THE GEOLOGY OF THE NORTHWESTERN PORTION OF THE ALHAMBRA QUADRANGLE

SENIOR THESIS

by

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TABLE OF CONTENTS

LIST OF PHOTOGRAPHS

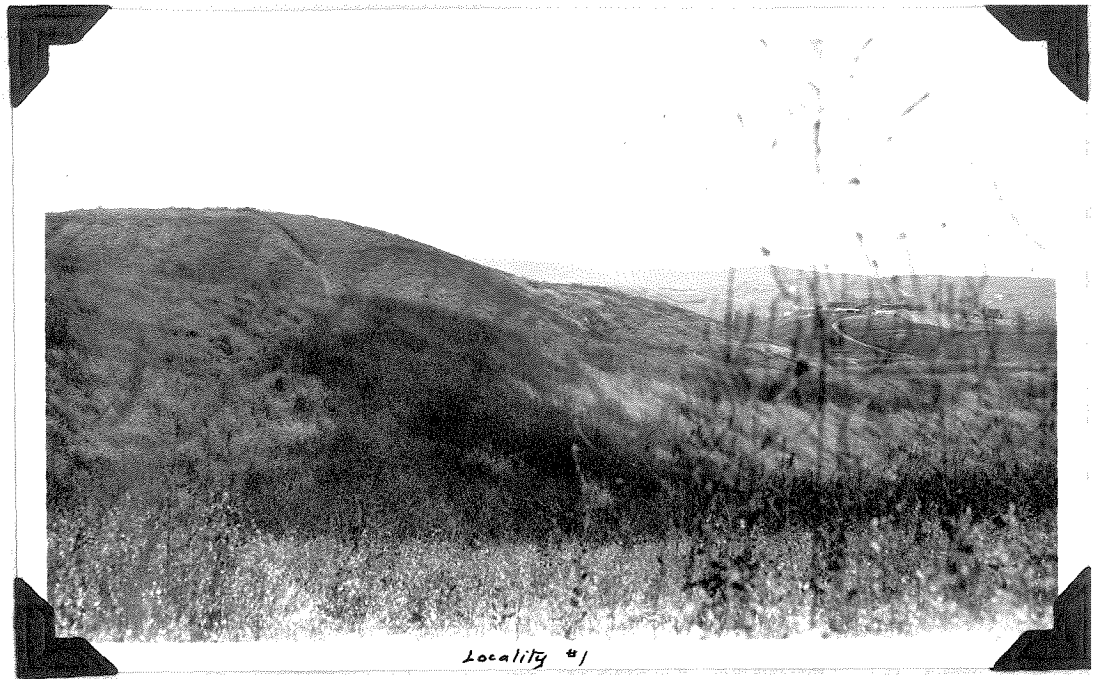
Introduction

The region considered lies between the principal sections of Los Angeles and Alhambra, more strictly it is bounded on the north by the 34°06' parallel, or about the southern limit of South Pasadena, on the west by the 118°12' meridian, on the south approximately by an extension of Garvey Avenue, and on the east by Fremont Avenue. The area included is about nine square miles. The map used is the Alhambra Quadrangle recently published by the U.S.G.S. The scale of the map is 2000 feet to the inch and the contour interval is 5 feet up to the 500 foot level and above this the interval is 25 feet. The map is quite satisfactory except that the variation in contour interval gives the hill-tops an unnatural aspect.

The problem was attacked by making a general study of the region with an eye toward becoming familiar with the different materials that were to be encountered, always recording dip, strike, locality, remarks and materials that were studied. The areal map was next constructed by using the principal sandstone as a key bed and correlating the structure of the formations above and below to the structure indicated by this sandstone. The boundaries of the Quarternary aluvium were located principally on the basis of change of slope.

The exposures of underground structure in the area are all good and consist principally of road cuts and other artificial excavations. However, in many places natural

outcrops as a result of erosion were of considerable value. Also, another somewhat unique circumstance facilitated the problem. Along the northern boundary of the southern branch of the El Sereno sandstones just above Ascot Park and extending to Alhambra Boulevard, the marked contrast in weeds and grasses on either side of the contact between shale on the north and sandstone on the south made it possible to trace the contact with great ease, the accuracy of the procedure being born out here and there by good exposures. The grass in the shale consisted principally of wild barley, etc. In the sandstone in addition to wild barley there was a fairly dense growth of wild mustard. The nearer to the contact the more dense was this growth; also, scattered here and there were cactus plants. No cactus was observed in the shale. Further investigation showed that the sands near the contact were more moist than the shale on the other side. It was also noted that the character of the surface soil was highly indicative of underground material; for example, the shale surface after a rain and then a couple of hot days became hard, compact, and cracked, but the sand surface did not crack and remained loose. The capillary action between the sands and ground water, and the compactness of the clay shales account for the contrast in vegetation. It was only in the hills that this feature was observed because of the thinness and "in situ" character of the soil.



