GEOLOGY OF THE SAN JOSE HILLS
LOS ANGELES COUNTY
CALIFORNIA

Thesis by

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In Partial Fulfillment of the

Requirements for the Degree of Master of Science

CALIFORNIA INSITUTE OF TECHNOLOGY

Pasadena, California

1933

ILLUSTRATIONS

INTRODUCTION

Location of the Area

The San Jose Hills, located in the eastern part of Los Angeles County, California, occupy a rectangular block some 40 square miles in area, the center of which is 30 miles to the east of Los Angeles (PlateI). Although a separate physiographic unit, the region may be described as that portion of the Puente Hills lying north of the San Jose Wash (Plate II). The area mapped extends from Pomona southwest to Puente, a distance of 11 miles. It may readily be reached from either town, both of which lie on the main line of the Southern Pacific Railroad and on U.S. Highway Number 99, known locally as the Valley Boulevard. All parts of the area are readily accessible, for it is cut by roads in the eastern, central, and western portions.

Purpose and Scope of the Investigation

A detailed study of the area was undertaken as partial fulfillment of the requirements for the degree of Master of Science at the California Institute of

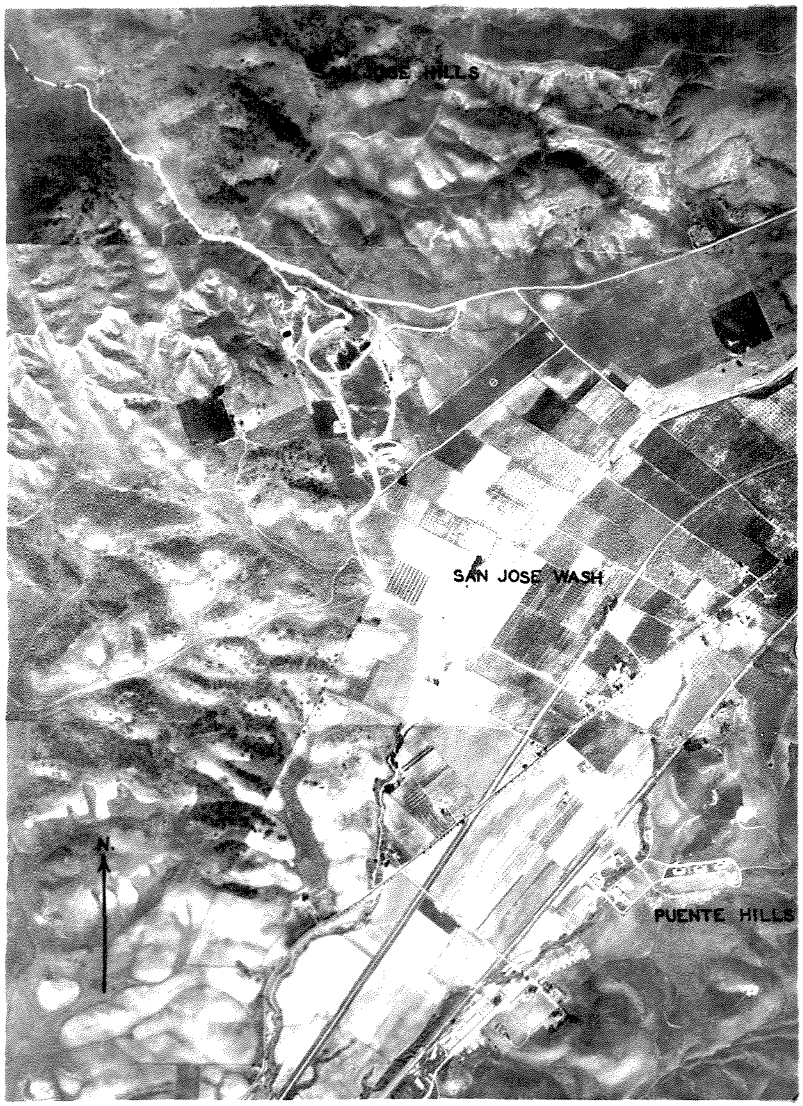


Plate I

Airplane photograph showing the relation of the San Jose and the Puente Hills.(east of Puente).

Technology, Pasadena, California.

The writer was principally interested in a structural and stratigraphic problem and was indeed fortunate in having such an excellent area readily accessible.

In 1926 the area was mapped by W.A.English[1] on small scale base maps (1 mile to the inch). The work was done in connection with the mapping of the Puente Hills region and little or no detailed mapping was carried on in the San Jose Hills. It was the writer's belief that a remapping was justified for now large scale maps of the Covina, Claremont, and Puente Quadrangles are available. These maps have a scale of 2000 feet to the inch and a contour interval of 5 and 25 feet. Furthermore, new roads have been built which facilitate the interpretation of a somewhat complex structure.

In the eastern portion there occur a series of igneous rocks, which while interesting and offering op-

1 W.A.English: Geology and Oil Resources of the Puente Hills Region, Southern California. United States Geological Survey Bulletin No. 768, 1926.

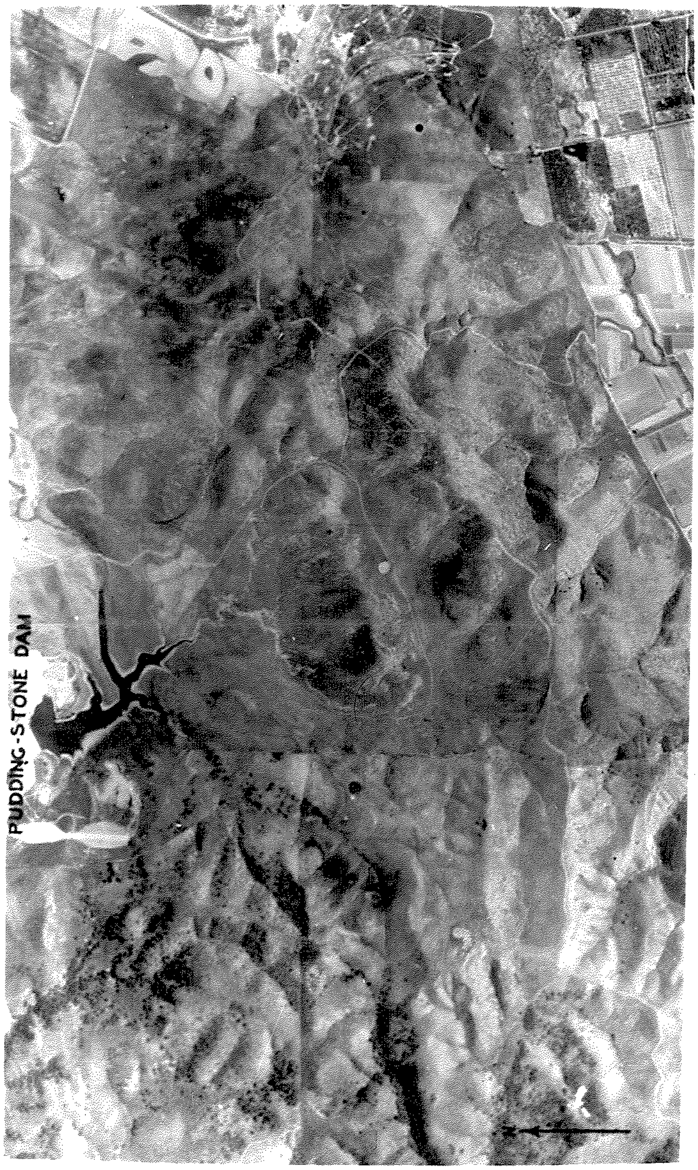


Plate II

Airplane photograph of the Puddingstone Dam area.

portunity for detailed study, will be but briefly considered. The writer was primarily interested in the sedimentary series lying to the west of the igneous complex, and most of the more detailed mapping was done in these Tertiary formations. However, a heretofore unrecognized relation between the extrusive lavas and the shale series was observed, making desirable detailed work along the shale lava contact.

