# GEOLOGY OF A PORTION OF THE SANTA ANA MOUNTAINS, CALIF.

Thesis by

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# GEOLOGY OF A PORTION OF THE

# SANTA ANA MTS.

## SUMMARY OF INVESTIGATION

In this paper is presented a geologic map of a part of the southern Santa Ana mountains. Studies in lithology were made especially of the Tejon formation. The structure was found to be simple with a few faults which were studied by the writer, especially the Cristianitos and the San Onofre faults. The physiographic and geologic history are discussed. Finally, some clay deposits of economic importance are described.

## INTRODUCTION

<u>Area and Purpose of Investigation:</u> The area described in this report comprises about seventy-five square miles in the southern portion of the Santa Ana mountains in Southern California, and embraces parts of Orange and San Diego counties. See Plate I. This area is covered by the south-east corner of the Corona, and the north-east corner of the Capistrano Quadrangles, respectively.

The region was studied, at the suggestion of Dr. J. P. Buwalda, in the nature of a research problem requisite to the Master of Science degree. The Santa Ana mountains present many interesting problems, to some of which the writer directed his attention. In this connection, it should be indicated that these problems are to a great extent regional ones, and that a study, even though intensive, can only shed light on these rather than solve them. For this reason, the writer did not hesitate to draw freely upon the information in the several reports on this general region, especially the notable paper by A. O. Woodford.* Specific references to these

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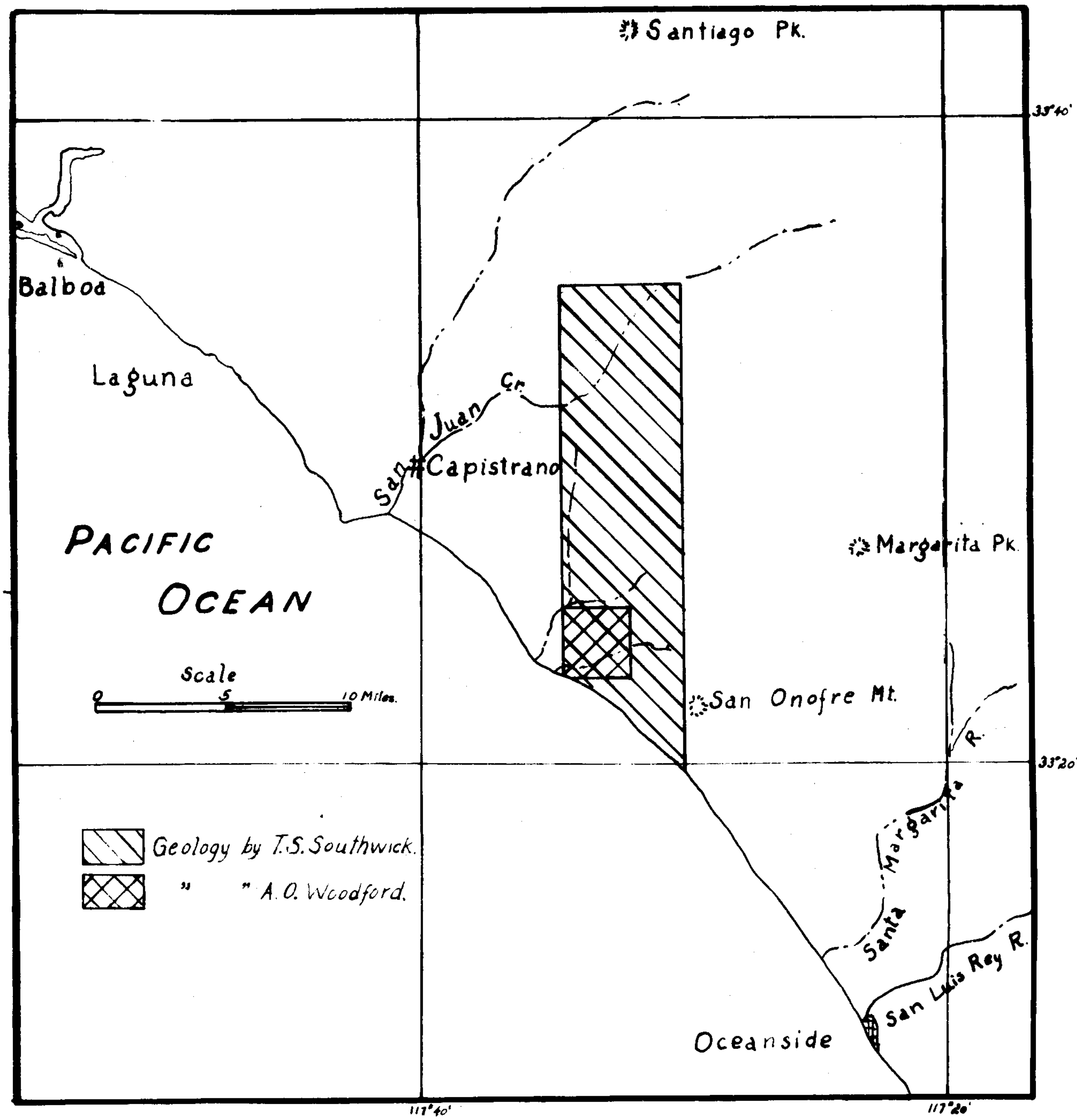
* Woodford, A. O., The San Onofre Breccia - Its Nature and Origin.: Univ. Cal. Publ., vol. 15, No. 7, pp159-280, 1925.




Index Map Showing Area Covered by this Report.

papers will be made throughout the course of this report. An excellent bibliography will be found in Woodford's paper.

A brief statement of the general geology of this portion of Southern California will perhaps clarify somewhat the following discussions. The Santa Ana Mountains are a tilted, seaward sloping mountain block with a very straight and abrupt fault scarp that faces the north-east and overlooks the Perris peneplain. The block is an elevated peneplain with Cretaceous and Tertiary sediments upon its flanks grading into the coastal plain. Farther south, the structure becomes somewhat more complicated due to other mountain ranges, but the same tilted structure predominates.*

Field Methods: About two months were spent in the field. Field methods of varying degrees of accuracy were employed. In general, the field work is believed to be consistent with the accuracy of the topographic maps which are on a scale of two miles to the inch. The region is quite rugged and difficult of access, so that every portion was not studied in detail. Most of the outcrops are cliff exposures and often inaccessible.

The areal geology in the region about San Onofre has been published by Woodford, and the writer merely checked these in cursory fashion, noting dips and strikes, and making a few minor changes. This area by Woodford is shown on the geologic map, Plate XVII.

Acknowledgments: The writer is deeply obligated to Mr. Chas. Hardy of the Rancho Santa Margarita for permission to travel thereon. Messrs. Magee and Trotter of the Rancho extended many courtesies to the writer while in the field for which he is very

* The above statements, with modifications, are taken from: Bowman, I., Forest Physiography, Wiley, p135.

grateful. Profs. Buwalda, Woodring and Engel of the Department of Geology, California Institute of Technology, made many suggestions to the writer which were very helpful. Finally, the writer wishes to acknowledge the kindness of Dr. E. L. Packard, who read the tedious manuscript and offered many helpful suggestions.

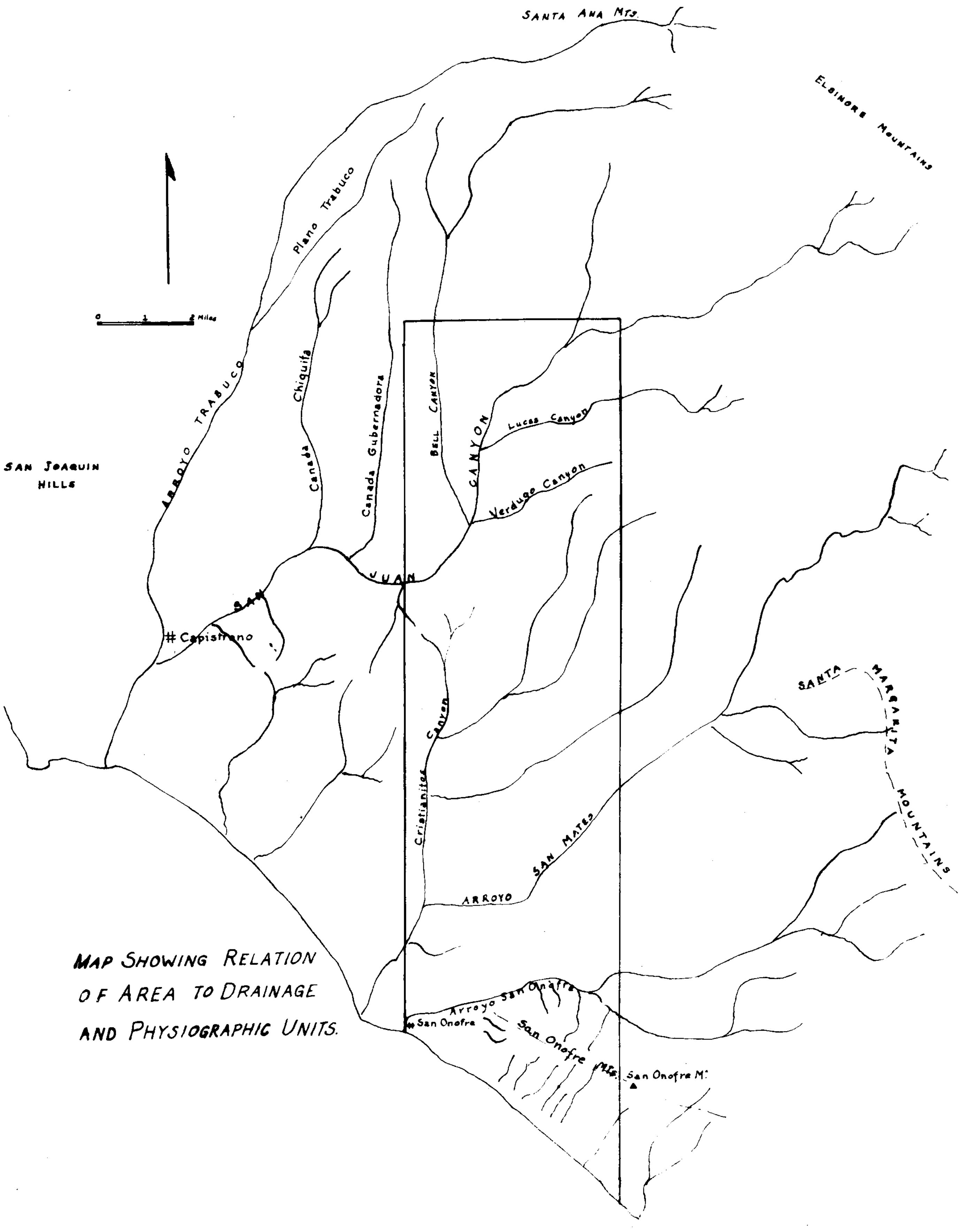
GEOGRAPHY

This region embraces a strip five miles wide extending from the ocean at San Onofre to the south slope of the Elsinore Mountains, the crest of which is several miles to the north-east. The area, with the exception of a narrow strip on the east boundary, lies within the Rancho Santa Margarita. The strip on the east is a part of the Cleveland National Forest.

This area is reached from either San Juan Capistrano or San Onofre, both being on the Los Angeles-San Diego State Highway. From these points a few poor, dirt roads afford access to the interior. All except the San Juan Canyon road are private roads of the Rancho. The Santa Fe Railroad traverses the southern edge of the region with a station at San Onofre.

Being a mountainous region, the land is given over to cattle grazing, with small amounts of farming on the river bottoms and on some of the larger flats, or potreros, on the mountain tops.

The various geographical units are indicated on the topographic map and on Plate II; they will not be discussed here except to note that the San Onofre Mountains form the only mountain crest in the region, the remainder of the area being on the flanks of the Elsinore and Santa Margarita Mountains. The Elsinore, Santa Margarita, and San Onofre Mountains together make up the southern continuation of the Santa Ana Mountains, making this part of the range more complex in form and structure.




MAP SHOWING RELATION OF AREA TO DRAINAGE AND PHYSIOGRAPHIC UNITS.

The vegetation is quite typical of the California Coast Ranges, the steeper slopes being brush covered with occasional scrub oak and much cactus, while the smoother hills support grass. Some of the larger valleys near the coast, such as Talega and San Onofre canyons contain many large picturesque oaks which afford agreeable contrast to the monotonous slopes above.

The climate is semi-arid with moderate temperatures due to its proximity to the ocean.

