12] and Simpson[13], and suggested that the beds are older, perhaps Oligocene or lowermost Lower Miocene. As such, it can be correlated with at least a part of Kew's[14] Sespe formation, which is extensively exposed far-

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[10] Eliot Blackwelder <u>Bull. G.S.A.</u>, Vol. 39, 1928, pp. 465-484.

[11] R.H.Jahns <u>Carnegie Institution of Washington</u>, Publication No. 514, June 1940, pp. 169-170.

[12] W.J.Miller <u>Univ. of Calif. at Los Angeles</u>, Publication Vol. 1, 1934.

[13] E.C.Simpson <u>Calif. Jour. Mines and Geol.</u>, Vol. 30, 1934.

[14] W.S.W.Kew <u>U.S.Geol.Surv.</u>Bull.753, 1924.

ther west in the Ventura Basin.

Tick Canyon formation

On the basis of mammalian fossil remains, Jahns[15] separated the lowermost beds of Kew's Mint Canyon formation and designated them the Tick Canyon formation. This usage is followed in this paper. A Lower Miocene age was established for the Tick Canyon formation by Jahns, but it should be pointed out that the field differentiation between the Tick Canyon formation and the Upper Miocene Mint Canyon formation is based also on lithologic differences. The bottom of the Mint Canyon formation was taken at the base of a thick cobble conglomerate layer (Plate 2), although according to Lance[16], the contact should be taken approximately 50 feet higher. The Tick Canyon formation rests with a sharp angular unconformity on the underlying Vasquez series, (see Plate 3 and cross-sections on Plate 8) and probably was laid down on a surface of considerable relief.

Two major divisions of the Tick Canyon formation were made. About 600 feet of cobble conglomerate is overlain by a series of interbedded variegated sandstones and siltstones approximately 400 feet thick. From east to west, it seems that higher units of the Tick Canyon formation are in contact with the Vasquez formation, as if a progressive overlap took place.

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[15] R. H. Jahns American Journal of Science 5th Series, Vol. 37, p. 819, 1939.

[16] J. F. Lance personal communication.

Plate 2

Contact between Tick Canyon and Mint Canyon formations.

A. View looking south in Tick Canyon from Davenport Road.
Note the cliff-forming character of the basal Mint Canyon formation.

B. Basal conglomerate of Mint Canyon formation overlying friable siltstones of Tick Canyon formation.
Note slight unconformity.
View taken in roadcut west of Tick Canyon along Davenport Road.


Tmc1
Ttc2

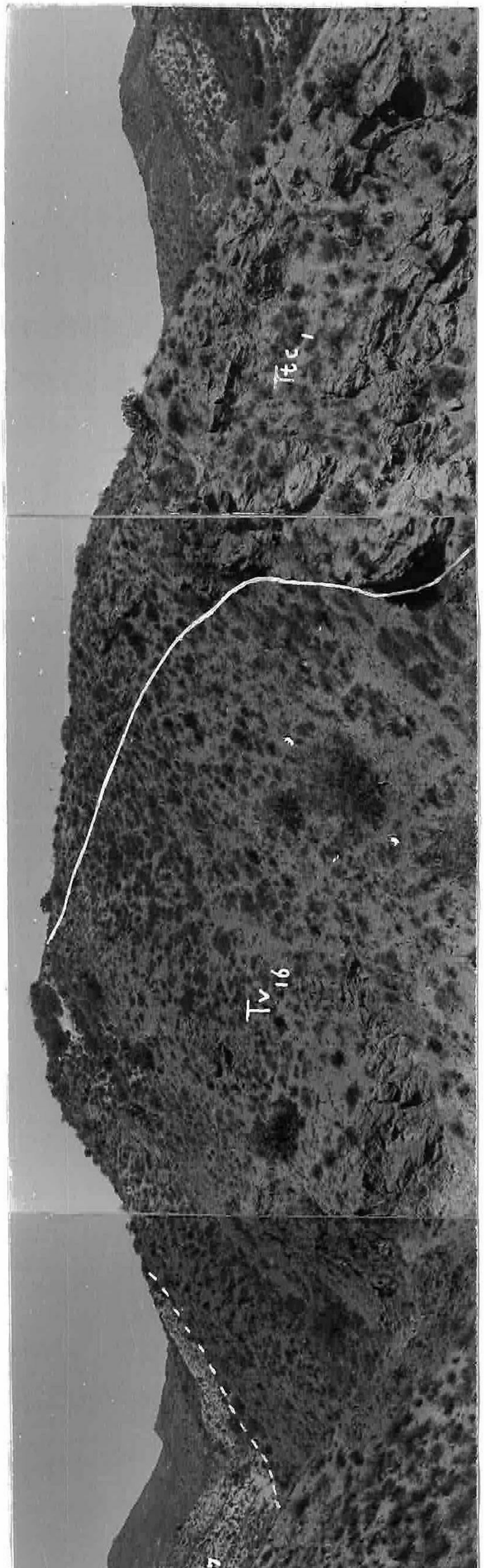

Tmc1
Ttc2

Plate 3

Contact between Tick Canyon formation and Vasquez series.

Thick, coarse basal conglomerate of Tick Canyon formation in depositional contact on irregular surface of east-ward-dipping members of the Vasquez formation.

Locality NW SE of Section 32, T. 5 N, R. 14 W. Looking east into Blue Agate Canyon.


Ttc1
Tv16
Tv17
Tv18

It is more likely, however, that the thick basal conglomerate in the east of the area near Agua Dulce Canyon thins rapidly westward and grades into finer-grained detrital sediments. The seemingly younger members are actually stratigraphic equivalents of the thick conglomerate beds. The beds dip generally southward (25°) where they are overlain by the Mint Canyon formation.