Method of Investigation

As a base map for recording observations, United States Geological Survey maps were used, having a scale of 2000 feet to the inch, ($\frac{1}{24,000}$), and a contour interval of 5 and 25 feet. These maps proved very satisfactory, their detail making recording of field observations rapid and accurate. The region was surveyed in 1924 and 1925 (the maps being issued in 1927); thus the cultural features, except for a few roads, are all clearly shown.

Airplane maps of the region are available, and were referred to by the writer during the investigation of the igneous complex and the eastern portion of the sediments. However, due to the low relief, rarely over 300 feet, contrast was poor, and it seemed desirable to use the topographic sheets for recording data.

The nature of the problem necessitated accurate plotting of certain details, yet it did not appear necessary to use a plane table for this work. The latter method is certainly more accurate than a Brunton Compass Survey, but as time is an important factor in any problem, all locations were made by Brunton Compass intersections on prominent features, both cultural and physiographic.

The field work was done intermittently during the summer and winter of 1932-1933, about six weeks being spent in the field.

Acknowledgements

Dr.J.H.Maxson, who supervised the work, was ever ready to discuss problems and to check field observations, and the writer owes him a debt of gratitude.

Frank W.Bell, of the California Institute of Technology, indentified the foraminifera collected in the upper shale member, and made an accurate correlation with the type Miocene deposits possible.

Mr.R.Eckis kindly offered information on subsurface water conditions which strengthened the postulate that the Buzzard Peak fault continued eastward along the base of the hills.

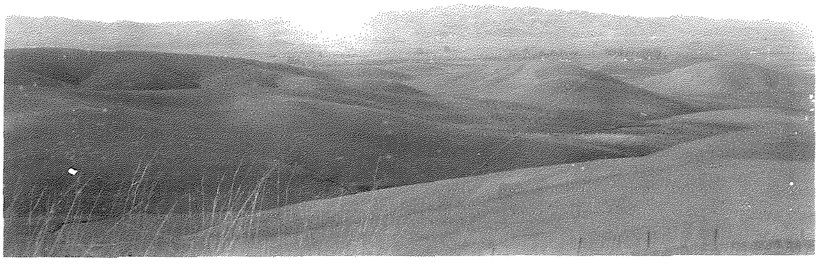


Fig.1 Characteristic low rolling topography of the upper Puente shale. East of Covina Road looking south, Puente Hills in the background.

Fig.2 Looking north from the vicinity of Buzzard Peak. Illustrating low rolling, weathering forms of the shale series. San Gabriel Mountains in the distance

GEOGRAPHY

Topography and Drainage

As most topographic features can be clearly seen on the accompanying map, only the more important will be considered in the following discussion.

The San Jose Hills have moderate relief, rising 750 feet above the floor of the valley. The hills are symmetrical with a crestline which trends northeast. They emerge from the valley immediately north of Puente, toward the east, gradually increasing in elevation to a maximum of 1360 feet at Buzzard Peak, then decreasing again, pass into the valley at Pomona.

The canyons, as cah be seen from the topographic map, are rarely over 200 feet deep. Those in the effusive series tend to be narrow and steep walled, while those in the sediments are wide and flat bottomed. Due to the nature of the sediments, particularly the shales, most of the hills are convex upward, giving a low rolling topography (Figs. 1 and 2). However, one exception is noted. The middle sandstone member of the Puente, exposed in the Buzzard Peak vicinity, gives a rather rugged, irregular topography, characteristic of poorly consolidated sediments

Fig.3 Buzzard Peak; illustrating rugged irregular topography characteristic of the middle sandstone member of the Puente. Looking north-east, with the San Gabriel Mountains in the distance.

Fig.4 Looking north-east from Buzzard Peak. Illustrating in the foreground rough topography of sandstone and in the middle distance the rolling shale forms. The San Gabriel Mountains in the distance.

in a semi-arid region (Figs. 3 and 4).

As is general in the drier regions of the western United States, the hills end rather abruptly in the nearly level plains. This is especially true along the southern border of the area, where the San Jose Wash passes between the region described and the Puente Hills.

No large rivers are present in the area, the drainage being carried westward to the San Gabriel River by two small streams, Walnut Creek on the north and the San Jose Creek on the south. In the rainy seasons these streams carry great volumes of water, but during most of the year are dry.

Climate

The climate of southern California makes it possible to carry on field work throughout the year, for rainfall is small and occurs almost exclusively in the winter months

The average annual precipitation for this region is about twelve inches, rains occurring in short spells, rarely over two or three days in length.

Due to the moderating effect of the prevailing ocean breeze, there are few extremes in temperature. In the winter light frosts may occur, and in the summer temperatures of over 95° are uncommon, although 100° is sometimes reached for short periods of time.

Natural Vegatation

Lack of abundant rainfall permits only a sparse growth of natural vegatation, the nature of which depends upon the type of soil. The shale members support an abundant growth of mustard, short grasses, and in the spring numerous wild flowers. On the other hand, the coarser sandstone and conglomerate members permit only the growth of cactus and drought resisting shrubs. A dense cactus growth is charcteristic of the lavas, and the hiker must pick his path with care least he encounter the sharp spines. In the more moist spots, clumps of wild walnut, live oak, and California holly thrive, as well as the bane of the geologist -- poison oak. The vegatation is short lived and the hills are turned to brown before summer is well under way, only a few of the more drought-resisting shrubs surviving.

Culture

This region is noted for its citrus fruits,

Fig.5 Cultivation of soil on the upper Puente shale in the hills north of Walnut (Sentous Ranch). Looking north-east with the San Gabriel Mountains in the distance.

Fig.6 Cultivation of soil on the upper Puente shale in the hills north of Walnut (Sentous Ranch). Looking north-west.

orchards of which bound it on all sides. In the area proper two occupations are important, both of which make the work of the geologist more difficult. The shale decomposes into soil very suitable for grain, and each year some of the steeper shale members as well as the low rolling hills are sowed with wheat and oats. The yearly disking of these shale beds has obliterated nearly all of the outcrops, and large areas are encountered where no idea of the structure can be gained (Figs. 5 and 6).

Pasturing of cattle, horses, and sheep constitutes the other important occupation. Almost the whole sedimentary series is fenced, making it impossible to drive a car to the otherwise very accessible outcrops.

The principal raods passing through the area are paved, as are many others around its bordess. Numerous dirt, side roads, etc. lead well back into the hills, but due to fencing few of them may be used.

