GEOLOGY OF THE SAN JUAN CANYON AREA

ORANGE COUNTY

CALIFORNIA

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I N D E X

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ABSTRACT

The area described in this report occupies a narrow strip along the San Juan River in the south-western portion of the Santa Ana Mountains in Southern California. This region includes a sedimentary series of rocks which forms a gentle westward-dipping homocline off the crystalline core of the Santa Ana Mountains. Rocks range in age from Triassic to Recent.

The basement complex comprises a series of Triassic slates, quartzites, and other rock types, with later intrusives of granitic masses.[1] A considerable thickness of Cretaceous rocks conformably overlie the crystalline complex and is composed of heavy coarse conglomerates, fine shales, and micaceous sandstones. A section of Eocene clays and sandstones, 2500 feet thick of probable Martinez age, overlies the Cretaceous section. These rocks have been faulted up against the Lower Miocene San Onofre facies of the Temblor. The upper Miocene Monterey shales and Capistrano sands overlie these rocks.

Local structure in the area includes faulting and some gentle folding. Structural and general topographic trends parallel the NW-SE structural trends of the Santa Ana Mountains.

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[1] Moore, B. N.: unpublished report, Calif. Inst. of Tech., 1930.

INTRODUCTION

Location of Area: The area discussed in this report occupies a narrow strip east of the town of San Juan Capistrano, Orange County, California. The area mapped was a strip four miles wide extending from San Juan Capistrano eastward to the Basement Complex, a distance of approximately ten miles. The strip followed in general the course of San Juan Creek.

Purpose of Investigation: The area considered in this report was investigated as partial fulfillment of the requirements for the degree of Master of Science at the California Institute of Technology. This particular area was selected at the suggestion of Dr. Hampton Smith of the Texas Company, Los Angeles.

Method of Investigation: The recording of field data was done on aereal photographs with a scale of 2500 feet to the inch. The data was then transferred to U.S.G.S. topographic sheets, with a scale of 1:125,000, and then enlarged two times. Field data was gathered by walking contacts and measuring attitudes of beds with a Brunton compass. Structural features, such as faulting and folding, were mapped whenever their magnitude warranted representation. Rock specimens were collected and later identified. No paleontological problem was studied, though numerous fossils were collected for correlation purposes.

Acknowledgements: The writer wishes to thank Dr. Hampton Smith of the Texas Company, Los Angeles, for his suggestion of the area to be studied, and also for his willing discussion before work was begun of the possible problems that might arise. The writer also wishes to express his gratitude to Dr. Francis D. Bode, of the Geology Department at the California Institute for his patient assistance in the field and for suggestions he offered during the course of the work, pertaining to completion of the problem. Acknowledgement is also made to the suggestions of Dr. W. P. Popenoe in connection with paleontological problems. The kindness of the owners of the Rancho Santa Margarita in permitting the writer to use their roads and trespass upon their land should not be overlooked.

PHYSICAL CONDITIONS

Relief and Elevations: Elevations in the area vary from about 400 feet to about 1200 feet above sea level. The western half of the area is comprised of gently rolling hills which are confined to the softer Miocene clays, siltstones and shales. Farther east, the relief gradually becomes greater--being accentuated by cuesta-forming massive Eocene sand stone members and Cretaceous sands and conglomerates. These cuestas often are continuous for several miles and attain heights of two to three hundred feet. At the eastern margin of the area studied, the harder and more resistant basement rocks result in still greater relief. Here, canyons are narrow and steep-walled with depths of six to eight hundred feet.

Topography: Topographic features in the area are intimately related to rock types and bedding planes. The softer and less resistant Miocene sands and shales have been eroded to form broad open valleys and gently rolling hills. Land-slides are common and often cover several acres. In the remainder of the area, including the Middle Miocene San Onofre facies of Temblor, the Eocene, Upper and Cretaceous beds, topographic expression coincides very closely with rock types. The alternate resistant and non-resistant beds, together with their relatively flat attitudes, has resulted in a topography that closely parallels the structural trends. Canyons have been developed where softer beds occur within the formations. The adjacent resistant beds have been developed into striking cuestas which parallel the strike of the beds with remarkable uniformity. The San Onofre facies of the Temblor, has resisted erosion to a relatively high degree and stands out as a resistant ridge which is prominent for several miles. The general trend of these features is NW-SE, and is closely allied with the NW-SE structural trends of the region.

The lower section of the Cretaceous beds have a topographic expression quite unrelated to the trends of features discussed above. Here the topographic forms are of a more common type, being roughly normal to themain range. The reason for this abrupt change in topographic representation is probably twofold. In the first place, the beds have a much steeper attitude than those previously mentioned. In the second place, the lower section of the Cretaceous is composed almost entirely of heavy, coarse conglomerates which possess none of the characteristics of the cuesta forming beds. These two factors, plus a decidedly increased stream gradient, have resulted in a topographic pattern normal to structural trends and topography farther west, but quite in line with ordinary erosional patterns which develop on mountain slopes.

The element of differential erosion and its importance in determining topographic features is ideally displayed at the San Onofre-Martinez contact, and is quite worthy of mention here. A fault contact exists, in which the east side or Eocene side is the upthrown block. The relatively greater resistance of the San Onofre, however, has resulted in its having elevations of as much as 150 feet greater than the Eocene sands.

In summary, then, the topography within the area is directly associated with the physical characteristics of the rocks, and may be used as an aid in the structural interpretation of the area; especially as pertains to the relations of inter-formational members and formations with each other.

<u>Climate</u>: The climate of the area is typical of the semi-arid type of the Southern California Coastal region. The average rainfall amounts to 15 or 20 inches, most of which falls in intermittent storms during the winter months. Summer temperatures are especially mild, rarely exceeding 95° F.

<u>Drainage</u>: Drainage in the area is entirely into San Juan Canyon, which empties into the sea three miles south of San Juan Capistrano. In the western third of the area, the drainage pattern is quite heterogeneous, being strongly influenced by the soft nature of the Miocene sediments. In general, the pattern is insequent and appears to be superimposed upon a rectangular system of deeper NW-SE trending canyons. These canyons follow the structural lines very closely, and are closely allied with it. Capistrano canyon is of this nature, being coincident with a sharp local anticline in the Monterey Shales. It is a subsequent canyon since it has assumed its course through erosion of fractured area along the axis of the fold.

In the central portion of the area, the drainage pattern is distinctly different. It is rectangular in expression. Canyons are very straight and correspond closely with the structural trends. The eastern portion of the area shows still a different type of drainage. For reasons cited under <u>Topography</u>, a dendritic pattern is present which is quite unrelated to structural features. The large bend and southward trend of San Juan Creek marks the boundary between these two types of drainage patterns.

In conclusion, San Juan Canyon is an antecedent canyon which receives the loads of several types of drainage systems, including insequent patterns, subsequent streams, rectangular patterns, and dendritic patterns.

Vegetation: The vegetation in the area is common of the low lying country of the Pacific southwest.