## PHYSIOGRAPHY

General Statement: All of the region is either hilly or mountainous with varying degrees of relief, except for the narrow coastal plain. The maximum relief is expressed by the highest elevation in the area, which is 2042 feet, a peak near the San Juan Hot Springs and which is approximately fifteen miles from the ocean. The relief in this northern part, the area of crystalline rocks, varies from 800 to 1200 feet. The relief becomes more gradual towards the south, 300 or 400 feet being the average. In general, slopes are steep except for some rolling country in the southern portion of the area. As the ocean is approached the San Onofre Mountains interpose themselves upon this rolling terrain, with a maximum elevation of 1500 feet and a relief of about 600 feet. This San Onofre range is somewhat unique in that it trends parallel with the coast rather than striking into it.

The mountains are characterized by accordance of peaks; long, smooth topped ridges; and flats or potreros, which are smooth flat swales upon the mountain tops and are remnants of former erosion surfaces. From the oldest of these surfaces to the present there have been recognized three physiographic cycles of erosion.

The mountains end with the San Onofre range which merges on its southern flank with a coastal plain varying in width from one-quarter to one-half mile. Its elevation above sea level varies from seventy-five or one-hundred feet at the seaward side to 200 feet at the base of the mountain. This marine terrace meets the sea with an abrupt vertical cliff.

Drainage: The drainage system is shown on Plate II and hence will not be explained in detail. San Juan Creek, the Arroyo San Mateo, and the Arroyo San Onofre are the main drainages in that they all head in the mountains, San Juan Creek in the Elsinore Mountains, and the other two in the Santa Margarita Mountains.

The canyons are all dry except for San Juan, Lucas and San Onofre canyons, a result of the aridity of the region. An interesting feature is shown by the streams in San Juan and Lucas canyons. In the region of crystalline rocks, the streams have their normal flow and are quite typical of Southern California mountain streams. Upon reaching the contact with the sedimentary rocks they immediately diminish and soon flow entirely underground. In San Juan Canyon, the st eam disappears inside of half a mile, while the Lucas Canyon stream, being smaller, disappears in about one-hundred feet. That he major flow in this region is underground is shown by the fact that windmills are in nearly all the large canyons and abundant water obtained, even in summer.

The drainage system is quite well developed as can be seen on the topographic map, the divides being low and the heads of opposite streams very close together.

The valleys, although steep sided, have flat floors covered with sand and gravel; a consequence of the torrential nature of Southern California rains. Alluvial fans are conspicuously absent due to the fact that the region is well drained into the ocean.

Most of the canyons and valleys are bordered by terraces. They occur at heights varying from twenty-five to 200 feet above the valley floor. In San Juan and a few other canyons, there are three distinct terraces, the highest being 200 feet above the stream. In San Juan Canyon, just above the Hot Springs, there is a remnant of a terrace 400 feet above the canyon floor, These terraces are cut terraces with a few feet of gravelly alluvium resting upon the cut bench. The position and form of these terraces have an interesting bearing on the past history of the region which will be discussed later under Physiographic Development.

The streams are prevented from flowing directly into the ocean by bars across their mouths. On the immediate landward side of these bars are salt marshes which gradually merge upstream into the valley alluvium. These bars are the result of coastwise currents whose ability to create a bar is greater than the tendency of the streams to keep their channels clear. If there had been no shore currents, the streams, upon debouching into the sea, would have dropped their detritus in the form of a delta rather than a bar.

Physiographic Cycles: As mentioned previously, three cycles of erosion have been recognized. This is a minimum number and doubtless more stages of physiographic development might be postulated with supporting data, but the writer is inclined to the belief that the minimum number of cycles which can be set up to explain existing phenomena is more likely to approximate verity than the maximum. The normal function of erosion is to destroy past land forms in the creating of new ones; ancient erosion surfaces represent the abnormal rather than the true course of nature. Hence when we postulate several erosion cycles, we should seek reasons for the persistance of the older cycles. In agreement with the foregoing, the writer has restricted the various stages of erosion to the peneplain, a later cycle of mature dissection, and a recent stage of youth. These cycles are denoted as A, B, C, and are so indicated on Plates III to VI inclusive.

<u>Peneplain or A Cycle:</u> Evidences of a former peneplain are found in the long, smooth ridges, nearly devoid of peaks, which characterize this region, and in the potreros which are flat meadows high upon the mountain ridges. Plate III shows typical views of ridges in the crystalline rock area comprising the core of the range. In the field, it is easy to reconstruct the peneplain by means of these smooth ridges, and the few peaks which are present show a corresponding accordance. This plain of erosion can be seen to dip slightly toward the ocean. See Plate IV. This peneplain truncates not only the Basement Complex, but also the Cretaceous and Eocene sediments. Unfortunately, this surface of erosion becomes incoherent in the region of the softer sedimentary rocks, so that its relation to the Miocene and Pliocene sediments could not be ascertained.

The age of this peneplanation is generally considered to correspond to that of the Perris Peneplain and is probably Pliocene.*

The potreros afford very conclusive evidence of peneplanation. One gains access to them by means of steep, tortuous

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* Dickerson, R. E., The Martinez and Tejon Eocene and Associated Formations of the Santa Ana Mountains. Univ. Calif. Publ. Bull. Dept. Geol., vol 8, p 260, 1914.

A.
Showing Flat Crests of Basement Complex.

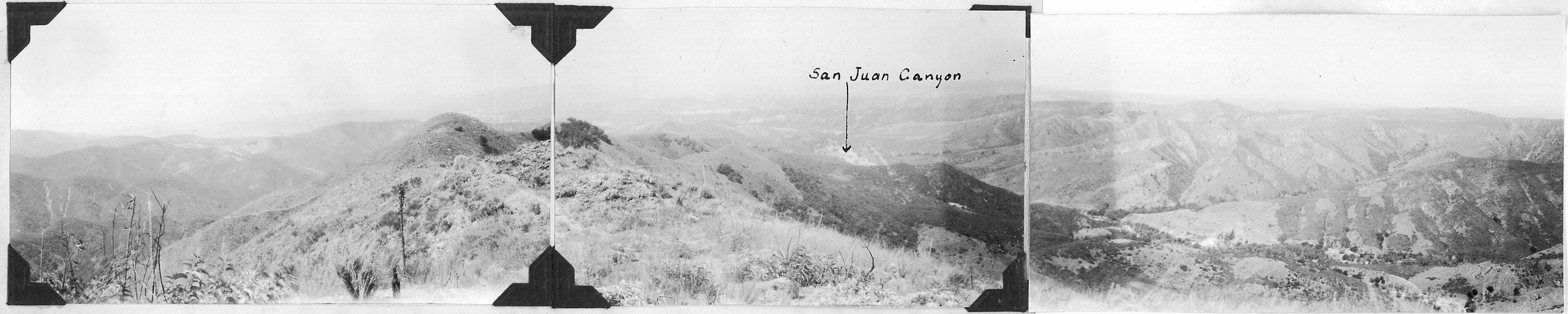
Looking West from Ranger Station.


B.
Looking North fr om Government Lookout.

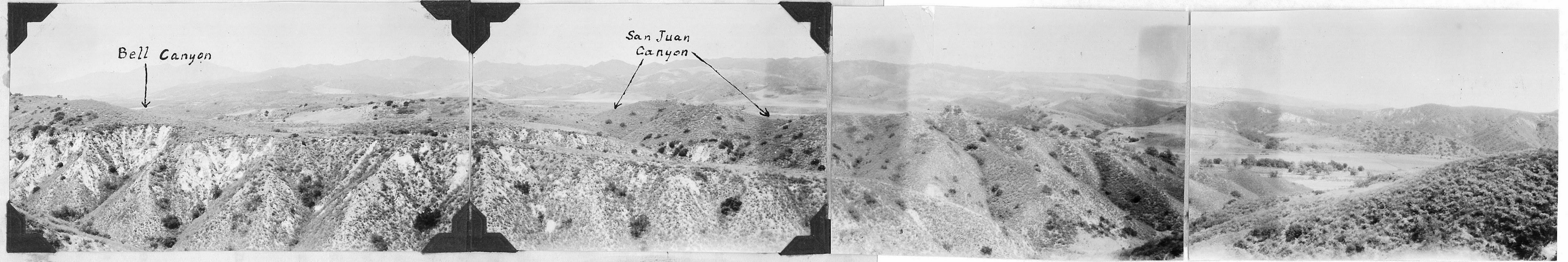
A,B,C, Show Erosion Surfaces.

roads which suddenly debouch onto a flat or slightly undulating terrain. The contact with the valley sides is usually quite distinct and clearly represents a topographic unconformity. These mountain meadows are not present in the area mapped, being confined to the region of crystalline rocks; but they are very abundant in the Elsinore Quadrangle. One, the Potrero Verdugo, which contains the Carrillo Rancho is just east of this area in the vicinity of Verdugo Canyon. In the area of sedimentary rocks are found many smaller 'flats' which have been placed in the later cycle. They may belong to this peneplain, but their lower elevation seems to place them later in the time scale.

Mature or B Cycle: The next succeeding cycle of erosion is presented by the broad open valleys of the major drainages of the region. Plates III, IV, V and VI, show these features. The general region east of San Juan Canyon partakes of a mature topography as shown in Plate VI B. The valleys are open and broad, and slopes are smooth and gentle. As mentioned, this mature topography is shown by the major drainages of the region which have a trend normal to the axis of the range, evidently a drainage partly consequent and partly antecedent upon the uplifted peneplain. This cycle appears to have reached that stage of mature dissection in which the peneplain is just evident upon the interfluves. The slopes of the valleys merge with the ridges, and no topographic unconformities are visible. The question may be raised as to whether this mature topography may not be old age topography and therefore of the same cycle as the peneplain. The extreme flatness of the peneplain where viewed seems to exclude the amount of relief that the mature cycle possesses. This possibility cannot be definitely excluded, and




Panorama South from Lookout




Panorama from South End Bell Canyon

it is very probable that the drainage of this later cycle corresponds to that of the former cycle.

In San Juan Canyon it was noticed that some of the long ridges extending from the divides to the canyon were covered with about ten feet of a reddish, crumbly arkosic conglomerate which grades into the fresh Cretaceous conglomerate below. This, coupled with the fact that the ridges are long, straight, and smooth topped, shows them to be residual spurs from the mature cycle.

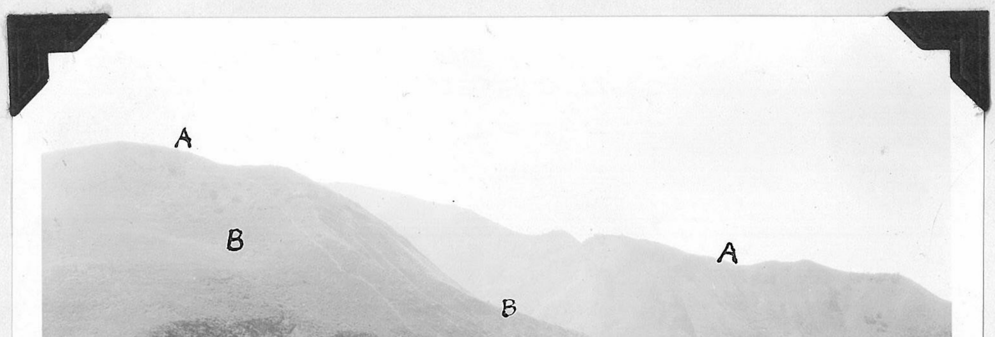
River gravels are found extensively on top of the divides on each side of Bell Canyon, and mark a former plain similar to the Plano Trabuco.

Young or C Cycle: Thruout the entire region there is evidence of a rejuvenation of the previous cycle which now presents the characteristics of a youthful topography. This cycle is most evident in the region of and west of San Juan Canyon. The walls of the canyons tributary to San Juan Canyon are extremely steep; to such an extent that landslides are very common. The interfluves, belonging to the mature cycle, have been steadily reduced so that highly serrated, knifelike ridges result. It is not uncommon, in the region immediately south of the Hot Springs and in the vicinity of Hill 1645, to find ridges so sharp that one cannot walk upon them. See Plate VI A.

This youthful topography, being induced upon one of mature dissection, quite naturally has an antecedent drainage, the major drainages with their tributaries being rejuvenated, their valleys more deeply incised. In addition to this, insequent drainages are cutting back by headward erosion and rapidly sapping the interfluves. Most of the landslides are a result of

A.
Looking up San Juan Canyon.

Hill 2042 in Background.



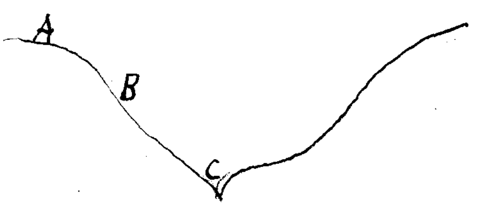

B.
Hill 2042 from the West.

A,B,C, Show Erosion Surfaces.

this insequent erosion. Plate VII shows terraces dissected by headward drainages.