Railroads, electric railways, and good raods connect most of the important towns in the region, making access by automobile or by train a simple matter.

PREVIOUS PUBLICATIONS

The folâowing is a list of the publications dealing with the geology and the water supply of the San Jose Hills and surrounding territory.

Eldridge, G.H. The Puente Hills Oil District, Southern California. United States Geological Survey Bulletin No. 309. This does not deal with the San Jose Hills proper, but covers the geology of the closely related Puente Hills.

English, W.A. Geology and Oil Resources of the Puente Hills region, Southern California. United States Geological Survey Bulletin No. 768. This volume deals with the geology of the San Jose and Puente Hills. It also contains a section on the chemical character of oil by P.W.PRutsman.

Mendenhall, W.C. Ground Water and Irrigation Enterprises in the Foothill Belt, Southern California. United States Geological Surgey Water Supply Paper No, 219.

Willis, Bailey Index to the Stratigraphy of North America. United States Geological Survey Prof. Paper No. 71, page 818.

GEOLOGY

Stratigraphy

General Character of Formations

The Tertiary sediments in the area are represented by beds of middle Miocene, upper Miocene, and Pliocene age. They consist of shale, sandstone and conglomerate, occurring singularly or interbedded. Their origin may be ascribed to an area of acidic rocks for quartz grains predominate in the shale and sandstone, while boulders of pegmatite, granite, and granite gneiss make up a large percentage of the conglomerate.

Considering their Tertiary age it may be said that the formations present, especially the shale and sandstone, are very well indurated. Several factors have been active in their consolidation. Perhaps the most important of these was the post Fernando folding, which no doubt produced heat and pressure, two vital factors in the consolidation of any sedimentary series. Calcareous material is often present in the shales, as well as colloidal silica, both adding hardness to an otherwise soft and friable rock type. It is well established that in the final stages of vulcanism, silica rich solutions often permeate the surrounding rocks. Since vulcanism was active in the region the writer attributes the great quantity of secondary silica, found in the sediments and in the lavas, to this phenomenon of dying activity.

Cross-bedding and lensing are common, possibly indicating deposition close to shore. Within a distance of a few hundred feet a coarse conglomerate may be entirely replaced by a fine grained siliceous shale.

Effusive rock types are well represented in the eastern portion of the region. Several flows are present, but as the problem deals principally with the structure and stratigraphy of the sedimentary series, little detailed work was done in these lavas. Two units were, however, distinguished; one a dacite flow, the other a complex flow, or a series of flows, ranging from andesite to basalt in composition. The age of these effusives is open to some doubt, but it is believed that sufficient evidence has been found to justify their age determination as upper Miocene.

At the eastern end of the hills, in the vicinity of Ganesha Park, a complex of granitic intrusive rocks is found. It has been cut by a dacite dike which toward the east has, at three localities, been progressively displaced southward.

The Puente Formation
(Middle and upper Miocene)

The name Puente formation was derived from the Puente Hills and applied by Eldridge[1] to the Miocene strata outcropping throughout that region. This term was later used by English[2] to describe in a similar manner, the Miocene strata of the Puente and San Jose Hills. At that time microfossil paleontology was in its infancy, and since the formation is otherwise unfossiliferous, the age determination was based upon the stratigraphic position between the middle Miocene Topanga and the Pliocene Fernando, and on the lithologic character of the sediments. Determination of foraminifera collected during this work has verified the former conclusion that the Puente is middle and upper Miocene in age, and similar to the Modelo of

[1]Eldridge, G.H., Arnold, Ralph. The Puente Hills Oil District, Southern California. U.S.G.S. Bulletin 309, page 103, 1907.

[2]English, W.A. Geology and Oil Resources of the Puente Hills Region, Southern California. U.S.G.S Bulletin 768, pages 26-29, 1926

Fig.7 South dipping limb of a syncline passing through Sentous Ranch (north of Walnut). This view clearly illustrates the induration of the shale members due to the heat and pressure of deformation. (Looking north-east)

western Los Angeles and Ventura Counties.

With the exception of the igneous rocks, the Quaternary terraces, and one small outcrop of Pico, the Puente formation outcrops over the entire hills. It consists of alternating beds of shale, sandstone, and conglomerate.

The shales are composed of siliceous sands, muds, and clays, and often contain diatom remains. They are grey when unweathered, but on long exposure turn a rusty brown. Their hardness varies between wide limits, some being soft and crumbly while others are hard and flint-like. Hardness seems, in many cases, at least, to be dependent upon the degree of folding, harder members being found in the most contorted areas (figure 7).

According to Davis[1] the wide difference in hardness of most of the Tertiary siliceous shales and cherts, is due to the variation in amount of colloidal silica deposited as an original constituent of the beds. In the harder strata an abundance of silica has formed

[1] Davis, E.F. The Radiolarian Cherts of the Franciscan Group. University of California, Dept. of Geology Bulletin, vol. 11, 1918.

a cement, binding together the other constituents. It has been suggested by English[1] that as a result of the heat and pressure developed by folding, secondary solution and deposition has taken place. Davis believes this factor of less importance in the determination of hardness than original composition. The field evidence, however, seems to prove beyond doubt that due to folding, some secondary process has been active.

The sandstone members of the Puente have an areal extent nearly equal to that of the shale, and are composed of material ranging from well rounded quartz grains to angular grains of quartz and feldspar. These beds are buff to tan in color and contain an abundance of conglomerate. This coarser debris is very local in distribution, being rapidly replaced by sandstone or shale. Because of their resistance to erosion, the sandstone members give rugged outcrops, often forming ledges protruding

[1] English, W.A. Geology and Oil Resources of the Puente Hills Region, Southern California. U.S.G.S. Bull. 768, page 28, 1926.

Fig.8 Sandstone ledges protruding beyond the less resistant shale. Looking north from a point ½ mile east of the Sentous Ranch.

Fig.9 Outcrop typical of contorted upper Puente shale. Road cut ½ mile west of the summit of Pomona Road.

beyond the less resistent shale (figure 8).

The conglomerate of the upper Puente formation presents an interesting problem, for beds several hundred feet thick may totally disappear in less than a quarter mile. The beds do not terminate abruptly, as the areal map might lead one to belive, but are gradually replaced by finer material. Their appearance suggests immediate offshore deposition, the coarser material being dropped at the mouths of rivers, while the finer was carried greater distances to sea.

Figure 9 shows a typical shale outcrop, and one can readily see why difficulty is encountered in interpreting attitudes taken in such material. The isolation of outcrops adds to this problem, for apparent structures may be due to minor crumpling. Although compression has been active, these contortions are in part due to surface creep and minor slumping, for where observations are taken in deeply eroded canyons, more characteristic attitudes are obtained.

