A SHORT INVESTIGATION OF THE NORTH CENTRAL PORTION OF THE LANG QUADRANGLE CALIFORNIA

Senior Thesis

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ABSTRACT

This paper consists of a study of the Escondido and Mint Canyon formations and their structural relationships in the Lang Quadrangle, California. The Escondido formation was found to be approximately 4,500 feet thick and folded into a large pitching syncline with a small anticline in the center. This large syncline, which is in fault contact with the basement, is further modified by a series 4 major strike-slip faults in which the east side has moved northwards. The structure of the Mint Canyon formation is that of a syncline of depositional origin lying in depositional contact on the Escondido and the basement. The Mint Canyon is also modified by one of the major strike-slip faults.

The age determinations are not satisfactory where the Escondido and the basement are concerned. The basement is believed to be pre-Cretaceous; the Escondido is placed between the Eocene and the Upper-Middle Miocene and is suspected to be Middle Miocene in age. The Mint Canyon formation is thought to be Upper-Middle Miocene and Lower-Upper Miocene.

INTRODUCTION

LOCATION OF THE AREA

The area investigated is approximately 50 miles from Pasadena by way of Foothill Boulevard, Saugus, the Mint Canyon Highway, and the Davenport road and is located north of the Santa Clara River in the north central portion of the Lang Quadrangle.

SIZE OF AREA

About 6 square miles consisting of a strip to the Santa Clara River and a block 3 miles north of the river were mapped. The most intensive mapping was done in Sections 27, 28, 33, and 34 of Township 5 N. Range 14 W.

PURPOSE OF INVESTIGATION

This work was carried on as a Senior thesis project as required by the Geology Department of the California Institute of Technology for work leading to a B. S. The fundamental purpose of the work was to develop an efficient and accurate field technique in the mapping and interpretation of geologic structures.

METHOD OF INVESTIGATION

The field work was done on foot with a Brunton Compass, geologic pick, and U. S. Topographic map drawn to a scale of $\frac{1}{24000}$ with a contour interval of 25 feet. Most of the mapping consisted of plotting attitudes and contacts between easily distinguishable rock types or formations; in several instances marker beds were traced to help clarify the structural relationships. The most careful mapping was done in the northern section; the work in the southern section was done hastily in order to obtain a structural profile through the Mint Canyon Formation to the San Gabriel Anorthosite at the Santa Clara River. In this way it was felt that a careful study of the

Escondido Formation could be made without losing sight of the general structural relationships.

Although no attempt was made to make a petrographic study of the different rock types, three thin sections of rocks that showed promise of being interesting were made and studied under the microscope.

ACKNOWLEDGEMENTS

I wish to acknowledge helpful guidance and advice given in the field and in the writing of this paper by Dr. John H. Maxson of the Institute. Conversations with Mr. Richard Jahns and the information from a neighboring area given me by Mr. Clay Smith also proved very valuable.

PHYSICAL CONDITIONS

RELIEF AND ELEVATIONS

The two extremes of elevation in the area are 1900 feet in Soledad Canyon and 3000 feet on one of the high ridges in the northern part of the plot; the maximum order of relief is 800 feet.

TOPOGRAPHY

In the northern section the effect of the structure on the topography is very marked; this is largely due to two very resistant basaltic flows which form the highest and most prominent ridges. The abundance of structural control due to varying rock types creates a rugged topography in the north. The central section smooths out a bit only to become more rugged in the south. The Mint Canyon formation near Agua Dulce Canyon forms an upper surface that sags in the middle, a "topographic syncline." This "topographic syncline" is a structural expression of the syncline in the formation itself.

DRAINAGE

The drainage of the area is all southward through Tick, Spring, Bee, and Agua Dulce Canyons into the Santa Clara River and thence westward.

