GEOLOGY OF TICK CANYON

by

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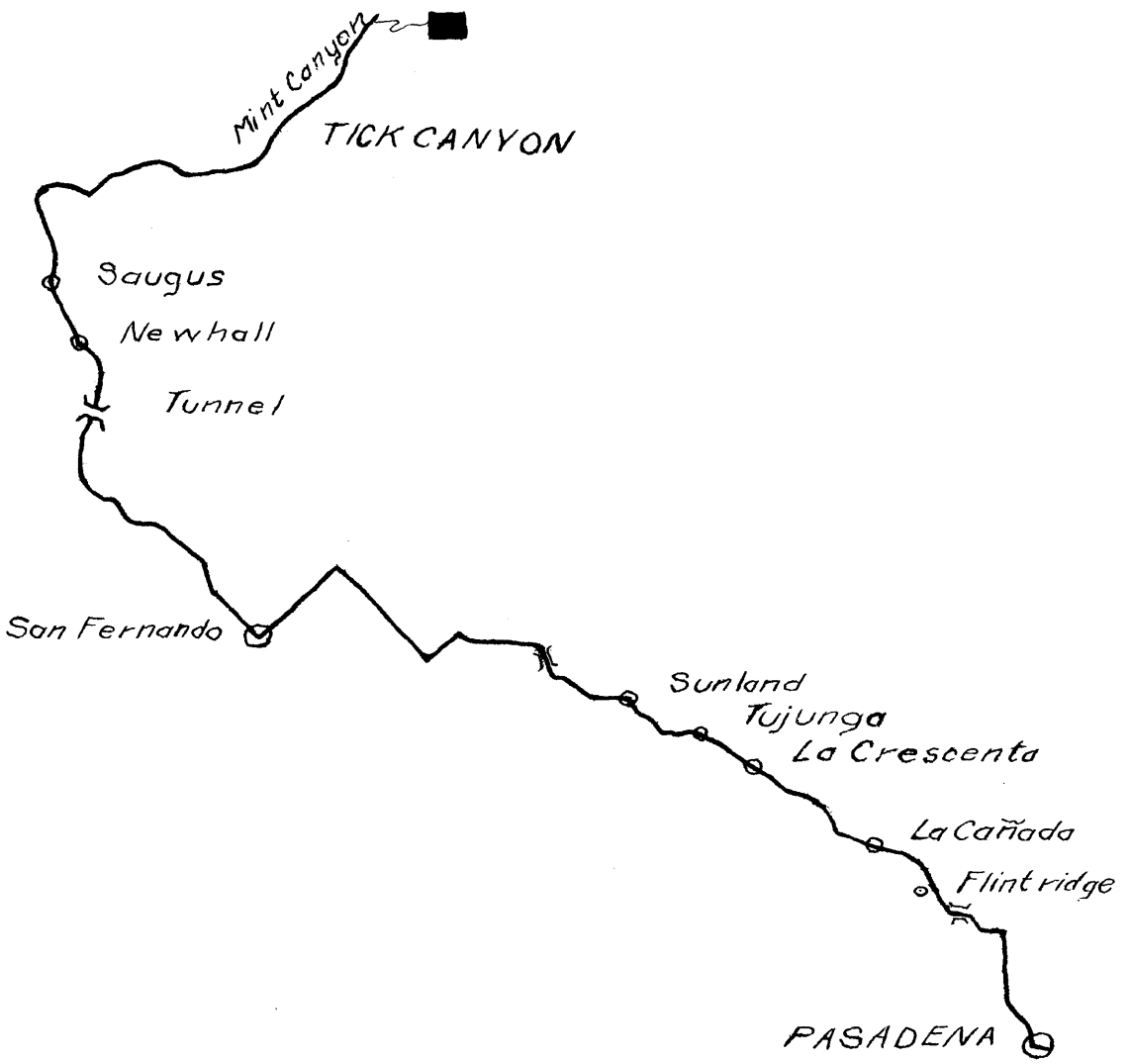