The thickness of the basal conglomerate was measured from a structure section along the northeast trending Agua Dulce fault. The detailed description and measurement of the uppermost member was made along the lines ZZ^1 and $Z_1Z_1^1$, slightly southeast of the Skyline Ranch.

The rapid thinning of the basal conglomerate over short lateral distance westward, and its gradation into finer-grained clastic sediments, suggests an alluvial fan type of deposit for this formation. The initial relief was presumably quite high. Crystalline igneous and metamorphic rocks and Vasquez rocks must have been exposed in the higher standing terranes, inasmuch as a great amount of material in the basal conglomerate was derived from both the crystalline complex and the Vasquez series. Later gradual wearing down of the higher standing areas allowed a more extensive deposition of siltstones and sandstones of more uniform thickness.

Mint Canyon formation

The two basal members of the Mint Canyon formation were mapped to determine the contact relationships between the Tick Canyon and the Mint Canyon formations, and to establish the age and space relationships of some of the faults that traverse the area in northeasterly direction.

The Mint Canyon formation overlies the Tick Canyon formation in all areas where the latter is exposed. The nature of the contact is difficult to establish. In some places, suggestions of a slight angular unconformity (about 5°) exists (Plate 2), but these differences could be just as readily explained by local irregularities of sedimentation. Owing to the fact that most of the exposures of the contact between the Tick Canyon siltstone member and Mint Canyon basal conglomerate are parallel to the strike of both formations, a definite conclusion could not be reached as to the exact relationships.

The name Mint Canyon formation was given by Kew[17] to a series of continental beds of coarse-to fine-grained clastic nature. All are distinctly lenticular. They represent in part fluviatile, in part lacustrine, deposits that contained abundant vertebrate remains. Although disagreement still exists concerning the exact boundary between Miocene and Pliocene (Jahns[18]), the burden of evidence seems to point towards an Upper Miocene age for the Mint Canyon formation, chiefly on the basis of uppermost Miocene marine fossils in beds that

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[17] W. S. W. Kew op. cit., p. 52, 1924.

[18] R. H. Jahns op. cit., pp. 171-172, 1940.

lie unconformably above this formation. The resistant cobble conglomerate that forms the base of the Mint Canyon formation thickens and thins between Agua Dulce Canyon and Mint Canyon, but is in general about 100 feet thick. The overlying siltstone member, with its hard resistant green arkosic sandstone beds, is remarkably consistent, and serves as an excellent marker for structural interpretations. Its thickness is slightly more than 380 feet. Within the scope of this investigation, only about 500 feet of Mint Canyon formation was mapped, although Jahns[19] measured an aggregate thickness of more than 4000 feet two miles west of Mint Canyon. The bottom members of the Mint Canyon formation were measured along the line ZZ[1] southeast of Skyline Ranch. The general geological environment of deposition was probably very similar to the one that existed in Tick Canyon time, when both crystalline rocks and Vasquez rocks were exposed in the surrounding areas. A great many fragments can be related to a Vasquez source, particularly in the basal parts of the Mint Canyon formation. The rapid change from thick siltstone beds to thick, coarse, cobble conglomerate members, particularly in lower parts of the Mint Canyon formation, is probably related to tectonic disturbances that were very active throughout middle and late Tertiary time.

Terrace gravels

Old floodplain type of deposits were mapped as a single

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[19] R. H. Jahns op. cit., p. 154, 1940.

unit. They overlie and obscure the underlying formations in many places, and flank particularly the topographically higher standing parts of the area. These deposits vary considerably in composition. They consist primarily of angular fragments of igneous or metamorphic rocks, but also contain reworked boulders of volcanic material and mudstones, hence reworked conglomerates of the Vasquez, Tick Canyon or Mint Canyon formations.

No effort was made to distinguish the different terrace deposits. They are all grouped together as Pleistocene terrace deposits.

Alluvium

Recent gravelly deposits occur in broad valley flats and extend as small tongues up the canyon bottoms. These have been mapped as alluvium. In many places, they represent old alluviated valley bottoms that have been uplifted in fairly recent time and are now in the process of being dissected by the rejuvenated streams.

STRUCTURE

Unconformities

Sharp[20] reports an erosional unconformity between the Vasquez series and igneous intrusives of Jurassic (?) age in Echo Canyon, near Ravenna, approximately seven miles east of Agua Dulce Canyon. Between Agua Dulce Canyon and Mint Canyon the contact between the crystalline complex and the Vasquez series seems to be a fault, and will be discussed later in this chapter.

Between the Oligocene (?) Vasquez series and the Lower Miocene Tick Canyon formation is a marked angular unconformity. The Vasquez formation was compressed into fairly tight folds and subsequently eroded to form a surface of fairly high relief. Beds are dipping with angles of more than 80 degrees and locally even slight overturning occurs. The Tick Canyon formation was deposited on this surface, and its basal strata show great irregularities in thickness and lithology. Deposition of the lowermost Tick Canyon beds may have taken place while folding of the Vasquez beds was still going on, as suggested by reversal in dip of Tick Canyon siltstones in the embayment along Davenport Road, slightly east of Tick Canyon. This initial steep topography explains at the same time the progressive overlap of younger formations on the Vasquez strata. Where the Vasquez volcanic rocks are in contact with the overlying Tick Canyon forma-

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[20] R. P. Sharp unpublished Master's thesis.

a distinct weathering and alteration zone is present. Evidence exists for a slight angular unconformity between the Tick Canyon and Mint Canyon formation, but the differences in attitude along the disconformity can be just as readily explained by local irregularities of sedimentation. The angular unconformities at the base of the terrace gravels, and alluvium require no further discussion.