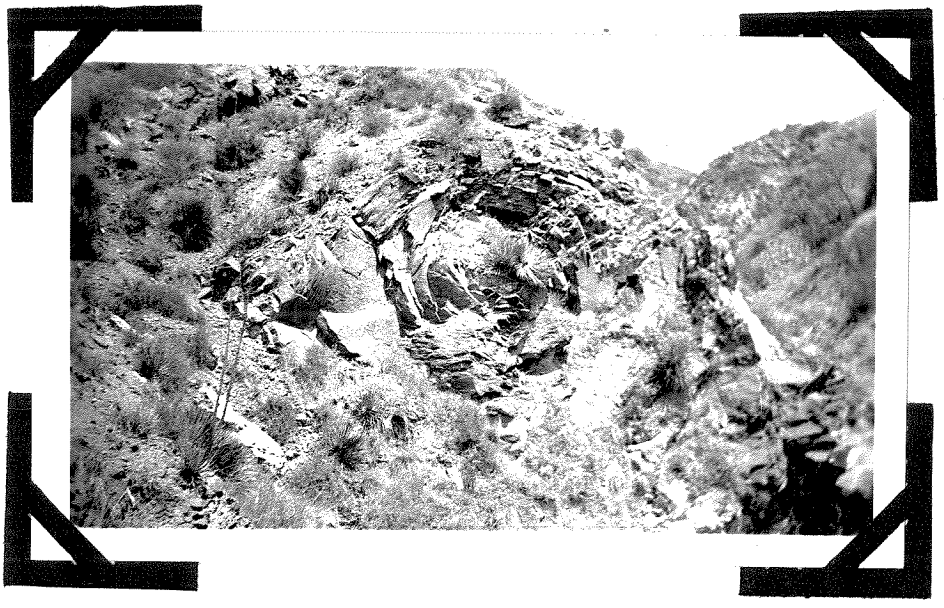
VEGETATION

The vegetation is typically of the semi-arid Southern California type, chaparral, sparse grass, and cottonwood trees near water.

EXPOSURES

Due to the general sparseness of the vegetation and soil covering and the generally prevalent rugged topography, the exposures of the region were excellent. The hardness and resistance to erosion of many of the rock types also aided considerably in providing abundant exposures.

A senic view of the Vasquez Rocks as viewed from the west. Note the excellent exposures and the steep attitude.



A curious structure in one of the Escondido flows, probably a cooling phenomenon.

STRATIGRAPHY AND PETROGRAPHY

REGIONAL

The general stratigraphy of the region consists of basement complexes of igneous intrusives and metamorphics believed to be pre-Cretaceous in age overlain by a section of Tertiary lavas and sediments of both marine and continental origin.

LOCAL

Basement Rocks

The two basement rocks of the area are the Parker Quartz-Diorite and the San Gabriel Anorthosite. According to Simpson* the Parker Quartz-Diorite is Pre-Cretaceous and the San Gabriel Anorthosite is either Late Jurassic or Early Cretaceous. The Anorthosite is believed to be one of the facies of the general San Gabriel batholith.

Escondido Formation

The Escondido formation is a series of interbedded sandstones, lavas, tuffs, shales, and a few conglomerates that are apparently of continental origin. A general characteristic of the whole formation, with the exception of a few shales, is its red color and competency.

The sandstones of the Escondido formation are generally reddish, arkosic, medium grained, and competent structurally. Just above the borax mine in Tick Canyon there is a freakish green sandstone; otherwise, there are no great variations from the mean.

The shales of the Escondido are a variety of colors but are confined mostly to greys and whites; they are structurally incompetent. The most interesting development in the shales of the Escondido is the presence of extensive deposits of borax minerals that were one time of economic significance. Most authorities agree that borax minerals are formed in playa lake deposits of arid regions. Foshag*

*See Bibliography

in his report on "The Origin of the Colemanite Deposits of California" discusses the deposits in this area. He reports the presence of Colemanite and Ulexite and holds that the Ulexite was first deposited in a playa lake, and then partially altered to Colemanite in its present state after an uplift of the region had taken place and the Sodium could be leached out of the Ulexite and replaced by Calcium, thus making Colemanite a secondary mineral.

The lavas of the region are believed to be both basalts and andesites. The thin section made was determined as basalt; Richard Jahns stated that both basalts and andesites were found. The reason that these lavas are believed to be flows is discussed later in the paper under Structure. Two flows are of interest because of their great development of flow brecciation. Included in the flow breccia we have fragments of shale as well as bits of the lava itself; all of these fragments are very angular.

At the base of the section we have approximately 900 feet of sediment, mainly sandstones. Above this we have approximately 1,100 feet of lava. Whether it is basalt or andesite is not known; a field determination would probably list it as a basalt. Above this is about 300 feet of interbedded tuffs, lavas and sandstones. Above this is a section of the brecciated lava varying in thickness from 200 to 900 feet. In the eastern part of the section the brecciated lava is separated by an interbed of white sandstone. One thin section was taken from the lower of the two brecciated lavas and was determined as a basalt.

Slide #3
- Megascopic description
  - Deep reddish brown, aphanitic phenocrystalline
- Microscopic description
  - Hematite-plentiful
  - Labradorite

Hornblende
Olivine
Apatite
Texture: Microcrystalline, jackstraw, phenocrystalline
Remarks: Femags very highly altered to hematite
Rock Name: Basalt

Another thin section was made of the contact between the upper flow and a tuff.

Slide #1
Megascopic description
Contact between tuff and lava very sharp.
Tuff: Grey, fine grain
Lava: Dark purplish grey, aphanitic
Microscopic description
Tuff
Magnetite
Hematite
Olivine
Hornblende
Albite to Oligoclase
Texture: Angular fragments in groundmass.
Remarks: Index of groundmass lower than that of Canada Balsam.
Lava
Magnetite
Hematite
Texture: Too fine grain to identify anything else.