Route from Pasadena to Tick Canyon

0 1 2 3 4 5 6 7 8 9 10 11 12

Scale in miles

Geology of Tick Canyon

Introduction

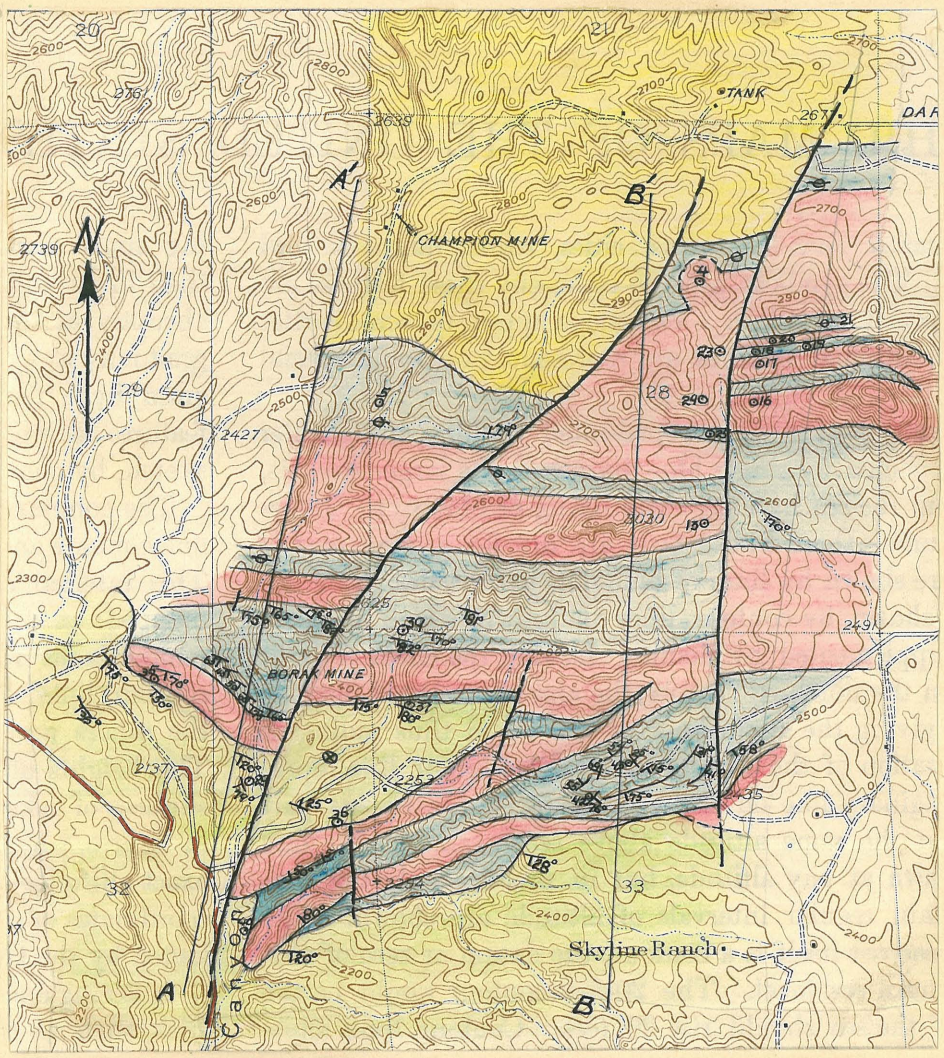
Tick Canyon lies in the north central portion of the Lang quadrangle, Los Angeles county, California. It is about twenty-five miles northwest from Pasadena as the crow flies, but fifty miles by the most direct roads. The area is easily reached by driving two miles east from the Mint Canyon highway on a road six miles north of the Santa Clara river.

Approximately three square miles were studied. The area is roughly rectangular, extending north and east of the head of Tick Canyon. The investigation was undertaken as a partial fulfillment of the requirments leading to the degree of Bachelor of Science at the California Institute of Technology. As a base map a Los Angeles county map surveyed in 1929 and published in 1933 was used. This has a scale of two-thousand feet to the inch and twenty-five foot contour intervals. It is very satisfactory and makes detailed work possible.

The author wishes to acknowledge his indebtedness to Dr. John H. Maxson of the Institute staff, and to thank him for his aid and for his fruitful suggestions, which have made the work possible.

This region was previously described by Dr. William S.W. Kew in Bulletin 753 (1924) of the United States Geological Survey.