The photograph shows the character of the vegetation near the contact between sandstone and shale. The contact lies between the dark growth in the center and the light grass to the left. It may be noticed that the dark patch swings to the right in the foreground, which is in keeping with the trace of the contact. The same occurrence is indistinctly visible on the hill in the background.

Geography

The topography of this general region is early old age in the cycle of erosion. The hills are all well rounded and the valleys widened, the principal slope being to the south. The highest point is the hill in the northwest corner of the area which has an elevation of 882 feet. The lowest point is in the southern extremity of the area in a creek bed where the Pacific Electric runs east and west. The elevation is about 340 feet. The average elevation of the area is about 500 feet. The hills show a N.N.E. trend and the valleys the same, but the streams themselves show a tendency to leave the main stream channel and flow down the next nearest channel to the east. This is well illustrated by the stream starting at the word South in South Pasadena at the top of the map. It flows southward to Huntington Drive and then passes into the next principal channel eastward and flows south toward the Southern Pacific tracks, and then instead of going down the valley through which Alhambra Road and the Southern Pacific tracks go - which, by the way, has a saddle about one third of the way down - it is again deflected down the next nearest channel to the east. This same phenomena is observed somewhat southeast of the area in the case of Coyote Pass. Here also, the normal channel, Coyote Pass, is robbed of its stream by a channel to the east. The pass has a saddle and all the water above this point drains north and around the hill to this other narrower and deeper channel.

All of the valleys have small stream beds, the majority of which are dry except immediately after rains. The two streams described above and the Alhambra Wash just northeast of Alhambra carry a small stream of water during the rainy season but are entirely dry in the summer months. The natural direction of the drainage in the area is to the Los Angeles River, but many of the smaller ones are caught behind artificial dams and evaporate or seep into the ground. Alhambra Wash drains southeast toward the Rio Hondo.

There are no natural lakes in the area but numerous reservoirs. The principal one is owned by the Los Angeles Water Department and receives its water by means of a pumping system from the Elysian Park reservoir. It is located on Omaha Heights and lies in the small ravine about half way between El Sereno Avenue and Mission Road.

The principal portion of the area is covered with a network of roads. The principal highways are Mission Road which eventually becomes Huntington Drive, Alhambra Avenue which is changed to Pomona Boulevard in the eastern part of the quadrangle, and Fremont Avenue which runs north and south and bounds the east side of the area. The area is traversed by the Southern Pacific Railroad and two branches of the Pacific Electric.

Very little seems to be done in the way of cultivation in the region; trees are scarce, lawns are very poor, and weeds run wild, although the area is fairly well settled. This is probably due to the character of the soil,

too much clay in the most part, and also to poverty which is evident in several sections of the area.

Stratigraphy

The total thickness exposed in the area has been divided into six different sections based on general composition and textural differences, and named according to prominent features in or near the areas characterized by the particular formations. The purpose of the subdivision was to facilitate description and to aid in solving and exposing the structural relations.

Omaha Sandstones These sands are exposed as a result of the erosion of the principal anticlines and make up the central section of Rose Hill and Omaha Heights. The sands are dull yellow to brown in color, and although not hard are of sufficient consistency to maintain vertical walls in road cuts. The sands are subangular in character and made of quartz, feldspar, kaolin, muscovite, biotite, magnetite, etc. grains. The size of the particles varies considerably up to a rather coarse sand. These layers, showing no bedding within themselves, are 6 inches or so up to about 10 feet in thickness, and are separated by a few inches or so - and sometimes considerable more - of very sandy shales, which are generally brownish to dull white in color.