Above the flow brecciated lavas lies another section of sediments in which the borax bearing shales are found; these beds are approximately 300 feet thick. And finally we have about 250 feet of sediment resting on this lava; this sediment also contains some of the borax beds.

An interesting looking tuff bed in the Escondido near Escondido Canyon was studied in thin section.

Slide #2
Megascopic description
Flesh color, fine grain with larger grains included, biotite, and feldspar.
Microscopic description
Hornblende
Magnetite
Hematite
Olivine
Oligoclase and Andesine up to Labradorite boundary
Biotite

Texture: Some fragments are rounded, others are angular; all is in a messy groundmass.
Name: Tuff

Thus we see that the total thickness of Escondido exposed in this area is of the order of 4,500 feet. Due to the absence of all fossils, the red coloration of the sediments, lack of pillow structure in lavas, and the presence of the borax deposits we may conclude that the Escondido is terrestrial in origin.

The age of the Escondido is very questionable; it has been placed all the way from Oligocene to Middle Miocene. Kew* in his paper on the region makes a question mark correlation with the Sespe of Oligocene age on the basis of lithologic similarity. Simpson* in his paper on the region attempts to make a correlation with the Topanga formation on the basis of the lava flows common to each, their same approximate thickness, and lithologic similarity; all this notwithstanding the fact that the Topanga is marine and the Escondido terrestrial. I favor Simpson's view and shall consider the Escondido as Middle Miocene(?). At any rate, it is certain that the Escondido overlies Martinez which is Eocene and underlies Mint Canyon which is either or both Upper Middle Miocene and Lower Upper Miocene.

Mint Canyon Formation

The Mint Canyon formation consists largely of coarse and angular conglomerates with occasional fine grained material of terrestrial origin.

In the northern part of the area the Mint Canyon is thick and rudely stratified with a tawny grey or dirty brownish grey color. The boulders are sub-angular and range from the mean size of about 4 to 6 inches to 14 inches in diameter.

*See Bibliography

Figure I. A boulder in the Mint Canyon formation showing the bedding and a strip of sand showing the direction of flow of the depositional current.

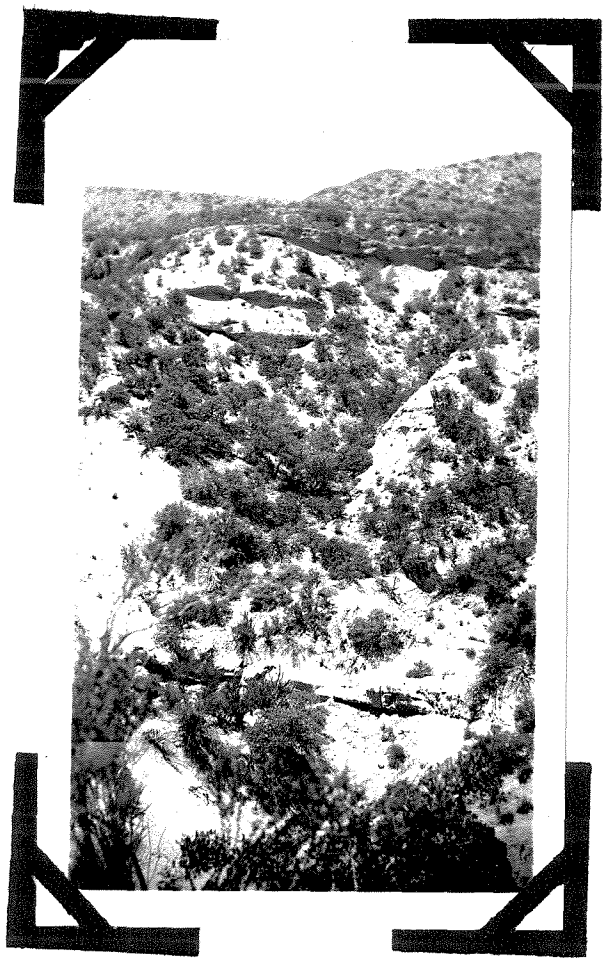


Figure II. Bad Lands in the Mint Canyon formation.

In the southern part of the area the boulders are larger and more angular and the stratification is very rude; some of the boulders are 3 feet in diameter. Figure (I) shows such a boulder. There are two interesting things about this picture. First, the flat bottom of the boulder shows the dip and strike of the bedding plane. Second, the presence of the small stringer of sandstone to the left of the boulder shows that the current of water at the time of deposition was flowing from right to left. Many of the very angular boulders in the southern part of the area are quite obviously fragments of the San Gabriel Anorthosite.

Higher in the Mint Canyon one finds sections of silty and shaly sediments up to 100 feet thick. Vertebrate fossil fragments are often found in this material where it makes bad lands of the type seen in Figure (II). The particular section of soft Mint Canyon shown in the photograph was mapped by Kew* as Escondido; it is, however conformable in every detail with the Mint Canyon and was mapped as such.