A description of the area was also published by Mr. O.H. Hershey: Am. Geologist, vol. 29,pp. 356-358, 1902.



Scale 1" = 2000'

Contour Interval = 25'

Physical Conditions

The topography is fairly rugged, although the relief is not more than eight hundred feet. The general course of the drainage is to the south. The region underlain by the Escondido series consists of westward trending valleys and ridges occasionally cut by streams at right angles thereto. In the areas of Mint Canyon rocks the uplands and lowlands are also controlled by the hard and soft beds, but the relief is not so great as in the Escondido series. Badlands are sometimes developed in the Mint Canyon formation, furnishing excellent opportunities for fossil collecting.

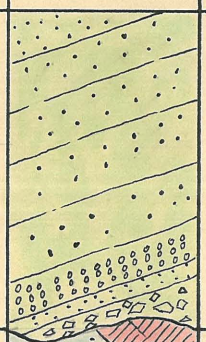
The vegetation is never thick and usually sparse. No springs were encountered, and the water courses are usually dry except in the winter months. The climate is semi-arid or arid. Exposures are very abundant except in the northeastern part of the area and in the lowlands.

No cultivated lands are included within the area studied, but some farming is carried on just to the southwest. This country was once economically important because of the borax deposits of the Escondido series, but mining operations have been discontinued since 1924.

Stratigraphy

The lowest rocks in the geologic column are, of course, the basement complex. No detailed study of the internal features of this formation was made. They are apparently of both igneous and sedimentary origin, and the sediments had been considerably metamorphosed by regional dynamic forces previous to the intrusions. The old sediments evidently included some lava flows, conglomerates, and similar rocks. The igneous

Columnar Section

System	Series	Formation	Thickness	Column	Character
Tertiary	Upper Miocene	Mint Canyon	4000'±		Sandstone Conglomerate Siltstone Agglomerate
	Oligocene Sespe?	Escondido Series	5000'±		Lava Siltstone and s.s. Borax shale, Ash Lava s.s., Ash Lava Boraxsh, s.s., cg.
Mesozoic	Jurassic	Basement Complex			Gneiss and Granodiorite

rock is probably granodiorite. The independent determination of the age of these rocks in a study such as this is practically impossible. They are evidently of pre-tertiary age, and the metamorphism and intrusion probably dates back to Jurassic times. The granodiorite of Liebre and Sawmill mountains, to the northwest of this area, has been considered as part of the Jurassic and post-Jurassic intrusions of the Nevadian revolution, and there seems to be no valid reason for not considering these rocks as a part of the same series. Kew considers the metamorphics to be of pre-Jurassic age, and the intrusives late Jurassic or early Cretaceous.

Lying unconformably on the basement complex are sediments and lavas which Hershey has called the Escondido series. The beds are not fossiliferous. Kew has tentatively regarded them as part of the Sespe ? formation (upper Oligocene or lower Miocene) on a basis of lithology and stratigraphic position. The thickness exposed in this region is a maximum of five thousand feet plus or minus, but cannot be very much less. The complete section, as it was deposited, may have been more extensive. The basal member of this series is a heavy, not very well consolidated conglomerate. Most of the boulders and cobbles of it resemble the basement complex, but numerous cobbles of one foot to eighteen inches in longest dimension of anorthosite are found. This is a good indication that the western end of the San Gabriel mountains, where occur the only anorthosites in this country, were elevated at the time of the deposition of these beds, and furnished material for them. It is possible that the anorthosite cobbles may have come from some earlier sedimentary formation, but as no cobbles or boulders

undoubted
of sedimentary origin were found, it does not seem probable. In the central fault block the basal member is a hard sandstone, overlain by borax shale.

The sandstones of the series are generally hard and well cemented. They range from fine grained, well bedded layers to rather coarse, massive types. Some of the beds appear to be extremely well sorted, and are apparently lake deposits. Most of the sandstones are poorly sorted, arkosic, and made up of angular fragments. An example of a poorly sorted massive layer is the marker bed, an arkosic breccia, which has been mapped in the southern part of the central fault block. Very similar beds occur just to the northeast of the Borax Mine.