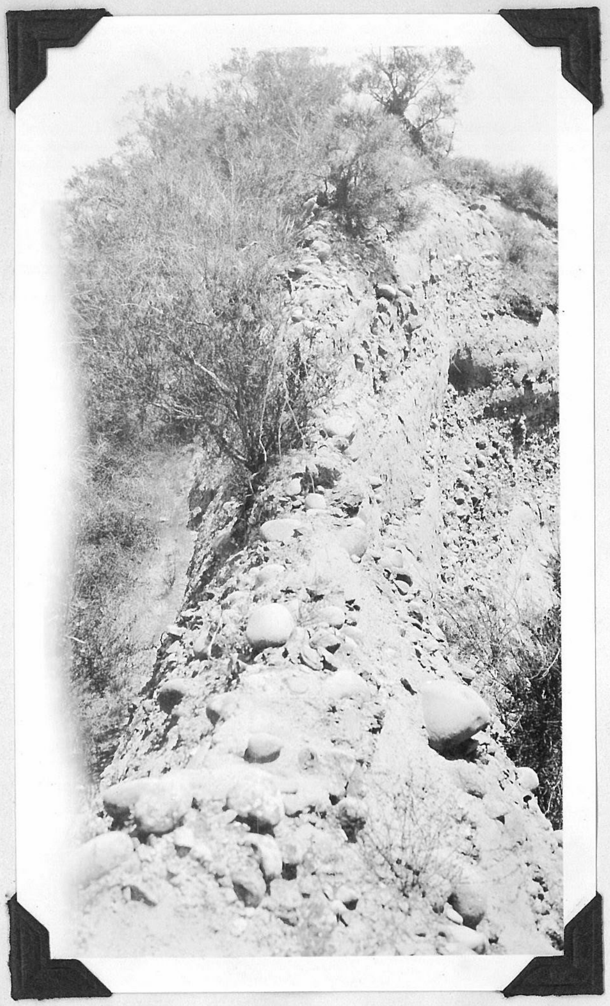
The region east of San Juan Canyon has not as yet suffered much under the advance of this new cycle. The valley walls and ridges partake of the same gentleness, except for some landslides; but the valley floors are marked by box-like gullies, varying in depth from a few feet to about fifteen feet, the depth depending upon a multitude of obvious factors.

The most marked effects of this new cycle are found in the northern portion of the area but confined to the area of sedimentary rocks, and as one progresses southward the youthful stage diminishes, but is made evident by the above mentioned gullies and landslides. The extreme northern part, composed of igneous rocks, shows the effects of the rejuvenation, but to not so marked a degree because of the less rapid rate of erosion. The evidence consists in the oversteepening of the valley walls toward their bases. A typical profile across any of the larger canyons such as San Juan or Hot Springs Canyon is about like this:




Compare with Plates III B and V A.

<u>Physiographic</u> <u>Development:</u> The earliest known condition is that of a peneplain, presumably in Pliocene time. The uplift of the Santa Ana and associated mountains caused dissection to a mature stage. An acceleration or renewal of uplift caused a youthful dissection in comparatively recent geologic time. The region is



A.
Chico Conglomerate West of San Juan Canyon
Showing Serrate Ridge.

B.
Open, Mature Topography of Gabino Canyon.

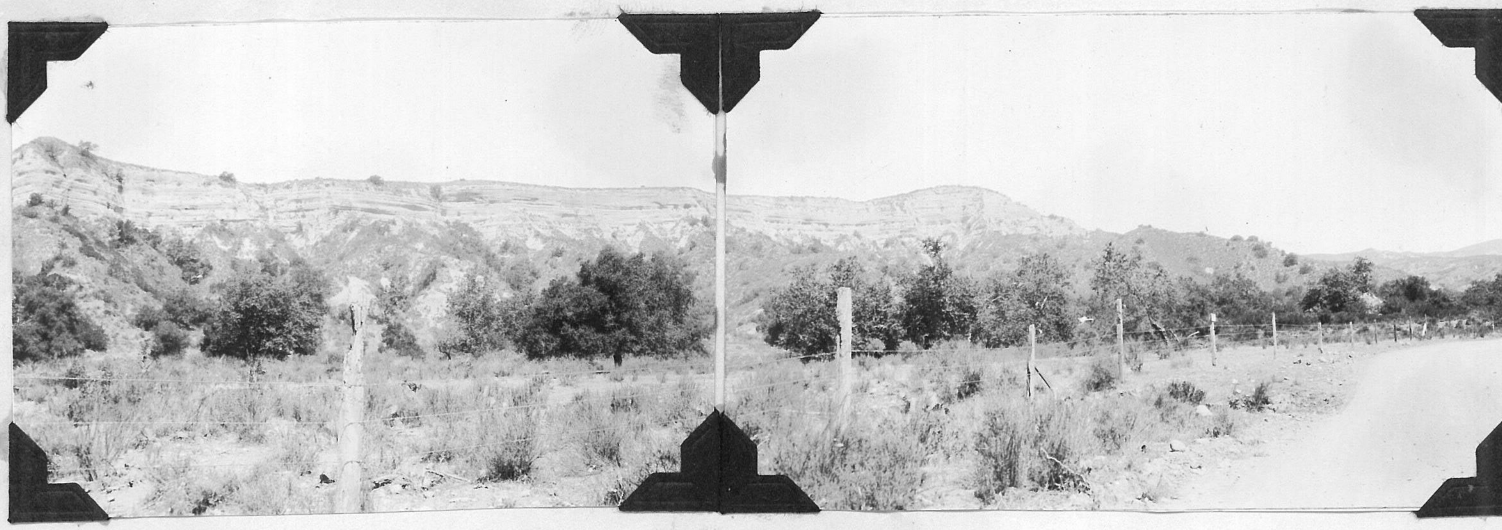
still adjusting itself to its new elevation, as many of the landslides are clearly very recent; their excavations have cirque-like walls, while others are still incipient or in the first stages of land slip.

Drainage Development: The drainage was initially consequent upon the uplifted peneplain, flowing into the ocean in a direction normal to the axis of the uplift. This condition is represented by San Juan Creek, the Arroyo Trabuco, and the Arroyo San Mateo. During the second or mature cycle, the drainage adjusted itself to structure. Examples of this subsequent drainage are Canada Chiquita, Canada Gubernadora, and Bell Canyon. These canyons, together with many smaller ones, are characterized by dip slopes on one side and cuestas on the other. Their trend is north and south altho the prevailing strike is more to the northwest, but if the difference in elevation between the heads and mouths of these canyons be considered, they will be found to be quite well adjusted to structure. Cristianitos canyon is probably subsequent as a large part of its course coincides with the major fault of the region. The Arroyo San Onofre is partly subsequent, its course being determined to a great extent by the position of the San Onofre Mountains.

As a result of this subsequent drainage development, several stream captures are imminent. Bell Canyon is rapidly heading back into Trabuco Creek, and the divide between Cristianitos and San Juan Canyons is very low. It will not be long, geologically speaking, before San Juan Creek flows into the ocean along Cristianitos Canyon.

Terraces were formed as a part of the mature cycle, the specific cause or causes not being known. Possible causes are:

PLATE VII



Chico - San Juan Canyon

Showing Dissected Terraces.


MAP SHOWING LOCATION OF TERRACES

Black- Fluviatile Terraces
Stippled- Marine-fluviatile Terraces

climatic changes, variations in rate of uplift, oscillations of the land, etc. They are now being dissected by recent erosion. The manner in which stream erosion has effected these terraces, by removing some and leaving others is quite interesting. A theoretical consideration may be taken up before turning to the concrete example in this case.

If we restore the topography of the mature stage to its appearance before the youthful cycle, we should find valleys bordered by terraces on both sides. (Exceptions will be considered later). If the region should receive a differential uplift whereby the northern portion were raised more than the southern, the streams would immediately begin downcutting to the new base level. It is evident that the streams will tend to shift away from the region of greatest uplift, in this case to the south. A stream flowing directly south would simply be accelerated and would entrench itself, leaving the terraces remaining on both sides. (An exception to this would be a meandering stream which at the moment found itself at one wall of the valley.) A stream flowing in any other direction, however, would shift to the south, cutting into the south terrace and leaving the north one intact. By studying Plate VIII it will be seen that the positions of the terraces verify these conclusions. In this case, the uplift has been greatest slightly east of north. The streams tend therefore, to shift to the south and slightly to the west. Terraces should then be found on the north and east sides of valleys and be absent or dissected on the south and west banks.

The objection may be raised that these terraces represent the terraces in their original condition, and that none have been destroyed. Evidence favoring this objection is found just northeast of the union of Cristianitos and San Mateo canyons where the terraces are clearly slip-off terraces. But this merely means that the two processes, namely the formation and the removal of the terraces were coincident, with the end result the same: a terrace on the north bank and none on the south. In either case we are able to infer uplift and the region of greatest uplift. The field evidence seems to show that terraces were formed on both sides of most valleys prior to the last uplift, as there are remnants of terraces on the south side of those streams which do not have terraces now.

Recent Uplift: It might be well to summarize the evidences for recent uplift in this region:

1. Youthful dissection.
2. Landslides.
3. Positions of Terraces.

In addition to the above which have been already discussed may be added the following:

4. Coast Line. The coast line is clearly one of emergence, the shore line being straight or with sweeping curves with no indentations. The coastal plain has but recently been dissected by a few box like canyons.

5. A fault with the north-east side the uplifted block. To be later described.

# GEOLOGY

## STRATIGRAPHY

The formations encountered in this area, with their thicknesses and typical facies are listed in the following table which has been modified from that of Woodford.*

Stratigraphic Table

| Age | Formation | Symbol | Thick | Lithology |
|---|---|---|---|---|
| Pleist | Terrace Mat | Tm | 150' | Marine: ss. River: red congl. |
| Unconf. | | | | |
| Plio. | San Mateo | Tsm | 400' | Coarse white ss & congl. |
| Uncon. | | | | |
| Up. Mio | Capistrano Shale | Tcp | Few hundred | Brown shale and ss. |
| ? | | | | |
| Mid. Mio | Monterey Sh. | Tmsh | 300'? | Diat. sh, chert, ss. |
| Low Mio | Temblor-San Onofre | Tso | 1300' | Schist breccia, congl., ss. |
| Unconf. | | | | |
| Eocene | Tejon | Tj | 3600' | Ss, minor shale Base of clay. |
| Unconf. | | | | |
| Cret | Chico | Kc | 4700' | Congl., ss, and sh. |
| Uncon. | | | | |
| Pre-Cret | Basement | B.C. | | Diorite, minor andesite. Basalt. |

All of the formations found in the Santa Ana Mountains outcrop in this area except for the Vaqueros, Martinez and Topanga. The last two formations occur in the northernmost portion of the range, while the Vaqueros pinches out just beyond the west boundary of the area mapped.

The thicknesses given are approximate in each case, but as they compare favorably with those calculated by Woodford, they are probably not far from wrong. The hasty nature of the field

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* Woodford, A. O., op. cit. p 169.

work, together with the fact that the attitude of the strata was difficult to accurately determine, accounts for the approximations.

The formations encountered in this particular region have been made the subject of an exhaustive study by Woodford, especially the San Onofre facies of the Temblor. For this reason, the writer did not attempt any detailed work in sedimentation, and in the field used freely the data published by Woodford. The descriptions given below are generalized from a study of hand specimens. The geologic age of the formations was accepted as that given on the Correlation Charts of the United States Geological Survey.

## Basement Complex

The crystalline rocks which outcrop in the north-eastern portion of the area are denoted as the Basement Complex and consist in the main of a diorite. The Triassic slates which are so extensive in the region about Santiago Canyon were not observed outcropping in this area, but abundant float testified to their presence in this drainage area.

A small outlier of andesite outcrops in Lucas Canyon about 100 yards east of the sedimentary contact. The fresh andesite is very fine grained and gray in color; at the contact with the diorite it becomes altered while the diorite has been rendered gneissic. This contact zone is about six feet in width. This andesite does not outcrop on top of the canyon and was not observed elsewhere in the area. The diorite which forms most of the basement complex is hard and fresh in some outcrops and altered and weathered in others. The fresh outcrops have a gray color while the altered ones are a muddy brown. This altered facies of the rock closely resembles an arkose. These outcrops are traversed by many narrow dikes from one-eighth to one-half inch in width consisting of orthoclase and quartz. These pegmatite dikes cut the diorite in every possible direction, but each one is straight. In the diorite, the feldspar is the most altered, the femic minerals being much less so. The decomposition and disintegration of the rock is probably due to these small dikes, as the fresh outcrops are not cut by the dikes.