Folds

Geometrically, two types of folds can be distinguished. In the northern and eastern part of the area, the tight folds occur in the beds of the Vasquez series. Dips are attained of more than 80° (Plate 4).

The southerly dipping beds of the Tick Canyon and Mint Canyon formations form the northern limb of a broad syncline, the axis of which lies south of the limits of the area under discussion. This is representative of the type of structures that occur in the younger Tertiary formation. These are typically broad, open flexures with a south of westerly trend.

The beds of the Vasquez series are folded into a broad syncline with a general east-northeast trend and a steeply northward dipping axial plane. This asymmetry is caused by the almost vertical attitude of the beds in the northern limb. In upper Tick Canyon slight overturning occurs, but this may be a secondary feature caused by drag along the nearby fault contact (See cross-section BB^1 in Plate 8).

The easternmost part of the syncline is offset to the

Plate 4

View looking northeast from Davenport Road north of Skyline Ranch.
Note reversal dip of the light colored beds, indicating an anticlinal development.

Plate 5

Example of bedding-plane faulting in Vasquez series. Movement is taken up in soft shale and borate beds of the Vasquez formation.
View of Borax Mine taken from west of Tick Canyon looking east.


Tv 15


Tv 10
Tv 11

northeast along a large strike-slip fault. South of this part of the syncline and trending parallel with it occur two more folded structures that were exposed by erosion of the once probably overlapping Tick Canyon formation. An anticline trending slightly south of west in the northeast corner of Section 33 of T.5 N, R.14 W plunges sharply westward, showing a slight drag in the axial plane along the above mentioned strike-slip fault (Plate 4). This anticline is parallelled in the south by another syncline that widens towards the west, the beds of which are cut off by the big Agua Dulce Canyon fault. The age of this folding is either late Oligocene or early Miocene, depending upon the age of the Vasquez beds. The folding that caused the broad subdued flexures in the Tick Canyon and Mint Canyon formation is, of course, post Mint Canyon in age.

Faults

To permit the deposition of 12,000 feet of coarse clastic sediments and volcanic rocks of the nonmarine Vasquez series, as was reported by Sharp[21] in the Ravenna Quadrangle, it becomes almost necessary to postulate a localized fault-block basin.[22] If this period of faulting initiated the deposition of the Oligocene (?) Vasquez series, the faulting could perhaps be late Eocene or early Oligocene in age. At present,

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[21] R. P. Sharp Unpublished Master's thesis.

[22] R. H. Jahns op. cit., p. 153, 1940.

no evidence of the once existing faults can be found. Suggestive for the existence of large normal faults is the vast extravasation of basic lavas in Vasquez time, which must have occurred along zones of weakness.

After the folding of the Vasquez series, a later period of faulting with dip-slip movement occurred, resulting in the deposition of the coarse basal members of the Tick Canyon formation. This faulting probably took place along the same old east-west lines of weakness, in the crystalline rocks. In case this faulting would be of a reverse nature signifying compression, it could be ascribed to the same compressive forces that brought about folding of the Vasquez strata. A definite later period of faulting, mainly of reverse character, becomes evident in the northern part of the area, where two nearly parallel faults have a slight east-northeasterly trend. The southern one forms the contact between the pre-Cretaceous crystalline rocks and the Vasquez series and Tick Canyon formation. The fault-like nature of the contact was not obvious in all places. The truncation of the folded upper Vasquez beds to the west, the extreme steepness of the contact (80°) or even slight overturning, the elimination of the lowermost cobble conglomerate member of the Vasquez series to the east and the zone of sheared rock parallel to the contact, support the interpretation of a fault contact. This period of faulting is certainly post Vasquez and probably post Tick Canyon, but its relation to the Mint Canyon formation could not be determined. Movements on a completely different set of faults, these with strike-slip displacements, may have started at approximately the same time as the reverse faults discussed in the last paragraph. The strike-slip faults were, in that case, certainly rejuvenated in later times. They offset the contact between the crystalline complex and the Vasquez series, and also involve the Mint Canyon formation (Plate 6). Three main faults with northeasterly trend and varying dip are present within the area under discussion, and all of these involve the Mint Canyon formation. They show a considerable horizontal displacement, whereby the southern block moved northeastward with respect to the northern block. Minor vertical components must have been present as well, inasmuch as the Tick Canyon and Mint Canyon formations have been eroded away differentially exposing more of the underlying Vasquez series on one side than on the other. These three faults have been named respectively from west to east, the Borax Mine fault (Plate 6), Tick Canyon fault, and Agua Dulce Canyon fault. It may well be that a large fault, entirely in the crystalline complex and marked by an obvious zone of brecciated and sheared rock and gouge, forms a part of this same system of strike-slip faults, and hence is younger than the one that forms the contact between the pre-Cretaceous rocks and the Vasquez series.

Many smaller faults, also with strike-slip or vertical displacement, are present in the area. Many of these have not been indicated on the map, and will not be discussed in this report. One series of faults, however, needs mentioning. Also of a strike-slip nature, they start as bedding plane faults and very often die out as bedding plane faults, with particular bedding plane displacement along the incompetent shale or borate beds of the Vasquez series (Plate 5).