A great deal of ash is present in the section, a fact which one might consider as evidence that the lavas are flows. However, it is possible that the lava and ash may have come from quite distinct sources. Moreover the ash is much more silicic than the lavas, and nowhere does the lava contact directly with it. The ash is generally hard, apparently silicified, but sometimes soft, due to alteration. It is white, massive, and contains quartz. Biotite flakes are common.

Of particular interest are the shales of the Escondido series. They are calcareous, grey or white, well bedded, and sometimes contain a great deal of Colemanite. The mineral often occurs in its characteristic milky white or transparent crystals, but the bulk of it seems to be included in fine grained shale, and is impure. Because the mineral occurs only in certain beds and is completely lacking elsewhere, it must have been deposited contemporaneously with the sediments. It

was probably deposited in playa lakes. The are often associated with brightly colored shales or fine sandstones. These sediments were evidently deposited by streams or lakes, probably under arid conditions. The beds are not continuous, non-fossiliferous, and the fragments are angular. The basal conglomerate shows especially well the terrestrial character of the formation, for it is very poorly sorted and commonly so full of very large basement complex boulders as to be almost indistinguishable from the solid rock.

Interbedded with the sediments are beds of lava which make up over half the thickness of the section. The petrographic microscope shows that these lavas are andesites. They are commonly exceedingly coarse grained. The groundmass is generally holocrystalline, with large phenocrysts of andesine feldspsr and augite imbedded therein. In places the lava contains large amounts of magnetite, largely altered to hematite and limonite. Most of the lavas are quite solid, but some are very vesicular, with amygdales of chalcedony and quartz or calcite. All the andesites show a large amount of alteration.

As to the origin or nature of occurence of these lavas, there is conflicting evidence. Kew classified all of them as flows, basing his conclusion on the fact that they are in some places vesicular. However, most of these rocks are solid, and a study of those contacts that are exposed well indicates that they are, or at least some of them are sills. The northern contact of the southern lava layer of the western fault block clearly indicates that the magma was intruded under pressure, for it has invaded the sandstone and been injected into the

interstices of the grains. The rock at the contact is a mixture of lava and sandstone. The sandstone has been considerably hardened, and its color has changed from grey to red. The sandstone at the contact appears fresh and unweathered. All other contacts show these baking effects, though they are generally obscured, so that detailed studies are impossible. In the places where the southern lava contacts show baking, the lava must be a sill. However, some of the lavas, as that labelled number 20, in the northern part of the eastern fault block, are so vesicular that even granting the possibility that vesicles may form in sills, it still seems doubtful that this particular bed, for example, is not a flow. The presence of ash beds need not be taken as evidence for flows, as the ash might have originated hundreds of miles away.

It is the belief of the author, on a basis of the evidence presented above, that both types of occurence of lava are represented in this region. Because all the lavas are of about the same composition, show about the same amount of alteration, the same types of vein material or amygdales, and because they all enter into the structure of the surrounding sediments, they are probably of approximately the same age, and came from the same magma. It is notable in these lavas that the cleavage is not in planes, so that no idea of the attitude of the beds can be obtained from it. The cleavage forms concentric structures or more irregular forms. These structures are usually quite large, depending on the thickness of the sill, but sometimes form small round structures, so that the lava takes on the appearance of a conglomerate. What the explanation of this phenomenon is I do not know, but it it certain that the clea-

vage can have no relation to the direction of flow, as is frequently the case in extrusives.

The Mint Canyon formation, first called the Mellenia series by Hershey, but renamed by Kew, lies with angular unconformity on the eroded edges of the Escondido series. The angular unconformity attains a maximum of eighty degrees where the Mint Canyon contacts with the south limb of the syncline formed by the Escondido. This formation is exposed over a very extensive area to the east and west of Tick Canyon and mostly on the north side of the Santa Clara river. A thickness of 4000 feet plus or minus is assigned by Kew to the whole formation. The basal member in the Tick Canyon area is a coarse agglomerate composed almost exclusively of angular fragments of green lava. This stratum is exposed at point 37 at the northern contact of the isolated body of Mint Canyon beds in the central fault block, at point 35 at the contact of the western fault block, and at point 40 at the southernmost contact in the central fault block. This bed serves to distinguish the Mint Canyon from the Escondido beds, for no lava fragments are to be found in the latter. This bed is followed by soft grey or reddish siltstones and harder sandstones and conglomerates. The hard conglomerates stand out as great reef beds and have a profound effect on the topography. Most of the finer deposits are soft and are broken up into very small fragments. The predominant colors of the formation are grey and brown, but some reddish and rather bright green beds are to be seen.