In San Juan Canyon, on the west bank at the point where the canyon narrows, four tenths miles below the Hot Springs, is an interesting outcrop. The diorite has been altered to serpentine but the feldspar is fresh or nearly so, the alteration to kaolin not being extensive. The normal procedure would be the reverse, the decomposition of the feldspar being greater than the conversion of the ferro-magnesian minerals into serpentine. In addition to this anomaly, there are two lines of evidence which indicate that this alteration is not due to surface weathering but to underground waters: 1. Considerable banding can be observed in the altered rock, the result of a local fissuring as no fault is present. 2. Sulphur springs outcrop shortly to the north and others have been reported nearby, altho not found by the writer.* This alteration then, is probably due to underground mineral waters which reached the surface along fissures in the rock.

In addition to the rocks mentioned abo e, there are some

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* Waring - Springs of California. U. S. G. S. - W. S. P. 338
1915. pp 48-49.

basalt lava flows which outcrop on the east bank of San Juan Canyon just north of the sedimentary contact; in fact at this point the Chico appears to rest upon the flows which have a south dip. The areal extent of these flows is unknown beyond San Juan Canyon. At least three flows are present. The age of these flows is evidently post-Basement Complex (Jurassic?) and pre-Chico.

## Chico

The Cretaceous rocks outcrop along the flank of the crystalline ridge in a strip varying in width from three to four miles. The outcrop is narrowest at its northern end. The strip trends roughly parallel with the strike which is somewhat west of north. In the vicinity of San Juan Canyon and the region to the immediate west, the outcrops of Chico are extremely good, cliff exposures being the rule, although they are somewhat inaccessible as previously explained. Plates IV B, VI A, and VII show typical exposures.

In the region east of San Juan Canyon, the topography is smooth and rolling; consequently there are few good outcrops. Most of the exposures found in this region were in gullies and landslips. As a result, detailed structure of the Chico, or of any succeeding rocks, could not be worked out.

The Chico consists of conglomerate, sandstone and shale. The conglomerate and sandstone occur as parallel bands trending along the strike. This basal conglomerate was not encountered south of Talega Canyon. The strike would carry it beyond the area at about this point. Most of the Chico outcrops are sandstone. The shale occurs only at one locality in Cristianitos Canyon, where its thickness probably does not exceed 200 feet.

This section is quite different from that found farther to the north, and the explanation advanced by Woodford is that the Cretaceous in this region is an eroded anticline, the shale having been almost completely removed.

The lowermost conglomerate beds resemble the Trabuco formation found shortly to the north. The conglomerate is of a reddish color, arkosic, poorly sorted and very slightly indurated. Under the microscope, the grains of the matrix appear to have no cement, the grains being simply compressed together. Locally, there is a thin film of iron oxide between the grains. The boulders range from two and a half feet to a fraction of an inch in diameter, four inches being the average. The thickness of this basal conglomerate is about 150 feet.

The typical conglomerate is of a gray brown color, better sorted and compacted. Its matrix is very similar to the typical sandstone. The mineral grains are subangular and quite fresh. They are derived from the basement complex and contain all of the types of igneous rocks found in that formation. The boulders are smaller in size than those of the lowermost conglomerate, the average being two or three inches in diameter; the boulders are more rounded than in the lower conglomerate. The conglomerate weathers to a reddish tinge characteristic of arkosic deposits.

The sandstone is medium grained and gray in color. The mineral grains are subangular and fresh. Most facies are well cemented with an oxide cement. Calcite is a common cement in some places, notably along San Juan Canyon, where it makes the sandstone very hard and resistant.

The Chico strata are characterized by the presence of flakes of biotite. This biotite is so diagnostic that it was used to differentiate the Chico from the Tejon which is free from mica. In the Chico rocks, the flakes may be very abundant, as in some of the sandy shales near Bell Canyon, or they may be rare, but always present. In Cristianitos Canyon, the upper facies of the Chico is very clayey and closely resembles the Tejon shale of that area, but the presence of mica served to differentiate the two. This content of biotite has given to the Cretaceous sandstone a light brown color which is likewise distinct from that of the Tejon.

The bedding is massive; the strata vary from two to ten feet in thickness with an average of four feet. The bedding is not very distinct and is not a cleavable bedding; erosion does not tend to expose bedding planes. In the conglomerate the bedding is only locally evident, the conglomerate standing out in reefs which are not, however, bounded by visible bedding planes.

In the sandstone, where the bedding is visible, the beds are uniform in thickness and extent, except in the vicinity of Bell Canyon, where on the west flank of San Juan Canyon, cross-bedding is evident. The sandstone is softer, less coherent, and finer in texture than elsewhere.

The sandstone often contains lenses of conglomerate, and in Cristianitos Canyon, there are conglomerate strata lying between shales. The variations which have just been mentioned would indicate that the Chico was deposited under conditions which fluctuated locally, probably near a shore line.

The shale facies of the Chico is the typical crumbly black shale found in this formation to the north and elsewhere. While the only large outcrop of shale was in Cristianitos Canyon, there are interbedded shale beds throughout the area, the thickness varying from a few inches to twenty-five feet (Lucas Canyon).

Fossils: An indeterminate ammonite was found in the conglomerate exposed on the west bank of San Juan Canyon about two miles below San Juan Hot Springs. (First stream crossing below Hot Springs). This ammonite was an almost perfect speciman and apparently a new species for the region.* The writer expects to devote more study to this speciman in the near future.

This fossil is important as it proves that at least the upper part of the conglomerate is marine in origin. The basal conglomerate beds, described above, are probably terrestrial in origin, and the lack of a break between the two members suggests that the lowermost Chico was deposited above the sea, and due to submergence passed into true marine deposits.

## Tejon

The Tejon formation outcrops in a tapering strip to the west of the Chico, having its maximum width of three miles at the south edge and tapering to a point at the north end of Bell Canyon. Like the Chico, it forms extensive cliff-like exposures (Plate XII B), altho in general, its topographic expression is more subdued than that of the Cretaceous rocks. An exception is found near the Tejon-Chico contact in San Mateo Canyon, where there are several mesas which owe their form to the superior hardness of the nearly flat lying Tejon beds.

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* Verbal communication to the writer by E. L. Packard.

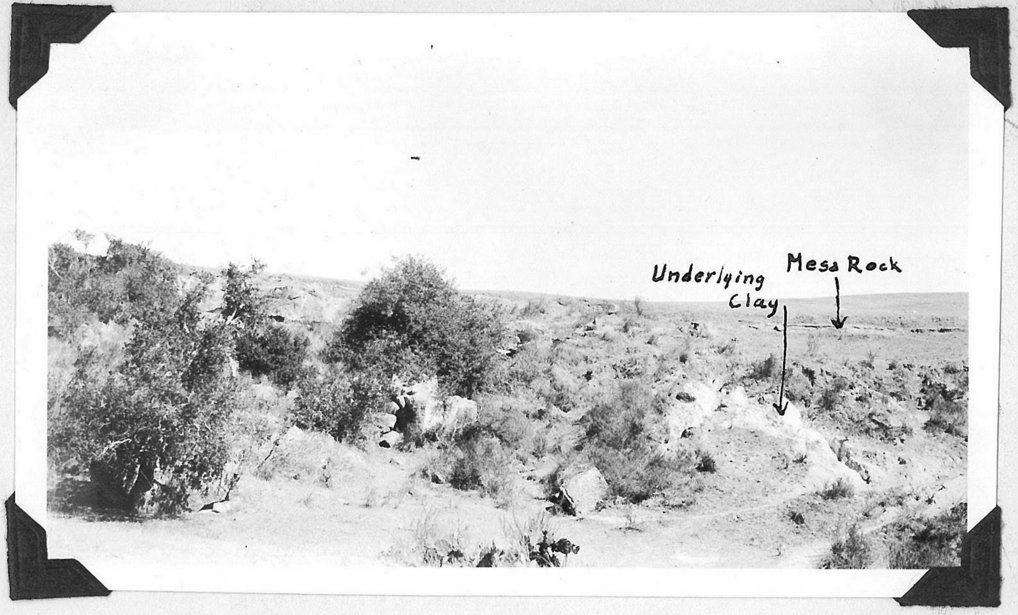
The Tejon strata are very similar in lithology to the Chico sandstone, except that they contain more quartz, some facies consisting exclusively of quartz; and in the absence of biotite which has been commented on. There is no conglomerate member of the Tejon, altho conglomerate occurs locally. Sandstone and shale are predominating facies, the sandstone being more common, with the shale largely confined to the vicinities of San Mateo and San Onofre Canyons.

The sandstone is rather thick bedded, like the Chico, and weathering does not tend to expose bedding planes. Its color is gray to white, but it appears quite white in contrast to the Chico; this difference in color being due to the absence of mica.

Overlying the sandstone is a green shale. The shale, where fresh, is a dense clayey shale having a conchoidal fracture. It weathers however, to a crumbly mass very much resembling a tuff in small rounded hillocks or in a 'bad land' topography. This shale closely resembles the basal member of the San Onofre formation, making it difficult to trace the contact and impossible to place it accurately.

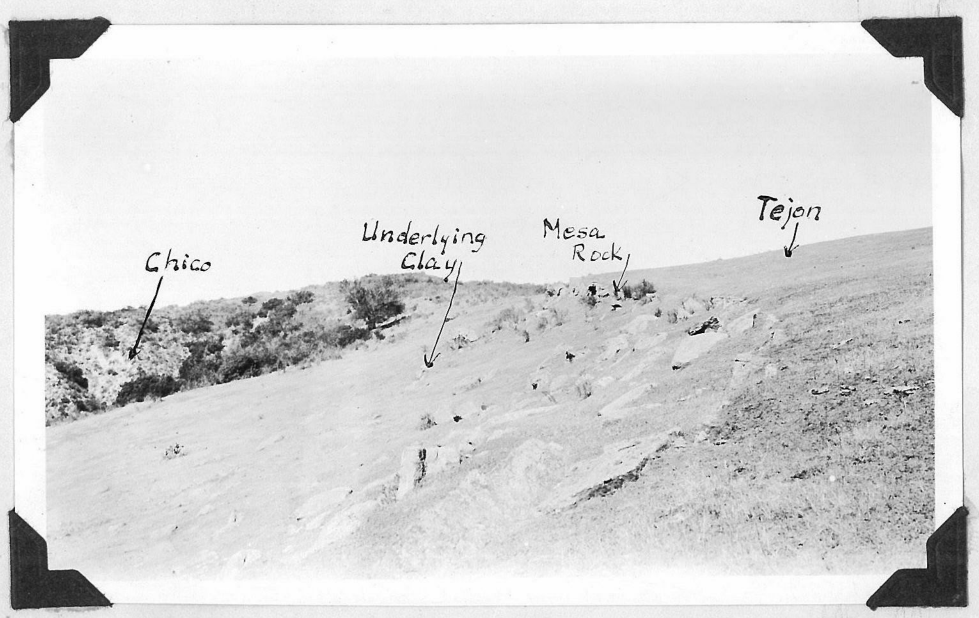
The base of the Tejon consists of about a hundred and fifty feet of clay or clayey sandstone. The true clay outcrops in Cristianitos Canyon. North of there, in Bell Canyon, the clay is not abundant, a reddish sandstone taking its place. This sandstone is composed of extremely fine fragments, largely arkose together with many small, greasy appearing flakes of clay. The color, predominately red with some yellow, is due to iron oxide.

South of Cristianitos Canyon, in the vicinity of San Mateo Canyon, the base of the Tejon is marked by a white clayey




Tejon- Mesa Rock Facies

San Mateo Canyon.



