THE GEOLOGY OF PORTIONS OF THE HUMPHREYS, SYLMAR, NEWHALL and SAUGUS QUADRANGLES LOS ANGELES COUNTY, CALIFORNIA

Thesis by

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SUMMARY

The area investigated is located in the southeastern corner of the Santa Clara River Basin in Los Angeles County, California, near the towns of Saugus and Newhall.

Five formations of Tertiary age, bounded on the south and east by the basement complex of the San Gabriel Range, are found in the area. The oldest formation, the Mint Canyon of upper Miocene age is successively overlain by upper Miocene Modelo, Pliocene Pico, Pliocene-Pleistocene Saugus and Pleistocene Terrace deposits.

These sedimentary formations have been folded and faulted during two major periods of deformation, the first at the end of the Miocene period when they were acted upon by compressive forces from the north and the second period during which they were subjected to the same set of compressive forces and in addition a new set of forces which caused the uplift of the crystalline mass of the San Gabriel Range. The latter period of deformation occurred after the deposition of the Saugus formation during Pleistocene time.

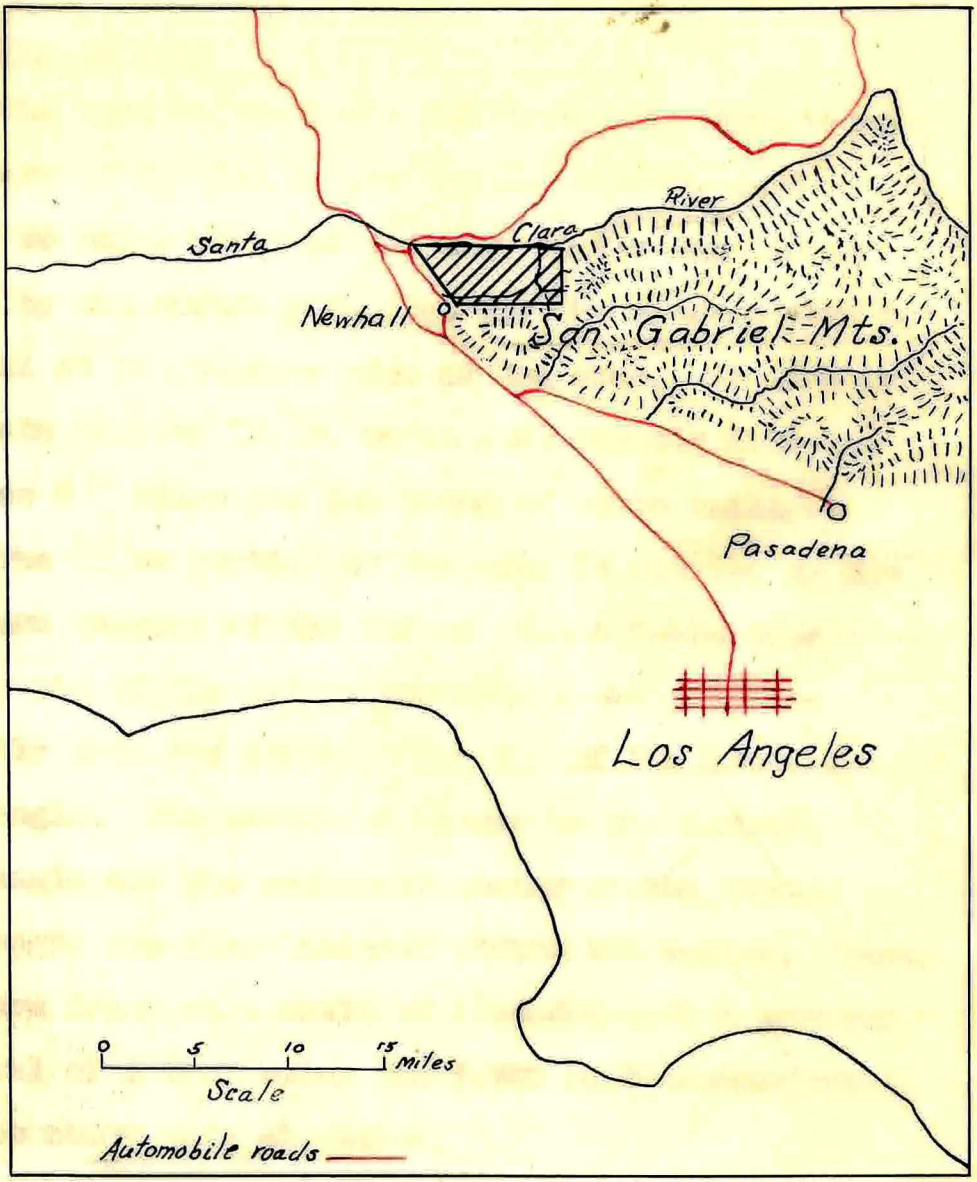

Fig. 1. Sketch map showing location of the area studied. Area marked by cross hatching.

INTRODUCTION

Location of Area

The area in which the field work for this report was carried on lies in Los Angeles County, California, about 25 miles north of the city of Los Angeles as shown by the sketch map, Fig. 1. The nearest town is Newhall at the western edge of the area. It lies on the main highway (U. S. route #99) running from Los Angeles to Mojave and the towns of Owens Valley.

The major portion of the area is covered by the northern quarter of the United States Geological Survey map of the Sylmar quadrangle and projects slightly into the southern portion of the Humphreys quadrangle. The northeast corner of the Newhall quadrangle and the southeast corner of the Saugus quadrangle are also included within the region. These maps are drawn on a scale of 1/24,000 with a contour interval of 5 feet below the 1,900 foot contour and 25 feet above this elevation.

The Santa Clara River flowing along the northern boundary is joined near the eastern edge of the area by Sand Canyon draining north from the San Gabriel Mts. Taking its name from this canyon, the region will be referred to as the Sand Canyon area throughout the rest of this report.

Size and Natural Boundaries

The region under consideration is roughly triangular in shape, the base of the triangle being formed by the Santa Clara River Valley on the north and the two sides by the crystalline mass of the San Gabriel Mts. and the lowlands between Saugus and Newhall.

The area of this triangle is approximately 20 to 25 square miles, most of which was covered by the writer during the course of the field work.

Purpose of Investigation

This investigation was carried out in partial fulfillment of the requirements for the degree of Master of Science at the California Institute of Technology. The work forms a unit in an extensive areal mapping program designed to cover those portions of the Santa Clara River basin lying between the San Gabriel Mts. on the south and the crystalline massif extending eastward from Liebre Mountain on the north.

It is hoped that by the final piecing together of a number of detailed studies, made possible by the splendid series of large scale maps that are now in the process of publication by the United States Geological Survey, some light will be shed on the problem of Coast Range structure.

Much of this area - including that studied by the author - has already been mapped and described by W.S.W. Kew in U.S.G.S. Bulletin number 753. This work, then, cannot be considered an original investigation of a previously unknown area, but is to be taken merely as an attempted refinement of an extensive reconnaisance map. In view of the area covered in a relatively short period of time on small scale maps, the author has been amazed at the general average accuracy of this earlier piece of work and advances with some trepidation what slight changes he has felt called upon to make.

The writer here wishes to express his thanks to Dr. John H. Maxson of the California Institute of Technology for having suggested this piece of field work and for his many helpful suggestions and criticism during the course of the field work. The author also feels greatly indebted to Messrs. Curry and Kemnitzer of the same school for their aid and comments during portions of the field work.

Topography and Physiography

The Sand Canyon area contains the first low series of hills immediately north of the high, rugged San Gabriel Mts. The maximum elevation attained in the sediments is 2,390 feet at a point in the southwest quarter of the area. The ridges decrease in altitude north towards the Santa Clara River and northwest to Saugus. The lowest elevation, 1,150 feet, is at Saugus.