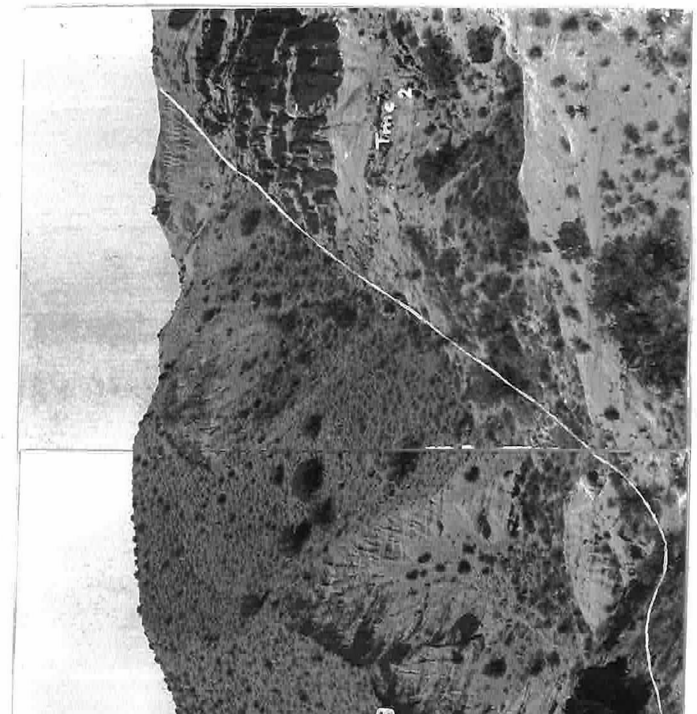
Tectonics

Ever since the end of Eocene time, the eastern part of the Ventura Basin seems to have been an area of almost continuous tectonic deformation, as is brought out in previous pages by the stratigraphic and structural relations between the various formations. The structural history is complex and not everywhere clearly shown. Periods of apparent tensional faulting seem to have been followed by periods of folding and faulting, quiescence, more folding and faulting. The youngest set of faults shows greater horizontal than vertical displacements. If the folds are surface expressions, in a relatively incompetent sedimentary cover, of shortening taking place in deeper parts of the crust due to compressive forces, it does not seem logical that at times these deeper portions yield by folding and at other times by faulting. All major types of faulting discussed so far, involve the pre-Cretaceous crystalline rocks at the surface. It may be assumed that these rocks underlie the sediments in this entire part of the Ventura Basin. The faults extend very likely down at depth and are, in that instance, not to be considered as adjustment structures of folding that takes place in the sedi-

Plate 6

Surface trace and fault-line scarp of Borax Mine fault. The fault trends northeast and causes offset in beds of the Mint Canyon formation.

Location of view; boundary of Section 32, T.5 N, R.14 W and Section 5, T.4 N, R.14 W.


Tmc 2
Tmc 3

mentary cover alone.

The explanation of the fold and fault features becomes simpler if they can be related to a common source, in this instance to faulting. The competent deeper part of the crust yielded by means of faulting. The only real tight folds occur in the Vasquez series and then where they parallel the fault with the crystalline complex. Neither in the region to the west mapped by Jahns, nor in the Ravenna Quadrangle to the east, have similar structures been described in the Vasquez series. Would it not be more reasonable to assume that these compressed fold features, with slight overturning of the limb along the fault are nothing but a consequence of compression in the veneer of sediments, caused by uplift along reverse faults, of deeper parts of the crust? This is similar on a small scale to what Taliaferro[23] shows in his cross-sections of the Coast Ranges.

The broad anticlinal and synclinal developments in the younger Tick Canyon and Mint Canyon formations can be related to gentle warping that takes place in deeper parts of the crust. The trend of the reverse faults would be roughly east-west. They would approximately be parallel to the old faults that bounded the original basin in which the Tertiary sediments were deposited. It could well be that this tendency to produce east-west trending structures, not only in this part of the Ventura Basin but in the entire Transverse Ranges, is

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[23]N. L. Taliaferro <u>State of Calif. Div. of Mines Bull.</u> 118, pp. 119-162.

nothing but an old line of weakness in the deeper portions of the crust, that expresses itself in the overlying sediments. Deep seated compressive forces applying with different intensity in north-south direction during Tertiary time, followed by periods of relaxation would then explain the structural features observed in the eastern portion of the Ventura Basin.

The northeast striking shear faults, with their south sides moving northeastward, have not only been observed in the area at present under discussion, but have also been reported by Sharp[24] in the Ravenna Quadrangle area to the east and by Jahns[25] and Judson[26] to the west (Fig. 2). The author agrees with Jahns[27] as to their possible gash fracture relation to the San Andreas fault that lies approximately ten miles to the northeast (Fig. 3). Although their latest movements indicate a definite post Mint Canyon age, movements probably started at an earlier time, as is suggested by differential displacement of older and younger formations along the faults. The displacement of the Vasquez series is considerably greater than the displacement of the Tick Canyon and Mint Canyon formations along both the Borax Mine fault and the Agua Dulce Canyon fault.

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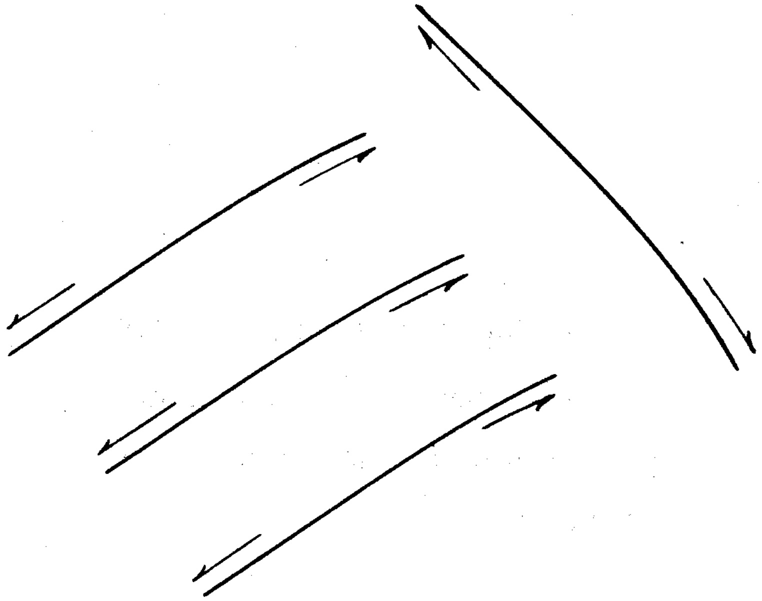
[24] R. P. Sharp Unpublished Master's thesis.