In general the Mint Canyon is distinguished from the Escondido series by low dips, the inclusion of many lava

fragments, and the softer and more massive character of it. Near the contact with the Escondido in the western fault block, and in the isolated body of Mint Canyon rocks in the central fault block, the dips are quite steep, so the determination rests on the lithology alone.

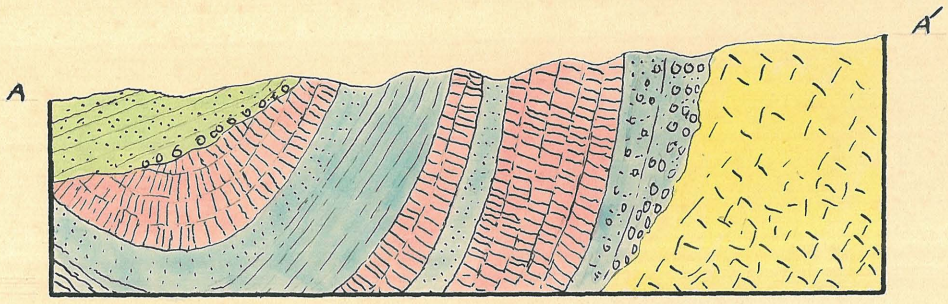
A mammalian fauna first mentioned by Kew and later studied more extensively by Dr, John H. Maxson indicates that the formation is terrestrial and of middle upper Miocene age.

Structure

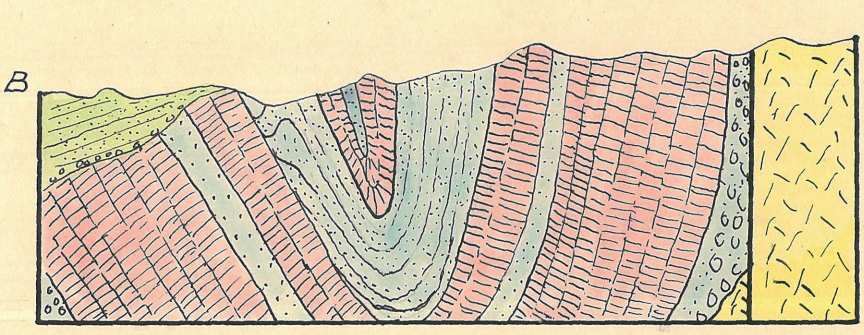
The basement complex contacts to the south with the Escondido series. In this region the contact is depositional, not very irregular, and unconformable. It is very steep, and probably has a slight hade to the south. That this contact is not a fault, as it is in Mint Canyon, one and one-half miles to the west, is shown by the slight irregularity, the lack of slickensiding, and the presence of the basal conglomerate of the Escondido series, containing many boulders from the basement. The contact is quite obscure, and can only be traced by noting the presence or absence of water worn pebbles. It is offset at two points by faults.

The structure of the Escondido series is somewhat complex. The areal geology indicates that the beds outcrop as alternating roughly eastward trending bands of lava and sediment. The series form a large westward plunging syncline, with minor folding on the south limb. The beds near the basement contact stand practically vertical, but show strong south dips in the Borax Mine and just northeast of the Mine. These strata are apparently repeated in reverse order and dipping north in the central

Structure Sections



Sea level



Sea level

1" = 2000'

fault block near the southernmost Mint Canyon contact. Massive sandstone and breccia beds exposed to the northeast of the Borax Mine are also present to the south, on the other limb of the fold. The fact that the beds are much thinner to the south may be explained as the effects of pressure or discontinuity in beds. The great effect of compression on these beds is illustrated just west of the Borax Mine, where the thickness is reduced by half. The effect of discontinuity of bedding is illustrated by these same beds as they appear on the south limb of the syncline in the central fault block. The great increase in thickness to the east is due largely to the appearance of several heavy sandstone and breccia layers.