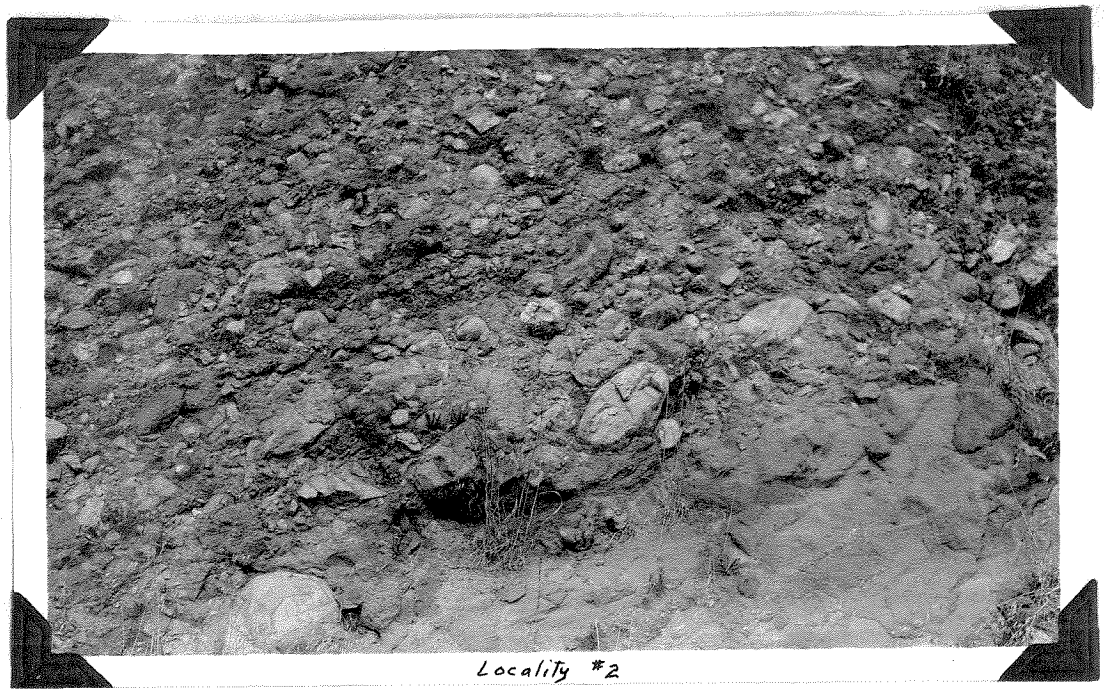
Rose Hill Shales The shales that constitute the largest portion of Rose Hill and extend eastward with the bounding El Sereno sandstones are quite similar to the upper portions and lowermost portion of the Ascot shales. They are uniformly sandy in character and make up the highest points in the group of hills which coincide with the principal anticline. The thickness of this group is about 800 feet.

El Sereno Sandstones This formation outcrops from Happy Valley southeast in the general direction of the Midwick Country Club, but not extending quite to it, and then west toward Lincoln High School which is just on the west edge of the map. This sandstone resembles in general the Omaha sandstones but is more varied in character, more extensive in exposure, and has been studied more carefully. The western end of the northern side of the principal anticline between Baird Park and Happy Valley is quite shaly in character and becomes more so toward Happy Valley. On the other hand, this same formation carries a remarkable conglomerate which is exposed on the hill side about 2500 feet northwest of Alhambra Boulevard.

The southern side of the principal anticline is more general and does not carry over these notable variations. In most cases the sandstone itself does not show evidence of bedding laminations. The beds are from a few inches to 10 or more feet in thickness and are separated by several inches of

sandy shales. These shales show various shades of red, brown, and yellow, and in general a ferruginous character. The sandstone grains are somewhat subangular in character, but in the region of conglomerate they are quite angular. At this point the material might be called arkosic sandstone, but not a true arkose. The sandstone is composed chiefly of quartz, feldspar, kaolin, muscovite, biotite, magnetite, and a small percentage of other ferro-magnesian minerals. The total thickness of the formation is about 500 - 600 feet.

In the conglomerate locality, the formation is quite different, the individual rocks varying in size from fine angular sand to large boulders one to two or more feet in diameter. The finer grains consist of quartz and feldspar, also muscovite, and biotite, etc., the whole having the characteristic yellowish brown color due to the iron content. The larger rocks are fragments of granites and other primary salic rocks, gabbros, gneisses, various schists, quartzites, clay boulders, concretions of sandy shale, and shale inclusions. This conglomerate is located well in the upper part of the sandstone and at this place is about 70 feet thick and shows in the excellent outcrops local indications of lenticularity in small aggregates which are a characteristic of the whole occurrence. This mass probably represents a deposit formed near a river mouth at a time when this formation was close to the strand.



Locality #2

The photograph is taken near the middle portion of the section of conglomerate. The idea of size may be gained by comparison with the wild barley plants.

Ascot Shales The Ascot shales have the largest areal extent of any one formation. They are bounded on top by the diatomaceous shales and on the bottom by the El Sereno sandstones. In dry weather these shales have a yellow brown color inclining sometimes to white and sometimes to reddish, but in wet weather they take on various blues, greens, tans, and gray due to the hydrolysis of the iron compounds and the presence of a certain amount of carbonaceous matter. The lowest portion of the shales - next to the sandstone - is quite sandy and shows evidence of ripple marks, but it rapidly changes to a clay shale which is quite pure in some places and notably lacking in bedding lines; that is, it is rather thick bedded. As one goes up in the section the shales become more sandy, at least, compared with the lower part. The whole of the section seems to contain a fair amount of lime which often when dry gives the outcrops a white color, notwithstanding the iron content, which is evident on close inspection.

In the vicinity of El Sereno just north of the sandstone there is a large outcrop of thick bedded marl, unconsolidated and having a conchoidal fracture. The outcrop is a dusty yellow color and has a high clay and lime content.

Another striking feature of the Ascot shales is the presence of a 150 - 200 foot formation of quite coarse and loose gravel or conglomerate in shale which outcrops on the hill to the southwest of the intersection of Fremont

Avenue and Alhambra Road. The grains vary in size up to about an inch in diameter and are bedded in a shaly matrix for the most part, except the portions that occur in sandy matrix and as a lense in the shale. The whole occurrence must be lenticular because nowhere else along the general strike does this gravel reappear.