Culture: The area lies within the Rancho Santa Margarita. Most of the land is grazing country with truck gardens and citrus groves on the flat alluvial floors and terrace benches. The Soil Conservation Service is undertaking erosional control programs in the lower portion of the San Juan Canyon just east of San Juan Capistrano. The Tierra Colorado Clay Products Company is operating a clay pit in the basal Eocene clays in Cristianitos Canyon, three miles south of San Juan Canyon.

Communication: There are numerous roads within the area, rendering it quite accessable. The Ortego Highway, a Riverside and Orange County Project, goes up San Juan Canyon to Lake Elsinore. Besides this highway, are numerous roads maintained jointly by the forestry department and Rancho Santa Margarita. In addition, are several other private ranch roads.

Exposures: Because of low relief and gentle attitude of beds, exposures are only moderately good. In the western portion of the area, they are limited to road cuts and canyon bottoms, being obliterated elsewhere by numerous slides and thick soil mantles. Soil creep is considerable, resulting in sediments in outcrops that often are not in place. The Capistrano-Monterey contact could be determined only on the basis of soil constituents, and in areas of very low relief, could only be inferred. The resistant character of the San Onofre facies of the Temblor has resulted in fairly good outcrops of these rocks. The deposits are not conductive to the formation of soil, and have a relatively fresh appearance at the surface, or at most only slightly below. Exposures in the Eocene Martinez beds are by far the best exposures within the area. The alternation of resistant and non-resistant beds with the consequant development of cuestas has resulted in excellent outcrops. Single sandstone members outcrop as bluffs ten to twenty feet high, and may be traced for great distances. The basal multi-colored clays outcrop on small ridges as striking colored deposits.

Outcrops of the upper Cretaceous sands are quite similar to those characteristic of the Eocene. Toward the lower portion of the section, however, the exposures become progressively worse, and are confined to canyons, road cuts, and a few outstanding conglomerate bluffs. Because of the loose, unlithified nature of the Cretaceous conglomerates it is quite difficult to find material in situ. The material weathers very easily and results in loose, rocky slopes.

GEOLOGIC CONDITIONS

Regional: The sediments which comprise the belt of rocks dipping off the west slope of the Santa Ana Mountains are typical of the sediments of the California Coast Ranges. An anomaly arises, however, in the fact that the mountain system is a tilted fault block. Uplift has occurred intermittently, and is probably going on at the present time along the Elsinore fault system to the north-east. The Elsinore fault system lies along the north-east face of the Santa Ana Mountains and gives rise to the very steep scarp which so bounds the range. The development of the block has taken place in a series of movements which have left as a record a large series of stream terraces. Consequent with uplift of the block from the north-east, has been general warping of the western side along the region stretching from Tustin to the coast below Oceanside. Structural trends in the block are in strict contrast with the east-west trends of the Los Angeles Basin to the north-west. NW-SE trends predominate, which is synchronous with the NW-SE trends of the Peninsular ranges. The relations between igneous rocks and sedimentary rocks in the Peninsular ranges is borne out in the area here studied. The central mountain mass is composed of granitic (diorites) rocks with later intrusions in the form of pegmatite and aplite dikes, while the margins of the ranges are composed of a belt, at most only a few miles wide, of Cretaceous and Tertiary rocks. Erosion has deeply unroofed the range, so that only minor amounts of the metamorphic cover are left. This deep erosion and stripping has exposed the batholithic character of the range.[2]

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2 Sauer, Carl: "Land Forms in the Peninsular Ranges of California as Developed about Warner's Hot Springs and Mesa Grande," U.C. Pubs. Geol., Vol. 3, (1929)

GEOLOGIC CONDITIONS--Local

Stratigraphy and Petrography: The rock types within the area fall into two classes: the crystalline metamorphic and igneaous rocks, which go to make up the mountain core; and a belt of sedimentary rocks which form an extensive series in the form of a westward dipping homocline at the foot of the range.

Basement Complex

The crystalline rocks comprising the basement complex were not studied further than to ascertain the general types present. B. N. Moore, in his thesis (CIT, 1930), for the first time differentiated the series. Formational names were applied but will not be referred to here. In general, the outer margin of the core is composed of several thousands of feet of a metamorphic series of various rock types. Apparently the series at one time formed a cover over the batholithic intrusion of later granitic rocks, but deep erosion has left only a marginal representation of the occurrance. The age of these rocks is not definitely known, but a few Triassic fossils have been reported limestone lenses.[3] It is generally held by previous writers that this series is a correlative of the phyllites and slates of the Santa Monica Mountains, and possibly of the Fransican of other areas, but of a different facies. The series on the other hand is distinctly different than the metamorphics of the San Gabriel Mountains which bound the Los Angeles Basin on the north. These facts point to the confirmation of the assigned Triassic age. The series is composed of quartzite beds, and conglomerate beds, with numerous phyllites or slates. In Upper San Juan Canyon, these quartzites and slates

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3 Dickerson:

have been exposed very well and are seen to be dipping very steeply toward the west. The quartzites are fine grained, and due to the presence of iron, have attained a rich brown color. The slates are for the most part gray, and show a poorly developed slaty cleavage. In Lucas Canyon, schists and gneisses are exposed in addition to the quartzites and slates. The metamorphic rocks represent a series of old sediments which have been vigorously deformed, uplifted and tilted. Their presence indicates a depositional basin previous to the Nevadan Revolution, at which time the Jurassic granites generally intruded the Pacific Coast. The extent of this basin is unknown, but as mentioned, above may have representations in the Santa Monica Mountains, and even in Franciscan areas, assuming of course, a facies difference.

In close proximity with the metamorphic rocks, and subsequent to them is a group of lavas and tuffs, intruded by andesite dikes. Moore[4] has listed three distinct flows of the lava and tuff accumulations. The volcanics have been considerably metamorphosed and show numerous evidences of minor faulting with gouge and slickensiding. In the vicinity of Hot Spring Canyon, the tuff is colored a brick red, and shows a very fine, homogeneous character. In thin section the material appears opaque, but contains numerous glass shards. The andesite portion of the volcanics appears universally in the area as a prominent bed, some tens of feet thick, and dipping about 35°-45° to the west. In all exposures, the rock immediately underlies the Cretaceous Trabuco conglomerates. The age of the volcanics is evidently later than the metamorphic series, being either late Triassic or early Jurassic.

The metamorphic rocks have been intruded by granites similar in

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4 Moore, B. N.: unpublished report, Calif. Inst. of Tech., 1930.

character to those of the Santa Monica Mountains. It is probably post-Triassic in age, and is present as bowlders in the unconformable overlying upper Cretaceous beds. Thus, it is also pre-Chico, and has been commonly supposed to be upper Jurassic, like the similar granite of the Sierra Nevadas. In some localities, notably, San Juan Canyon, the granites are also present at or very near the sedimentary contact. Eith these occurances represent cupolas of the main batholith, or they have been faulted into the metamorphics. In either advent, they are very much decomposed and show effects of having been subjected to considerable weathering. Alterations have occurred prolifically and are present as kaolinizations of the feldspars and calcitization in the vicinities of hydrothermal activity. In addition to the presence of calcite as seam and pore fillings, numerous lead deposits of minor extent are present (also attributable to the hydrothermal action).