The Puente formation is of economic interest, for it is postulated as the source of oil in the Whittier, Santa Fe Springs, and surrounding districts. Oil staining, especially in the middle sandstone member, tends to

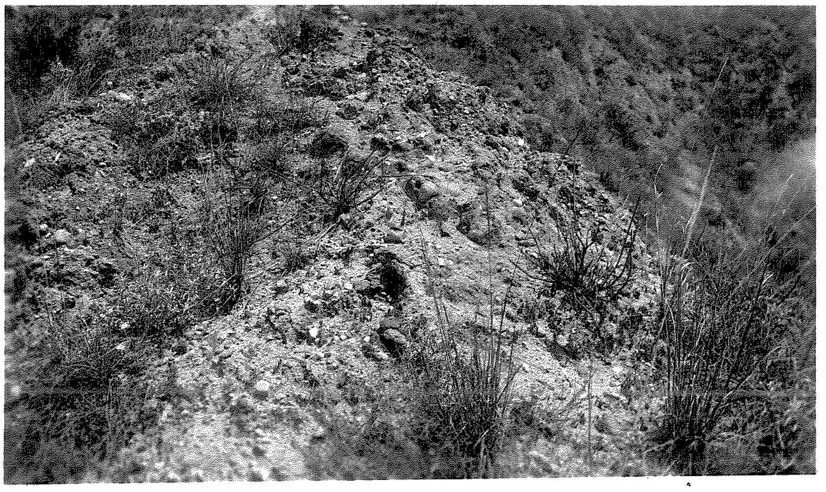


Fig. 10 Typical outcrop of middle Puente sandstone member, showing irregular bedding and lack of sorting of the material. View taken ½ mile west of the summit of Pomona Road.

corroborate this theory, and indicates an origin in the lower or middle member.

Middle Sandstone
(Middle Miocene)

The lowest formation present in the San Jose Hills is the middle sandstone member of the Puente series. Its exposed thickness is at least 2,700 feet, but due to faulting along its southern extremity, a maximum value cannot be obtained. The lower division, which in the Puente Hills is represented by 2,000 feet of shale, may be present at depth, but is not found outcropping. Nearly half of the thickness of the middle member is coarse, poorly sorted, irregularly bedded, siliceous sandstone. The remainder is a poorly bedded conglomerate, which shows little or no sorting (fig.10). The material ranges from a fraction of an inch to two feet in diameter, averaging about 2 inches. It is angular to subangular when small, but when large is well-rounded. These sediments originated in an area of acidic rocks, for the pebbles are composed of quartz, quartzite, granite, granodiorite, and granitic schist. These pebbles are cemented

Fig.11 Steep slopes of middle sandstone member south of Buzzard Peak. Looking east. (Pomona in the distance).

with a very angular, poorly sorted, quartz sand, with which is mixed much finer material.

Occassionally boulders of badly weathered lava are found, but it is not believed that they have been derived from the extrusive rocks lying to the east. Few dark colored grains are present, due possibly to the acidic origin and a somewhat lengthy transportation.

The middle sandstone is buff to rusty yellow in color, except where oil staining has turned it deep red. It weathers very steeply, in extreme cases giving slopes of 60° (Fig.11). Outcrops are better and slopes steeper to the south of Buzzard Peak for here the formation has been elevated at least 2,500 feet by faulting.

This unit is remarkably free from folding, a dip of 35° to 50° north being recorded through its areal extent.

An interesting feature is noted at the summit of Pomona Road. Just below the contact of the middle sandstone and the upper shale is an 8 to 10 foot zone of conglomeratic material that first appears to have an igneous origin. Upon closer examination, however, the writer concluded that the material represented a badly altered conglomerate. The entire zone is decomposed, the bedding disturbed, and a dark brownish color predominates (Figs. 27 and 28). The cause of this alteration cannot be definity ascertained but a possible explanation is one of fumarolic action or metamorphism by igneous intrusion. The limited extent of its distribution indicates that this altered zone is due to some local cause and not to conditions general throughout the length of the contact.

It has been reported by J.L.Soske of the Institute,[1] that the middle sandstone member has been intruded by a basaltic dike. It reaches the surface only in one small canyon, but a magnetometer-survey indicates an extent of several miles.

Upper Shale
(Upper Miocene)

The upper shale member of the Puente forms by far the larger part of the outcropping rocks in the area. Its contact with the middle member is well

[1] Oral communication.

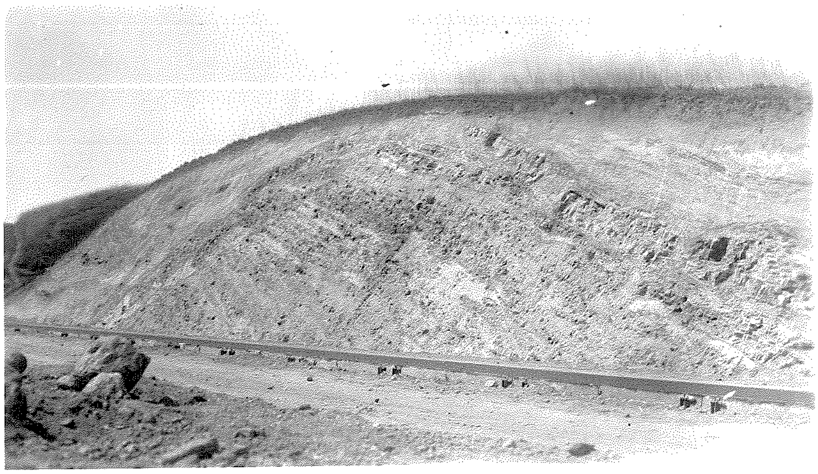


Fig.12 Folded,gradational contact betwêen middle sandstone and upper shale. (In cut at the summit of Pomona Road.

Fig.13 Contact betwêen middle Puente sandstone and upper Puente shale. Folding and gradational character of the contact is well shown. (In cut at the summit of Pomona Road).

exposed in the cut at the summit of the Pomona Road. As can be seen from figures 12 and 13 this contact is gradational, consisting of 10 to 15 feet of alternating conglomerate and shale. It has been complicated by faulting and minor folding, but detailed study shows no angular discordance or break in sedimentation.

This upper member may be roughly divided into two smaller lithologic units, which, although present throughout the area, are not constant enough to be separately mapped. The lower unit is nearly 1,500 feet thick and composed almost exclusively of shale. For sake of simplicity the lower shale unit of the upper Puente member will hereafter be designated as A and the upper alternating zones of sandstone, conglomerate, and shale, as B.

The shale of unit A is, in general, rather soft and powdery, but occasionally beds of hard flint-like material are encountered. In color it varies from grey to pinkish tan, the latter being due to a slight content of hematite. As is common through the Puente series, this shale contains a number of lenticular beds of sandstone and conglomerate, probably indicating deposition in shallow water.

Unit B consists of a succession of soft, clayey, and diatomaceous shales, interbedded with several lenticular conglomerates and sandstones. These beds are well exposed on the north flank of the San Jose Anticline, and in the two folds paralleling it on the south. On the geologic map the sandstone beds appear to pinch out, but this is not the case. As one proceeds westward the conglomerates are replaced by sandstones, which in turn are replaced by shales. The disappearance of a sandstone or conglomerate bed, is therefore, merely substitution of finer material in the bed itself, and not an actual thinning of that member.

In speaking of the upper conglomerate beds of unit B, English[1] says, "The conglomerates are very similar in character to those in the Fernando, and it is possible that some of them are actually of Fernando age. In general, thick zones of conglomerate are more common in the Fernando than in formations of the Monterey group, but in the absence of any indication of unconformity it is thought preferable to include

[1]English, W.A. Geology and Oil Resources of the Puente Hills Region, Southern California. U.S.G.S. Bulletin 768, pages 36-37, 1926.