The exact age of the Mint Canyon is, at present, under discussion. Richard Jahns is seeking to differentiate the Mint Canyon both faunaly and structurally into two age groups; one, Upper Middle Miocene; the other, Lower upper Miocene. This project has promise of being successful; therefore, we shall consider the Mint Canyon formation as belonging to both these age groups.

Due to the limited area of Mint Canyon formation investigated an estimate of its thickness will not be made. Its character and the presence of vertebrate fossils mark it plainly as a terrestrial formation.

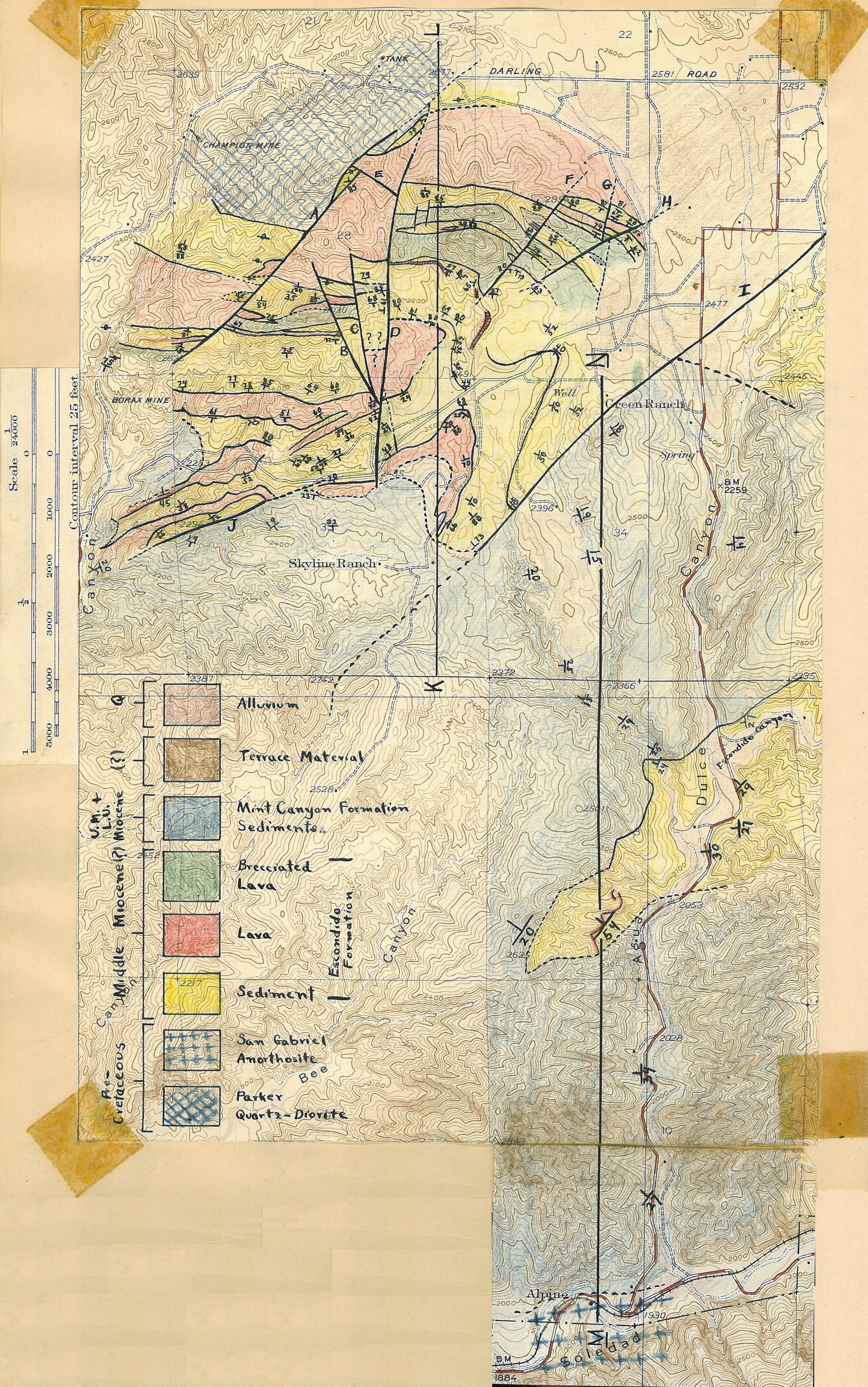
*See Bibliography

Terrace Material

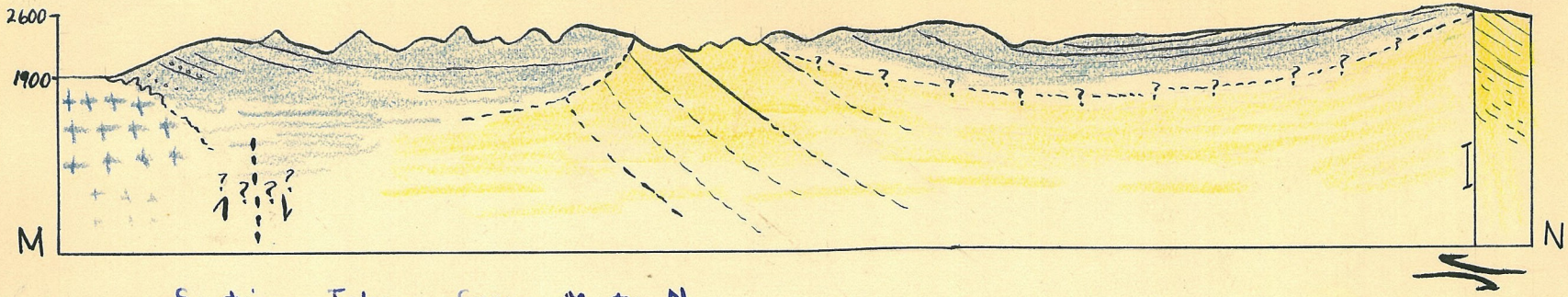
In several of the flatter places in the area a terrace deposit of material derived from the Escondido and Mint Canyon formations was found on the surface. In the area investigated the material was not more than 10 feet thick at the most. I hesitate to make an age determination.

Quaternary Alluvium

No place in the area is Quaternary alluvium developed on a mapable scale with the exception of the junction of Escondido and Agua Dulce Canyons.

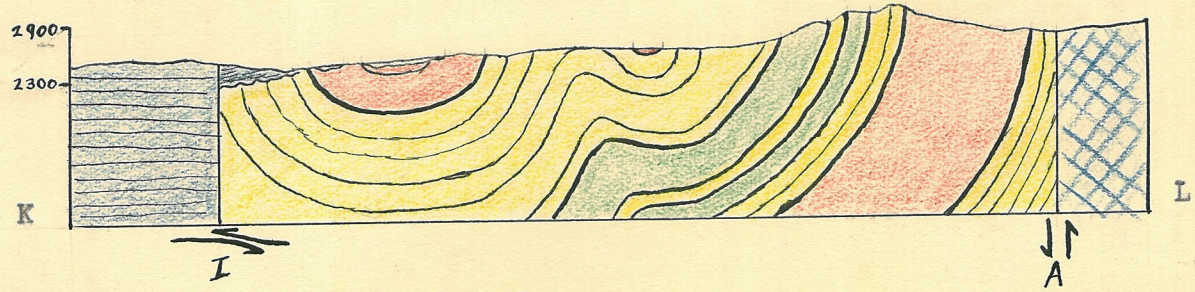


DARLING ROAD
TANK
CHAMPION MINE
BORAX MINE
Skyline Ranch
Green Ranch
Well
Spring
Canyon
Dulce
Escondido Canyon
Agua
Bee
Alpine
Soledad
BM 2259
BM 1884
Scale 1/24000
Contour interval 25 feet
Q
Alluvium
(?)
Terrace Material
U.M. + L.P. Miocene
Mint Canyon Formation Sediments
Middle Miocene(?)
Brecciated Lava
Lava