CRETACEOUS

The basement complex, comprising the core of the Santa Ana Mountains, is overlain unconformably by a section of Cretaceous, sediments, whose entire thickness amounts to some 5000 feet. Following Packard's[5] classification, the writer has differentiated this series into two groups: a lower section, the Trabuco formation; and an upper section, the Chico formation. In all localities studied within the area, the Trabuco beds dip off the basement rocks at angles of about 25°. The depositional nature of the beds on the crystalline complex is demonstrated by the medium dips of the rocks which carry them some distance up the slopes of ridges in such a way that often a thin veneer of well rounded boulders is all that remains. The belt of Trabuco conglomerates is only some three or four hundred feet in width, and, accounting for the dip, amount to about two hundred feet in thickness. The beds are brick red in color and show in some places a rapid change to the buff colored conglomerates of the overlying Chico, and in other localities, a gradational change to the Chico type. The conglomerate is composed of a poorly sorted and unlithified aggregation of rhyolite, andesite, schist, and granitic material ranging in size from peas to large boulders. The rocks are sub-rounded, and represent the types of rocks to be found within the central core of the range today. Apparently during Cretaceous time the range was much more extenside and higher toward the east than it is at the present time, and furnished a great amount of alluvial, fanglomerate, and outwash material to a large basin to the west.

The formation has generally a clay matrix throughout which is in

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5 Packard, E. L.: Cret. of Santa Ana Mts., U.C. Pubs. in Geol., Vol 9,1915-16.

contrast with the sandier matrix of the younger Chico conglomerates. The conglomerates of the basal Chico lie with apparent conformity upon the Trabuco beds, though the abrupt change from red to gray beds in some localities might suggest an erosion interval. A salient point to be noted in connection with the presumed different conglomerate facies, is that the loosely cemented conglomerates of the Trabuco formation develop upon weathering a rounded ropography which is in marked contrast with the abrupt cliffs formed by the gray conglomerates of the overlying Chico.

B. N. Moore[6] has referred to the Trabuco and Chico conglomerates being of marine origin. He attributed the red color of the Trabuco to excessive oxidation of iron present with the rocks. The writer of the present paper, however, is of the impression that the beds are continental in origin, and represent large amounts of fanglomerate material. Numerous channels within the conglomerates are present which exhibit lensing reddish sandstone beds which gradually grade in texture into the conglomerates. If the red color of the Trabuco is due to exidation of iron (wherein the writer is in agreement with Moore), it seems more than likely that it would be produced under continental conditions which lends itself to the oxidation by air far more readily than would be the case if the material were marine.

Since no fossils have been reported from the Trabuco, its age, based on stratigraphic relations, is slightly older than the Chico series and presumably represents some phase of pre-Chico Cretaceous.

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6 Moore, B. N.: unpublished report, Calif. Inst. of Tech., 1930.

THE CHICO GROUP

The Chico formation has here been differtiated into three units, all marine in origin: a lower buff colored conglomerate of generally unsorted and semi-cemented rounded material varying in size from peas to large boulders; a middle shale member comprised of finely bedded black micaceous shales with gray limy sandstone lenses; and an upper series of massive brown micaceous sandstones and shales, the latter containing numerous gray limestone concretions. The division of the Chico in the manner here discussed is based on lithologic features alone. Since the paleontological aspects were not studied, it seemed logical to make the division in this manner, though the divisions are slightly different than those made by W. P. Popence in his studies farther north. In general nature, the lower conglomerate is a correlative of his Baker conglomerate. The division between the lower conglomerate and the middle shale is the same as made by W. P. Popence, as indicated by the presence of Acteonella oviformis in the hard beds just below the shales. (However, Dr. Popence has grouped together into what he calls the Holt Shales, the two units here described as the Middle shale, and upper sandstone.) Wrong - WPP

The conformable relations between units points to the continuous deposition of the series, the differences in lithology being attributed to an oscillotory shore line during the period of submergence. Notable within the series is the abundance of mica, a fact quite in contrast with the overlying Eocene beds which are relatively free of ferromagnesium minerals.

LOWER CONGLOMERATE

Resting with apparent conformity upon the Trabuco formation, is a series of conglomerates which differ from those of the lower formation. The matrix, instead of the brick red color of the Trabuco, is much lighter, grading from gray to a buff. In places, the conglomerate is more firmly cemented and reflects the attitudes of the beds much better than the more loosely cemented Trabuco. The material is well rounded, and is composed of derivatives of the Eastern Complex much the same as the underlying beds, though quartzites and acidic rocks are in greater abundance. An increase in size of material is apparent in the lower portion of the formation, but becomes smaller as one goes higher in the section.

The lower conglomerate becomes very well lithified as toward the top of the section. Here it is interbedded with hard santstones which have a calcareous cement. The size of material in the conglomeratic phases are much smaller than the conglomerates below, and appear in plases to be more angular. Interbedded with these sands and conglomerates are hard gray limestone lenses containing an abundance of Acteonella oviformis. In general these resistant facies of the lower conglomerate appear as gray beds, but due to lateral variation they may occur as distinctly diff-erent. In Lucas Canyon the beds outcrop and display a yellow color due to oxidation of iron within the material. Here the calcareous cement has given way to a sandy cement and matrix. The difference in the type of matrix indicates that the material was deposited under different depth conditions in the basin. In general, it may be said that the lower conglomerate member was deposited under shallow water conditions, near shore, and that variations in the depth conditions have led to a lateral variation in lithology. The maximum thickness of the section amounts to about 25oo feet and point to the extensive nature of the source of material to the East.

MIDDLE SHALES

Overlying the lower conglomerate conformably, the Middle Shales occur as a very soft series varying considerably in thickness along strike. Their aereal extent is very clearly marked by a thick growth of grass which is in contrast with the dense brush so characteristic over areas of conglomerates and sandstones. The shales are generally darker than those occurring within the upper sandstone, ranging in color from dark browns to gray or even black. They are of a much finer texture than the younger shales higher in the section. Interbedded with the shales are lenses of hard gray limestone and calcareous cemented sandstone varying in thickness from a few inches to a foot. In the northern extent of the facies in the area studied, a conglomerate bed is interbedded with the shales. The material is of a similar nature to the other conglomerates within the Chico. Similar occurrances have been reported by L. A. Lewis in his work along the northern margin of the Santa Ana Mountains, and also in the report by W. P. Popenoe.

The shale facies represent an environment quite in contrast with the near shore conglomerate accumulations. Presumably a deepening of the seas occurred which terminated the shallower accumulations. The subsidence was evidently not uniform throughout the region, since the shales have a constantly varying thickness and appear to lense in places, especially toward the northern boundary of the area. To the south, notably below Verdugo Canyon, the shales appear to grade into and become interbedded with gray and brown micaceous sandstones. In road cuts along Verdugo Canyon, in the stratigraphic position of the shales, the shales are interbedded with sands and show alternations of beds a few inches to a few feet in thickness.