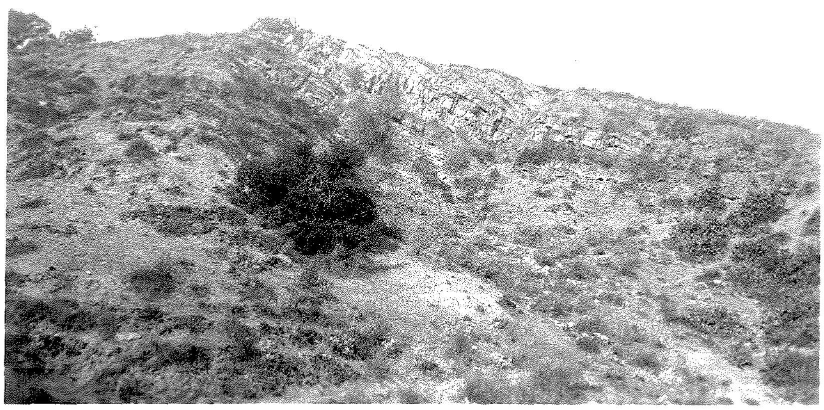


Fig.14 Protruding ledges of sandstone in upper Puente shale. Looking north from a point 2 miles north-east of Walnut.

the whole succession in the Puente".

A Fernando age is impossible, however, for foraminifera collected near the top of unit B definitely place it in the upper Miocene, and not in the lower Pliocene.

The sandstone of unit B is buff to rusty tan in color, composed of angular grains of quartz and feldspar, and cemented with fine grained quartz. It is often well indurated, and due to its superior hardness weathers in steep cliffs, giving rise to ledges protruding several feet beyond the less resistant shale (Fig. 14).

In some regions relatively heavy beds of sandstone (5 to 8 feet thick) are found, but in general conglomeratic material accounts for over half the total thickness. This conglomerate is not unlike that of the Puente middle sandstone. It is composed of boulders of granite, quartz, granodiorite, quartzite, granitic schists, ranging in diameter from a fraction of an inch to 3 feet. Toward the top of the sandstone members of unit B lava boulders become frequent, which may or may not have had their origin in the area of extrusive rock in the eastern portion of the region. The finer pebbles are very angular, but the larger boulders are subangular to rounded.

Fig.15 Quarry in upper Puente diatomite, illustrating the well bedded thinly laminated nature of the deposit. Looking north from a point 1 mile south-east of the Masonic Home.

At the top of the Puente upper shale member is a bed of diatomite 500 feet thick. Most of the material is light and punky, but some of it is composed of almost pure silica, and is hard and flint-like. The diatomite is light grey to white in color, and has an uneven, though persistent bedding (Fig. 15). The thickness of individual beds varies from less than one inch to one foot, and each bed may be split into innumerable thin layers. Individual beds of the material are very pure, but throughout its thickness occur thin seams of clay shale.

For the following reasons this diatomite is considered to represent the final stages of the Miocene deposition. First, it is located at the top of the upper Miocene Puente shales. Secondly, it is common throughout California to find diatomite representing late or final stages in the Miocene, and, lastly, this material is overlain by a massive conglomerate lithologically like the Pliocene Pico formation.

The thickness of the Puente upper shale can not be less than 5,000 feet, for this thickness outcrops. It may well be greater than this, for enormously thick upper Miocene sections are known to occur elsewhere in California.

Origin

In a recent talk discussing the Pliocene conglomerates of the Los Angeles Basin E.C.Edwards[1] of the Institute stated that any sediments containing white pegmatite could not be derived from the San Gabriel range, for there were no representatives of this rock type outcropping. Evidence was presented to prove that the San Gabriels were not a positive land mass in Miocene and Pliocene time. This does not agree with Dr.Maxson's[2]work in the Mint Canyon area, or with the writer's work in the Newhall area, for at both localities boulders of anorthosite, most certainly derived from the San Gabriel occurence, were found in Miocene and Pliocene sediments. However, if the first statement is true the San Gabriels are eliminated as a possible origin for the sediments of the San Jose Hills. Furthermore, the westward replacement of conglomerate by sandstone and shale indicates a north-south shore line with the material

[1]Edwards,E.C. Unpublished Thesis, California Institute of Technology, 1933.

[2]Oral communication.

being derived from the east.

With the San Gabriel origin eliminated, a likely source is the Perris block. It lies a few miles to the east, and is known to have been high standing during Miocene and early Pliocene time. Acidic rocks and lavas are well represented in that region. Admitting a westward drainage parallel to the possibly low standing San Gabriels, these rocks could have served as a source of material for the sediments of the San Jose Hills.

Mode of Deposition

The common textbook presentation on the origin of sediments states that deposition ranging from shallow to deep water proceeds in the order, conglomerate, sandstone, and shale. In recent years this idea has been weakened, for numerous shallow water shales and deep water conglomerates have been discussed. In the San Jose Hills sedimentary record, definite evidence is found for shallow water deposition of shales.

The upper member contains at least four, and possibly more, beds of coarse, poorly bedded, poorly sorted conglomerate. Thet lens rapidly and change in physical character along the strike. They most certainly represent deposition near the mouths of rivers and at a shallow depth. One might postulate four fluctuations of the land during upper Miocene time, but this seems improbable, for such movements, would necessitate at least minor unconformities. Detailed study of the shale-conglomerate contacts reveal no such discordance, and one must conclude that little or no change in the basin of deposition took plade.

Throughout the shale large perfectly preserved leaves are obtained, which are of such fragile nature that deep water deposition and therefore long transportation seems unlikely.

The above evidence seems adequate to establish shallow water deposition of the San Jose Hills sediments.

Age

The shale of the upper Puente contains an abundance of foraminifera. At several localities samples were collected and their determination places this member in the upper Miocene. A fauna taken at 10 feet above the contact between the upper shale and middle sandstone may be correlated with beds lying 250 to 1375 feet above the top of the Temblor. It is therefore possible that the lower portion of the upper member extends slightly downward into the middle Miocene.

Mr. F. W. Bell of the California Institute of Technology determined the foraminifera collected and makes the following comments.

"Foraminifera from the San Jose Hills collected by E. N. Harshman.

Loc. 234 Top of upper 'Puente' shale.

Buliminella brevior Cushman
Buliminella curta Cushman
Buliminella subfusiformis Cushman
Bolivina brevior Cushman
Bolivina hughesi Cushman
Planulina ornata (d'Orbigny) (?)
Uvigerina sp.
Bolivina decurtata Cushman
Bolivina sp.
Bolivina sp.
Nodosaria sp.
Eponides sp.
Nonion (?) sp.
Gyroidina soldanii d'Orbigny

This fauna characterized by very abundant Bolivina especially Bolivina hughesi can be correlated with the Bolivina Hughesi zone of the Modelo formation of the Los Angeles and Ventura basins.

Hoots[1] obtained this fauna in the Modelo exposed in the section between Mohn Springs and Girard. The fauna listed above corresponds to the range between samples 125 and 138 probably nearer to the base of that range.