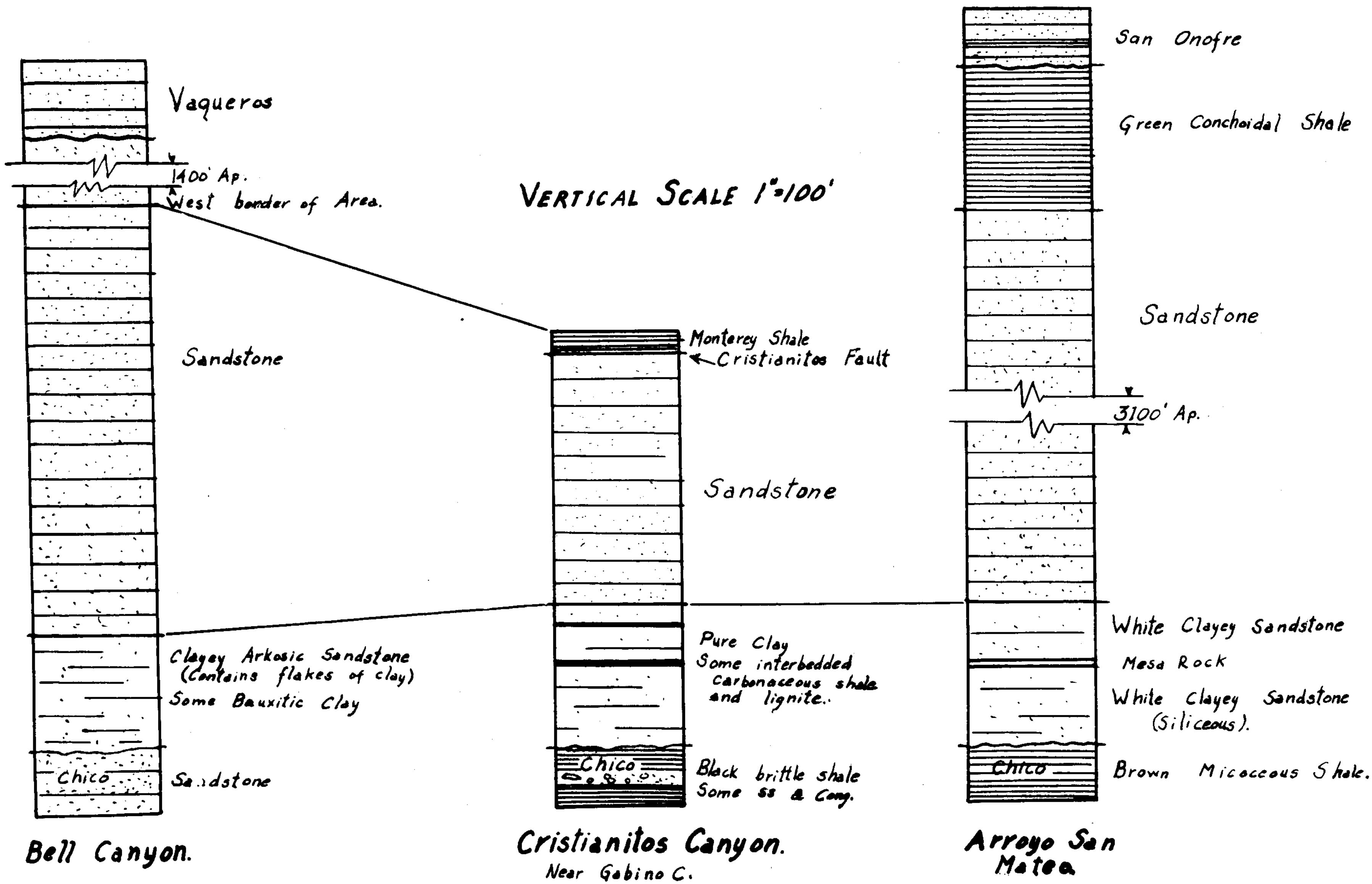
sandstone. The grains are quartz with a matrix of clay which does not appear in the form of flakes and cannot be resolved under the microscope. This facies varies from highly siliceous sandstone to pure clay.

In San Mateo Canyon, about three and a half miles northeast from its union with Cristianitos Canyon, are the mesas mentioned above. These mesas consist of a hard siliceous sandstone. The grains are of quartz arranged in intersertal fashion with a siliceous cement. These mesas are perhaps fifteen feet thick ith no visible bedding. The color on fresh break is gray, weathering to brown or reddish brown. The general appearance of these mesas is that of rhyolite flows. The sandstone weathers by large blocks breaking off. Plate IX shows the lower slopes strewn with the large blocks. Sometimes a covernous aspect to the weathering is encountered.

This mesa rock is interbedded in the clay member, the clay above it, however, is now largely stripped off. The white clayey sandstone below weathers into typical 'bad-land' topography. It is the weathering away of this lower clay which causes the mesa rock to break off in large blocks.

The superior resistance of the mesa rock has caused it to form an outlier of Tejon surrounded by Chico. This will be observed on the geologic map near the Tejon-Chico contact in San Mateo Canyon. This mesa forms the cap of a hill which consists of a base of brown micaceous Chico shale surmounted by the white clayey sandstone of the Tejon and finally the mesa rock. Due to the similarity between the Chico and Tejon shales, the contact could not be accurately ascertained, but the abund-

PLATE X




COLUMNAR SECTIONS TEJON

ance of biotite places the base in the Cretaceous.

The clay in Cristianitos Canyon is a sedimentary clay of economic value and will be more fully described later. Interbedded with the clay are some carbonaceous shales which vary from lignite to a black shale containing fossil charcoal. This fact, together with the sedimentary nature of the clay, indicates deposition under swamp conditions.

In order to clarify somewhat the above discussion, approximate stratigraphic columns for the Tejon are shown in Plate X. It is to be emphasized that this is merely approximate, there being many variations along the strike.

The angular relations of the Tejon to the Chico was sought for in the field, but unfortunately no sections were obtained which showed the relations clearly. In general, the Tejon appears to dip less steeply than the Chico and an angular unconformity of several degrees seems apparent. It is very probable that in the same places the two formations are conformable.

No fossils were found by the writer, but this formation has been considered Tejon for some time past, and the fossils of A. O. Woodford indicate that it is probably Tejon in age. However, there is need for paleontologic research in this formation as much has been assigned to the Tejon that may well be of another age.

San Onofre Facies of the Temblor

The San Onofre facies of the Temblor formation outcrops near San Onofre, the San Onofre ridge being composed almost exclusively of it. For reasons already stated, page 2, little detailed work was done in this formation aside from noting dips and strikes. The San Onofre formation is rather unique because of the great variety of sediments that enter into its makeup; it is because of this diversity that the origin and conditions of deposition of this formation constitute a major problem in Pacific Coast Geology. The outstanding member is the San Onofre Breccia, which makes up the bulk of the San Onofre ridge and the south bank of the Arroyo San Mateo at its junction with Cristianitos Canyon. This breccia consists of angular particles, of exceptionally wide range in sizes (microscopic to several feet across), of a glaucophane schist which Woodford has shown was deposited from a land mass to the west of the present outcrops. This schist is very compactly cemented by a siliceous matrix and presents bold erosional forms shown at the localities just mentioned. The course of the Arroyo San Mateo has been visibly affected by the resistant nature of the schist, as can be seen on the topographic map.

Besides the schist, the writer noted a siliceous conglomerate or more nearly a breccia interbedded with the schist in the San Onofre ridge. This breccia was composed exclusively of quartz with the boulders several inches across.

A common facies is a siliceous sandstone, very fine grained and bedded, and very hard. This is common along the north flank of the San Onofre ridge, where it lies below the schist breccia. Another common member was a clay-like shale which very much resembles the top of the Tejon. This shale is light in color and weathers like the Tejon into a 'bad-land' topography. It is interbedded with the sandstone near the Temblor-Tejon contact north of Arroyo San Onofre.

Along the sea cliff section, Monterey shale was found interbedded with the breccia. Both diatomaceous and cherty facies were encountered.

The angular relations with the Tejon were no where observed. Elsewhere, the Vaqueros lies between these two formations; its absence in the area mapped (it outcrops just to the west) implies a period of erosion and hence unconformity. The angular unconformity must be slight as nowhere were great differences in attitude observed.

Monterey Shale

Shale considered to belong to the Monterey outcrops in the southern portion of the area. A small outcrop is found lying beneath the Capistrano Shale on the west side of the Cristianitos fault. In this region, both the Capistrano and Monterey shales are highly distorted by the fault, and their mutual angular relations could not be determined.

South of San Mateo Canyon, Monterey Shale outcrops on the east side of the fault; the shale is quite extensive in the sea cliff section.

The shale is characteristically Monterey Shale and need not be described here. Both diatomaceous and cherty shale are common. Some fine grained sandstone, similar to that of the San Onofre, is found.

The shale along the sea cliff lies at the top of the San Onofre and at places is interbedded with it. Thus the two formations are, at least in part, contemporaneous.

As is to be expected in a faulted region, the shale is so highly folded that no measurements of thickness and few of attitude could be made.

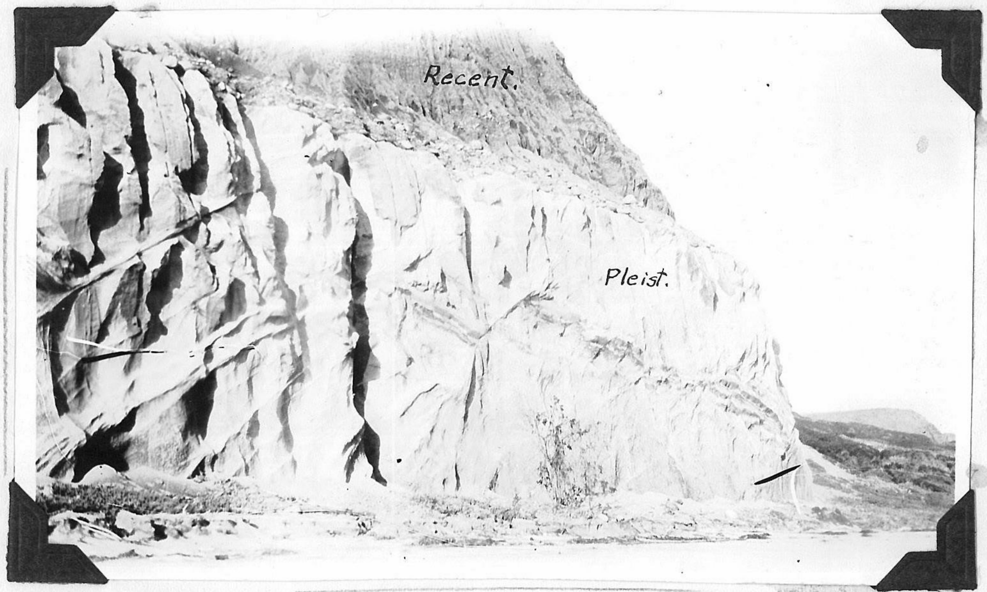
Capistrano Shale

The Capistrano Shale outcrops along the west side of Cristianitos Canyon with an isolated outcrop two miles north of San Onofre.

The Capistrano formation has two facies, a shale and a sandstone. The shale is very sandy consisting of angular grains of quartz and feldspar, the latter predominating, which are visible by the unaided eye. This shale contains biotite as

A.
Capistrano Shale.

Cristianitos Canyon.




B.
Sea Cliff

Two Miles East San Onofre.

a major constituent, the flakes lying with the bedding and imparting a very shiny luster to the shale. In fact, much of the shale has the appearance of a mica schist. This shale is thinly and sharply bedded; see Plate XI A.

The sandstone is very similar to the shale, but more thickly bedded; and on weathering gives a 'bad-land' appearance. Very little sandstone is exposed in this area, although it becomes abundant to the immediate west.

The Capistrano Shale is very flat compared to the older formations, and was probably deposited in a synclinal trough formed by the gentle folding of the Chico and Tejon.

The Capistrano Shale once extended eastward of the Cristianitos fault. The shale does not show any change in texture as the fault is approached, and hence could not have been deposited against a fault scarp.

## San Mateo

The San Mateo formation forms the southern part of the ridge to the immediate north of the Arroyo San Onofre. Towards the ocean, the San Mateo is flanked by terrace sands. On the north, it lies unconformably on the Capistrano and Monterey Shales, the evidence for unconformity being the difference in dip and strike and the fact that the San Mateo truncates more than one formation. To the east, this formation is bounded by the Cristianitos fault.

The San Mateo formation is a medium grained highly silicic sandstone. The grains consist of subangular quartz grains with small amounts of feldspars. Under the microscope small prisms of tourmaline and particles of smoky quartz can be observed. No schist fragments were observed.

Like most of the sandstones in this region, cement was almost totally lacking, the grains being compressed together. The color is of various shades of yellow.

Towards the north the formation becomes conglomeritic which suggests that it might have been deposited against a scarp of the Cristianitos fault, but the lack of San Onofre schist particles negatives this possibility. Both the San Mateo and Capistrano formations extended more to the east in past geologic time.

The San Mateo weathers into a 'bad-lands' topography with cavernous reefs due to its rather incoherent nature.

## Terrace Material

There are two types of terrace material in this region: that along the coast which is dominantly marine; and that found inland and terrestrial in origin.