The soft nature of the middle shales has contributed toward important physiographic conditions in the area. Transverse ridges to the strike of the beds show excellent developments of kerncols and kernbuts, the resistant conglomerates resulting in prominent knolls, and the less resistant shales resulting in low saddles. In addition, the shales have controlled the course of San Juan Creek to the west. The creek has maintained its course through the resistant lower conglomerates, but on encountering the shales, over which lie the upper resistant sandstones, sought a course along the strike and coincident with the shales. An abrupt change in course thus took place at the contact between the shales and upper sandstones. This change in course has resulted in the scouring out of great quantities of the shales.

UPPER SANDSTONE

The upper sandstone portion of the Chico includes several rock types. Immediately overlying the middle shales is a small thickness of conglomerate. This is followed by several hundred feet of tan sandstone, which is in turn overlain by tan shales. Deposition of the series was evidently initiated by a shallowing of the seas following deposition of the shale series. Conformable relations exist, and the supposition is that deposition was continuous. The conglomerate beds immediately overlying the shale member is very similar in composition and texture to the lower conglomerates. A predominance of acidic and quartzitic boulders occurs over basic and volcanic types. In places the conglomerate weathers to a brick red, very similar in appearance to the Trabuco facies.

Gradationally overlying the conglomerate occurs a considerable thickness of massive tan sandstone. These beds are excellently exposed on the west side of San Juan Creek along its southerly trend. The beds, due to their low dip and massive characteristics have formed extensive bluffs and cuestas. The bluffs are very linear in structure, having been subjected to the gradual westward movement of San Juan Creek. This migration of the course of the stream is indicated more fully by the occurance of extensive terraces on the east side, and their entire absence on the west bank. The sandstone bluffs attain heights of two to three hundred feet above the creek.

The sandstones are a light tan in color throughout and are very fine grained. They are distinctly micaceous and show deep weathering of the feldspars. Occasional conglomerate and shale lenses which often exhibit local unconformities and crossbedding. The conglomerate horizons and lenses are composed almost entirely of well rounded acidic boulders, and have a sandy matrix similar to the sands of the remainder of the section. Overlying the massive sandstones, occurs a series of well indurated sandy shales. The series shows well defined bedding planes and are interbedded with thin gray lime stone beds of a very resistant nature. Throughout the shales are an abundance of spherical concretions composed of hard sandstone with a lime cement. These nodules range in size from an inch to several inches. In addition to the spherical concretions are numerous irregularly shaped hard gray limestone concretions. Many of these are very fossiliferous. One such concretion yielded an indeterminant ammonite about 10 inches in diameter. It is the largest of its kind thus far found in the region.

Near the Chico-Martinez contact, the buff shales often assume a darker color and become finer grained. This is well shown in Christianitos canyon where they are in contact with basal Eocene conglomerates. The darker appearance of the shales is thought to be due to considerable carbonization. Packard reports lignite seams interbedded with the shales farther north, and these black shales may correlate with them. However, the scope of the present work has shown only lignite of Eocene age interbedded with the Eocene clays. The black shales show a very obscure and oscillatory bedding, indicating considerable movement of water during deposition.

In summary, the Cretaceous section represents a sequence of deposits whose source was in a high lying land mass to the East. The method of deposition varied from a lower continental accumulation of alluvial material to successively younger marine deposits varying from near shore to deeper water facies.

NATURE OF THE EOCENE--
CRETACEOUS CONTACT

The Cretaceous period was not terminated by strong stuctural movements within the region studied. Attitudes of Eocene and Cretaceous beds are comparable and indicate relatively stable conditions during the interval between the time of deposition of their respective beds. The presence of a hiatus is, however, conclusive. In the several exposures of the contact, the uppermost Cretaceous shales show very irregular suffaces, indicating an erosion period following their deposition. The change from upper Cretaceous marine shales to Eocene basal beds is an abrupt one, the basal Eocene being composed of a heavy conglomerate.

It was at first suspected that a fault existed between the Cretaceous and the Eocene because of the higher topographic position of the Cretaceous, and the occurance in one locality of white Eocene sands butting against brown Cretaceous shales. More detailed work, however, showed this conception to be erroneous. Throughout the extent of the contact, basal Eocene conglomerates, sands, and clays were found, a singular point in a depositional contact. In areas of higher relief transverse ridges showed Eocene beds eastward on ridges, and Cretaceous beds westward in canyons. This was in further substantiation of a depositional contact. The occurance of the white sands against the brown Cretaceous sands may be due to local faulting or slump conditions. The presence of topographically higher Cretaceous beds may be due either to sliding of the soft Eocene clays, or to a high lying cretaceous mass at time of deposition of the basal Eocene, with an Eocene basin at the foot of the mass. This would suggest the possibility of primary dips in the deposits, which is borne out by the presence of generally greater dips near the contact.

EOCENE

MARTINEZ FORMATION

The name Martinez has here been applied to the entire section of sediments representing the Eocene. Woodford[7] refers to the section as belonging to the Tejon; but, after conversations with W. P. Popenoe concerning the Eocene farther north, the writer of the present paper is of the opinion that the deposits belong to the Martinez period of deposition, since in lithology, they are similar to the beds farther north.

A basal conglomerate of variable thickness disconformably overlies the Cretaceous. The conglomerate is composed of well rounded pebbles which in fresh exposures are very well cemented by a sandy matrix. The material, presumably laid down in very shallow continental basins, represents reworked Cretaceous material with the addition of further material from the Eastern complex. Acidic crystalline rocks predominate and, on the surface of the ground, resemble more recent terrace materials. Overlying the basal conglomerates, and occurring as lenses, is a greenish colored, coarse grained sandstone containing abundant very large mica flakes. The greenish tinge of the sands is attributed to alteration due to chloritization of the ferromagnesium constituents. These beds are correlated with similar horizons farther north studied by the writer in the vicinity of Santiago canyon. Their stratigraphic position immediately above the basal conglomerate is common in both localities.

A variable section of clays, shales, variegated siltstones, and

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7 Woodford, A. O.: U. C. Pubs. Geol., Vol. 15.

lignite beds immediately overlies the basal conglomerate and chloritic sandstone. The accumulation represent continental deposition under a marshy environment. The lignite deposits indicate a warm, humid climate. The most extensive deposits of clay occur in Cristianitos Canyon at the southern margin of the area. Here they have been mined extensively by the Tierra Colo. Clay company. Chemical analysis of the clay have shown the Al_2O_3 to run as high as 50%, and the Fe_2O_3 about 2.5%. From information received from McNeese of the company, it has been found that the Aluminum/ iron ratio is nearly a constant. The clay represents a very fine fireclay and is white to blue-gray in color. Its occurrance is in beds a few inches to several feet in thickness. The deposits occur as localized basin-like accumulations, representing aggragation from standing water in which the fine suspended particles gradually settled out.

Overlying the white clays, are thin beds of black carbonaceous plastic clays and lignite seams. The carbon ratio is high enough to support combustion, but on burning leaves a klinker type of residue. Immediately underlying the fir clay is a mottled plastic clay which is quite similar to the Eocene deposits at Alber Hill to the north.[8]

The fireclays and carbonaceous seams grade laterally into highly colored friable silts which contain a greater percentage of iron and silica. The deposits are finely bedded with alternating red, buff, yellow, and white horizons. These deposits weather into local badland topography and are very striking.