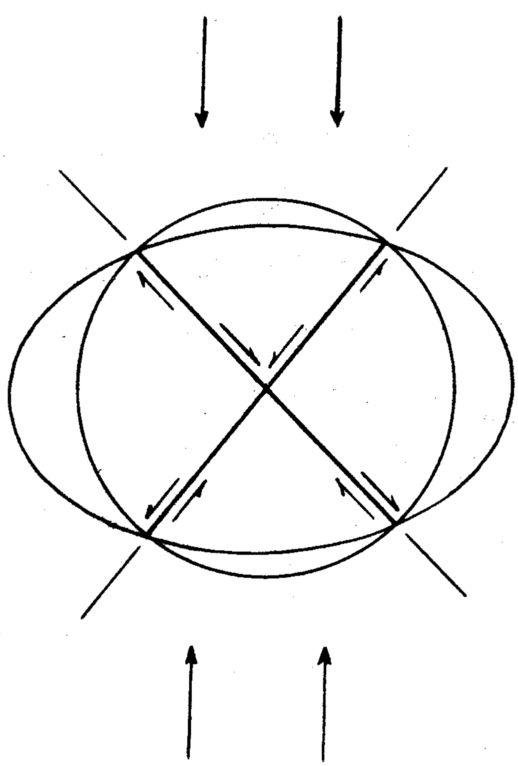
[25] R. H. Jahns op. cit. pp. 169.

[26] J. F. Judson Unpublished Master's thesis.

[27] R. H. Jahns op. cit., pp. 169.

It is not difficult to visualize the relationship of these faults with the above mentioned postulated set of north-south forces with the aid of the strain-ellipsoid (Fig. 4).





GEOMORPHOLOGY

The more resistant beds in the Tick Canyon area stand topographically higher than the less resistant sandstones and siltstones. A very hard volcanic flow breccia forms peaks as high as 3100 feet. The slopes are very steep. The well consolidated conglomerates in the Tick Canyon and Mint Canyon formations also stand in high cliffs and are being slowly undermined by the weathering away of the soft, friable siltstones or sandstones (Plate 2). Most of the canyon development is by subsequent streams. South of Davenport Road, the more resistant beds form practically dipslopes to the south. This is only true in broad general terms, and a great deal of cross-cutting of canyons takes place, as is very clearly shown by Tick Canyon proper.

The size of the area investigated does not warrant a thorough analysis of the geomorphic events in the easternmost part of the Ventura Basin. Investigations of this kind were conducted by Wallace[28] in this general area, and some of his conclusions find supporting evidence in the Tick Canyon area. The strong deformations that have taken place in the very recent past or that are still taking place, have obliterated most of the old geomorphologic features.

A series of terraces and benches occurs at an elevation several hundred feet above the present canyon bottoms (Plate 7).

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[28]R. E. Wallace Bull. G.S.A., Vol. 60, April 1949.

The terraces were probably formed during Pleistocene time. A post-Pleistocene uplift rejuvenated the streams that dissected their old valley bottoms, leaving remnants in the form of gravel deposits along the margins and on top of the interstream areas. Since then, a new stage of alluviation took place, as is evidenced in the headwater region of Agua Dulce Canyon, in the eastern half of Section 27, T.5 N, R.14 W. A minor recent uplift introduced a new stage of canyon cutting. Streams flowing at present in fairly steep canyons are working their way headward, and are in the process of dissecting the old alluviated surfaces. A good example of this phenomenon is in Agua Dulce Canyon. This same process of recent rejuvenation has been observed by Wallace[29] over a larger part of the Ventura Basin.

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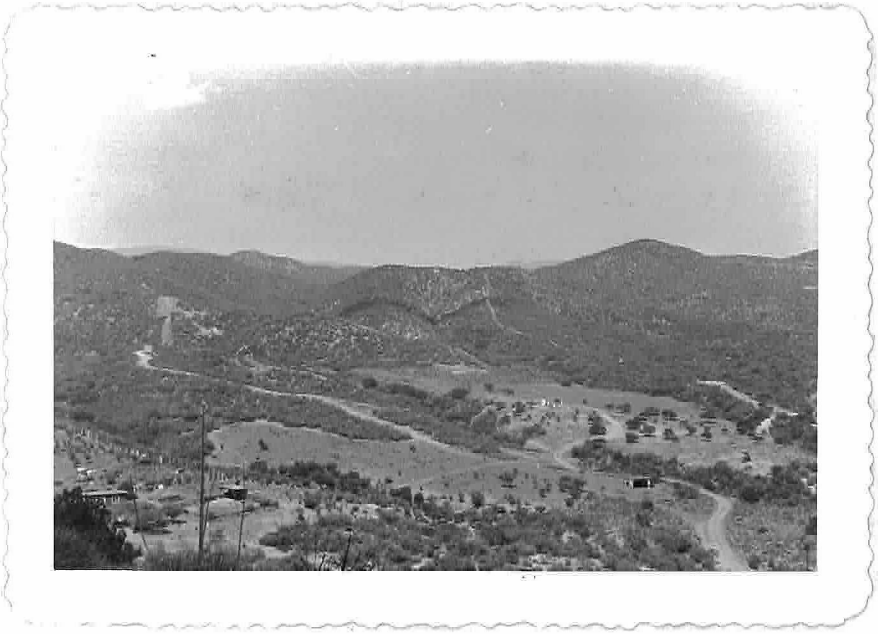
[29] R. E. Wallace op. cit., p. 800.