Sierra Vista Shales This diatomaceous formation is visible in an excellent outcrop on a hill just south of Sierra Vista and ~~sometimes~~ extends westward as indicated by a number of good outcrops. The lower part of these shales is well stratified and is white, light in weight and rather pulpy in texture. This particular horizon contains an abundance of fossil fish and a few leaf impressions. The shales weather to a fine white powder. At various intervals there are layers of very hard calcareous siliceous shales, pale brown in color and from a few inches to about a foot and a half in thickness. In the lower part of the section these hard beds are separated by quite large intervals. The fracture of this well indurated rock is somewhat conchoidal and it does not have a definite cleavage plane. A cross fracture shows quite clearly the fine bedding lines and also shows a slight bituminous as well as a ferruginous character. In the upper part of this section the material is characterized by a lack of stratification, except for occasional hard beds which become quite numerous near the top. This upper part of the section seems to be rich in lime and phosphates. The total thickness of the shales is in the neighborhood of

700 to 1000 feet.

A microscopic examination of a fragment of the well bedded portion of the shales showed the character of the diatoms. The diatoms as observed under a magnification of x480 were broken up and no whole cell group could be seen. In appearances they looked like little networks of hexagons with a rather broken boundary.

The species was not identified but they compare favorably with Ralph Arnold's microphotograph of the genus coscinodiscus from the Monterey Shales.

Harmon Shales This group is the furthest north in the area considered. It is characterized by the abundance of well indurated highly siliceous shales, interbedded with soft sandy clay shales. The base of the section varies along the strike but in general is more coarse and more resisant to erosion than either directly above or directly below. At the left end of this basal portion near the top of the map and extending out from the hill and into the valley above Newton Park is a very pronounced ridge of very coarse sandstone which contains a little conglomerate. The coarser grains show sorting consistent with the bedding plane. The expression of this bed apparently continues over the next two ridges to the east, but the outcrops on these hills show

instead of the coarse sand a group of highly indurated beds of siliceous shales. On the hill second removed from the sand the softer marl just between the contact and hard shales contains a rather subangular grained breccia. The principal portion of the general formation consists of yellow to brownish sandy shales and hard siliceous calcareous shales. Further up the hard beds are quite pure diatomaceous shale.

Structure

The principal structural feature of the area is the large eastward plunging asymmetric anticline. The clue to this structure was not at once evident, but after numerous facts have come to light it seems that the conclusion is irrefutable. In the first place the continuity of the principal sandstone horizon as shown in areal extent was determined with considerable ease, except in the vicinity of Happy Valley where the exact location of the bed is somewhat conjectural, this being due to the scarcity of good outcrops in this section and also to the apparent tendency for the sandstone to assume a shaly character here. The notable difference in strike on the opposite sides of anticlinal axis which were consistent over large areas is a factor which supports the conclusion but which at first gave the impression of a fault relation until an actual section through the plane of the anticline was found.

Locality #3

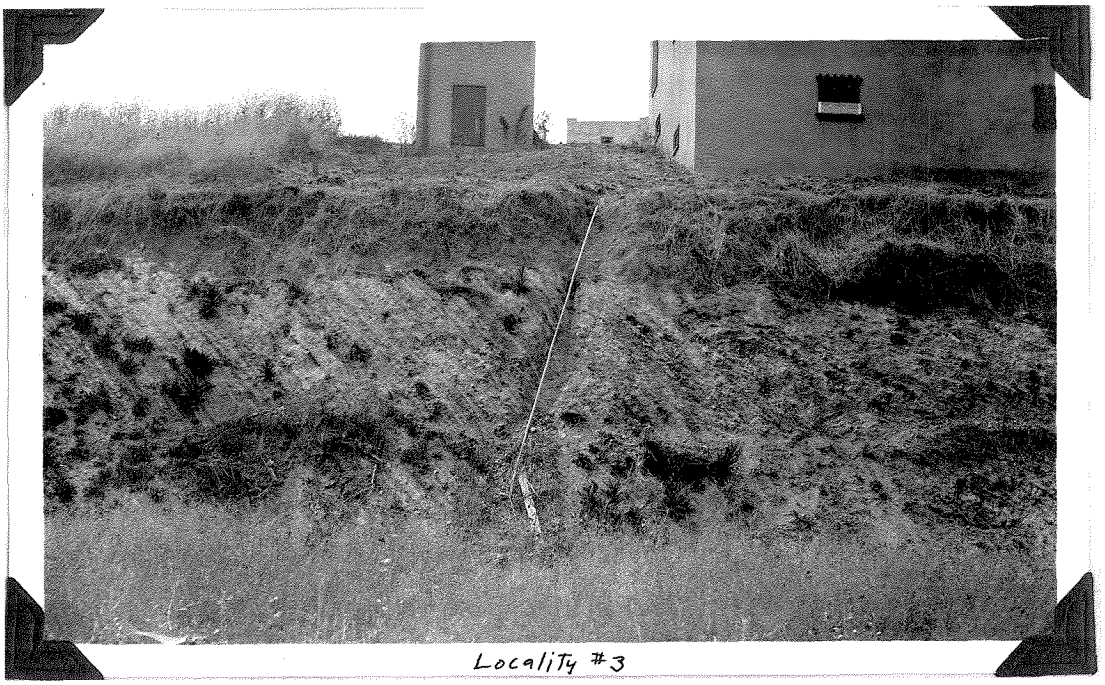
A section through the plane of the principal anticline in which the character of the fold can be seen. (See text for further description).