Locally, and in addition to the fire clays, plastic clays and sands,

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8 Clay Resources and Ceramic Industries of Calif. Bull 99, Calif. State Mining Bureau.

a rather continuous bed of red and yellow pisolitic clay occurs near the base of the series. This bed attains a thickness of several feet just south of San Juan Creek, but becomes progressively thinner toward the north, though it does remain persistant. In Cristianitos Canyon the bed grades into the white fire clay.

In the northern portion of the area, the colored sands and clays show considerable interbedding of sands and conglomerates. The conglomerate horizons are very friable, and have a soft red sandy matrix.

The total thickness of the basal member of the Martinez, which includes the basal conglomerates, clay beds, and variegated sands, amounts to about 200 - 300 feet. The conglomerate has a thickness of about 100 feet, the clays and sands comprising the remaining 200 feet. A detailed section of sands and clays at a locality north of the San Juan Creek shows the following sequence (top to bottom):

White arkosic sandstone	(great thickness in upper portion of formation)
white-yellow-red pisolitic clay	2-3 feet
massive yellow sandstone, clay	15 feet
red clay, arkosic	15 feet
red, yellow sandy clays, arkosic	10 feet
buff, soily sands, clays, large biotite flakes	3 feet
red clay	1 foot
buff sands, biotitic	?
Cretaceous	

The basal member is gradually overlain by 1500 feet of massive arkosic sandstone. The sandstone outcrops in continuous bluffs along canyons and is a brilliant white compared with the older Cretaceous sands. The sandstones are composed entirely of angular quartz grains with an arkosic cement and matrix. Mica and other ferromagnesium minerals are entirely lacking. Occasionally, green, gray, or red shale beds occur interbedded with the sands. The shales show irregular contacts with the sands, indicating variable depth conditions during deposition. Throughout the sands are conglomerate lenses and pebble horizons of very well rounded acidic rocks.

That deposition of the sands occurred very rapidly in a large delta is suggested by the angularity of the grains and intercalated shale and conglomerate horizons. Cross bedding is also readily discernable in fresh exposures.

In summary, the Martinez formation represents a formation composed of beds of continental and marine origin. The basal member indicates accumulations in marshes or swamps, which , as indicated by the upper member, gave way to a deltaic marine accumulation of sands with conglomeratic facies intercalated throughout.

MIOCENE SERIES

The Miocene group within the area is represented by a thin section of Middle Miocene Temblor and its related San Onofre facies, a section of upper Miocene Monterey shales, and a section of questionable upper Miocene of Lower Pliocene Capistrano rocks. The Miocene rocks compose a series of marine sediments, whose deposition is separated by periods of emergence and erosion. Shallow and deep water types of deposits are present. True contact relations of the Miocene rocks with the underlying Eocene is not known within the area since the Cristianitos fault forms the contact and cuts out the whole of the Vaqueror present farther north. Presumably the interval between Eocene and Miocene was marked by an extensive period of emergence which had a duration comparable with Oligocene time. At any extent, the attitudes and structural relations in the Miocene beds are such as to indicate disconformable relations and possible even unconformable relations.

TEMBLOR FORMATION

The Temblor formation, middle Miocene in age, is represented by only a few hundred feet of friable yellow sandstones and interbedded shales. The sandstone is poorly lithified and shows little or no bedding. Great quantities of iron have produced limonite seams which also contain poorly preserved marine fossil remains. The sandstones are micaceous and are generally free of arkosic material. Occasional glaucophane flakes are present indicating its source as being the old land mass of Catalinia rather than the Eastern complex.[9] In numerous places are intercalated fine gray shales. A prominent fossil reef member is also present just west of the Cristianitos fault and north of San Juan Canyon. It is composed of a very limy sandstone which contains numerous species of pelecypods and gastorpods. The beds vary from one to several feet in thickness. Glaucophase flakes are present in instances in the reefs, but not in sufficient amounts to warrant assigning them to the San Onofre facies.

SAN ONOFRE FACIES

The San Onofre facies is a facies of the Temblor. It is a unique horizon in the stratigraphy of Southern California. The type locality is San Onofre Mountain, which lies just inland a few miles south of the town of San Clemente. It has been carefully described by Woodford.[10]

Briefly, the material forming the San Onefre was derived from a postulated Miocene high lying land mass Catalinia to the south-west.[10] The mass

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9 Woodford, A. O.: The San Onofre Breccia, U.C.Pub. in Geol. Vol.15, 1925.

10 Woodford, A. O.: U.C.Pub. Geol., vol. 15, 1925.

was composed entirely of Franciscan rock types of Jurassic age, and shed material intermittently in great quantitites from a presumably high and steep north face into a northern basin of deposition. Arid conditions probably prevailed, as indicated by the extreme angularity and great size of the material. The presence of such angularity has led to the use of the term "breccia" when referring to the formation.

The rock types include old shists and gneisses of several varieties, as well as quartzite fragments, slate fragments and a few igneous fragments. The characterizing metamorphic is a glaucophane schist, which makes up a good portion of the formation. This rock appears blue and contains laminae of almost pure glaucophane. Other fragments show good crystalline development of the mineral. In addition, there are quantities of actinolite schist, mica schist and gneisses, and pyroxene schists. The breccia has a silicious cement and in fresh exposures exhibits a characteristic blue-green color. The material is very poorly sorted and has a very wide range in size. Some fragments attain diameters of three or more feet. These large boulders often show the intense folding characteristic of the Fransican complexes. Interbedded with the breccia is an occassional sandstone horizon, also containing abundant glaucophane. In exposures along San Juan Creek, the breccia shows excellent cross bedding of material somewhat smaller in size than the ordinary fragments. Immediately overlying these beds are striking horizontal beds which are crossed by resistant vertical beds of the same composition (see figure 3). This peculiar arrangement of reef forming horizons is probably due to joint or fracture filling with subsequent cementation. Curiously enough, both sets of beds are fossiliferous, containing species of pecten, ostracea, and various gastropods.

From the fauna occurring within the San Onofre a marine origin is indicated which bears coarser barren littoral phases. The marked angularity of material in the formation suggests that the rocks were carried only very short distances, but intermittently in great quantities, since sorting is very poor. The highly resistant characteristics of the formation as a whole is shown by the high topography it has retained. In general, the material tends to weather off into huge rectangular blocks of breeciated material, which are subsequently decomposed into smaller fragments.

MONTEREY SHALES

The shales immediately above the San Onofre are correlated with the type Monterey in Northern California, and the local facies in the Los Angeles Basin which include the Modelo and Puente Shales. Rather than assign a local name to the deposits here mapped, the writer has chosen to refer to the formation in a general sanse by using the term Monterey Shales. The shales are upper Miocene in age and overlie the San Onofre and Temblor with uncertain relations. Woodford[11] has indicated an interbedding of San Onofre with lower Monterey in cliffs along the coast; but, due to very poor exposures, the relations in the area here studied are obscure. Field relations suggest that the Monterey has lapped up on the San Onofre which, at the time of deposition of upper Miocene sediments, may have formed a topographic feature of greater relief than the surrounding country. This is borne out by the fact that the Monterey occupies higher topographic positions in the southern portion of the area, completely covering the San Onofre.