From this it is evident that the relief within the sediments is not very great as the maximum difference in elevation is only 1,240 feet. This fact becomes even more apparent upon comparison with the slopes found in the immediately adjoining San Gabriel Mountains. Here differences in elevation of 2,000 feet or more are common, while in the sediments the average relief does not exceed 275 feet.

Fig. 2 shows clearly the relatively much finer textured topography found within the sediments as compared to the adjoining crystalline mass. Long, steep slopes descend from the higher elevations of the latter, cut occasionally by deep canyons and only slightly dissected by minor streams. On reaching the area underlain by the soft sedimentary formations, however, a striking change takes place. The ridges become strongly dissected by many small ravines, the floors of the larger canyons become wider and more

Fig. 2. Airplane photograph showing difference in topography between the sedimentary rocks and the basement complex (bc).

heavily alluviated, in short, the whole aspect of the lower country is constructed along finer lines.

Within the sediments not much difference is to be observed in the topography of sections underlain by different formations. The coarse gravels of the Quaternary and Saugus formations tend to slightly coarser textured slopes while the maximum fineness of dissection is in the Mint Canyon. The difference, however, is small and is greatly overshadowed by comparison with the topography of the main mountain mass.

Flowing from east to west along the northern boundary of this area, the Santa Clara River is the most important factor governing its drainage pattern. Along the north front all canyons enter directly into the Santa Clara. The largest of these is Sand Canyon, from which the area derives its name. It is formed at the foot of the San Gabriel Mts. by the junction of several canyons. It has a broad alluviated floor sloping northward about 96 feet to the mile.

From near the head of Sand Canyon a long straight ridge extends in a northwesterly direction to Saugus, thus forming the main divide within the area. On its south flanks the gullies open into Placerita Canyon which flows west to Newhall along the general line of contact between the crystalline rocks of the San Gabriels on the south and the sediments of the

Santa Clara basin. About midway of its length a point of crystalline rock projects across its path, through which it winds in a narrow gorge. It has an average gradient of 74 feet per mile.

The structure of the region does not seem to exert a very strong control on the drainage. Of the larger streams, Placerita Creek seems to be the most strongly influenced, in this case by the contact between the hard metamorphics and the sediments. The presence of the gorge cut through hard rock is a rather anomalous feature in this explanation, but the tortuous course that it pursues in this section suggests that it became entrenched during an earlier cycle of erosion during which time this area was overlain by sedimentary beds.

Although Placerita Canyon is the only major drainage line showing evidence of control, many of the small gullies feeding down from the ridges clearly parallel the strike of the underlying strata. This conformity is frequently valuable in visualizing the structure when the slopes are too brush-covered to yield many outcrops.

Two physiographic features give a clue to the history of the region following the deposition of the Saugus formation during the early part of Pleistocene time. The first of these is the uplift

of the San Gabriel Mts. along lines of a faulting during such relatively recent time that there is still apparent a partially dissected fault scarp facing the sediments. The flat lying terrace deposits truncating the upturned Saugus formation, however, point to a period of quiescence during this uplift. The streams within this region went through a period of aggradation, depositing coarse debris derived from the San Gabriels over their extensive flood plains. Following this period of quiescence in the basin a general slight uplift without folding has allowed the streams to cut into the terraces.

STRATIGRAPHY and PETROGRAPHY

General Statement

The formations encountered during the field investigations are five in number, all of Teriary age ranging from upper Miocene to Pleistocene.

The oldest present is the Mint Canyon, a land laid deposit which is overlain unconformably by the marine Modelo of upper Miocene age. Above this comes the Fernando group, the lower member of which, the Pico, lies above the Modelo unconformably. The Pico is also marine. It is in turn separated from the Saugus, upper Pliocene, by an unconformity. In the Sand Canyon area the Saugus is probably a river deposit. Uppermost in the series comes the Pleistocene Terrace deposits which lie without dip over the upturned edges of the Saugus and older formations.

A generalized section is given showing the relation of the rocks exposed in this area to older members of the Tertiary section of the Los Angeles region (Fig. 3).(1) Approximate thicknesses are given for the formations at their type localities.

(1) Kew, W.S.W.; U.S.G.S. Bull. 753, pg. 6, 1924

Geologic age	Kew 1923; U.S.G.S.Bull. 753, 1924
	Parts of L.A. & Ventura Counties
Quaternary	Alluvium
	Terrace deposits 250'
Pliocene	Saugus formation (u.Pliocene & Pleistocene) 2,000'
	Pico formation (l.Pliocene) 4,000'
Unconformity	
Miocene	Intrusive basic rocks Modelo formation (u.Miocene) 9,000' Mint Canyon formation (u.Miocene) 4,000' Topanga formation (m.Miocene) 6,000' Vaqueros formation (l.Miocene) 100-1,800'
Oligocene	Sespe formation (Oligocene) 3,500-4,000'
Eocene	Tejon formation (u.Eocene) 2,000'
	Meganos formation (m.Miocene) 2,000-3,000'
	? ?
	Martinez formation (l.Eocene) 1,500-3,500'
Unconformity	
Cretaceous	Chico formation (u.Cretaceous) 5,500'
	Absent
Unconformity	
Jurassic	Absent
Jurassic?	Granitic rocks (Jurassic?)
Pre-Jurassic	Metamorphic rocks (pre-Jurassic)

Fig. 3. Generalized column showing relation of the formations found in the Sand Canyon area to the other formations found in the Santa Clara basin (taken from U.S.G.S.Bull. 753)

Basement Complex

The details of the petrology of such of the crystalline rocks of the San Gabriels as occur in the Sand Canyon area have not been worked out by the author since the major concern of this problem is with the structures in the sedimentary series, not the crystallines. In general the age of the metamorphic rock is generally assumed to be pre-Jurassic and most of the igneous intrusions by which they are invaded are thought of as having occurred at the same time as the igneous injection of the Sierra Nevada in late Jurassic or early Cretaceous time.

Mint Canyon Formation

The first description of the Mint Canyon formation was published by O. H. Hershey (2) who gave it the name of the Mellenia series. It was later renamed

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(2) Hershey, O. H.;

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by W. S. W. Kew who applied to it the name Mint Canyon: "Above the conglomerates of the Sespe (?) formation in the upper part of the Santa Clara Valley are beds several thousand feet thick which have been called by Hershey the "Mellenia series" and which from their stratigraphic position and fauna are believed to be

of upper Miocene age. As the term "Mellenia", so far as fould be ascertained, is not a place name, and its origin is doubtful, this series of strata is here renamed, to correspond to the rules of nomenclature of the United States Geological Survey, and the term Mint Canyon formation is adopted because the beds are particularly well developed in the Mint Canyon region."(3) Since the publication of this bulletin

(3) Kew, W.S.W.; U.S.G.S. Bull. 753, pg. 52, 1924

the name Mint Canyon has supplanted the older term and is now universally used.

The Mint Canyon, as exposed in the type area, has been shown to be a land laid deposit resting unconformably on beds questionably referred to the Sespe by Kew.(4) In the same bulletin he gives a

(4) Idem. pg. 52

thickness for the deposits of 4000 feet plus or minus. The general characteristics of the formation in the type region are those of a variable sandstone and conglomerate. According to Maxson:(5) "Beds

(5) Maxson, J.H.; Carn. Inst. Washington Pub. #404, pg. 81, 1930

comprising the formation are heterogeneous and vary laterally. There is no well marked break in type of sedimentation, although it was observed that beds of reddish tinge predominate in the lower part of the exposed section, intermingled brownish and grayish beds in the middle portion, and grayish colored deposits are particularly in evidence in the uppermost portion. Gray beds are, however, common throughout the formation, and the more highly colored deposits do not show sufficient regularity in their distribution to be useful in establishing zones.

The lower beds are largely coarse red sandstones with interbedded grayish and reddish silts. They are occasionally fossiliferous. In the middle part of the formation brown soily members and gray silty members, both fossiliferous, are interbedded with coarse, gray, crossbedded conglomerates and fanglomerates."