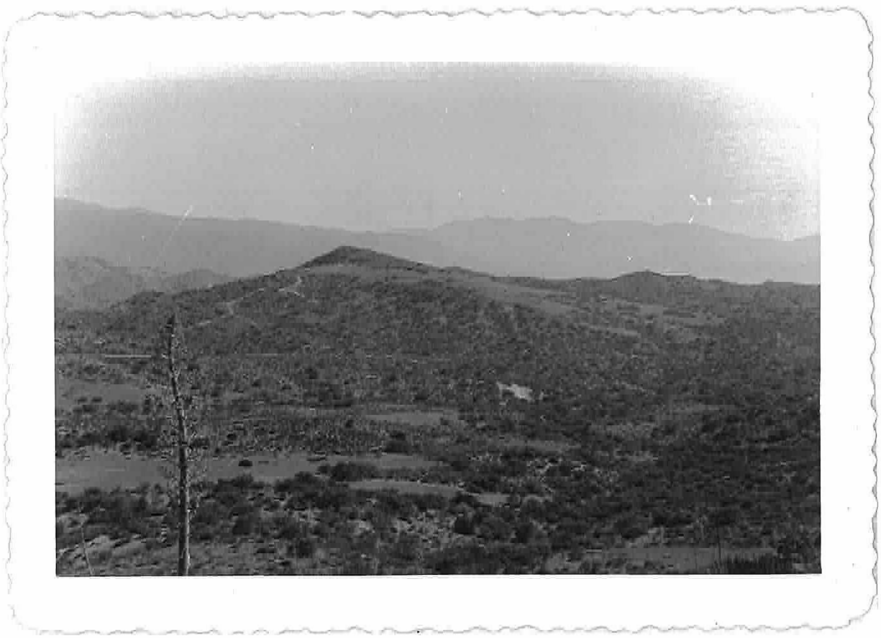
Plate 7

Terrace developments in upper Tick Canyon area.

A. Terraces in center of Section 29, T.5 N, R.14 W. View looking northeast.

B. View looking south. Terraces in Sections 29 and 32 in T.5 N, R.14 W.





GEOLOGIC HISTORY

Inasmuch as most of the history of the Tick Canyon area has been discussed in the various sections of this study, a brief tabulation will suffice to summarize the geologic events in their proper chronological order.

1. Faulting in early Tertiary time, maybe late Eocene or Oligocene, with general east-west trend giving rise to a trough-like feature. The higher standing surrounding terrane probably consisted of highly metamorphosed metasedimentary and metavolcanic rocks and igneous intrusives.
2. Deposition during Oligocene and perhaps early Miocene time of a thick series of fluviatile and lacustrine deposits consisting of coarse conglomerates and fanglomerates, siltstones and sandstones in a slowly subsiding basin. Strong volcanic activity existed during that period as is evidenced by thick sections of basaltic and andesitic extrusives and shallow intrusives.
3. Folding of the Vasquez series in early Miocene time, probably as a consequence of shortening taking place in the deeper portions of the crust by means of reverse faulting.
4. Development of an erosion surface of fairly high relief on top of the folded and tilted Vasquez beds, and deposition of the Tick Canyon strata in late Lower Miocene time. The Tick Canyon beds indicate, in general, deposition in the same type of geologic environment as existed in Vasquez time.

The mammalian fauna in the Tick Canyon formation suggests a milder climate with different vegetation than existing at present in this part of the Ventura Basin.[30]

5. Faulting, accompanied by perhaps minor folding or tilting, followed the deposition of the Tick Canyon strata.

6. The Mint Canyon formation was laid down in Upper Miocene time, also as alluvial fans or as fluviatile and lacustrine deposits.

7. Minor folding in post Mint Canyon time, producing broad gentle east-west trending flexures.

8. During the remainder of Tertiary time, this portion of the Ventura Basin in the vicinity of Tick Canyon underwent continuous erosion, probably leading to a surface of low relief in Pliocene time. Farther to the southwest, marine transgression took place in late Miocene and Pliocene time. Sometime after Mint Canyon time, strike-slip faulting of wide extent was induced. These faults can perhaps be related to displacements occurring along the San Andreas fault.

9. General warping, folding or faulting in late Pliocene or early Pleistocene time, followed by deposition of Pleistocene terrace gravels.

10. Uplift initiated rejuvenation of the landscape, and dissection of the terrace deposits.

11. This was followed in more recent time by a renewed period of alluviation.

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[30] R. H. Jahns op. cit., p. 174.

12. Recent minor uplift caused the canyon cutting downstream of the broadly alluviated headwater regions of the streams.

ECONOMIC GEOLOGY

The Champion Mine, a small gold mine, is located in the rocks of the crystalline complex of upper Tick Canyon. This mine was not in operation at the time of the present study, but must have been worked in the very recent past. Although no geological information could be obtained, the gold ore seemed to be associated with shear zones in the crystalline complex. A great many shallow prospect pits are present in this general area, but were dug without apparent success.