Loc. 234A, 10 feet above the base of
the upper 'Puente' shale

This sample contains a few foraminifera, including Baggina californisa Cushman. This species has recorded only from the Valvulinaria californica zone of the Miocene of California. In the Chico-Martinez Creek section Baggina californica occurs from 250 to 1375 feet above the top of the Temblor formation. Baggina californica does not occur in the Mohn Springs-Girard section mentioned above but does occur in a neighboring canyon in which beds of lower stratigraphic position in the Miocene occur".

Pico?
(Pliocene)

General Description

The name Pico was first used by B.L.Clark to describe

[1]Hoots,H.W. Geology of the Eastern Part of the Santa Monica Mountains, Los Angeles County, California. U.S.G.S. Prof. Paper 165-c,p.113,1931

[2]Clark,B.L. Journal of Geology. 29 : 608-609

Fig.16 Outcrop of Pico ? conglomerate, illustrating the well rounded and well sorted nature of this sedimentary series. (On a quarry road 1 mile south-east of the Masonic Home).

beds of lower Pliocene age outcropping in Pico Canyon. The term is now generally applied to those beds lying above the Miocene Modelo formation, and its correlatives, and below the upper Pliocene Saugus formation.

In the north central part of the area, and lying conformably above the upper diatomite, is a 300 foot bed of conglomerate. Its lithology is unlike that of the Miocene conglomerate, for it is well bedded, poorly indurated, well sorted, and has a small percentage of siliceous material. The pebbles are rounded and average 2 inches in diameter (Fig.16).

Age

In the Puente Hills region the end of the Miocene is marked by thick beds of diatomite. This material is overlain, sometimes conformably and sometimes unconformably, by the lower Pliocene Pico formation. It seems justifiable to assume that the same sequence of events transpired in both the San Jose and the Puente Hills, for they are separated by a distance of less than 2 miles. Furthermore, the lithology of the conglomerate in question is very similar to that of the Pico in the Puente Hills and

Los Angeles Basin. For these reasons the conglomerate overlying the diatomite in the San Jose Hills is termed Pico and placed in the lower Pliocene.

Terrace Deposits

Along the north central portion of the area are several old stream terraces. They dip slightly northwest and are composed of poorly sorted, unconsolidated conglomerate, together with sand and soil. They are reddish in color and represent fanglomerates deposited by Pleistocene streams. Due to recent uplift, erosion has proceeded rapidly, cutting deep canyons with nearly vertical walls.

Alluvium

The present streams are transporting large quantities of material from the steep slopes toward the valleys. This weathering product consists of sand near the hills, but becomes finer where stream gradients decrease. The valleys are underlain by coarse, unconsolidated river gravels and angular sands.

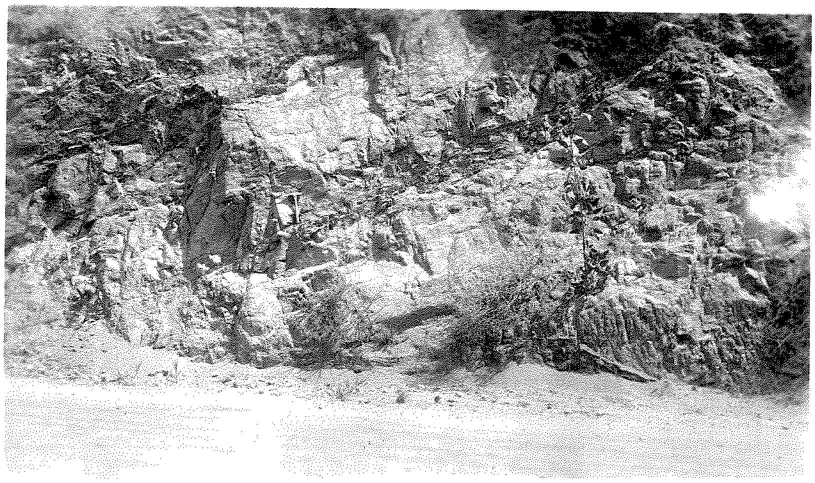


Fig.17 Outcrop of granitic rocks of the "Basement Complex". Taken in road cut along the south-western border of Ganesha Park.

Fig.18 Exposure of dacite dike cutting the "Basement Complex". Jointed nature of the dike is clearly shown, as is lack of metamorphic effects along the contact. (In road cut ¼ mile south-west of Ganesha Park).

Igneous Rocks

Basement Complex

In the extreme eastern portion of the area occur intrusive igneous rocks. Many granitic rock types are represented but due to lack of detailed work all have been included under the general term "basement complex", (Fig. 17).

Because of jointing and fracturing these rocks are greatly weathered, and excavations penetrating them to a depth of 30 feet expose only a much decomposed facies. This complex has been intruded by a dacite dike, which may have served as a conduit for the material extruded in the flow lying to the west (Fig. 18). Subsequent minor faulting has, at three localities, displaced this dike. In passing eastward the relative movement has been progressively southward.

The age of this intrusive igneous mass is definitely pre-middle Miocene, and probably may be correlated with the Jurassic igneous activity so common throughout the Pacific Coast.

Fig.19 Exposure of lava north of Puddingston Dam.

Extrusive Lavas

General Discussion

Late in the Miocene vulcanism was active, extruding lavas upon the "basement complex" and existing sediments. Undoubtedly several flows are present in the region but only two units were separately mapped.

One is a vesicular lava flow or series of flows, which is divided by a strip of alluvium into a northern and southern area. It is basaltic to andesitic in composition and contains much secondary silica, probably deposited from waters originating in the parent magma (Fig. 19). The other is a flow of dacite porphyry containing phenocrysts of plagioclase and considerable biotite. A good system of jointing has developed in this dacite, greatly aiding its recognition.

These lavas have been considered flows rather than sills for the following reasons. (1) Flow structure indicates that the "bedding" of the lava and that of the overlying and underlying sediments is not parallel. (2) The lavas are very vesicular especially in their upper and lower portions, indicating rapid cooling. (3) Metamorphism of the underlying sediments was seen in nearly all exposures of the contact, but in no case did the overlying material show the effect of heat. (4) Flow breccia was present in the lavas throughout the area.

The origin of both flows was evidently to the east of their present outcrop for flow structure and banding indicate a gentle westward dip. Interbedded in this volcanic series occur beds of tuff, tuffaceous sandstone, and agglomerate.

Age

The northwestern portion of the basaltic-andesitic flow is definitely upper Miocene in age, and was extruded during the deposition of the upper Puente shale. Evidence for this age determination can be easily seen on the accompanying map. The tributaries of Walnut Creek have eroded steep canyons through this volcanic series and expose at its base baked and contorted shale. Where section EF crosses the extrusives an island of lava underlain by shale is easily recognized. Approximately one half mile to the east of this locality, shales of the upper Puente rest unconformably upon the lava surface. In the first canyon east of section EF one can see in the steep wall, the sequence shale, lava, and shale, adequate proof for the foregoing determination.