Sediment
Escondido Formation
Pre-Cretaceous
San Gabriel Anorthosite
Parker Quartz-Diorite



Section Taken from M to N.

Vertical and Horizontal Scale : 1 inch equals 2,000 feet.



Section taken from K to L

Vertical and Horizontal Scale: 1 inch equals 2,000 ft.

GEOLOGIC STRUCTURE

REGIONAL

Generally speaking, the region is bounded on the north and on the south by old metamorphics and igneous rocks of Pre-Cretaceous Age. In between these two boundaries of basement we have Tertiary sediments lying in depositional and fault contact with the basement. The Tertiary sediments and lavas may be divided structurally into two main groups. The first, the Martinez and Escondido formations, seem to be predominately, if not completely, in fault contact with the basement; they are well faulted and contorted and have, in most cases, dips of from 60 to 90 degrees.

The Escondido consists of sediment interbedded with lava flows and lies on the Martinez unconformably. The second group of sediments is the Mint Canyon formation which lies at about 30 degrees unconformity on the Escondido and meets the basement complex in both depositional and fault contacts. The general configuration of the Mint Canyon is that of a gantle syncline containing many minor faults and several larger faults producing horizontal displacements of $\frac{3}{4}$ of a mile. With the exception of the basement faults, most of the faulting in the region has been predominately strike-slip with the east side moving northward.