As exposed in the Sand Canyon region this formation represents a southward extension from the type area almost directly north on the other side of the Santa Clara Valley. Here they represent the lowest beds exposed, resting directly on the basement complex along the eastern margin of the area. Their general characteristics agree with the description quoted above. Between Sand Canyon and the eastern margin of the area the beds have an average strike from

N10-20° E dipping NW from 20 to 30°. They are composed of incoherent brown to gray sandstones with interbeds and lenses of pebbles, and occasional beds of better consolidated silty to shaly beds (Fig. 4a). Near the mouth of Bear Canyon in the southeast corner of the area a heavy, brown colored conglomerate - almost a breccia - was noted. It was composed almost entirely of angular to subangular cobbles of metamorphic and igneous rock. The beds were traced southward to the low ridge separating Coyote and German Canyons, but could not be followed north of Iron Canyon. They appear to be basal beds.

At the divide separating Placerita Canyon from Sand Canyon a soft shaly member of the Mint Canyon is exposed which gives rise to rolling topography, strongly inclined to slump. The shale is greenish in color and very incoherent. Two ash beds occur in this section separated by about 100 feet of material. Neither bed is over 10 to 15 feet thick, and the lower is very discontinuous (Fig. 4b). The upper bed was traced for some distance and is indicated on the map (Plate 1) by a series of dots.

In the vicinity of the small anticline and syncline in the northern and central parts of section 28 the Mint Canyon outcrops as a series of gray sandstones and conglomerates of different degrees of

Fig. 4a. Gray, shaly member of the Mint Canyon formation, cut by a small fault.

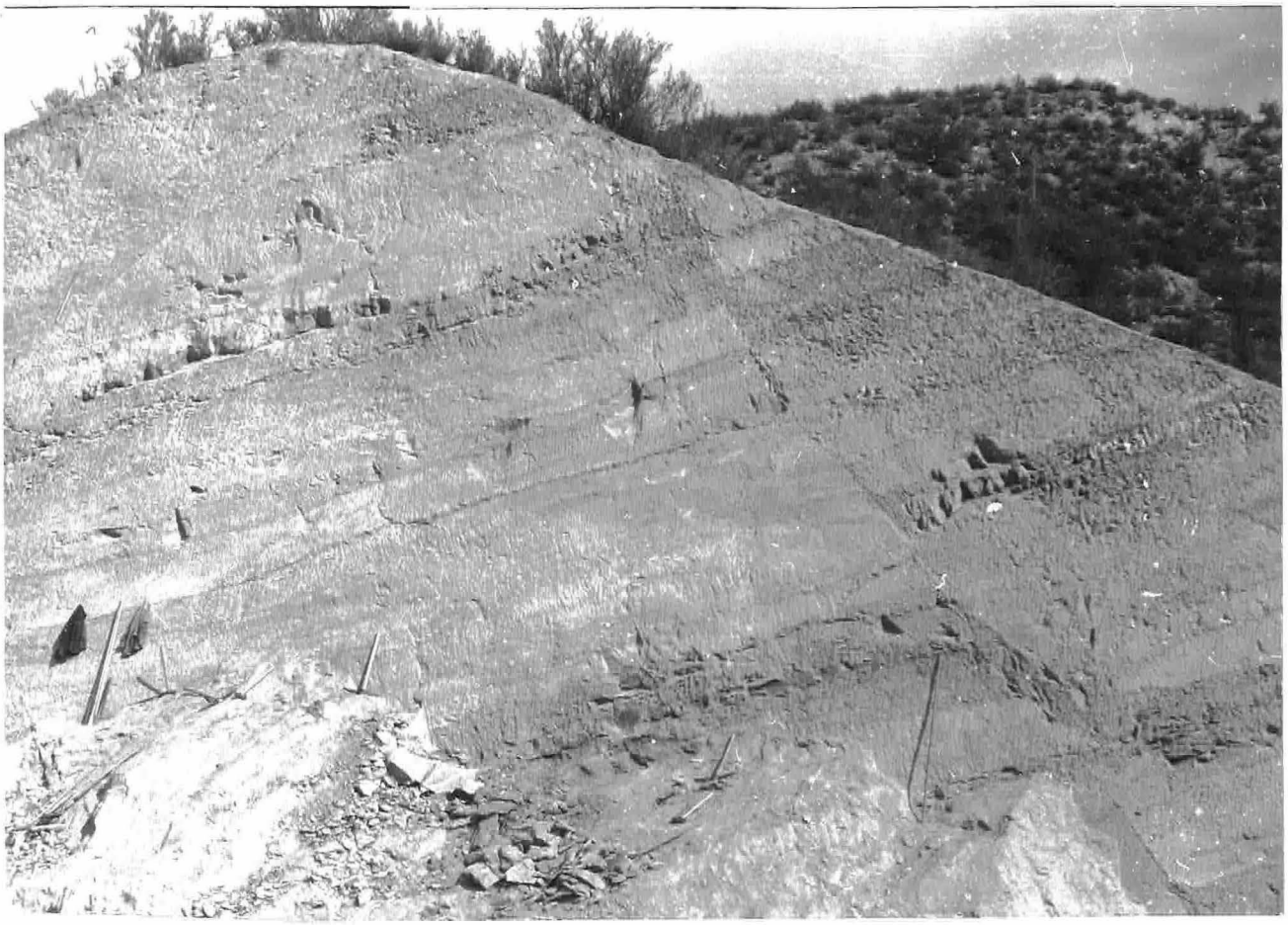
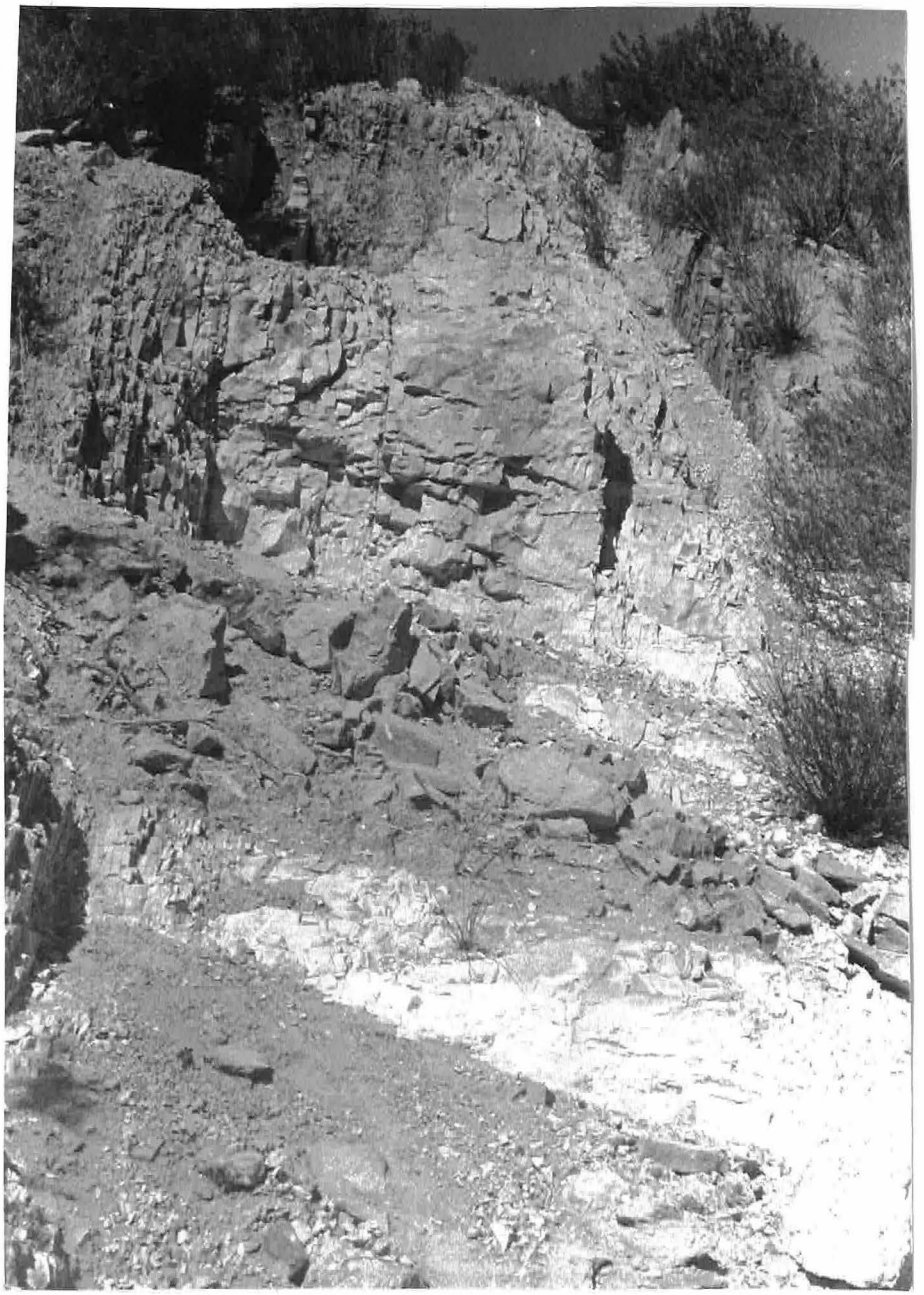