In the southeastern portion of this rather complex flow may be found reasonable proof of a similar but possibly slightly earlier age. About one mile south of Puddingstone Reservoir streams have dissected the agglomerate which borders the eastern edge of the lava flow and have exposed the underlying shale. As can be seen from the geological map of the area, a tongue of this shale protrudes well back into the agglomerate, almost reaching the lava. This definitely proves the shales older than the agglomerate, but only indicates that they may be also older than the lava. Further, if the slope of the present lava surface were projected toward the shale-agglomerate contact the flow would definitely overly the shale.

The best indication of age is found in the westernmost extremity of this southern lava series. Here a tongue of lava forms a series of peaks, which seems rather definitely to be underlain by shale. Although outcrops were poor the contact could be definitely traced, and inference from the map bears out this assumption of underlying shale.

The attitude of the shale varies considerably, but in general strikes toward the lava contact, not parallel to it. This, of course, could be explained by faulting, but as no such evidence could be found, and it was indeed looked for, this evidence seems to indicate a pre-lava deposition of the shales.

A final indication of age may be derived from the similarity of composition, and proximity of the northern and southern portions of this flow. It seems justifiable to assume that two lavas petrographically so alike and separated by only a few hundred feet of recent alluvium are of the same age.

Against this reasoning apparently only the following argument can be advanced. It is true that if the present surface is projected it will lie well above the lava-shale contact, but where will the base of

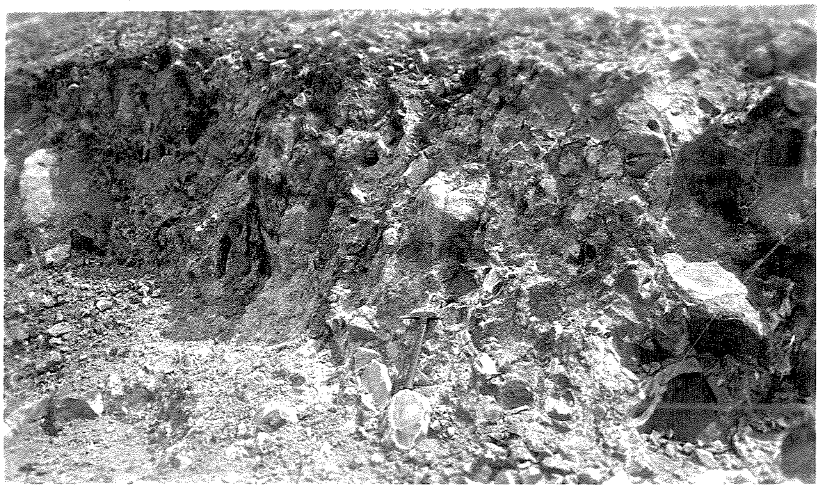


Fig.20 Outcrop of agglomerate bordering lava flow north of Puddingstone Dam. This rock type may be classed as a puddingstone, from which the name of the dam was derived.

the flow project? It must be admitted that it will possibly fall below the present shale surface, but unless this flow is over 5,000 feet thick, it will still be interbedded in the upper shale member of the Puente, for that thickness of shale is definitely known to be present.

Agglomerate

General Discussion

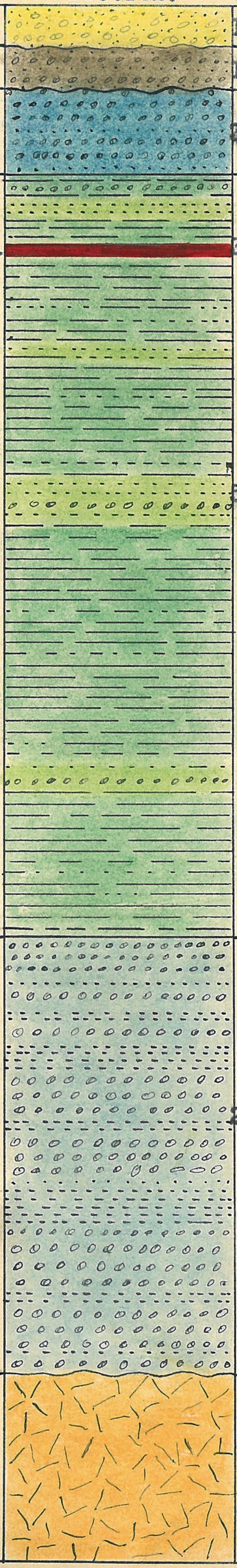
Beds of agglomerate were mapped along the eastern border of the southern basaltic-andesitic flow, and along the southern border of the northern flow. They consist of angular fragments of volcanic rock imbedded in a fine granied volcanic ground mass (Fig. 20). This rock type is common throughout the lavas but was only separately mapped at the 2 mentioned localities. In some places it exhibits a rough bedding, but in general it haphazardly arranged. Flow breccia is also common near the base of several of the flows and is well exposed in a road cut traversing the western extention of the southern basaltic-andesitic lava flow.

Origin

The agglomerate is the product of explosive volcanic activity, and in general was deposited where it fell. However, in some regions this material shows a rudimentary bedding, indicating deposition by water.

As the lava flows moved westward their surfaces became hardened and the continued movement fractured this newly formed crust. This gave rise to the flow breccia found in the western part of the extrusives, especially near their base.

COLUMNAR SECTION
of the
SAN JOSE HILLS.



System.	Series.	Formation	Symbol.	Columnar section.	Thickness.	Character
Quat.	Rec.	Alluvium	Qyal		100'±	Unconsolidated gravels
		Unconformity				
	Pliest	Terrace Deposits	Qt		100'±	Red river gravels.
		Unconformity				
Tertiary	Plio.	Pico ?	Tp		300'±	Buff to brown roughly bedded conglomerate.
	Miocene	Extrusives			300'±	Basaltic, andesitic, & dacitic lava flows, & Agglomerate
		Puente upper shale	Tpuss Tpush		5,000'±	Grey to reddish calcareous, silicious, and diatomaceous shale (Tpush); buff sandstone and conglomerate (Tpuss).
		Puente middle sandstone	Tpmss		2,700'±	Grey to rusty brown conglomerate.
		Unconformity				
Pre-Tertiary	Jurassic	Basement complex	Jc		?	Intrusive granitic rocks.

Plate IV

Structure

General Features

The dominant structural trend of the region is N 70° E, roughly parallel to the edge of the hills. Folding is common, especially in the incompetent upper shale member. One minor and two major faults can be easily traced in the region, but both appear to terminate in the soft shale. At the summit of Pomona Road five minor faults have been recognized, but due to lack of exposures they cannot be traced for any great distance. Five small cross faults have been mapped, three in the "basement complex" of the Ganesha Park region, one near the summit of Pomona Road, and one in the small group of hills just east of Puente. These hills are confusingly known as the Puente Hills, but since they are not connected with the larger physiographic unit bearing the same name, they are referred to by location alone

Folding

The principal structural feature in the region is a series of northeast trending folds, the most important of which occupy the western portion of the area.