The dip and strike of the Ascot shales near the intersection of Alhambra and Fremont Avenues, as indicated by the coarse gravel bed on the hill, shows a disposition of the beds consistent with the rounding off of this portion of the nose of the anticline. Also, the strike of the sandstone itself is consistent with the rounding at the eastern end of its areal extent. The Omaha sandstones show in a cut made by the Los Angeles Water Department for their reservoir the change from north dip at the north end of the cut to south at the south end passing through an east dip.

The character of the fold at the axial plane varies considerably with different strata. In the shales the fold is very sharp and abrupt, as shown in the first photograph of locality No. 3, which was taken on the axis about two blocks northwest of Alhambra Avenue. The shale on the south of this point is overturned, but rather even and uniform in appearance for a considerable thickness.

North of the anticline the shales are crushed and crumpled without appreciable folding. The strata are very nearly roughly level for about a thousand feet beyond which it they changes to a uniform north dip before the sandstones on the north are reached. Any dip and strike taken in the crumpled zone is essentially useless.

In contrast with the abrupt and sharp folds in shale the sandstone shows a well rounded fold with no abrupt change in the dip. This is shown in the Omaha sandstones in the vicinity of the Los Angeles Reservoir cut and accounts for the broad extent of the sandstones on the map at this particular area.



Locality #3

The photograph shows the attitude of the beds south of the anticline. This overturned relation is maintained well down through the El Sereno sandstones to the south of the locality shown, and then as in other localities south of the sandstones, the dip passes through vertical to south and from there southward? down the beds are top up.

a la normal position

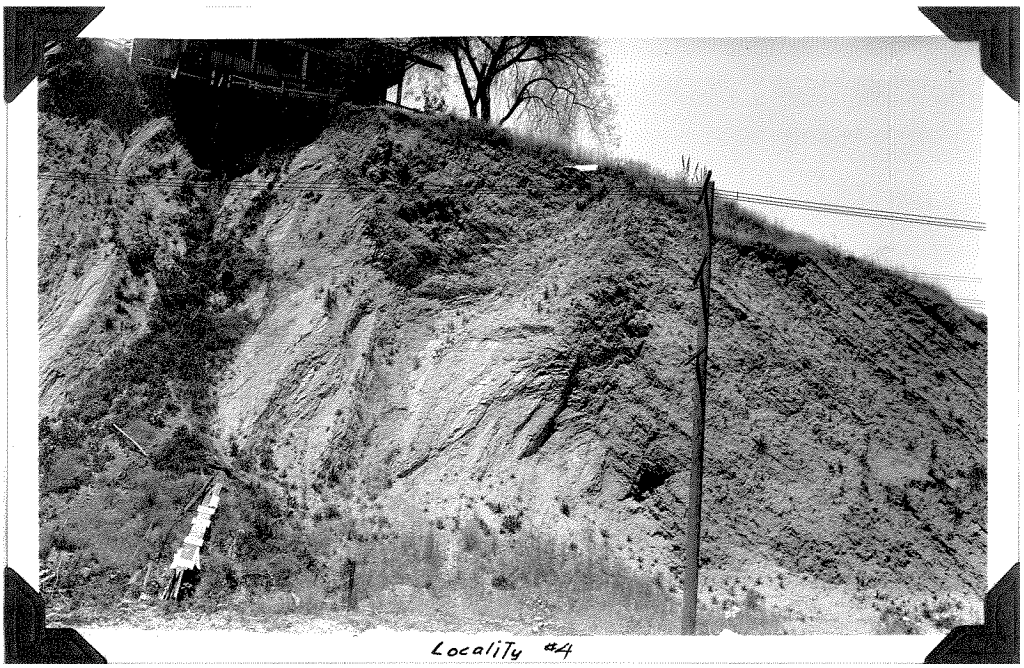
Locality #3

The photograph shows somewhat indistinctly the indefinite aspect of the zone to the north of the axial plane.