The evidence for the direction of plunge of the syncline is that the lavas close around the sediments to the east. Moreover in the eastern fault block the northern beds tend to curve to the south, illustrating the same closure.

On the south limb of this syncline in the sediments exposed just north of the road there is a small anticline plunging about twenty degrees west-northwest. At point 42 ripple marks are visible from the road, and they show that the beds are right side up and dipping steeply south. On the north side of the hill are beds dipping to the north, and near the top of the hill are beds dipping almost west. Ripple marks on these latter also indicate that they are right side up. As a further check on the structure two marker beds of heavy coarse breccia have been maped. Both these beds tend to flatten out and curve northward as one traces them east, showing that their structure is a plunging anticline.

The Mint Canyon beds in general form a homocline dipping

to the south or southwest. The amount of dip varies from twenty to thirty degrees except near the contact with the Escondido series in the western fault block. Here the dip is quite steep, going up to seventy-five degrees. This may be due to initial dip, or to the fact that the beds were bent up against the strong butress of the older beds, or both. However, a small body of Mint Canyon beds in the central fault block partakes of the synclinal structure of the Escondido series. It is an anomalous situation, since nowhere else are the Mint Canyon strata so folded. This small series of beds does not appear to have an angular unconformity with the underlying beds. That they have a synclinal structure is indicated by south dips near the northern contact, north dips near the southern contact, and horizontal beds in between.

All these structures are cut by two roughly northward trending faults. These faults have apparent strike slip displacements of 1000 and 2000 feet respectively, at the basement contact, but the dissimilarity of the patterns of the rocks on either side of them, and particularly in the case of the eastern fault, shows that some vertical motion must have occured. The general distribution of the Mint Canyon formation indicates that in each case the east block has moved up with respect to the west block. It is also true that in both cases the apparent lateral displacement decreases very rapidly toward the south. In the case of the eastern fault the displacement has become so small near the Mint Canyon contact that it could be located only by noting the dissimilarity of the structures of the sediments on either side of it. The decrease in displacement may be due to the fact that the dips are lower toward the

south. This would mean that vertical movements would result in apparent horizontal movements in a direction opposite to the actual displacement. It may also be that the faults actually die out to the south. The relation of the faults to topography indicates that they are very steep, probably vertical. No locality was found in which the fault planes could be seen, and the faults were not traced directly. The were located by tracing the contacts up to the points at which they are offset. Two other similar, but very minor faults were noted. Just south of the Mint Canyon contact and just west of the western fault the sediments show a series of small reverse faults trending about east, and having displacements of only a few inches. But no large fault corresponding to these was found.

Historical Geology

In Jurassic or post-Jurassic time a deeply buried, metamorphosed series of sediments and lavas were intruded by a granodiorite batholith. These rocks were subsequently uplifted and deeply eroded. In Oligocene or lower Miocene time (?) the Escondido series was deposited. These sediments were laid down under arid conditions by streams, lakes, and playas. They were accompanied by the deposition of quantities of ash and perhaps by some minor extrusions of lava. This series was invaded by sills of andesite, following which they were folded and eroded. A period of erosion was followed by renewed deposition in middle upper Miocene time. This resulted in the Mint Canyon formation, also a terrestrial deposit. Apparently renewed folding took place in the Escondido series while most of the region was merely tilted, for the small

isolated area of Mint Canyon is folded into a syncline, while all the other Mint Canyon beds are merely tilted to the south. Following this remarkable behaviour the beds were cut by the north trending faults. That these faults occured after the deposition of the Mint Canyon and after the tilting is shown by the fact that the synclinal structure of the small area of Mint Canyon is cut off by the faults at either end of it. This is also shown by the abrupt, sharp manner in which the Mint Canyon contact is cut off. Since that time the region has evidently been uplifted, for there is apparently no tendency for the streams to aggrade. The physiography reflects the geological conditions quite clearly, except in the case of south flowing streams similar to that which forms Tick Canyon. These streams cut across hard and soft rock, and were probably superposed. The hard lavas stand up as strong ridges, while the softer sediments make up the valleys in the central portion of the region. The faults also affect the topography in that their paths are marked by stream channels and numerous saddles. In the Mint Canyon beds the soft layers often form badlands, while the harder layers form the backbones of the hills.