The Monterey comprises a series of diatomaceous shales and cherts, The strata are very well bedded, and show easy cleavage into fine laminae.

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11 Woodford, A. O.: U.C.Pubs. Geol., Vol. 15, 1925.

The cherts are light colored and occasionally grade into a sandy or shaly facies. They weather into rounded blocks which contain an abundance of siliceous veins. A group of light colored friable poorly bedded shales lies beneath the diatomaceous shales. The shales are fine grained and tend to weather into badland topography. Bone fragments were found, but not sufficient enough to be identified. Ash beds associated with white,hard gray sandstones were found at one locllity. It is thought that these beds occupy a stratigraphically higher position than the diatomaceous shales and cherts, and represent a possible continental or shallow water facies.

The Monterey represents, in general, a depp water type of deposition in which siliceous oozes and diatoms were deposited in great quantities. The incompetency of the beds is demonstrated in local folds occurring throughout the formation. In some cases this folding becomes very tight and results in vertical, or even overturned beds.

The formation is very poorly exposed, and attitudes can be obtained only in canyons where, even then, they may be deformed by slumping or sliding of considerable magnitude.

CAPISTRANO FORMATION

The Capistrano Formation overlies the Monterey with apparent con formity. An hiatus is indicated, however in the change in lithology from diatomaceous shales to sandstones. The age of the formation is doubtfully Pliocene, and may be upper Miocene. In places, the lower part of the formation notably just north of the Ortego highway, is composed of white sandy conglomerates of a very arkosic nature. The conglomerates contain small rounded pebbles which are very poorly cemented. Elsewhere, the lower portion of the formation is composed of yellow sandstones containing considerable mica and caliche. At several localities near the contact, material was found, though not in place, which showed an angular conglomerate composed of fragments of Monterey chert. These occurances suggest a basal bed in the Capistrano of this nature. Several hundred feet of friable sandy-shale and silts occur above the yellow sandstone. They are buff colored and contain intercalated seams of gypsum sometimes two inches thick. Transverse veins of gypsum are also present as fracture fillings. One local occurrance of very white well-rounded beach sands was found in the buff shales. Little or no arkose was present, indicating an origin similar to that of the sandy beaches forming along the coast at the present time. Numerous well weathered fossil remains were present. These deposits represent shallower conditions than the adjacent sediments, possessing near-shore characteristics. Numerous littoral facies were noticed in the north-west portion of the area mapped. These accumulations are very limonitic and contain numerous horizons of well rounded pebbles.

The faunal record is limited to the fragments mentioned above plus fragmentary skelatal remains of whale (rib bones and portions of the vertabral column.)

In summary, the Capistrano is represented by marine deposits of much shallower origin than the underlying Monterey. Littoral and near shore deposits are present throughout the formation.

QUATERNARY DEPOSITS

The quaternary is represented in the area by three mappable units. These are, in order of discussion: 1) alluvial material; 2) landslides of considerable magnitude; and 3) extensive stream terraces.

ALLUVIUM

Stream and canyon fillings, resulting from outwash material from the higher mountains and the reworked sediments of adjecent sedimentary strata form the alluvial deposits. These deposits are composed of sands and gravels of variable composition. In the lower reaches of Arroyo Trabuco, a gravel pit is being operated by Graham Bros. Gravel Co. Here, the maximum depth of gravels probably amounts to about 100 feet.

LANDSLIDES

Landslides are of considerable size in the area, especially in the Miocene sediments which are of a very soft nature and lend themselves to mud flows when wet. In most places the slides have been influenced by the undercutting action of streams. Perhaps the most spectacular slide present in the area is the one occurring in the San Onofre Breccia just west of the Cristianitos fault. This movement of material has involved an area of about 25 acres and has been extensive enough to develop an interesting physiographic feature on the uphill side. The rocks in place occupy a high ridge which bound an amphitheatre to the north. 100 feet lower and to the north of the south bounding ridge, a subsequent concentric arrangement of knolls representing material rotated up by movement on the curved slide-surface has developed. The presence of the slide is further indicated by an admixture San Onofre material, Monterey ash material, and to the east quantities of Martines sandstone. Further evidence pointing to this feature is in the occurance of many small closed basins in the altered area which reflect the rotating movement of material. The slide has presummably been influenced by the brecciated zone along the Cristianitos fault and the probable associated local faults. Several other smaller slides occur along the fault zone, but do not reflect the features as well as the one just discussed.

TERRACES

Stream terraces are best developed in San Juan Canyon and its tributary, the Arroyo Trabuco. Repeated uplifts of the Santa Ana block are well reflected in the successive series of flat benches. Three levels of terraces, with the strong possibility of a fourth are present. Correlation of the various levels was not attempted, but the problem presents interesting aspects and encouraging possibilities. Occupying step-like benches on the backward side of the creek, the terraces maintain consistant heights and very flat surfaces. The material represented in them includes Pleistocene alluvial material which was deposited when San Juan Creek flowed at the respective levels of the terraces. The material is well rounded shows poor sorting, and contains large amounts of sand and gravel. An interesting development of the terraces is shown on the flat areas betwenn Bell Canyon and San Juan Canyon. Here the material represents a derivative of exposures to the north, where the Trabuco formation is very well exposed. The matrix of the Trabuco is retained in the terrace deposits and forms a hard red cement. Because of the resistant nature of the rock, the attitudes of the terrace material are still retained. The terrace deposit forms a brick red cap over the underlying Cretaceous sediments.

The terraces in general have a glay or gumbo matrix which serves effectively to retain great quantities of water. For this reason, the larger flat areas have been cultivated extensively and bear numerous citrus groves.

GEOLOGIC STRUCTURE

Regional: In general, structural features trend NW-SE and belong to the province of Peninsular ranges. The Santa Ana Mountains are distinct from the general Coast Range in structure by virtue of the fact that they are a fault blocked range on the north-east face. Tilting has occurred at successive intervals by uplift along the Elsinore fault system which bounds the north-east face of the range. The late movements of the fault are reflected by the development of the San Juan Canyon terraces. The north-east face of the range is in sharp contrast with south-west side. It represents a fault scarp in which the face drops sharply from the crest of the range at 4000 feet to the base at 1000 feet. Steep and precipitous canyons have been developed in the scarp, whose streams carry quantities of material into the Elsinore Basin. The south slope of the block is the tilted back surface of the block. The gradient on the back slope is very gradual, and has developed a drainage into the Santa Ana Plain, or River, which empties into the sea near Newport.

In general, a gently dipping homocline is formed by the sedimentary series of rocks on the western slope of the Santa Ana Range. These deposits are locally faulted and folded and dip into the Capistrano syncline which trends NW-SE in the Capistrano drainage trough. The west flank of the anticline makes up the Eastern part of the San Joaquin Hills north of Laguna, where the same series of sediments are faulted extensively.

Local structural conditions: Forming a gentle westward dipping homocline, a thick series of sedimentary rocks represent the Cretaceous, Eocene, and Miocene. Angular unconformities in the area are lacking, but disconformities and possible overlap condition exist. The beds in general are very flat lying and so not show strong structural activities.