The situation is different on Rose Hill. Here the sandstones, which form the core of the fold as expressed on the surface, are much more steep and remain so close up to the point of the contact, which in no case has been observed. This is true on both sides, the sides being identified by the general difference in dip and strike. In case these thick beds of sandstones are abruptly folded, as they evidently are, there must be a considerable crushing and fracturing along the axial plane, and possibly some thrust faulting.

The greater extent of the Rose Hill shales in the northern portion is due to a more level attitude in many places and minor folding, the detail of which is too obscure. The southern portion dips uniformly steep to the south.

On the southern end of Rose Hill the El Sereno sandstones expose an accessory fold on the flank of the large anticline. The syncline is located about where North Broadway cuts through the hill, and the anticline forms the crest of the small hill to the south of Broadway. The plunge of this anticline is about 30° in an easterly direction, and gives rise to the narrow strip of sandstone extending south from the main sandstone along the Pacific Electric cut on the east side of the valley. This small exposure shows that the folding has become considerably modified, and still further to the east there is apparently no trace of it. The further appearance of the sand on the hill east of Lincoln Park is due to two more small folds which have caused the upper portion of the sandstone to be exposed again. The first fold is small and has been obscured by the aluvium north of the hill.



Locality #4

A section through the anticline as exposed in the Mission Road cut south of Broadway. The core here shown is principally the underlying Rose Hill shales which are exposed across the face of the hill as a result of the erosion of the overlying sandstones.

Locality #4

This photograph is a continuation to the left of the one on the preceding page and shows the attitude of the overlying sandstone. This particular portion of the sandstone is well stratified. A photograph still further south would show the rapid tendency of the beds to become more horizontal, indicating a syncline to the south which may be correlated on the east side of the valley.

Excellent photograph. Would like a slide from this negative sometime.

The second fold has formed the two knobs of the principal hill and has a plunge of about 30° in an easterly direction. None of these folds appear again to the east within the bounds of the area.

The altitude and structural characters of the three lower formations, Omaha sandstones, Rose Hill shales, and El Sereno sandstones have already been discussed. It might be further mentioned, as has been assumed above, these three formations lie in a conformable sequence. Above the El Sereno sandstones and conformable on them lie the Ascot shales. The areal extent of this formation is due partly to its thickness and partly to the minor crumpling and folding that has taken place. The incompetent shales are soft, easily eroded, and easily folded, and consequently the folding and crumpling as a result of deformational forces is complex and uncomprehensible for detailed analysis. The diatomaceous shales lie stratigraphically above and conformable on the Ascot shales. The dip is quite variable, but 50 - 60 N is about average although in some places, as south of Sierra Vista, the crumpling is quite bad and the dip is practically worthless.

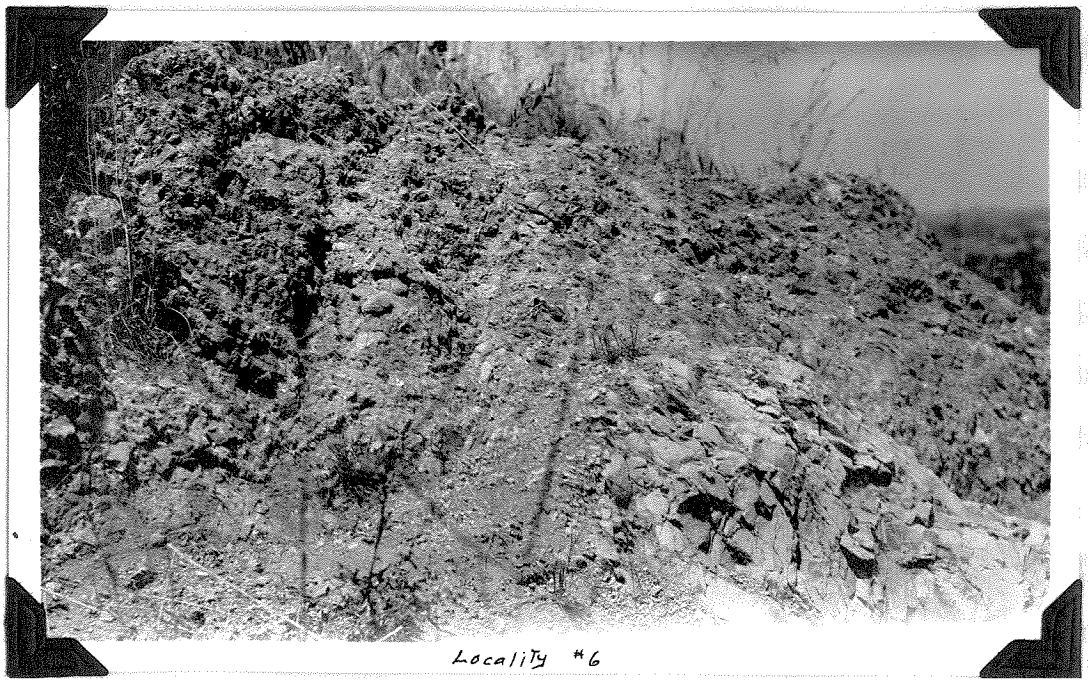
Between the diatomaceous and Harmon shales the nature of the contact is not so definite. The upper portion of the diatomaceous shales, as stated in their description, is relatively thick bedded; however, the dip and strike taken as near the contact as possible in the shale agrees in general with that on the other side. The lower portion of the

Harmon shales is rather crumpled and contains many well consolidated beds, but also includes between the beds much of the same material contained in the Sierra Vista shales, however, near the contact the Sierra Vista shales do not contain any hard beds.