LOCAL

Briefly, the local structure consists of a syncline of Escondido in the north faulted against the Parker Quartz-Diorite and a syncline of Mint Canyon in the central and south portion of the area lying in depositional contact on the Escondido and the San Gabriel Anorthosite. Both of these general structures are complicated by minor folds and by very extensive strike-slip faulting.

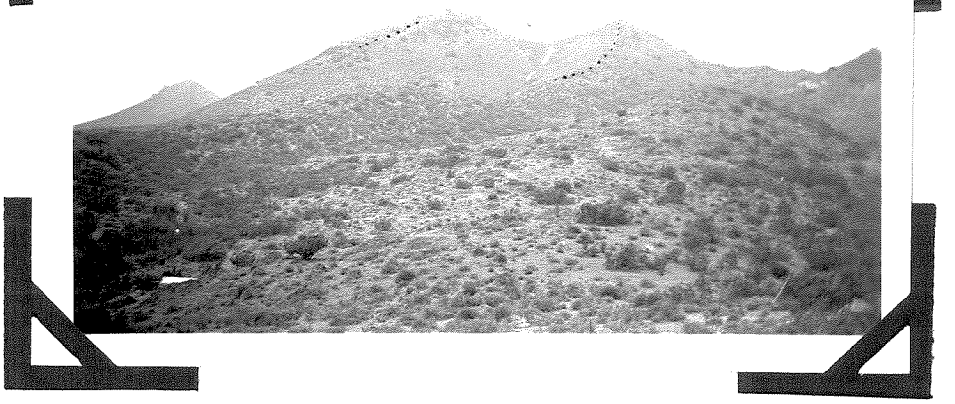


Figure III. Resistant ridges of flow-breccia'ted lava showing the synclinal structure of the Escondido.

Figure IV. The contact between a lava and a tuff. The lava lies on the handle side of the contact.

The Escondido formation is much more complex structurally than the Mint Canyon formation. Basically the Escondido consists of a syncline with an anticlinal "wrinkle" in the center of the syncline; the whole syncline is plunging to the west. The structure is further complicated by a series of strike-slip faults of varying magnitude in which the east side has been faulted northward; the majority of these faults trend in a north-easterly direction.

The general synclinal configuration of the Escondido and the presence of the small anticline is clearly shown by the plots of the dips and strikes in the Escondido and by tracing out several marker beds; the very resistant basalts of the Escondido form prominent ridges that also reflect the synclinal structure very plainly, (Figure III). The small anticline in the center of the syncline is quite normal in the central part of the area but becomes overturned near the western boundary of the area. This is demonstrated by change of dips on the south flank of the anticline from south dips to steep north dips. In the center of the anticline a sketch was made to show the repetition of a lava flow and the change of dips from approximately 45 degrees north to approximately 70 degrees north. The conclusion that the anticline is overturned appears to the author to be inescapable.

The lavas in the area are believed to be flows. The lavas are interbedded with the sediments and tuffs and nowhere do they seem to cut the bedding. The abundance of amygdules and the direct evidence of vesicles show that the lava solidified on or very near the surface. Figure (IV) shows the contact between the brecciated lava and a tuff. In a thin section of such a contact (Slide #1) small vesicles were present in the flow. The study of the textural and structural rela-

tionships of the lavas leads to the conclusion that they are flows.

Faulting is a major consideration in the structure of the Escondido. Although no direct evidence was obtained, the contact of the Escondido with the Parker Quartz-Diorite seems to be a nearly vertical fault. This is indicated by the straightness of the contact and the nearly vertical position of the Escondido near this contact. The evidence was not very complete in this area but this conclusion has been largely borne out in Mr. Clay Smith's investigation of the next area to the west. A series of later strike-slip faults break up the Escondido and also continue out into the basement offsetting the Escondido into the basement. Each one of these faults is evidenced by displacement of mapable proportions up to 5,000 feet; faults D, F, and I were further shown by drag effects along the faults.

Fault A presents an interesting basis for speculation. The small bit of sediment found at the intersection of faults A and E contains some of the borax shale which was observed only above the flow brecciated lava in the Escondido section. Thus, while the apparent strike-slip on fault A is of the order of 1,100 feet, the borax-bearing shale is displaced a distance of 5,000 feet. This leaves us two conclusions; either the east side of fault A has moved 5,500 feet south and then back 6,700 feet to the north or borax-bearing shale is found elsewhere in the section. In the absence of any observed borax-bearing shale below the flow-brecciated lava I can only conclude that there has been a reversal of movement along this fault. It is likely that fault E moved in the interval between this reversal of movement and caught the bit of sediment found at the intersection of A and E by diverting fault A around this sediment