Of the non-metallic minerals, the borate deposits in Tick Canyon in the Vasquez series need mentioning. These deposits of the minerals neocolemanite, howlite and ulexite occur in shaly beds of the Vasquez series, probably as playa-lake accumulations. The boracic acid was most likely of volcanic origin, issued by vents or springs in or on the margins of the lake, and transported by little streams to the lake. The acid reacted here with limestone to form the calcium borate and calcium borate silicate minerals. The borate deposits were originally mined by the Sterling Borax Company of Los Angeles. The mine was abandoned in the early twenties, when competition from other richer deposits became too severe. It is said that the property is now owned by the Pacific Coast Borax Company.

Possibilities of accumulation of oil or natural gas seem to be very slight. A lthough a great many porous sandstones and conglomerates occur through the entire section, that could serve as good reservoir rock, there are no indications of good source rock for oil or gas in these nonmarine deposits.

DETAILED DESCRIPTION OF STRATIGRAPHIC SECTION

Mint Canyon formation	Thickness (feet)	
Member 3		
Conglomerate; olive green to brown; cobbly, well rounded, made up of mudstones, volcanics and a little basement debris, mainly Vasquez source....................	100≠	
Total thickness, member 3		100≠
Member 2		
Sandstone; light pink to gray, fine grained arkosic, poorly sorted, subangular grains. Contains few lenses of coarse green arkosic sandstone..................	18	
Siltstone; pink..............................	14	
Siltstone; gray green........................	13	
Siltstone; red, poorly outcropping..........	22	
Siltstone; yellowish, with limonite staining along fractures......................	23	
Siltstone; dark grayish green, arkosic......	39	
Sandstone; pinkish to buff, grading to siltstone................................	7	
Siltstone; light greenish gray, not outcropping..................................	7	
Sandstone; light gray, fine grained.........	28	
Sandstone; distinctly green, coarse arkosic, grading to fine pebbly conglomerate with volcanic material causing green color....	47	
Siltstone; red, hard with mudcracks.........	2	
Siltstone; gray green, grading to fine sandstone................................	33	
Conglomerate; green, pebbly to coarse arkosic sandstone, outcropping as ridges on slopes	40	

Mint Canyon formation - Continued	Thickness (feet)	
Sandstone; grayish green, fine grained, well sorted with considerable basement material; clastic mica is present. Forms resistant ridges..........	75	
Conglomerate; gray, well rounded cobbles.....	3	
Sandstone; red, fine grained, poorly sorted, with here and there pebbles of basement material..................................	14	
Total thickness, member 2		383
Member 1		
Conglomerate; to coarse sandstone, green, pebbly, both basement and volcanic material..................................	14	
Conglomerate; greenish gray, cobbly, made up of Vasquez volcanic material; cliff-former	11	
Total thickness, member 1		25
Total thickness, Mint Canyon formation		508±

UNCONFORMITY (?)

Tick Canyon formation	Thickness (feet)
Member 2	
Siltstone; predominantly grayish green, forms poor outcrops......................	30
Conglomerate; greenish, pebbly to cobbly, poorly sorted...........................	7
Siltstone; greenish gray, badly outcropping..	15
Conglomerate; gray green, pebbly, badly sorted, moderately well rounded..........	6
Siltstone; red and green, poorly outcropping.	8

Tick Canyon formation - Continued

	Thickness (feet)	
Sandstone; green, coarse with angular fragments; forms cliffs......................	6	
Siltstones and fine sandstone; light gray to green, alternating with red siltstone beds..	97	
Sandstone; green gray, arkosic, finely laminated, well sorted and bedded. Quite resistant..	9	
Sandstone and siltstone; green gray and reddish, friable and fragmental, forms poor outcrops..	45	
Sandstone; green, coarse arkosic, silty groundmass. Contains here and there pebbles and cobbles. Fairly resistant......	2	
Siltstone; gray green and red, interbedded, forms rounded slopes........................	45	
Sandstone; light gray, arkosic, interbedded with fine grained friable siltstone..........	47	
Covered under terrace material.................	60	
Total thickness, member 2		377
Member 1		
Conglomerate; gray green, pebbly to cobbly, hard resistant, cobbles well rounded. Mainly Vasquez but also basement material represented up to 10%. Greenish cast caused by volcanics........................	600	
Total thickness, member 1		600
Total thickness, Tick Canyon formation		977

Vasquez series		Thickness (feet)
Member 18		
Volcanic breccia of olivine basalt..........	48	
Andesite; reddish brown, highly vesicular and amygdaloidal, feldspar laths in red brownish groundmass; top of flow highly weathered..................................	52	
Volcanic breccia; subrounded to subangular cobbles of 3" to 8" in diameter. They consist of olivine basalt very similar as described in member 16. Groundmass consists of fine grained volcanic material......................................	150	
Total thickness, member 18		250
Member 17		
Sandstone; red, very coarse, with angular to subangular grains, poorly sorted, not very resistant........................	13	
Shales; variegated red to gray, interbedded with arkosic coarse sandstone stringers..	46	
Shales; gray with borate beds, thinly bedded. Alternating with this unit is a sill-like feature of olivine basalt......	10	
Shales and siltstone; variegated orange, red, interbedded with gray sandstones....	53	
Sandstone; reddish to purplish, coarse to medium grained, poorly sorted with subangular grains. Thickly bedded with thin, shaly partings.......................	53	
Total thickness, member 17		175
Member 16		
Olivine basalt; dark olive green to black, slightly porphritic with phenocrysts of mainly olivine and some augites and plagioclase bedded in dark aphanitic		