Fig. 4b. Ash bed in the Mint Canyon Formation



consolidation. Ash beds were again found in this vicinity, none of which could be traced for any distance. The most persistent bed is shown as a series of circles where it bends over the steeply dipping axis of the small anticline. A thin, brown sandstone, hard and flaggy, outcrops at one or two horizons in this section. It frequently shows well developed ripple marks.

The lithology and nature of the contained fauna indicate that the Mint Canyon was laid down on land. The beds of sand and conglomerate with their lateral variability indicate stream deposition. The presence of beds of shale point to periods when deposition took place in bodies of quiet water or in very slow flowing streams, carrying only the inert material. The basal conglomerate beds mentioned above point to an adjacent, high standing mass of material essentially the same as that composing the present day San Gabriel Mts. Although it would be rather hazardous to suggest that the mountains as blocked out by the faults of today were present during Miocene time, it does seem apparent that the margin of the basin of deposition was emphasized by a sharp upwarping.

As shown by the areal map the Mint Canyon is the most extensively exposed formation in the area. Along

the eastern margin it abuts directly against the metamorphic rocks of the higher mountains while in the southern and western portions it is overlain directly by the Saugus formation. Throughout the northern half of the large northwest trending syncline it is overlain by Pico and only in the relatively small area north of the headwaters of Placerita Creek does it underlie the Modelo formation.

The stratigraphic position of the Mint Canyon is not as yet completely understood. Much of the work on this question has been done by Dr. Maxson, who, from his studies of the vertebrate fauna collected in it, has placed it as a near correlative of the Barstow beds: "Faunal relationships suggest that the Mint Canyon formation is younger than the Mascall, Virgin Valley, and Cedar Mountain occurences, while close to, although somewhat younger than Barstow. The Ricardo is slightly younger than the Mint Canyon. This evidence appears sufficient to assign an upper Miocene age to the formation. Further information bearing upon age is given by the stratigraphic position. If the overlying marine formation is of approximately Cierbo age as believed by Woodring, the Mint Canyon formation is precluded from occupying the uppermost

part of the Miocene represented by the Santa Margarita and possibly by a portion of the Cierbo. The Mint Canyon formation is further depressed in the geologic column by the hiatus during which deformation and erosion of the Mint Canyon beds occurred before submergence and deposition of the overlying marine series. Taking into consideration the facts available, it appears that the Mint Canyon beds were deposited during approximately the middle portion of the upper Miocene."(6) R. A. Stirton, in a recent

(6) Idem. pgs. 85-86

publication,(7) has interpreted the evidence of the

(7) Stirton, R.A.; Am. Journal Sci., V. XXVI, pg.570,1933

mammalian fauna slightly differently, making the Mint Canyon a correlative of the Ricardo-Esmerelda series thus placing it higher than the Barstow and more nearly an equivalent of Woodring's "Cierbo" formation. Which of these two views is correct remains to be seen, although it seems apparent that some light might be shed on the question by a careful investigation of the Modelo (?) where it overlies the Mint Canyon. If a more extensive fauna were collected which checked Dr.

Woodring's determination,[8] it would not seem

(8) Woodring, W.P.; Bull. G.S.A.; vol. 41, pg. 155, 1930.

plausible to place the Mint Canyon at exactly the same time level as the Cierbo as Stirton[9] has done

(9) Stirton, R.A.; Am. Jour. Sci., vol. XXVI, pg. 569, 1933.

in his correlation table.

The following faunal list is taken from Dr. Maxson's description:[10]

(10) Maxson, J.H.; Carn. Inst. Washington Publ. #404, pgs. 87-111, 1930.

Testudinata

Aves

Carnivora

Aelurodon sp.

Lagomorphi

Hypolagus ? cf. spachensis Cazin

Proboscidea

Trilophodon sp.

Equidae

Parahippus ? (Archeohippus) near mourningi Merriam

Merychippus sumani Merriam

Merychippus sp.

Merychippus (Protohippus) intermontanas Merriam

Protohippus sp.

Hipparion ? sp. A

Hipparion ? sp. B

Hipparion ? near mohavense Merriam

Rhinocerotidae

Rhinocerotid indet.

Tagassuidae

Prosthennops ? sp.

Camelidae

Miolabis Californicus n-sp.

Alticamelus ? sp.

Antilocapridae

Merycodus near necatus Leidy

Antilocaprid indet.

Oreodontidae

Oreodont cf. Merychyus

Three localities within the Sand Canyon area have yielded fossil remains. The first is located in the northern part of the southeast quarter of section 35, in a bed of gray sandstone forming a small bluff close to Sand Canyon. At this point was found Prosthennops ? sp. In a road cut just south of the railroad in the east central part of section 23 was

found the lower jaw of Hypohippus sp. ?. The description of this form has not yet been published. Finally in the northeast quarter of section 32 where the Mint Canyon formation abuts against the San Gabriel fault a considerable amount of scattered material was found by Mr. Curry and the author in a bed of soft gray shale. None of this material has been identified yet, but with further work in this locality, doubtless more diagnostic material can be found.

Modelo (?) Formation

The Modelo Formation was apparently first described by E. H. Eldridge[11] from the type section in Modelo and Hopper Canyons north of the Santa Clara Valley, Kew[12] later redefined the formation to include some beds that Eldridge had placed in the Vaqueros. Kew states: "As redefined the Modelo formation aggregates 9,000 feet in thickness. It is primarily clay, diatomaceous shale, and fine-grained laminated sandstone and cherty beds, and contains huge lenses of coarse brown and tan sandstone about

(11) Eldridge, G. H.; U. S. G. S. Bull. 309

(12) Kew, W.S.W.; U.S.G.S. Bull. 753, pg. 6, 1924

4,000 feet in maximum thickness. It rests unconformably on the Topanga formation, and is unconformably overlain by the Pico formation, the basal division of the Fernando group."

In and near the Sand Canyon area, lithologically similar beds, unconformably overlying the Mint Canyon formation, have been tentatively assigned to the Modelo by Kew[13] on the basis of their

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(13) Idem, pg. 67

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stratigraphic position and a limited invertebrate fauna taken from Haskell Canyon. This formation has about the smallest areal distribution of any of the formations found in the Sand Canyon region. It is confined to the southern end of the large northwest trending syncline, in the vicinity of the divide separating Placerita and Sand Canyons. It is also involved in a small syncline just south of the larger one. In both of these localities, the Modelo overlies the Mint Canyon presumably unconformably, although no direct evidence was found in this region. At the south end of the large syncline it is overlain by Pico while somewhat farther west it lies in contact directly with the Saugus.