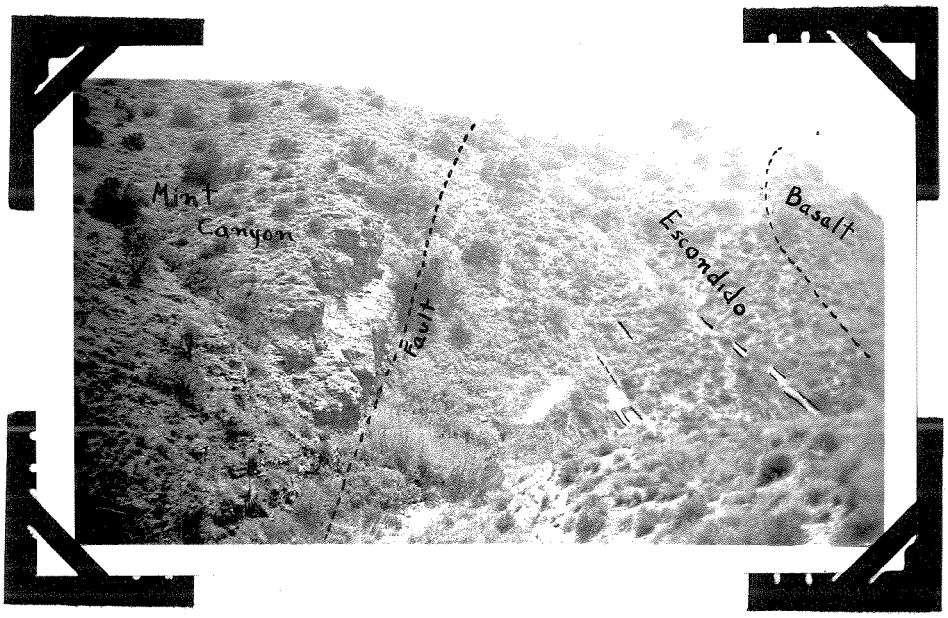
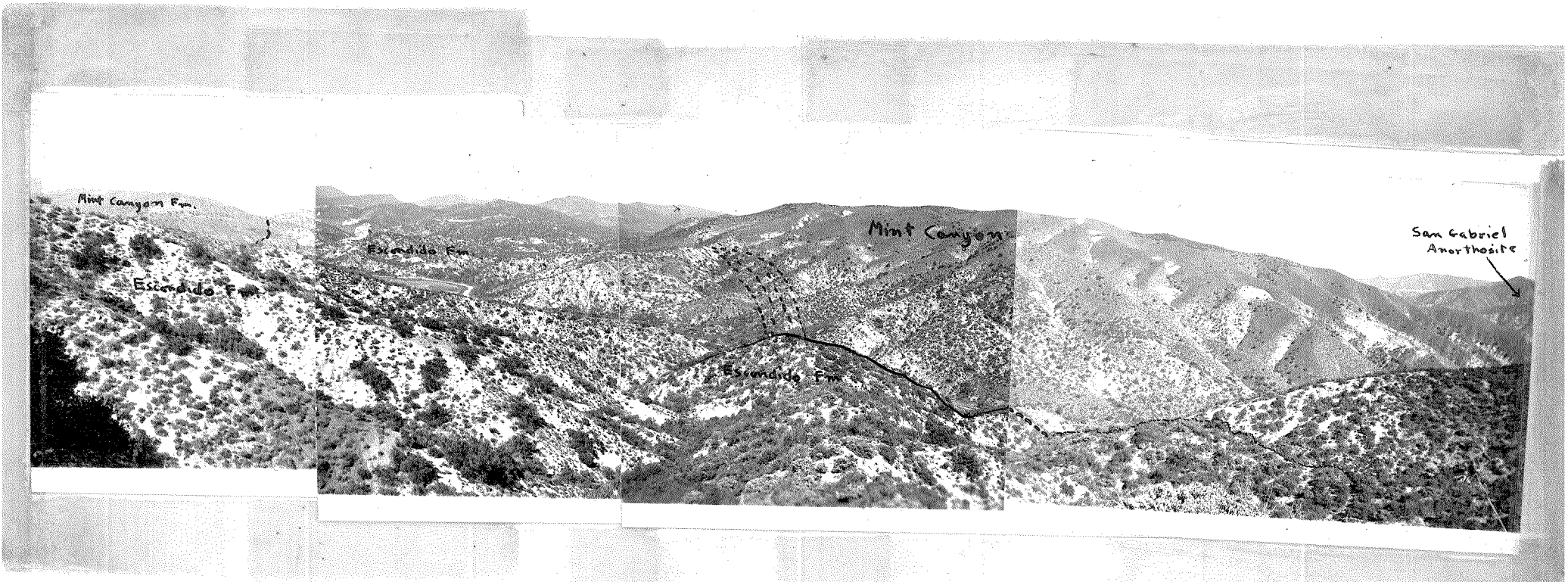


Figure V. Fault J, the contact between the Escondido and the Mint Canyon formations in the vicinity of Tick Canyon.