The best exposures of the first type are to be found in the sea cliff section along the entire southern border of the area. Plate XI B. The cliff varies in height from twenty-five to almost a hundred feet. The cliff is lowest at the points where the streams empty into the ocean.

The marine facies of this cliff section consists of a clean, friable, very fine-grained yellow sandstone. The particles are varied in mineral composition with considerable feldspar and schist particles.

The terrace shows very little bedding; its general appearance being quite massive. However, along the highway banks of the Arroyo San Onofre, there is cross bedding on a large scale with several conglomeritic beds, which are absent elsewhere. This indicates deposition under turbulent conditions and suggests that the streams emptied into the ocean at the same points as at present.

This sandstone weathers either into a 'bad-land' topography or forms small talus slopes at the base of the cliff which consist of loose sand with a fine texture; it resembles corn meal in both texture and appearance.

Overlying this soft sandstone with a few degrees of unconformity is a soft earth deposit of recent alluvium. The base of this alluvium is marked by from two to twenty-five feet of a sandy conglomerate. The boulders are extremely rounded, and the matrix is very similar to the sand lying beneath. This suggests a beach deposit grading into land laid alluvium above. This alluvium has the reddish color so characteristic of semi-arid alluvial deposits. The unconformable relations with the sandstone is shown by Plate XII A where it will be seen that the alluvium covers the Monterey Shale as well as the terrace sand.

Alluvial deposits of terrestrial origin are found inland in the vicinity of Bell Canyon. Just north of this canyon, along the west bank of San Juan Canyon, the Chico is beveled and covered by a red conglomerate. The boulders are poorly sorted and highly fractured and decomposed. The matrix is very earthy and deep red in color; indicators of subaerial deposition. The thickness varies from a few feet to almost a hundred. This terrace material has a four degree dip towards the south-east. Just north of the junction of Bell Canyon with San Juan Canyon, the surface of the conglomerate forms a broad shallow swale sloping towards San Juan Canyon, and this swale undoubtably marks the point where Bell Canyon formerly emptied into San Juan Canyon. The present channel has shifted to the south about a mile, leaving a series of terraces. The significance of this has already been commented upon.

The divide between Canada Gubernadora and Bell Canyon is remarkably flat topped, and at places is covered with this veneer of red conglomerate suggesting that this region at one time was a large flood plain.

This red conglomerate shows every gradation from the old, semi-indurated, flood plain deposit to the recent alluvium being deposited today, and in mapping it was difficult to draw a sharp distinction.

The red terrestrial conglomerate and the marine sandstone are considered Pleistocene, while the alluvium overlying both is referred to the Recent because of its fresh nature.

## STRUCTURE

General Statement: The structure of this region is somewhat in contrast to typical "coast range structure" in that it is comparatively simple. Faults are few and the folds broad and shallow. The structure may be summarized by saying that the sediments on the flank of the crystalline core of the range dip toward the ocean, the dip being at a maximum in the mountains and decreasing toward the ocean - thus forming a broad open syncline, only the east flank of which is exposed in this area. This syncline is broken by a fault parallel to the general structural strike with the west side the downthrown block. Other structures are present which will be discussed in this section. Structure sections are shown on the geologic map, Plate XVII.

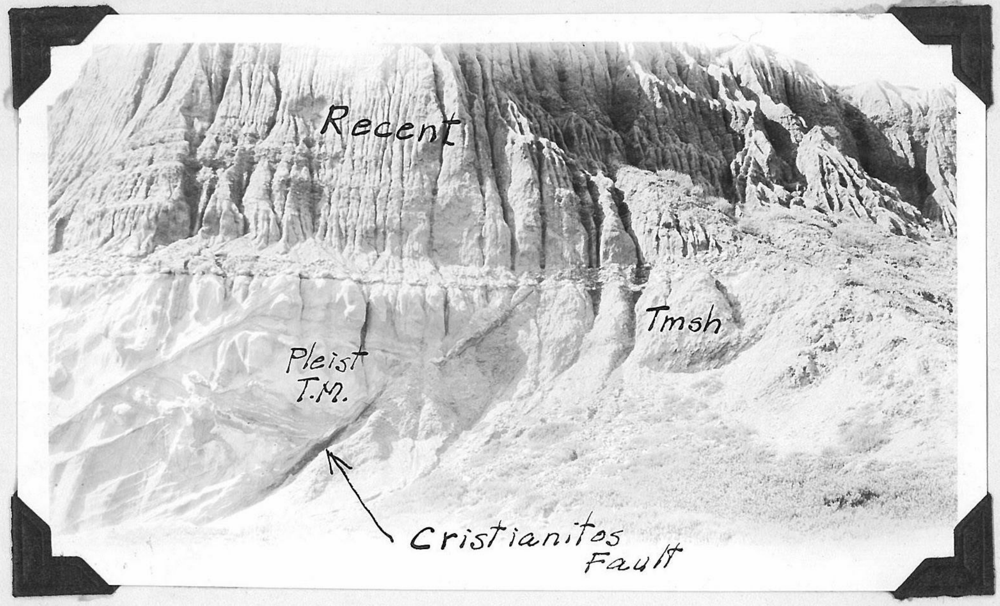
Folds: Little can be added to the statement describing the syncline mentioned above. The dips of the Chico near the igneous contact are approximately 30 degrees south-west, and decrease to 12-18 degrees away from the axis of the range. The strike of this syncline is north-west, as are practically all of the structural elements of the area. By studying the cross sections, it will be evident that this open fold is not due to tangential compression, but rather to the vertical uplift of the range, evidence for which has been previously cited. This uplift caused the sediments to acquire a steeper attitude than the strata underlying the coastal plain to the west.

In Cristianitos Canyon, there is a small anticline superposed upon this syncline. Due to the lack of accurate dips and strikes, it could not be accurately plotted, but appears to have a north and south trend, plunging to the south. Its presence is best revealed by the 'window' of Cretaceous strata outcropping in the bed of the canyon. (See Geologic map). The basal Tejon beds at this locality have a slight dip to the north-east (zero to four degrees) in contrast to the prevailing regional dip.

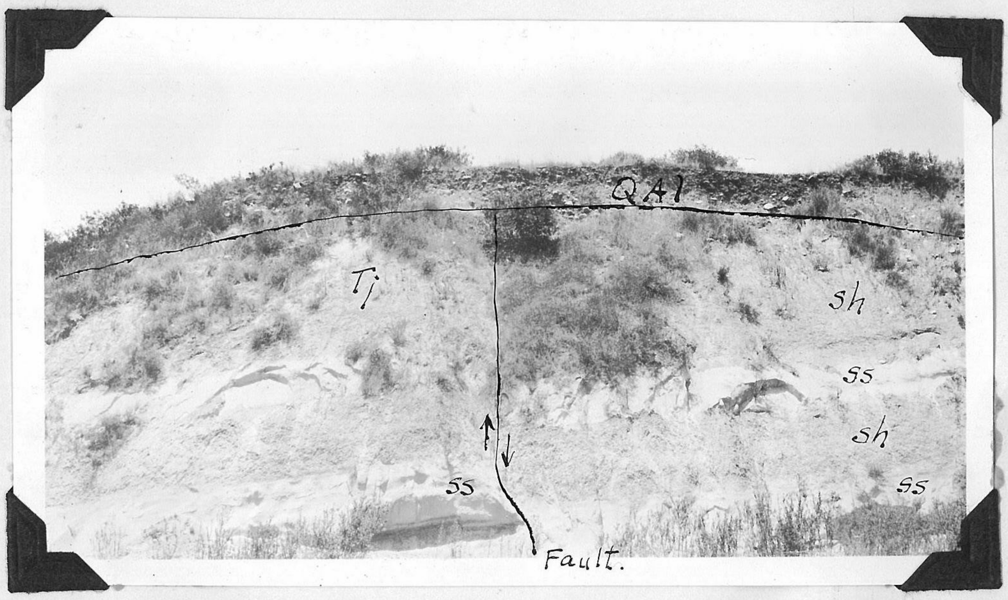
Thruout the region there are anomalous dips indicating minor variations of the main fold, but no other folded structures were observed, unless the San Onofre structure (to be discussed later) is explicable on a basis of folding.

There is no direct topographic expression of the syncline unless the increasing elevations toward the Santa Ana crest be considered in this light.

Faults: Cristianitos Fault: This is the most important fault




A
Sea Cliff Showing Cristianitos Fault.




B.
Faulted Tejon

San Mateo Canyon.

of the general region, extending from near El Toro to the coast near San Onofre, where it runs out to sea. Its total length is eighteen miles, the last eight miles of which it traverses the area mapped.

The east side is the uplifted block, older sediments being brought into juxtaposition with younger. In the vicinity of Cristianitos Canyon, Tejon is in contact with Monterey and Capistrano Shale. The latter formation has been dragged upward in the fault zone, the dip changing from a normal one of four degrees to sixty degrees within a hundred yards.

North of San Onofre, the Monterey Shale and San Onofre formation appear on both sides of the fault, but the same relationship mentioned above still holds, as the San Onofre exposed on the west is the schist facies which is stratigraphically above the San Onofre sandstone appearing on the east side of the fault.

The fault is excellently exposed in the sea cliff two and a half miles south-east of San Onofre. See Plate XII A. The Pleistocene sandstone is faulted against Monterey shale. This is the only point at which an actual fault plane is visible. This plane dips westward fifty-five degrees; therefore, this is a normal fault at this point. The Monterey shale has been sharply downfolded at the fault plane; a few feet away it changes to an eastward dip. Where ever exposed along the cliff section, the shale is highly folded and at some places has been brecciated and then recemented; this is especially characteristic of the cherty facies.

The fault plane shows horizontal slickensides showing that the latest movement was a horizontal one. The coast line shows no offset at this point, but as the formations are both soft, wave action would remove any irregularities as soon as formed.

It will be noted from the photograph that the recent alluvium, with the beach deposit already discussed, bevels both sides of the fault. If we consider this soft sandstone to be Pleistocene, the age of the fault is clearly indicated as post-Pleistocene and pre-Recent time. The faulting occured before the most recent regional uplift for the following reasons:

1) The base of the alluvium has already been shown to be a beach deposit. This conglomerate is now twenty-five feet above sea level. Since the deposition of this member was subsequent to the faulting, there has been an uplift of approximately twenty-five feet since then.

2) Near the fault there are many small faults in the terrace sandstone. See Plate XI B. There are two sets of such faults, one approximately parallel to the fault and one normal to it, forming diamond shaped markings on the cliff wall. These fault lines do not show visible effects of fracture being now filled with sand; in some the sand appears to have flowed. They have every indication of being formed while the sand was still in a semi-plastic condition, presumably before its emergence from the sea. These faults decrease in frequency away from the main fault and finally disappear; hence a genetic relationship can be inferred.

The displacement of the fault could not be definitely ascertained, although it cannot be large in this vicinity as

Monterey Shale outcrops on both sides of the fault. Since this formation has a thickness of several hundred feet, the throw of the fault must be within the same order of magnitude.

There is very little topographic expression of the fault. In the vicinity of Cristianitos Canyon, the line of the fault is marked by many springs and small swamps. These springs are not in a straight line, but distributed over a zone. North of San Onofre, the fault is marked by a few broad swales, and patches of tule and other swampy plants. The fault follows down a deep canyon on the south side of this ridge, but it is doubtful if this is a fault valley. The most positive indication of the fault, aside from the sea cliff exposure, is the areal relations of the formations. The straight line of the contacts indicate that this is a vertical fault, altho the southern part of it is a normal fault.

San Onofre Fault (?): The San Onofre ridge was considered by the earlier workers to represent a tilted fault block, its north edge being bounded by a fault. Fairbanks* so considered it, and the geological map of Ellis and Lee** shows a fault traversing the north front of the ridge. However, Morse and Tangier Smith*** have concluded that the structure is due not to folding, but to flexure without faulting; that is, that the steeper attitude of the San Onofre strata is due to a down warp. In view

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* Fairbanks, H. W., Geology of San Diego County; also Portions of Orange and San Bernardino Cos., 11th Ann. Rpt. State Min. 1893.

** Ellis, A. J., and Lee, C. H., Geology and Ground Waters of the Western Part of San Diego County, Calif. U. S. G. S. Water Supply Paper 446, 1919.