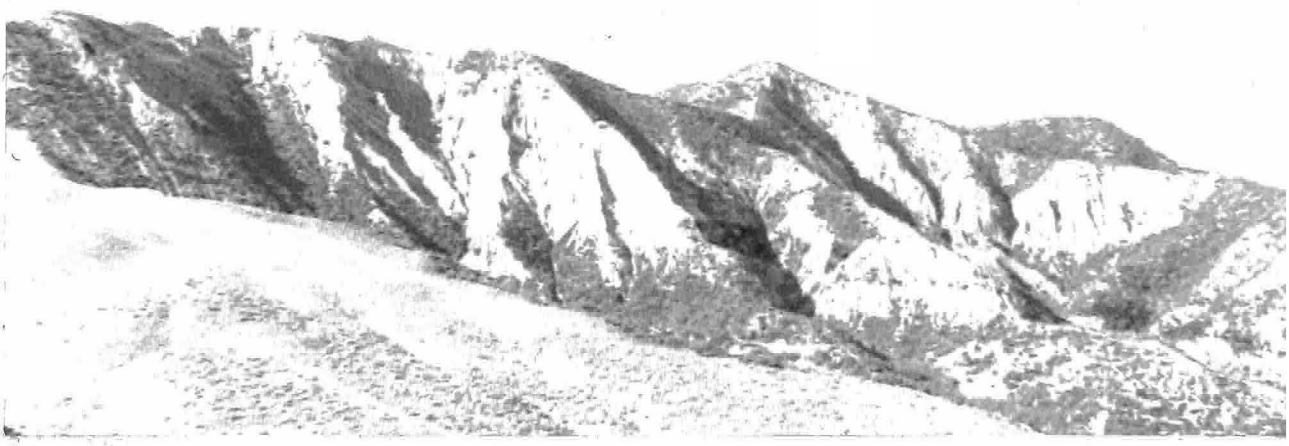
The beds as exposed in this region are generally creamy to buff colored, thin-bedded and diatomaceous shales (Fig. 5). These seem to grade laterally along the south end of the large syncline into beds averaging 10 to 15 feet in thickness, but still composed of fine grained material. In the smaller syncline to the south a similar series is exposed with the thinner-bedded material overlying the thicker beds. Throughout the area in which it is exposed, the Modelo shows the characteristics of an incompetent formation. Dips are everywhere variable and small flexures can be observed in any extensive exposure. It supports, mainly, a rather thick sagebrush growth.

In the northwest corner of section 2 just above the Mint Canyon contact a few pelecypods were found in the shale. These were not identified, but they were evidently of marine origin. Apparently the formation was deposited under deep water conditions at a time when the whole Santa Clara basin was invaded by an arm of the ocean.

Pico Formation

The Pico formation is exposed only in the large syncline lying immediately west of Sand Canyon where, at the southern end it lies above the Modelo shale and below the Saugus formation. In the central and

Fig. 5. Bluff of Modelo exposed in Syncline near Sand Canyon.



northern portions however, it lies between the Mint Canyon and Saugus formations.

The Pico as first described by Eldridge and Arnold[14] was not differentiated from the Saugus

(14) Eldridge, R.H.; U.S.G.S. Bull. 309

formation, the two units being called the Fernando Group. In 1923 Kew[15] named the older unit the

(15) Kew, W.S.W.; Am. Ass. Pet. Geol. Bull. V. 7,1923

Pico formation on the basis of the unconformity separating the two units and described Pico Canyon, Los Angeles County as the type locality. Kew thus defines the formation:[16] "It is of marine origin and consists

(16) Kew, W.S.W.; U.S.G.S. Bull. 753, pg. 70, 1924

mainly of both fine and coarse grained sandstones with a few interbedded strata of conglomerate. It rests unconformably overlain by the Saugus formation.------ the unconformity between the two (Pico and Saugus) is marked, and the separation is made largely on that basis.--------- The fauna in the Pico, from which large collections have been made at Elsmere Canyon, indicate that it is of lower Pliocene age."

In the Sand Canyon area the best exposures are to be found near its northern limit where it outcrops as a prominent bluff. The material here is a fine grained, incoherent sand, a dull brownish in color. It tends to weather into steep banks, at times approaching a 'badlands' topography. At the base a fairly consistent, white colored basal conglomerate was observed, in which the pebbles were beautifully rounded. Near the top it showed a tendency to grade laterally into a coarse conglomerate very similar in appearance to the Saugus formation. In several places this led to some confusion as to the accurate placing of the contact between the two formations. Invertebrate remains are scattered liberally throughout the formation and are often useful in field identification where the formation is underlain by Mint Canyon beds.

Invertebrate fossils are abundant throughout the exposures of Pico, especially near its northern limit. In the southwest quarter of section 27 gastropods may be found, loosely weathered out of the soft, unconsolidated beds. In the west central part of section 27, on the shoulder just west of the road leading south from Humphreys there is another good occurrence. It was in this region - specifically on section line 27-28 - that the skull of a cetothere was found by E. L. Furlong and described by Remington

Kellogg.[17] The skull is described as showing the

(17) Kellogg, Remington; Uni. Calif. Publ., Vol. 18, pgs. 449-457, 1929

primitive characteristics of Lower Miocene, or earlier whales and therefore presenting a decided anomaly in being found in a formation of Lower Pliocene age. Unfortunately its incarceration in a calcareous boulder brings up the possibility of its being secondary in origin and not truly representative of the Pico.

The large proportion of fine material present in this exposure of Pico points to deposition in deep, quiet water with either a distant or low lying land mass contributing the sediments. This view is altered somewhat by the presence of interbedded conglomerate lenses indicating a rapid transport of material. It is possible that this period of deposition is characterized by rather abrupt changes in level of the adjoining land mass.

Saugus

The upper division of the Fernando Group was first recognized by Hershey[18] who described it from

(18) Hershey, O. H.;

the type locality near Saugus, California, at the

northwest end of the Sand Canyon area. Its aerial extent is perhaps the greatest of any encountered during the field work. Swinging in a broad arc from Soledad Canyon over the nose of hills projecting out toward Saugus, it swings into Placerita Canyon, extending almost to the headwaters of this creek. On its southern and western flank it is unconformably overlain by Pleistocene river gravels, and on its northern margin it overlies the Mint Canyon. In the isolated syncline near Sand Canyon it is found lying above the Pico (Fig. 6).

The physical characteristics of the Saugus are variable. Along the upper part of Placerita Canyon and in the vicinity of Sand Canyon it is almost entirely a coarse conglomerate, a reddish brown in color, with only occasional lenses and beds of sand. The boulders are all of igneous and metamorphic origin suggesting a derivation from the neighboring hills. In places they attain a good size, being 2 feet or more in diameter. Proceeding northwestward the beds of loose sand become more common while the heavier beds die out until, in the vicinity of Saugus, the formation is almost entirely formed of poorly consolidated, coarse to medium sandstone, varying from reddish brown to gray in color. Oil sands occur in

Fig. 6. Exposure of Saugus sandstone and conglomerate overlying the Pico.


Ts
Tp

one or two of the smaller canyons tributary to Placerita Canyon.

In this region the deposits seem to be fluviatile or deltaic in occurrence, as suggested by Hershey[19] and Kew.[20] Farther west they are

(19) Idem. pg. 360.

(20) Kew, W.S.W.; U.S.G.S. Bull. 753, pgs. 82-83, 1924.

supposed to be marine, fossils having been found at various localities.