The Cristianitos fault is the most important fault within the area, and shows considerable movements. The fault is vertical and has had mainly a dip slip movement, in which the east side has gone up relative to the west side. The fault has brought the Martinez Eocene beds up into contact with the San Onofre. Exposures of the fault show a considerable admixture of materials of the two formations with quantities of clay and narrow gouge zones. Minor faults in the area are the result of adjustment to stress and strain. One such fault, trending NE-SW, is located just north of the intersection of the Ortego highway with lower San Juan Creek. Here, the Temblor and San Onofre have been faulted up into contact with Monterey Shales.

Folding in the area is limited entirely to the Monterey Shales, and has developed a series of small anticlines and synclines in these rocks. They are possibly reflections of movement of the entire block that have occurred in the less competent shales.

HISTORICAL GEOLOGY

The earliest known geologic event in the Santa Ana Mountain region was, presumabley, the deposition of sands, conglomerates and some limestones which apparently took place during the Triassic. In the late Triassic or early Jurassic, these beds were covered by a series of volcanic materials of known origin. A general intrusion of the gegion by batholiths with considerable deformation and metamorphism of the intruded sediments occurred subsequently to volcanism. An erosional interval probably existed during the lower Cretaceous time, which included most of the Horsetown and Knoxville interval. The area was then subjected to continental deposition of upper Cretaceous Trabuco sediments in the form of extensive fanglomerates and alluvial outwash areas. The region was then gradually drpressed below sea-level and the coarde conglomerates of the Chico were deposited. Submergence continued, sediments became finer and showed thicknesses of sands, shales and silts. Marine fossils were buried.

A period of emergence then prevailed toward the close of Chico time, and deformation resulted in erosion of the upper portion of the Chico. During this period of emergence, swamp and marsh conditions developed which resulted in accumulations of organic materials and fine clay deposits. These materials represent the basal Eocene. Continental deposition of fine material was followed by a submergence of the region to a very shallow depth. Deltaic conditions existed in which great quantities of angular Eocene sands were deposited. Sea level evidentally oscillated somewhat, since numerous shale and conglomerate beds were laid down. Emergence occurred during the late Eocene period and lasted throughtout the Oligocene, in which erosional agencies were actively stripping toward the west great quantities of material. In lower Miocene time, subsidence again occurred and resulted in the deposition of marine and continental deposits representing the Vaqueros formation found farther north. A new source of material appeared between the lower Miocene and the middle Miocene. Heretofore, the Eastern complex supplied the sedimentary debris. A new land mass to the South west began to shed material in great abundance into the area. This was the Franciscan Land mass of Catalinia and, following subsidence below sea-level, contributed material to the Temblor and San Onofre. The material of the San Onofre is extremely coarse and, though marine, probably represents shallow-nearshore and littoral deposits. A subsidence of several thousand feet occurred in upper Miocene time and resulted in deposition of great quantities of diatomaceous shales and siliceous oozes. Following deposition of the Monterey, was a general shallowing of seas in which the Capistrano formation was laid down. The sea level had dropped considerably and the deposits represented shallow water types, and littoral facies, including beach deposits of clean sands.

Following the deposition of at least a part of the Capistrano in the Pliocene (?), a period of emergence took place and was followed by erosion. During the Pleistocene the Santa Ana block was tilted. Folding and faulting occurred throughout the region. Pleistocene alluvium and terrace materials were laid down. Repeated uplifts of the block resulted in the development of terrace deposits. Then deformation and erosional agencies have continued into the recent.

Figure 1
View of San Onofre Breccia Showing Cross Bedded Angular Beds Underlain by Fine Buff Colored Sandstones

Figure 2
View showing Group of Small subsidiary Hills Formed as a Result of Landslide Action in The San Onofre. Landslide Surface Lies in Saddles Between Hills and Higher Range to The Left

Figure 3
View of San Onofre Breccia Showing Perpendicular and Horizontal Intersecting Beds. Material Composed of Coarse, Angular Fragments.

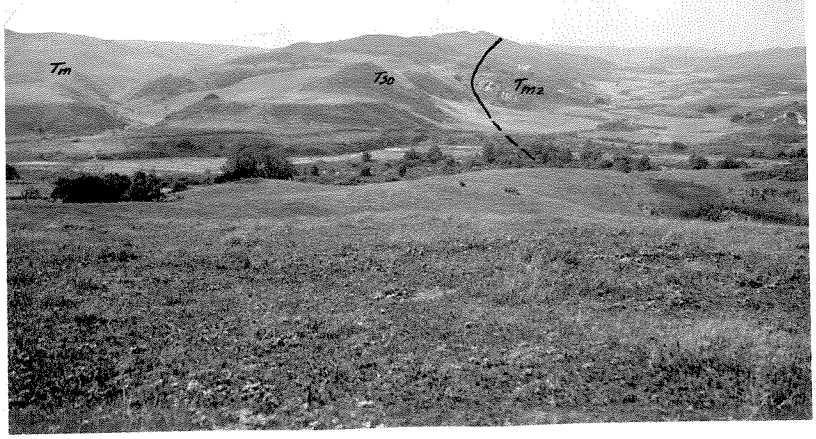


Figure 4
View of Cristianitos Fault from the South Side of San Juan Canyon. Tm: Martinez, Tso: San Onofre, Tm: Monterey. View Looking North.

Figure 5
View of Small Fault in San Onofre Breccia. Slickensides show Vertical and Horizontal Component.

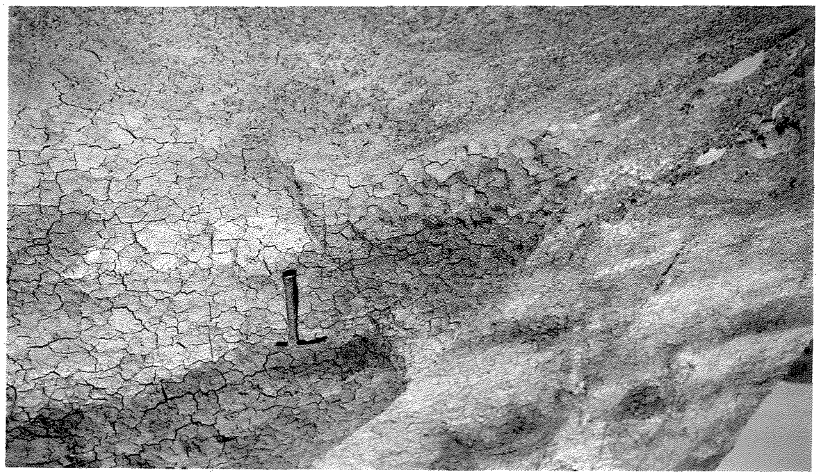


Figure 6
Photo of Small Fault in Martinez Basal Clays and Silts. Clays are very Fine-grained and of variegated colors.

Figure 7
View of Gently Dipping Basal Eocene Clays and Silts. In Background Are Upper Massive Sandstone Beds. View Looking NW

Figure 8
View of Martinez-Chico Contact.
Coarse, Well rounded Conglo-
Merates overlie Fine,
Well Bedded Black
Shales.