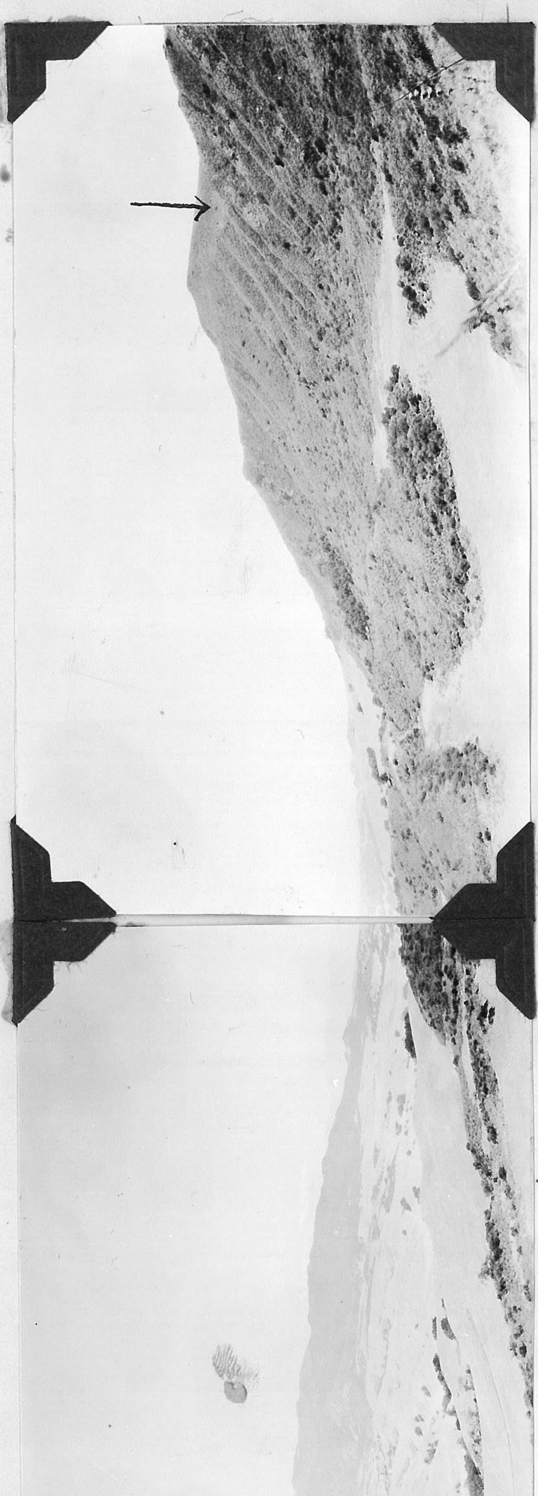
*** Woodford, A. O., op. cit. p 167

of these conflicting reports, the writer devoted a part of his time to examining the structure of the San Onofre mountain. Unfortunately, time was not available for the detailed investigation which should have been made, but certain lines of evidence were encountered, some favoring one interpretation and some another. A conclusion was arrived at which it is hoped further investigation of the entire San Onofre mountains (only that part within the area mapped was studied), will confirm.

In order to understand the problem, the physiography and the areal geology of this immediate region should be visualized by the reader.

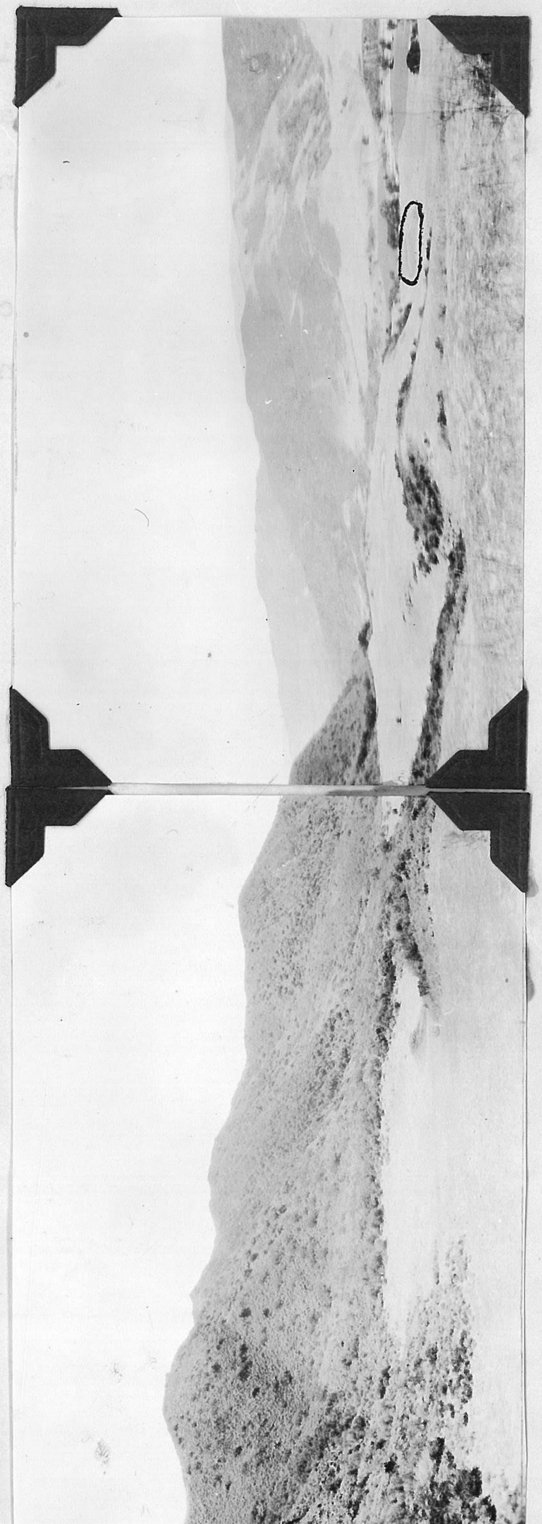
Structure section C-C and Plate XIII show the physiographic and geologic relationships. The north slope of the Arroyo San Onofre is relatively gentle while the south bank slopes rather steeply. About 300 feet above the stream bottom, this south slope flattens out somewhat, then it abruptly rises to the crest of San Onofre mountain. The flattened portion, which may be likened to a piedmont apron, is well shown by the photographs. This plain is characterized by many longitudinal ridges and hillocks, having their longer dimension parallel with the range front. As a consequence of this, the drainage of this piedmont slope is not simple consequent; that is, the streams do not flow directly down the slope in a direction normal to that of San Onofre creek, but many of them flow parallel to the ridge before plunging down the lower steep slope. The basins of these longitudinal valleys are often filled with swampy lakes, which are dry in summer, altho there is one fresh water lake about two and a half miles from San Onofre. This

PLATE XIII



A.

See Other Side for Explanation.



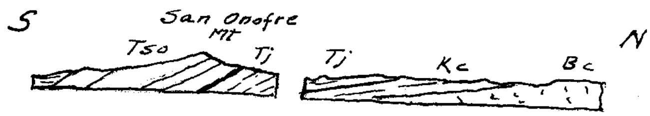
B

last named lake (Plate XIII) is apparently fed by a spring, as it was very clear when visited by the writer in August, with no scum around the edges.

The Tejon and San Onofre contact trends parallel to the range and is located along the lower part of this piedmont slope, altho it could not be accurately traced due to the similarity between the two formations and lack of outcrops. This is unfortunate as the structural problem involved could be definitely solved if the areal geology and stratigraphic sections could be accurately determined.

The designation of these longitudinal ridges is somewhat dependant on our interpretation of the structure of the region. If it is assumed that the ridge owes its position to faulting, these ridges may very well be slice ridges, and were so considered by the writer on his first inspection of the area. On the other hand, they may be landslides. In support of this, some of the smaller hillocks are clearly landslip blocks, the ampitheater which they have excavated being visible, and known landslides are observed lower down the slope in the Tejon rocks. Therefore, these longitudinal ridges can scarcely be considered as evidence bearing on the structure, as landslips could occur with both faulting or folding. If they are landslips on a folded structure, their cause is the same as of those lower down; namely, rapid downcutting of the stream oversteepened the banks and caused instability. It is evident that at present, the entire south bank of the San Onofre Creek is in an unstable condition.

The structure section on Plate XVII shows the structure due to faulting, while the figure below gives the structure on a basis of downfolding. This latter section is taken from Woodford's paper (p 168).




The data in favor of a downfold seems to be:

1. The strike of the range is parallel to the strike of the strata. If a fault, it must be a strike fault, which is of course not impossible but more imprcbable than a diagonal fault.
2. The fault line appears to be rather irregular in plan.
3. There are no talus slopes or piedmont aprons of detrital material, such as are usually found at the base of fault scarps. (Note that the piedmont slope described above is an erosional feature, not depositional.)
4. The schist facies of the San Onofre is more resistant to erosion than the other formations, and one might well expect this formation to show a more rugged appearance.
5. The origin of the ridge is explicable by assuming that the slight monoclinal dip of the Tertiary sediments suddenly increases in dip (up to thirty or more degrees), followed by erosion of a cuesta.

The irregular fault line mentioned in 2, does not eliminate faulting. Gilbert, in his recent paper on Basin Range faulting*, shows conclusively that a straight fault line is as much

* Gilbert, G. K. Studies in Basin Range Structure. U. S. G. S., P. P. 153. 1928.

of an exception as a rule.

The lack of detrital material, 3 above, is explicable because of the perfect drainage of the region. The detrital accumulations are associated with block faults only in arid regions. Any material eroded from the scarp would be quickly carried to the ocean.

Regarding 5 and 6 above, the cliffs along San Juan canyon are broken at intervals by tributaries emptying into the river; the cliff along San Onofre Canyon does not have such canyons, most of the rainfall draining to the south slope. See Plate XIII.

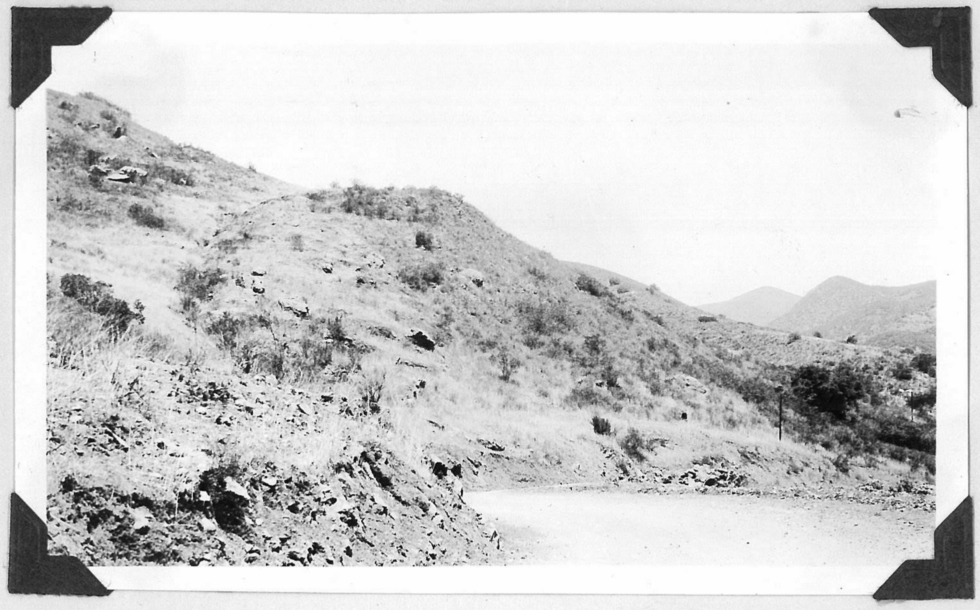
Evidence favoring faulting:

1. The San Onofre ridge has the typical profile of a block mountain, with a steep north scarp, and a gradual south slope.
2. The elevation of the range is higher than the hills to the imme iate north; the natural condition is for the mountains to decrease in height toward the ocean.
3. The strike of the range is a topographic anomaly. Ridges formed by erosion trend normal to the coast rather than parallel.
4. The drainage does not appear to be consistent with that of the remainder of the region, which is well drained. This drainage has an appearance of 'newness'. See Plate II. The north slope does not have much drainage; the south slope is marked by many parallel, deep gorges emptying into the ocean. The Arroyo San Onofre runs more or less parallel to the coast, in contrast to the other streams of the region which empty directly into the ocean. In other words, the stream has been forced to adjust it-

self to structure and flows around the tilted block. If this is an exhumed downfold, we should expect to find the drainage antecedent, flowing directly across the range. Eventually, the streams on the south slope will capture this stream and establish an entirely new drainage.

5. On top of the ridge, there are large flat areas which appear to be remnants of the peneplain described previously. This peneplained surface, which can be seen in Plate XIII A, lies about 300 feet higher than the projection of the peneplain in the northern part. Uplifting by faulting is the only explanation. Even if this flat surface is not be correlated with the peneplain to the north, its position at an elevation of more than a thousand feet above sea level is an anomaly. It is not necessary to postulate a fault with a throw of a thousand feet; regional uplift is responsible for part of the elevation.