The Saugus, then, is made up of fluviatile and deltaic conglomerates in the vicinity of Placerita Canyon which grade westward and northward into marine deposits. Moreover, the rocks comprising the conglomerates is made up of material typical of the crystalline mass of the San Gabriels. The inference, as in the case of the Mint Canyon basal conglomerate, is that there was a high standing mass immediately south of Placerita Canyon during deposition of the Saugus formation which shed sediments northward into an ocean filled basin. It seems probable from this that during the post-Pico uplift and continuing into the period of deposition of the Saugus the San Gabriel

range was being either upfaulted or upwarped relative to the Santa Clara basin of deposition. Whether this was accomplished by differential warping or by actual faulting is difficult to say, but evidently sufficient elevation was attained to allow rapid removal of relatively coarse material.

The age of this formation has been generally placed as extending from upper Pliocene to Pleistocene, on the basis of its stratigraphic relation to the overlying Pleistocene deposits.(21)

(21) Idem. pgs. 81 to 89.

Quaternary Terrace Deposits

Well exposed in the western end of the Sand Canyon area between Saugus and Placerita Canyon are a number of flat topped ridges quite well dissected by small canyons. These represent the post-Saugus terrace deposits separated from that formation by a decided angular unconformity. They are almost entirely made up of coarse boulders, subangular to round, in a sandy matrix. They have a striking resemblence to the Saugus conglomerates being made up of very similar material with about the same weathered appearance. The best means of telling the two apart is by difference in dip, the gravels

being nearly or actually flat while the Saugus has a pronounced dip.

Although the greater extent of these beds is confined to the western part of the region, one or two smaller patches have been noticed east of Sand Canyon. The most prominent of these lies at the mouth of Bear Canyon formation. It is level bedded, a dark reddish brown in color and composed of coarse metamorphic material.

STRUCTURE

General Statement

Structurally the Sand Canyon area is an element in the great east-west trending branch of the Coast Ranges extending roughly from Santa Barbara eastward through the San Gabriel and San Bernardino Ranges. Specifically it lies in an angle in the northwest corner of the San Gabriel Mountains. Crystalline masses bound it to the east and the south, meeting at nearly right angles near the head waters of Sand Canyon. Lying thus in the drainage of the Santa Clara river it forms a structural unit of this basin and as such its relation to the deformation of the basin is best shown by the structural sketch opposite page 94 of Kew's U.S.G.S. Bulletin 753.

The folding and faulting within the Sand Canyon area involves the Miocene, Pliocene and Pleistocene formations in varying degrees. Quaternary deposits do not seem to have been involved in the faulting, although they have suffered uplift to a certain extent.

The structual pattern indicates two dominant trends, one N70° W, the other N50° W. The first is typified by the long San Gabriel fault, the parallel fault north of it and the folds lying between the two faults. The other trend is followed by the large syncline west of Sand Canyon and the small

pair of folds farther west. Another trend is expressed in this region, although it lies for the most part outside the area covered by this map. This direction, N30° E, is the trend of the eastern boundary between the sedimentary rocks and the basement complex. The start of this line is shown between Bear and Iron Canyons. A small, subparallel syncline is shown near German Canyon.

Detailed Description

Faulting

The largest single structure found in this region is the San Gabriel fault or fault zone, (Plate I, Fig. 7), which enters the area near German Canyon proceeding in a northwesterly direction through the sediments until it is hidden by the quarternary terrace deposits near Saugus. To the west this fault extends down the Santa Clara River to Castaic Valley and the hills farther on. Eastward it crosses the San Gabriel Mountains over the divide between Pacoima Canyon and the Santa Clara River. Along the south front of the mountains it follows the headwaters of Little Tujunga Canyon and finally splits, the main branch following the east and west branches of San Gabriel River.(22)

(22) Kew, W.S.W.; U.S.G.S. Bull. 753, pg. 99, 1924

Fig. 7. Airplane photograph showing trace of the San Gabriel fault through the sedimentary rocks.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A branch or connecting fault leaves the main San Gabriel zone near Pinetos Canyon, crosses Placerita Creek, makes a sharp bend to the south recrossing Placerita Canyon where it leaves the area.

The most definite information concerning the San Gabriel fault was obtained where it crosses German Canyon. A fault plane, lying in a zone of crushing, indicated a strike of N80° E and a dip of 85° N. Although it is not believed that this is the major fault plane, these measurements serve to give some idea of the dips within the zone. General evidence from the trace of the fault seems to indicate that it is very steeply dipping, more nearly vertical than otherwise.

The evidence as to direction of motion is conflicting. From Placerita Canyon westward through the sedimentary beds the fault zone lies almost entirely in the Saugus formation and no direct evidence can be found to determine the offset except drag folds. Near the line of section D-D' it was found that the Saugus beds south of the fault are upturned against a massive conglomerate bed on the north. Farther west soft beds of Saugus to the north of the fault are sharply bent down. Both of these cases point to uplift of the block north of the fault relative to the block south of it.

From the junction of the San Gabriel fault with the one immediately south of it to German Canyon the high standing crystalline mass indicates uplift of the southern block relative to the deposits north of it. Farther east along the southern front of the San Gabriel Mountains similar evidence goes to show that once more the northern block was uplifted relative to the southern one. Along the fault branch from the San Gabriel at Pinetos Canyon the motion has apparently been up to the south.

This evidence seems to point to a rotation of blocks around a north-south or northeast-southwest axis passing through the region between the headwaters of Sand Canyon and Pacoima Canyon, the main mass of the San Gabriels having been uplifted with throw increasing to the east. In a similar way the smaller crystalline mass would have increasing throw to the west. With such a mechanism the San Gabriel fault in the Sand Canyon area would be a relatively unimportant branch, the wedge of sediments separating it from the next fault to the south being a slightly downdropped block.

Parallel to the San Gabriel fault and north of it another fault cuts through the Hint Canyon formation (Figs. 8a, b.). The trace of this fault strikes

Fig. 8a. View southeast showing course of fault to point where it passes under the Pico and Saugus formations in the syncline near Sand Canyon.

Fig. 8b. Looking northwest along the same fault.

approximately N70°W, forming the northern limit of the Modelo formation. It passes under the Pico and Saugus formations without disturbing their contacts.

The Modelo-Mint Canyon contact immediately west of Sand Canyon is offset in such a way that the Mint Canyon formation is slightly thrust over the Modelo. Although the fault plane is nowhere actually visible, the dip of the fault was taken to be northward from the above evidence. The straightness of the trace, however, is indicative of a high dip. It is shown on cross sections A-A', C-C', and D-D'.

The movement on the fault has been such as to uplift the north side relative to the south. The magnitude of this movement is conjectual, but it was at least enough to remove the Modelo from the region immediately to the north by erosion. Drag folding farther west in the vicinity of the small anticline and syncline supports this interpretation.

The age of the fault is evidently pre-Pliocene, since the overlying Pico and Saugus formations are undisturbed in the large syncline.

Along the eastern border of the area the contact between the basement complex and the Mint

Canyon formation appears to be faulted. The fault plane appears to dip steeply westward between 85 and 90°. It joins the San Gabriel fault zone in the complex at the headwaters of Sand Canyon.

Folding

The axis of the syncline adjacent to Sand Canyon extends from Bear Canyon northwesterly to the vicinity of Humphreys, with an average axial direction N55°W. In the southern half of the fold Mint Canyon, Modelo, Pico and Saugus formations are involved in the deformation (Fig. 5). The dips of the two older formations average between 30 and 40°, the Pico and Saugus are less strongly deformed having average dips less than 20°. North of the concealed fault the Modelo formation is missing and the Pico directly overlies the Mint Canyon.

This fold has apparetly suffered two periods of deformation, the first occurring after deposition of the Modelo and probably contemporaneously with the faulting by means of which the Modelo was removed from the northern half of the fold. The second period of folding was subsequent to the deposition of the Saugus during the period of Pleistocene diastrophism. These relationships are indicated in cross sections A-A' and C-C'.