Figure 9
Photo Showing Development of Kerncols and
Kernbuts in Cretaceous Sediments,
Cols occur in Middle Shale Mem-
ber, Buts in Upper and Low-
er Sand and Conglomer-
ate Members.

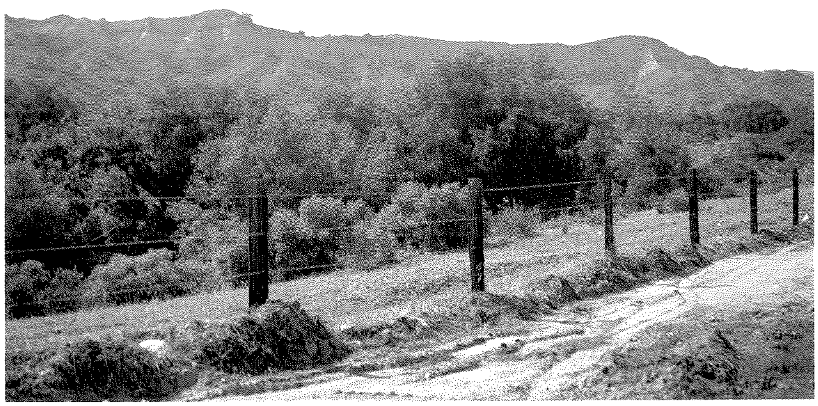
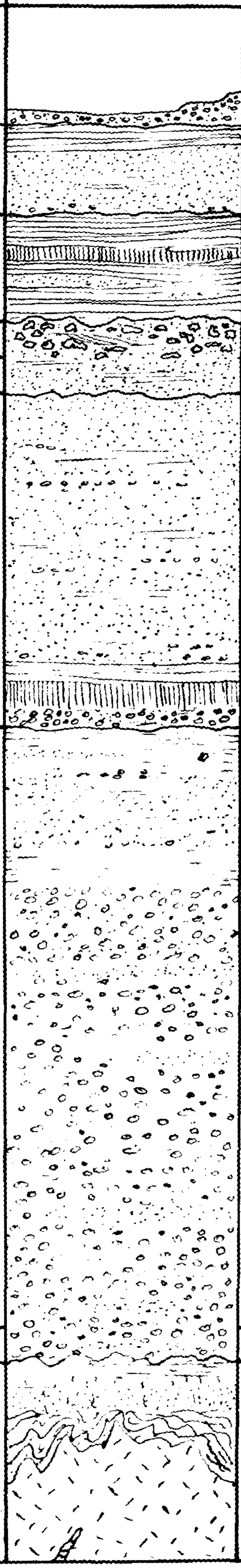


Figure 10

View Looking NW of Cuestas Formed in Westward Dipping Cretaceous Sandstones.

System	Series	Formation	Symbol	Columnar Section	Thickness in feet	Charcteristics
Quater.	Pleist. & Recent	Alluvium, Terraces	Qal.t		100 ±	Stream gravels, Sands; Terrace Materials, Coarse conglomerates
		Unconformity				
Tertiary	Pliocene ?	Capistrano	Tc		700 +	Brown micaceous sandstone, shales, silts, iron stains, caliche.
		Unconformity				
	Miocene Upper	Monterey	Tm		800 −	White diatomaceous shales, chert lenses, sandstone lenses.
		Unconformity				
	Miocene Mid.	San Onofre	Tso		150 +	Coarse breccia + Glaucophane
		Temblor	Ttb		150 +	Brown micaceous sandstone, Fossiliferous.
		Unconformity				
	Eocene	Martinez	Tmz		2600 ±	Brilliant white Arkosic sandstone, Angular quartz. Basal conglomerate, variegated shales and clay, Lignite Beds.
		Unconformity				
Cretaceous	Cretaceous	Chico	Kc		5000 −	Lower buff colored conglomerates, sandy matrix, Acidic & basic bowlders. Middle blue-gray micaceous shales - finely bedded Upper micaceous brown sandstone, Limy concretions - fossiliferous.
		Trabuco	Kt		200 ±	Massive red conglomerates.
		Unconformity				
Triassic	Triassic	Basement Complex	Trb		?	Quartzites, slates, schists, volcanics i.e. tuffs, lavas, andesite; Granitic intrusion and pegmatite and Aplite dikes.

Idealized Columnar Section
of the
San Juan Canyon Area

Plate I

SAN JUAN CANYON AREA

IDEALIZED E-W PROFILE VIEW

by MELVIN N. LEVET

1940

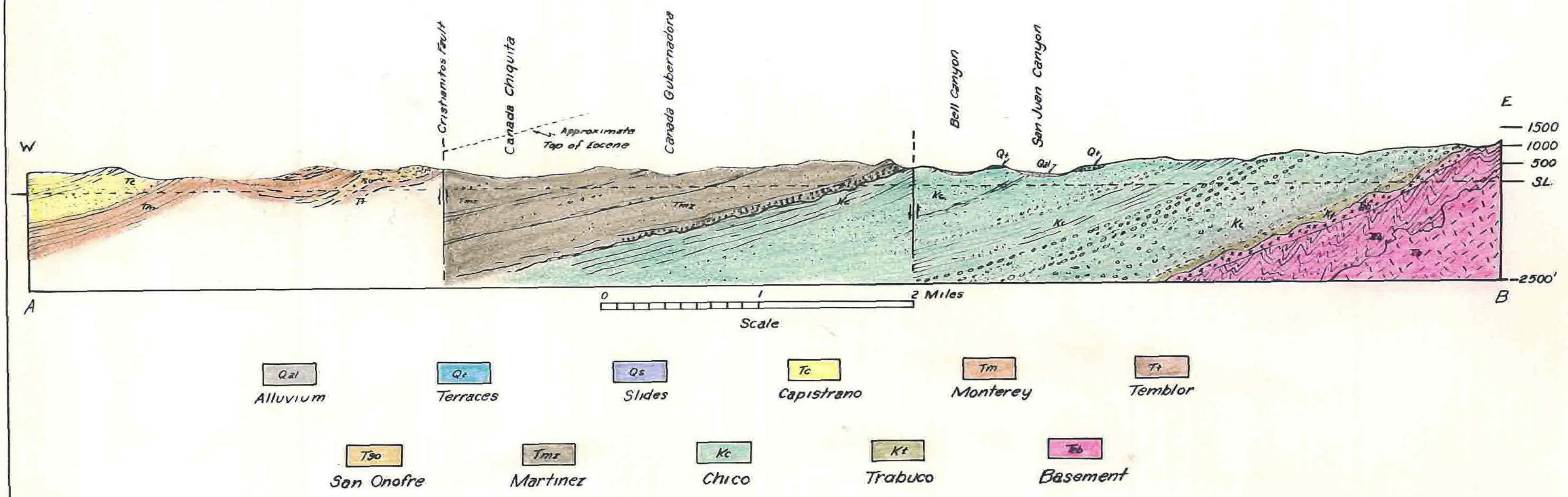


Plate II