<u>Vasquez series</u> - Continued Thickness (feet)

groundmass. Platy separation along what seems primary flow layers. Top one-third of the section is extremely weathered, strongly epidotized; this part is very amygdaloidal.................................120

Total thickness, member 16 120

Member 15

Sandstone; green, medium to coarse grained grading into pebbly conglomerate, massive, uppermost is formed by a one-foot red baked zone of sandstone....... 78

Sandstone; red, coarse to fine grained, well bedded........................... 13

Shales and siltstone; light green, poorly bedded, lower portion sandy............ 36

Total thickness, member 15 127

Member 14

Sandstone and siltstone; red, crossbedded. 73

Breccia; red, fine, sandy matrix, angular fragments of basement material 1/4" in size.................................. 11

Total thickness, member 14 84

Member 13

Sandstone and siltstone; red, crossbedded.130

Sandstone; light gray, coarse grained, massively bedded...................... 82

Shale; light green, thinly bedded, friable 13

Sandstone and siltstone; gray green, coarse to fine grained, moderately hard, fairly well bedded...................... 51

Total thickness, member 13 276

Vasquez series - Continued	Thickness (feet)	
Member 12		
Shale, borate bearing; white, thinly bedded, with some shales at top showing mudcracks. Borate minerals are neo-colemanite, ulexite, howlite	10	
Olivine basalt; black vesicular, highly weathered to loose fragments; no out-crops	8	
Sandstone and siltstone; buff, thinly bedded	23	
Tuff; white to yellowish, highly fractured with concoidal surfaces	24	
Shales and borate beds; green, ripple marks and mudcracks in shales	86	
Siltstone; green, well bedded, fairly hard.	11	
Siltstone; purple, shaly, thinly bedded	4	
Sandstone; light red, medium grained, sub-angular, arkosic, locally hard resis-tant nodules; poorly bedded	2	
Siltstone; yellow green, massive, resis-tant	3	
Siltstone; blue, shaly	3	
Sandstone; gray, fine grained	2	
Siltstone; blue, shaly	6	
Total thickness, member 12		182
Member 11		
Sandstone and siltstone; variegated blue, red and green, well sorted, well rounded grains, well bedded; probably water laid	86	
Total thickness, member 11		86

Vasquez series - Continued	Thickness (feet)	
Member 10		
Flow breccia; red to brown, very hard, red aphanitic groundmass with baked sedimentary and volcanic blocks; angular from 1/4" to 1'; sedimentary material comprises shale, mudstones and sandstones........	450	
Total thickness, member 10		450
Member 9		
Sandstone; white to gray, evenly fine grained, mainly quartzitic in composition. Interbedded with medium grained resistant purplish quartz sandstone.......	50	
Total thickness, member 9		50
Member 8		
Andesite; purplish lavender, dense aphanitic....................................	150	
Total thickness, member 8		150
Member 7		
Sandstone; red, medium grained, predominantly quartz, subrounded, fairly hard, well sorted, well bedded..................	26	
Sandstone; green, grading into pebbly conglomerate. Poorly sorted sandstone, fairly well bedded; subangular grains.....	27	
Tuffaceous sandstone; light gray, hard, highly fractured. Fine grained and dense. Shows slight traces of bedding planes, along which biotite flakes occur, as if deposited in a lake......................	20	
Total thickness, member 7		73

Vasquez series - Continued	Thickness (feet)	
Member 6		
Andesite; highly vesicular and amygdaloidal, elongate, tabular, plagioclase phenocrysts bedded in purple dense groundmass.........	169	
Total thickness, member 6		169
Member 5		
Sandstone; red, well bedded with silty partings. Water laid. Locally channel fillings with angular 1/4" size quartz fragments, probably derived from crystalline complex. Upper one foot highly baked by overlying crystalline rock................	98	
Total thickness, member 5		98
Member 4		
Olivine basalt; dark olive brown to black with phenocrysts of olivine, pyroxene and feldspar in dense dark aphanitic groundmass. This member can probably be differentiated in a series of at least four flows, all of about the same composition. Vesicular basalt and greenish epidotized basalt forming the top of each flow. The fillings in the vesicles range from 1/4" to 1" in size and can be calcite or chalcedony. The bottom section of each flow shows good cleavage. The younger flows show a stronger porphyrytic character...	1375	
Total thickness, member 4		1375
Member 3		
Sandstone; grayish white, medium grained, fairly hard, poorly outcropping..........	73	
Sandstone; buff, hard, arkosic, medium grained, well sorted, subrounded grains, great amount of biotite flakes...........	2	

Vasquez series - Continued	Thickness (feet)	
Tuff; white, resistant, highly fractured vitrophyric..............................	6	
Sandstone; gray, arkosic, medium grained, well sorted, resistant....................	5	
Tuff; white, resistant, shattered with concoidal fractures, dense................	3	
Siltstone and sandstone; light gray, fine grained, subangular to subrounded, well sorted and well bedded; fairly resistant....................................	260	
Total thickness, member 3		349
Member 2		
Sandstone; variegated red and green; coarse and friable. Sorting fair, subrounded grains, arkosic. Fine silty matrix.....................................	250	
Total thickness, member 2		250
Member 1		
Conglomerate; pink to green, pebbly to cobbly. Size of fragments 1/4" to 3", sandy arkosic matrix. Cobbles of basement materials; smaller fragments consist of chert and quartz, subangular. Poorly sorted, badly sheared, gradational into overlying member....................	440	
Total thickness, member 1		440
Total thickness, Vasquez series		4704

UNCONFORMITY

Crystalline complex

Biotite schist, granodiorite, augen gneiss, phyllitic and migmatitic rock types.