Figure VI. A panorama view of the "ridge" of Escondido sticking out into the Mint Canyon formation. Taken from west slopes of Agua Dulce Canyon near Escondido canyon.



N32°E

N52°E

52

N82°E

S55°E

when the reversal of movement took place. The small sliver of sediment in the triangle formed by faults A, E, and D is similar in character to that found between the lava and the basement fault and was probably left there by the action of fault D.

Fault J is evidenced by a vertical contact between the Escondido and the Mint Canyon and the presence of a small escarpment as shown in Figure (V). The fault produced a horizontal displacement of the order of 500 feet in the lava of the Escondido and must have had a vertical component of at least 120 feet.

Fault I between the Mint Canyon and the Escondido has a horizontal displacement of the order of 5,000 feet and is the largest in the area, with the possible exception of the basement fault.

There also seems to be some downward movement and general lengthening or enfolding along faults C and D. This is evidenced by the increase in the size of the outcrop of the lava flow in the center of the synclinal structure; the thickness of the flow of brecciated lava also increases.

The Mint Canyon formation lies with a depositional unconformity of approximately 30 degrees upon the Escondido; in some places the unconformity is only one degree, in others, approximately 90 degrees. There is abundant evidence that the old Escondido surface upon which the Mint Canyon was deposited was very rugged. Most striking of all is the "ridge" of Escondido that comes out of Escondido Canyon and projects out into the Mint Canyon (Figure (VI). This ridge seems to be the south flank of the large syncline in the Escondido; it was probably a topographic expression of several resistant beds in the formation because the strikes roughly parallel this ridge. Two small isolated bits of sediment, rudely stratified, angular, containing

fragments of the Escondido, and unconformable on the Escondido were found in a canyon in Section 27. I suspect that these bits may be of the Mint Canyon formation. On the western edge of the area the Mint Canyon again seems to tongue into the little valley south of the borax mine. Thus a rugged Escondido surface of deposition is well indicated. In the southern part of the area the Mint Canyon lies with a depositional unconformity upon the San Gabriel Anorthosite. The old anorthosite surface was evidently very rugged also; this is shown by a knob of anorthosite sticking up into the Mint Canyon that is exposed along the highway near the end of Agua Dulce Canyon.

Structurally, the Mint Canyon presents a contrast in simplicity to the Escondido; it consists fundamentally of syncline modified by a major fault and a ridge of Escondido. If one follows the dips and strikes in the Mint Canyon from near Skyline Ranch to the buried ridge in the Escondido near Escondido Canyon, it will be seen that a syncline lies in this region. To the south of this buried ridge the strikes straighten out again and then resume the northeasterly direction they had on the north side of the buried ridge. The generally low dips dipping away from the surfaces upon which the formation was deposited and the coarseness of the material, lead me to believe that this structure is largely of depositional origin and that later warping was not very important as far as the syncline in the Mint Canyon is concerned.

There are many minor faults of small displacement in the Mint Canyon, but due to the time which remained to run a profile to the Santa Clara River they were not mapped or carefully investigated. The large fault I, however, was carefully mapped along its contact

with the Escondido. This fault, which has a horizontal displacement of approximately 5,000 feet has moved the southeastern corner of the Mint Canyon syncline in a northeasterly direction.

Thus, we see that our local structures consist of two synclines modified by faulting of a strike-slip nature.

HISTORICAL GEOLOGY

(1) Sometime before the Cretaceous or in the Early Cretaceous all of the basement rock had been intruded, namely, the Parker Quartz-Diorite and the Anorthosite facie of the San Gabriel batholith.

(2) In Middle Miocene time (?) the Escondido formation was deposited on these igneous surfaces. Lava flows alternated with the sedimentary deposition. Later in the cycle, when the grade was reduced and a great playa lake basin had formed, the arid climate caused deposits of Ulexite to form along with fine shales. The grade was increased again and another flow followed. After this flow the grade was again reduced and more shales with some Ulexite were deposited.

(3) Then followed a period of great Tectonic activity. Intensive folding and faulting took place in the Escondido formation. The basement to the north was faulted up and more strike-slip faulting occurred. A short period of erosion followed. Then the San Gabriel Mountains were faulted up and the area depressed.

(4) The uplift of the masses to the south and to the north offered ample material for the Mint Canyon formation which was deposited in Upper Middle Miocene and Lower Upper Miocene. So short was the elapsed time between the folding and faulting of the Escondido and the deposition of the Mint Canyon that the erosional surface of the Escondido was very rugged. Most of the material for the Mint Canyon formation came from the east and the south.

(5) Then followed a period of additional folding and faulting. Though it was not as violent as the first it produced one long fault,I.

(6) Slight uplift and a period of erosion at low grade followed and produced the terrace material which is found in some of the flatter places.

(7) A renewed uplift caused canyons to cut deeper and flow in their present channels.

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