The photograph of locality No. 5 shows what appears to be a fault but closer examination reveals no particular evidence to support it but the two thin somewhat parallel lines left of the center of the picture. The portion on the left of the picture does not indicate the true bedding which is the same as on the right. The marl like character of the material between the two lines is the same as that immediately on either side. The lines themselves are tightly closed clay lined fissures. The probability here is that a minor displacement has occurred.

About 2000 feet east of here the contact takes on a different character, as shown in the photograph of locality No. 6. The formation to the north here is based with a breccia and is in contact on the south with the characteristic shaly marl. The marl is here shown in the right and fore part of the picture, apparently reclining against the breccia. The character of the breccia itself does not necessarily imply movement, and no slickensiding has been found. This particular locality is the only place where the breccia zone is observed.

Locality #5



Locality #6

(Refer to page 22 of the text for the description of the above photographs.)

The basal portion of the Harmon shales above the contact zone are twisted, distorted and badly folded, but further up they become more regular with an average N dip of about 40° depending upon the particular locality.

Evidence for Age

The principal portion, and probably all, of the sequence is Puente Miocene in age. This is based partly on W. A. English's description of the stratigraphy of the Puente Hills region and partly on correlation with the formation described as Puente by Ralph Arnold in his bulletin on the Los Angeles Oil District. Mr. Arnold's work covers as far east as Rose Hill and areas immediately north and south, but his map is on a scale of one mile to the inch and no detail is shown more than an indication of the general areal extent of the Upper and Lower Puente; also his descriptions are somewhat restricted to the principal oil districts of Los Angeles. Based on this correlation everything stratigraphically above the El Sereno sandstones is Upper Puente and everything below is Lower Puente. The scale of Mr. Arnold's map makes it difficult to classify the El Sereno sandstones as either upper or lower. Furthermore, his map does not show the reappearance of a portion of the Upper Puente south of Rose Hill.

No fossil material was found outside of the fish remains and an occasional leaf print in the diatomaceous shales.

Geologic History and Physiography

The area shows no indication of the history of the region further back than Miocene. During this period there was a considerable variation in elevation of land, change in stream gradient, variation in climate, or a combination of these and other factors acting to bring about the alternations between sandstone, conglomerate, and shale. At the end of the Puente (?) there was an uplift - based on probable absence of the Fernando in the area - and considerable folding resulting in the origin of the large anticline clearly shown on the map. During Fernando or Pliocene time the area was leveled in accordance with the generally accepted belief that peneplaination occurred extensively during this period. At this time the topography was low with little or no relief. The edges of the strata were beveled off, and there was probably little or no surface expression for the large anticline. Is there evidence for this peneplanation here, or is the reasoning entirely deductive and hence questionable?

At the end of the Pliocene a period of major deformation and uplift occurred, during which the Coast Ranges were folded up and the Sierra Nevadas were uplifted. At this time the area under consideration was uplifted quite a bit and tilted somewhat to the south. As a result, the streams were given a new impetus and large well defined channels were cut in a direction somewhat west of south, this direction being roughly at right angles to the general strike in the region, hence with the sufficient gradient and at right angles to the

This sentence should be broken up.

strike there was no particular tendency for the streams to be deflected by any somewhat harder strata. Meanwhile the softer shales, particularly the Ascot shales, were washed down causing the ridges to become isolated groups of hills, reinforced near the ends by more resistant sandstone in the case of the southern group of hills, and held together by the well indurated groups of shale in the northern portion of the area.

At this stage, sometime in Pleistocene or early Recent, more deformation took place, resulting in additional folding along the already established anticlines and synclines. In addition to this there was a tilting to the southeast. As a result of these last movements the principal streams have been deflected as described under Geography. The additional folding was inferred from the presence of saddles in the channels over the axis of anticlines with the deflection of streams between the groups of hills. The tilting is inferred from the stream deflection and also from the general tilt of the approximate plane of the hilltops which could not have been present at the time the streams cut their larger original channels.

In this way the principal channels are consequent to a Fernando leveling and a post-Fernando tilting, and the present streams are in a way partially consequent to a later tilting and folding, and partially subsequent to the hard and soft beds with which they have had to deal.