Southwest of this syncline and abutting into it at an approximate angle of 20° is an anticline. (Figs. 9a, b). This fold makes its first appearance in the Modelo formation north of the headwaters of Placerita Canyon. From this point it trends N70° W, the axis lying almost entirely in the Mint Canyon formation with Saugus lapping up along the southern flank.

The fold is distinctly asymmetric with steeper dips on the north flank. The Saugus formation has an average dip of about 20° to the south and the Mint Canyon undoubtedly dips under it at a higher angle as indicated in section A-A', but on the north flank there are dips in the Mint Canyon ranging as high as 70° N with an average of about 40°. Structure section D-D' brings out this asymmetry more clearly. There appears to be a plunge and flattening out of the fold westward where the Saugus contact bends around toward Santa Clara River and the dips are westerly in direction. In the vicinity of the Los Angeles aqueduct the Saugus flattens for a short distance forming a small monocline, but the dips almost immediately become westerly again until they reverse near Baker Ranch forming a small syncline which

Fig. 9a. Looking southeast along the axis of the large anticline paralleling the San Gabriel fault.

Fig. 9b. Same anticline farther west.

trends northeasterly across Santa Clara River.

The north flank of the large anticline is broken by a pair of sharp folds as shown by structure section D-D'. Both the anticline (Fig. 10a) and syncline are steeply folded and plunge 15 or 20° northwest. Their axes trend N55° W. The dips range from 40 to 70° on either flank of the folds and in several places near the axis of the anticline are very nearly vertical. The folds do not show any pronounced asymmetry, although the strata on the northeast flank of the anticline show a steady decrease in dip away from the axis. Somewhat south of section line D-D' an ash bed, included in the anticlinal fold, shows the structure very clearly (Fig. 10b).

Two folds occur in the Saugus formation, one north of the San Gabriel fault, the other south of it near Placerita Canyon. The former is a gentle fold with dips not greatly exceeding 20°. It is cut off by the San Gabriel fault at its west end. The anticline is a short, sharp fold plunging southwesterly.

A small synclinal fold with a northeast trending axis occurs in the Modelo and Mint Canyon formations adjacent to German Canyon and minor flexure was found in the Mint Canyon near Sulphur Springs School.

Fig. 10a. A small, sharply folded anti-. cline in the Mint Canyon formation.

Fig. 10b. The same anticline with the structure outlined by an ash bed.

Times of Deformation

As shown by the legend (Plate I) every formation is separated from the one adjacent to it by an unconformity representing an interval of erosion or diastrophism of greater or lesser magnitude. The least certain of these intervals is that of separating the Modelo formation from the underlying Mint Canyon. In view of the fact that the Mint Canyon is a localized, land-laid deposit and the Modelo a widespread marine formation and the absence of any conclusive evidence pointing to a continuous sequence of deposition the author has followed the general procedure of separating the two units by an unconformity (23). As the Modelo formation has such a slight

(23) Iden, p. 68

areal extent in this region its importance in the structual relation is not great.

Elsewhere in the region the Mint Canyon formation rests directly under either the Pico or Saugus formations, and, as shown by sections A-A' and C-C' (Plate II) it is more intensely folded than the members of the Fernando group. The conclusion follows that at the end of Modelo time the area was subjected to deformation involving folding and faulting with sufficient uplift to have much of the Modelo formation removed by erosion. During this, the post-Miocene epoch of deformation, most of the structures

found in the area were blocked out. The major syncline with its buried fault and the major anticline with its two subsidiary folds underwent their first period of folding. Possibly the anticline and syncline near Placerita Canyon were partially developed at this time also. It is doubtful whether the San Gabriel fault or marginal faults separating the mountain mass from the sediments were formed at this time.

The small exposure showing Pico in contact with Saugus, with the Mint Canyon formation elsewhere making direct contact with the Saugus formation indicates an interval of erosion separating the two members of the Fernando group. Not much evidence as to the nature of the uplift is forthcoming as no good comparison between the dips of the Saugus and Pico formation could be found in the syncline where they are exposed together. This evidence points to the conclusion that in post-Pico time the area was uplifted and possibly deformed slightly, thus allowing the removal of a large part of the Pico formation before deposition of Saugus.

Subsequent to the deposition of the Saugus formation this region again underwent deformation. Deformation was renewed on the folds this time

involving both members of the Fernando group and accentuating the folds in the older underlying formations. The Quarternary terrace deposits lie undisturbed over the eroded edges of the upturned Saugus formation indicating that following the interval of post-Saugus or Pleistocene deformation the basin has remained relatively quiet with only a slight amount of uplift. The crystalline mass appears to have become the active element at this time, gradually being uplifted to its present elevation.

Mechanics of Deformation

In considering the mechanics of the deformation suffered by the Sand Canyon area, the time element is best kept in mind by dividing the consideration into two general periods. The first we shall call the Pre-Pliocene period; the second the Pleistocene period.

1) Pre-Pliocene Period

The pre-Pliocene structual picture first of all involves the concept of a basin, or perhaps more properly, the southern edge of a basin, of unknown age, but certainly pre-Miocene, in which is deposited a land laid deposit, the Mint Canyon. Above this lies the marine Modelo. At the end of Modelo time this