In the writer's opinion, the evidence in favor of faulting outweighs that for folding, and the structure is considered a normal block fault, the north slope being a fault line scarp. The age of the fault cannot be definitely ascertained. It is obviously later than the age of the Temblor (San Onofre) which is lower Miocene. The fact that it abuts against the Cristianitos Fault indicates that it must be later than the latter, but the Pleistocene age of the movement on the latter fault is only the age of the last movement, and is probably later than the movement on the San Onofre Fault. The lack of definite fault features on the last named fault places the age as pre-pleistocene. The writer tentatively assigns it to the later Pliocene, but later than the extensive peneplanation.



A.
Landslide

San Juan Canyon ¼ Mile S. Hot Springs.

B.
Incipient Landslips

Gabino Canyon.

The displacement of the fault could not be determined, but cannot be great as there is no great stratigraphic displacement. The height of the scarp varies from 300 to 500 feet. The displacement is probably of this magnitude.

Other faults A few minor faults of a few feet displacement were noticed thruout the region. Plate XII B shows such a one in San Mateo Canyon. Note that the alluvium bevels both sides of the fault.

There is a small fault in the San Onofre schist spur at the intersection of Cristianitos and San Mateo Canyons. The evidence is a fault gap bordered on each side by crushed and distorted rocks. It is probably a subsidiary fault of the Critianitos Fault.

Landslides: Landslides are quite numerous thruout the area. Most of them occur in sedimentary rocks with a few in the igneous. The slide shown in Plate XIV A is an example of the latter type. They are all due to oversteepened slopes. The first indications of a slide is a longitudinal fissure parallel to the valley wall. This widens and eventually the mass below begins to move downward. The slide blocks observed thruout the area, show the characteristic backward tilt. Plate XIV B shows incipient landslides.

## GEOLOGIC HISTORY

The first recorded event is the deposition of the Chico in upper Cretaceous time upon the flanks of the Jurassic (?) Basement Complex. This was followed by emergence and erosion, but with practically no deformation; then submergence and the deposition of the Tejon in upper Eocene time. During the

Oligocene and Vaqueros (lower Miocene), this region was above sea and may have supplied sediments for the Sespee and Vaqueros found to the north. As before, there was little diastrophism during the emergence. Then submergence again took place with the deposition of the San Onofre and the Monterey shale. The sediments for the San Onofre formation came from a land mass to the west while the Monterey shale came from the east. These two processes were in part contemporaneous, altho the deposition of the Monterey shale persisted after the cessation of the San Onofre deposition.

Emergence again occured, this time sufficient to form a broad shallow syncline between the core of the embryonic Santa Ana mountains and the ocean, in which the Capistrano shale was deposited. This was followed by the peneplanation of the mountainous region. This peneplanation probably supplied sediments for the San Mateo formation in Pliocene time. The sequence for the events just mentioned is not substantiated by any evidence, and they may have been concurrent or the peneplanation may have occured before the deposition of the Capistrano shale, if a Miocene age is to be attached to the peneplain.

After the peneplanation there was renewal of uplift associated by faulting. The San Onofre block was uplifted. As a result of this regional uplift, dissection took place to a mature stage in Late Pliocene or Pleistocene time.

During the Pliocene and Pleistocene only the southern part of the area was submerged as the sediments of these periods are confined to the southern strip.

After the deposition of the Pleistocene sandstone, uplift caused the emergence of the coastal plain. Uplift has been more or less continuous up to the present time altho sporadic. Streams are now adjusting themselves to this new elevation of the land. As the beach slopes quite steeply toward the ocean, the region is still emerging from the sea.

Clay Pits - Cristianitos Canyon

# E C O N O M I C - G E O L O G Y

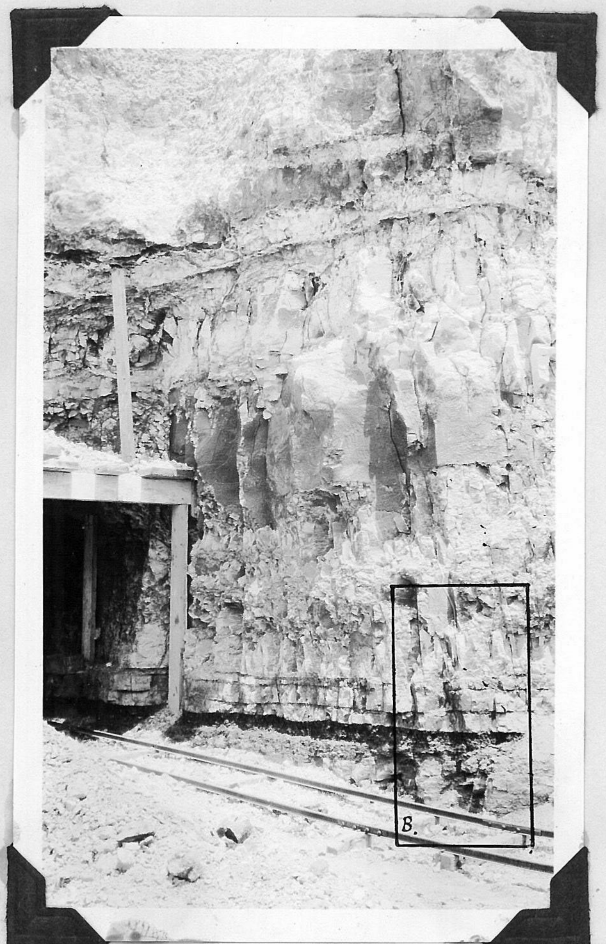
## Clay

Occurrence: The clay pits being developed at the present time are located in Cristianitos Canyon. Most of the pits are on the east slope with a few on the west, all being north of Gabino Canyon. The clay forms natural outcrops on the hill slopes where it is known as the 'Tierra Colorada' due to its prevalent red color. While there are a great number of outcrops, only a relative few, about ten or twelve, have been worked or are being worked.

The clay is a bedded deposit, and as noted elsewhere, forms the base of the Tejon formation. Most of the outcrops have a south westward dip, although the deposits near Gabino Canyon which are undergoing extensive development at present (August 1928), have a slight dip, four to five degrees, to the north-east due to a slight anticline in the Tejon at this point. This anticline is revealed by the window of Cretaceous strata outcropping in the floor of Cristianitos Canyon.

The clay is sharply bedded with thicknesses varying from a few inches to four feet; Plate XVI. The clay is interbedded with carbonaceous shale which approaches lignite at some places. This shale contains much charcoal. Some of the deposits rest upon Chico shale and some upon Chico conglomerate. The clay is not uniform in composition at all places. At some outcrops very little bedding is observed, while in those showing good bedding there seems to be no definite sequence of strata. The total thickness of the clay is approximately one hundred feet with considerable variation among the several clay pits.

PLATE XVI




A. Stratified Clay

B Detail of A

Characteristics of the Clay: There are three types of clay, based on color: white, blue and red. The white clay is softer than either the red or blue and is more porous. The blue clay is blue-gray in color, very dense and breaking with a conchoidal fracture. The red clay appears to be the same as the white, but colored red by iron staining. Most of the red and some of the white is bauxitic, being high in alumina, and displaying a characteristic pisolitic structure. In general, the red clay is not associated with the white or blue, although the blue and white occur together.

Origin: The origin of the clay is not evident at all of the pits, but since they all occur at the same geologic horizon, a common origin is inferred. The outcrop at which the relations are best shown occurs on the east side of Cristianitos Canyon, just north of the union with Gabino Canyon. This deposit is being extensively developed at present, and excellent exposures are obtained. There are several factors which indicate conclusively that the clay is a transported deposit, that is, sedimentary in origin. These are:

1. The even stratification of the clay layers. If the clay were due to the decomposition in situ of a sedimentary series, the leaching out of the soluble constituents would cause slumping; such slumping has not been observed. See Plate XVI.
2. The greatest concentration of clay is not necessarily at the surface as the pit is worked by tunnels. How extensive is the clay is not known at the present stage of development.
3. The presence of coal and shale seams interbedded

with the clay.

4. The clay is sharply differentiated both above and below from the sandstones of the region. If a residual deposit, it would grade downward into the country rock.

5. The clay outcrops only along a definite geologic horizon rather than on an old erosion surface. The great residual deposits of Alabama and Georgia occur at the level of an Eocene peneplain. There are old erosion surfaces exposed in this area, but clay is not associated with them. The fact that the clay occurs on hill slopes in a region of mature dissection at first suggests the residual origin, but the geologic relations offset this.

Development: All but the deposit just referred to have been mined by open pit methods. The deposits are located along the valley walls, there is little overburden, and this method can be employed. At the latter clay pit, the surficial part is mined by open cut, but as mining proceeds, the overburden becomes considerable, and tunneling is resorted to. See Plate XV. The clay is carried by truck to San Juan Capistrano where rail connections are made.

## Gold

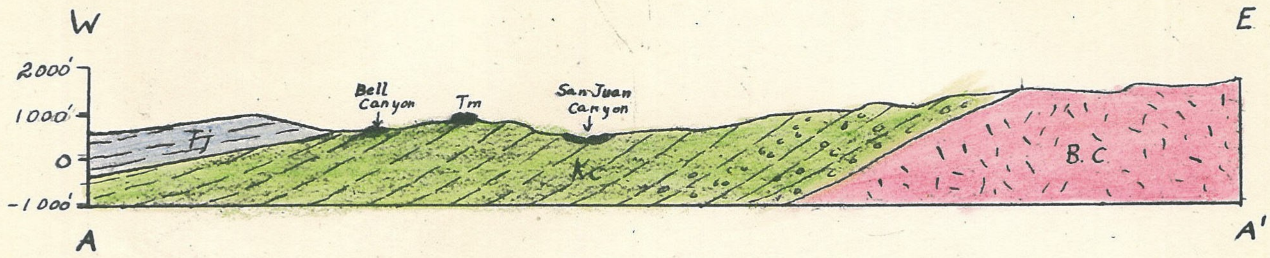
There is a little placer gold in the end of Lucas Canyon, but the paucity of the deposit and the lack of water thru most of the year has prevented any development. Several claims have been staked out in this canyon.

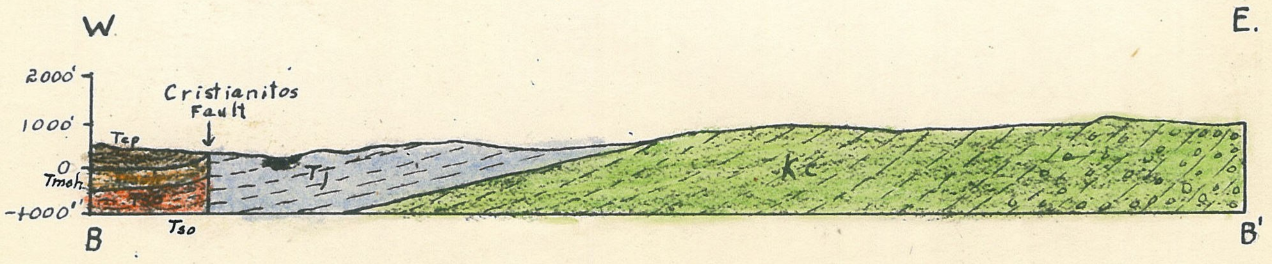
Southwick-ts-1929
MS

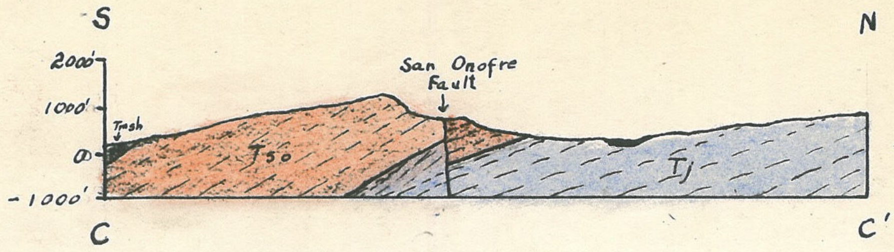
Southwick
1929

PLATE XVII

| | | |
|---|---|---|
| Recent. | Qal | Alluvium. |
| Pleist. | Tm | Terrace Material |
| Pliocene | Tsm | San Mateo |
| Up. Mio. | Tcp | Capistrano |
| Mid. Mio. | Tmsh | Monterey |
| Low. Mio. | Tso | San Onofre |
| Eocene | Tj | Tejon |
| Cret. | Kc | Chico |
| Pre-Cret. | B.C. | Basement Complex. |




# GEOLOGIC MAP
AND
# STRUCTURE SECTIONS
OF A
PORTION OF THE SANTA ANA MTS. CALIF.