Economic Geology

Two of the formations described under Stratigraphy yield a material of commercial value. In the first place, the lower portion of the Ascot shales consists of a good quality of clay with enough silica to form a good brick. As a consequence, on the northeast side of the hill which divides the Southern Pacific tracks and Alhambra Avenue a brick yard has just recently been started. The clay is mined with a steam-shovel and carried by belt into the building where it is pressed and cut. After drying in the open it is then fire treated.

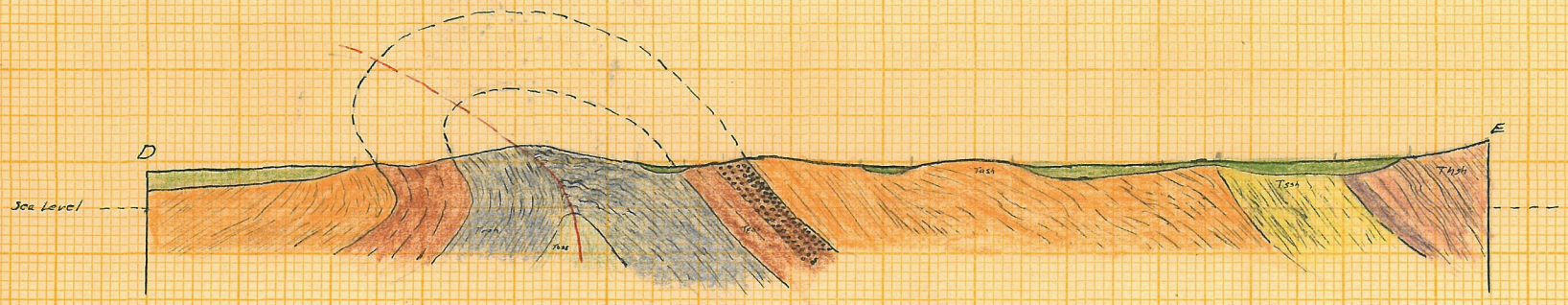
The other formation in the area found to be of mining value is the Sierra Vista or diatomaceous shales. These are mined both in the bedded and unbedded protions. The locality is midway in the formation on the west side of the hill 2500 feet west of Sierra Vista Junction. This kieselguhr or diatomaceous earth is used as a base in the production of a certain brand of fertilizer known as Fertilite. The base which already contains besides silica and calcite, a certain amount of gypsum, and a little phosphate, has added to it nitrate of soda, potassium sulphate, and super-phosphate. The mixture also contains iron, aluminum, magnesium, and organic matter, the organic matter being in part manure.

Locality #7

The photograph shows the formation in the cut, method of mining, and the stacks of bricks drying. To the right just off the photograph are the high stacks where

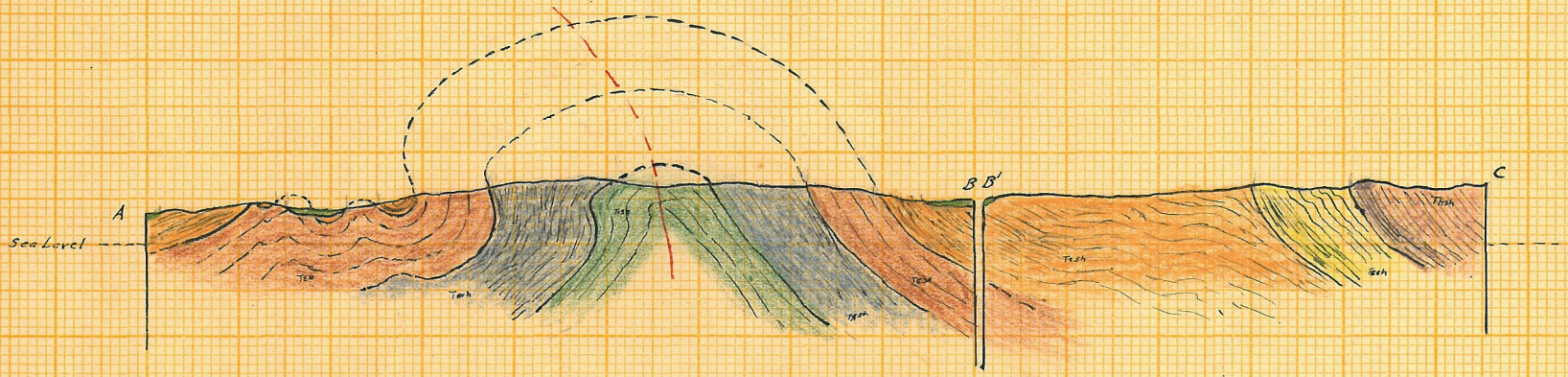
Locality #8

The photograph shows the mine tunnel, the carrier tracks and the mixing plant. At a place further along on the hillside can be seen a place where other excavation work has been carried out.



Cross Section D-E (see map) N.N.E.

N.N.E.



Cross Section AB, B'-C (See map) N.N.E.

Normal Profile 2000 ft. = 1 in.
Legend as on Areal Map.