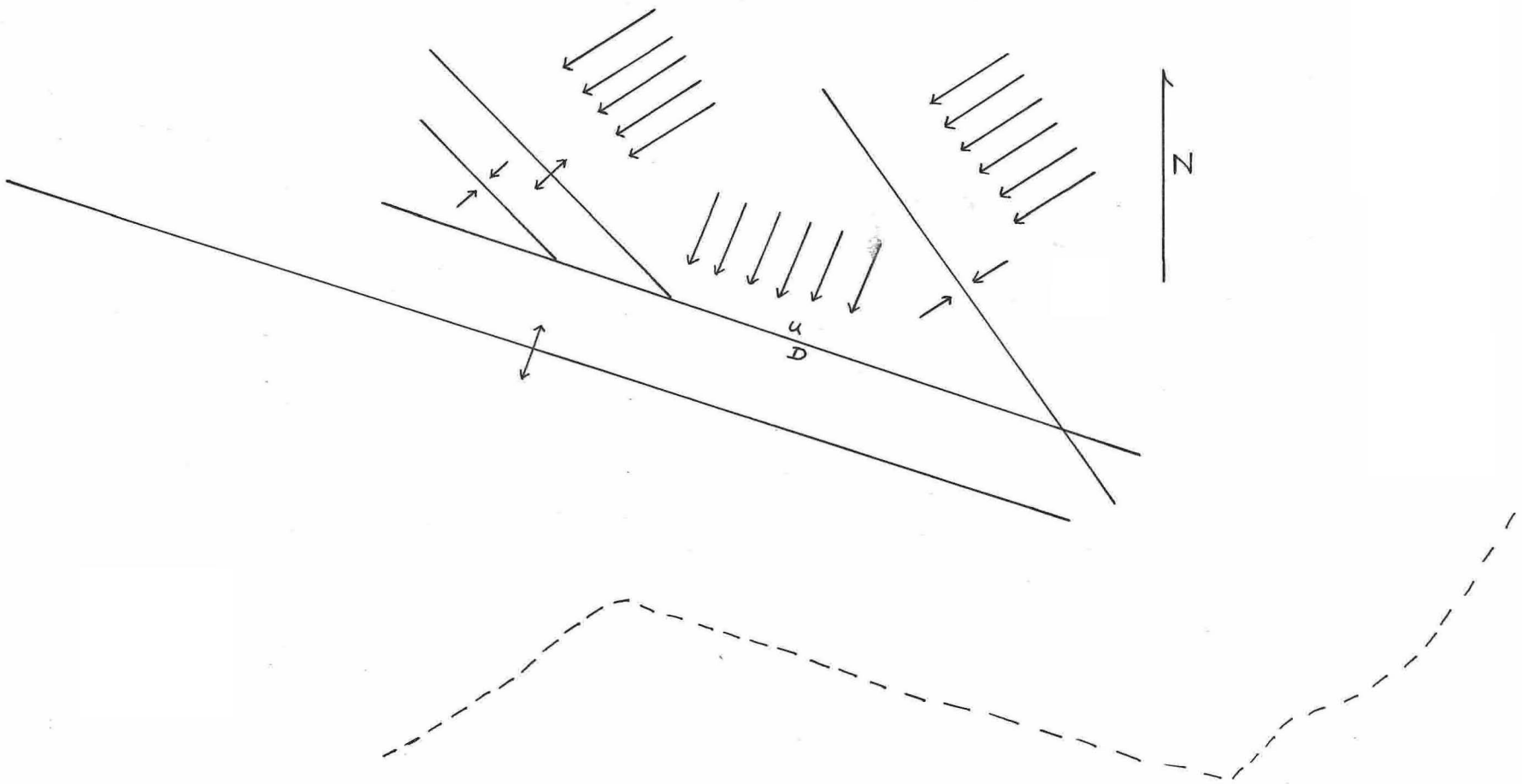

Fig. 11. Structural sketch map — end of Miocene time

portion of the basin is deformed and the thin layer of sediments folded and faulted in the manner shown by Fig. 11. The problem is to determine the nature of the forces producing this arrangement of structures.

Assuming the folds to have easiest relief upwards and the fault to be reverse with - for the sake of simplicity - dip slip movement, the folds would appear to have been produced by the action of two sets of forces, one acting in a direction N20° E, the other N55° E. The general trend of the folds in the Santa Clara Basin indicates a compression or shortening from north to south. If the present day crystalline mass south of Placerita Canyon is any indication of the southern margin of the basin at the end of Miocene time, this would form a stratic bulwark tending to resolve the forces locally in a direction about N20° E. The other set of forces is more difficult of derivation from a general north-south compression. It might best be explained by the proximity of a northeast trending basin margin, occupying approximately the position of the present sedimentary-metamorphic contact between Sand Canyon and Soledad Canyon. This section, however, would

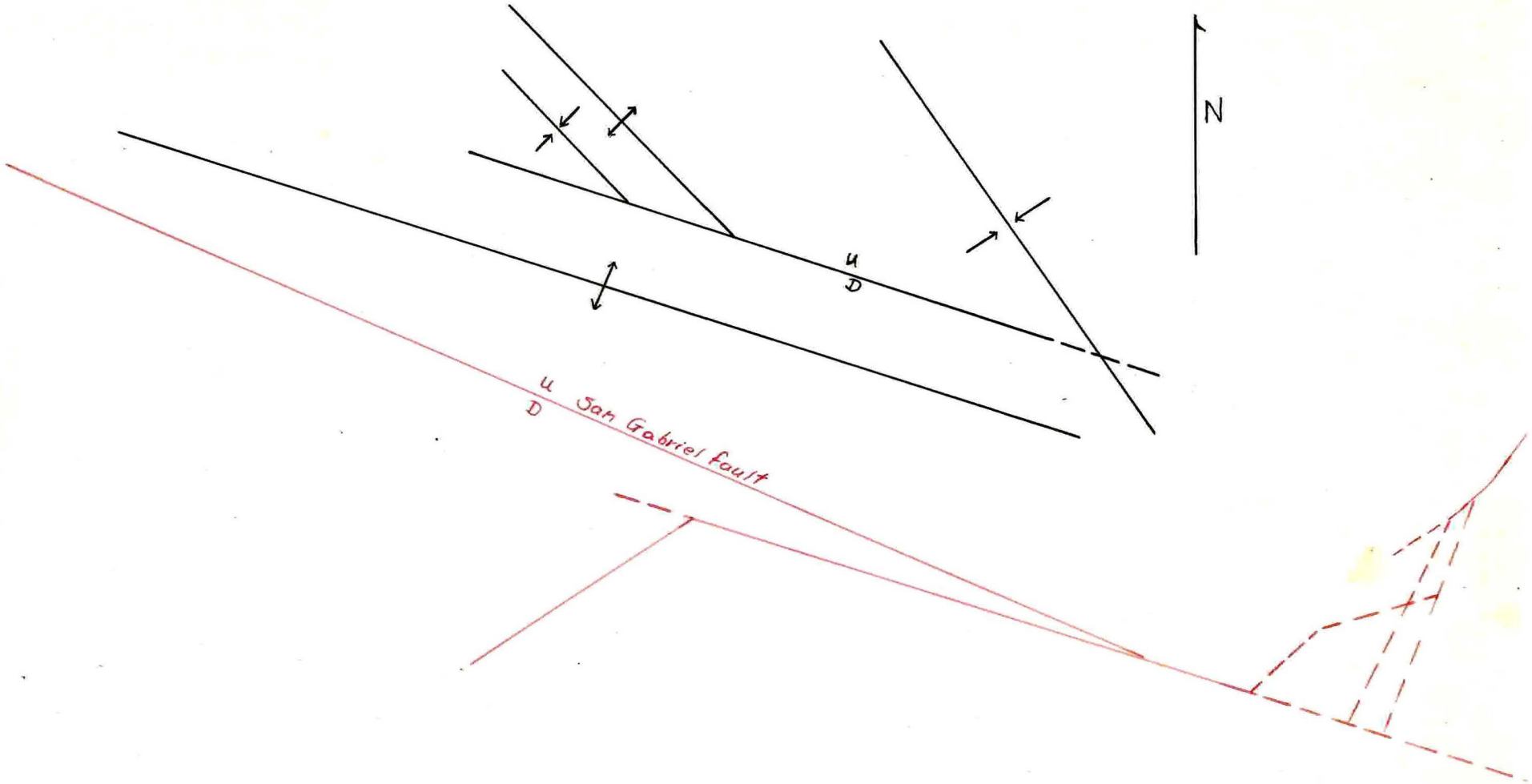

Fig. 12. Structural sketch map

Pleistocene deformation in red

have to be actively in motion to produce the necessary cross folding. It might, for example, have been undergoing a local upwarping which would tend to induce a certain amount of shortening.

2) Pleistocene Period

The structural picture during the second major period of deformation is shown on the structural sketch map (Fig. 12). Old structural trends are still present and some of them active, but only slightly so. New structures have been introduced, but are confined to the margins of the basin.

The situation is similar to the earlier one in so far as compressive stresses have acted on the folds in the sediments. But the presence of the new structures does not appear to be genetically related to the earlier forces. Here the structures are steep dipping faults more nearly to be classed as normal than otherwise.

Inferences as to the nature of the forces causing this latter stage appear to be so implausible that the author does not feel competent to go farther than to point out the fact that there appears to be a change in the type of orogeny affecting this area during the latter period of deformation.

GEOLOGIC HISTORY

A brief outline of the principal geologic events is given here with the author's conclusions concerning the deformation of this region:

1). Pre-Jurassic intrusion of granitic batholith into Cretaceous and pre-Cretaceous sediments.

2). Formation of a basin of deposition for Tertiary sediments.

3). Deposition of the Mint Canyon formation in upper Middle Miocene time with the possibility of a high standing mass nearby to the east and south east.

4). Deposition of the marine Modelo formation above the Mint Canyon with a probable interval of erosion and deformation.

5). Post-Miocene diastrophism forming folds and faults in the sedimentary series, and caused by forces acting in direction N20° E and N55° E.

6). Deposition of marine Pico followed by an interval of erosion.

7). Deposition of the Saugus formation followed by a period of deformation which involved the rejuvenation of pre-existing structures and the introduction of new lines of movement, the newer deformation, however, being genetically unrelated to the former.

8). Period of quiet during which Quaternary terrace deposits were laid down followed by late quaternary uplift and dissection.

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