The San Jose anticline is probably the most important of these. Its axis forms the crest of the hills and extends from the region immediately south of Buzzard Peak westward to the alluvium. It is an asymmetrical flexure with its northern limb dipping 30° to 35° and its southern limb 35° to 40°. Several sandstone beds may be easily traced around its nose, and give some clue to the subsurface nature of this fold. From attitudes taken on both flanks, as well as on the nose, it appears that with increasing depth the limbs slowly decrease in dip. One may therefore postulate that this, and probably most of the other folds in the area, can be classified as similar folds, and that while they persist downward for some distance they are with depth slowly dying out. This type of folding should be expected in a sedimentary series consisting of incompetent shales interbedded with competent sandstones. Eastward from the Buzzard Peak region the northern flank of this major anticline is occupied by the coarse conglomerate of the middle Puente sandstone. Attitudes taken in this material may indicate a slightly domed structure but as the southern limb of this questionable domed anticline has been removed by faulting, concrete evidence for its existence is lacking. The change in attitude from EW to N45°W may be due to the southward lying Buzzard Peak fault, which has a vertical displacement of at least 2,500 feet.

South of the San Jose anticline is a definite and easily traceable syncline. It also plunges westward, but at a low angle, possibly not more than 12° to 15°. It runs roughly parallel to the San Jose anticline and can be definitely traced to a point directly south of Buzzard Peak. This fold is also asymmetrical with its north limb dipping more steeply than its southern limb (dip of northern limb 35° to 40°, dip of southern limb 25 to 30°). Two interesting features are noted in the central portion of this syncline. On two low sandstone peaks may be traced isolated patches of shale, which in both cases are again overlain by sandstone. These two patches probably represent erosion remnants of a formerly thin stratum of shale lying between two thicker sandstone members.

Another important anticline parallels on the south the above-mentioned syncline. It may possibly be the longest fold in the region, but due complications of attitudes in the hills lying north of Walnut, it has been impossible to definitely continue this fold eastward past that point. However, less than a mile east of this uninterpretable region a minor anticline has been traced which is in direct line with the western fold. It is therefore possible that this anticline extends from the alluvium at Puente to the edge of the hills just west of Spadra, with minor folding in the hills north of Walnut obscuring its axial trace.

In the region 1½ miles north of Rincon de la Brea the southern flank of this fold is occupied by 3 minor folds. These folds are, however, small, and cannot be traced for more than a few thousand feet

For most of its length this anticline is one

Fig.21 Gently north dipping upper limb of overturned anticline. (East of Puente, looking north-east).

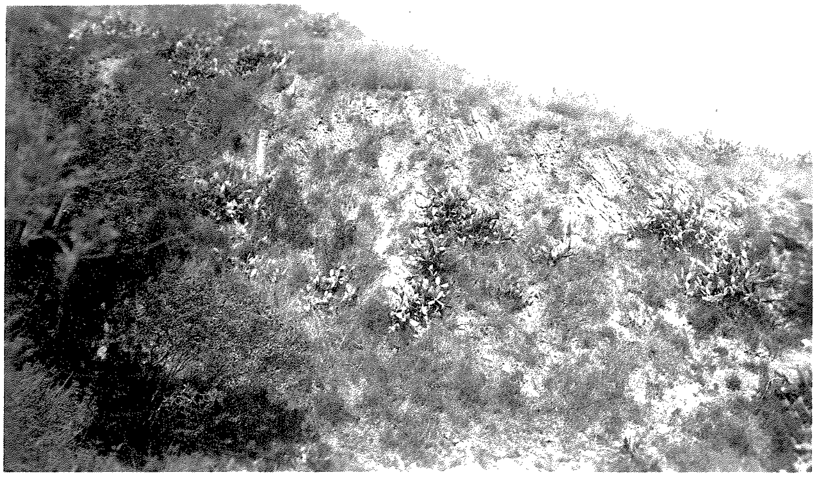


Fig.22 Steep north dipping limb of normal continuation of anticline in hills east of Puente. (Looking north-east).

of the normal asymmetrical type with an average dip of 85° for the northern limb, and 40° for the southern. However, west of Covina Road in the small group of nearly isolated hills east of Puente this fold is overturned southward (Fig. 21). This fact is clearly evidenced by the repetition of several well indurated sandstone beds, by the sudden change in dip from N30° to N65°, and by the inversion of the normal gradation in the size of the grains of the individual beds. Directly north of Rowland school a transverse fault has displaced this fold and its eastern portion has been thrust southward. Its western continuation is a normal, symmetrical, anticline, plunging west at an angle of 25° (Fig. 22).

South of these three major folds are several smaller flexures, none of which are important. The largest is a syncline extending eastward from section AB to section CD. It is asymmetrical with the steeper south limb dipping 40°.

Another series of folds has been mapped in the region west of Spadra. The area is probably

Fig.23 Small, contorted, overturned fold in the upper Puente shale. (In a road cut $1\frac{3}{4}$ miles west of summit of Pomona Road).

synclinal, but due to extensive shortening, minor contortions have been produced. Two anticlines and three synclines have been recognized. All are apparently symmetrical but little information is available on their characters. Outcrops are rare in this upper shale member and surface creep has so contorted the few found, that detailed structural investigation is almost impossible, (Fig.23). However, from the trace of the sandstone-shale contact, which crosses several of the folds, it may be concluded that the most northerly syncline and anticline both plunge eastward at an angle of 15° to 25°.

In the Puddingstone Dam area 10 folds have been mapped, only four of which are of importance. A minor syncline has been recognized in the shale underlying the lavas, but due to lack of exposures can only be traced for a short distance. Paralleling it on the south is an easily traceable anticline, which extends from the region south of the Masonic Home eastward to Puddigstone Dam. This flexure is symmetrical, with dips of 20° to 25° being recorded for both limbs.

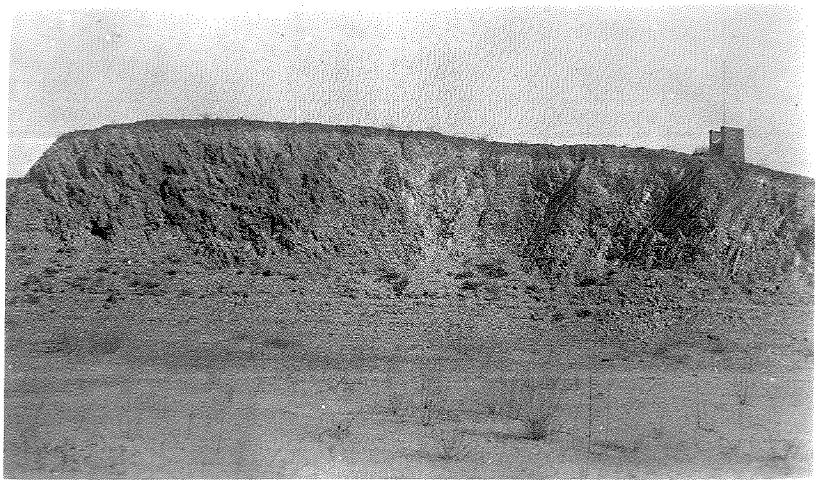


Fig.24 Syncline in upper Puente shale. Exposed by excavation along the east wall of Puddingstone Reservoir. (Looking north-east).

The small patch of Pico lying south of the Masonic Homm has been preserved by synclinal folding, which can be traced from the border of the Quaternary Terrace traversed by Pomona Road, to the eastern border of the excavation made for Puddingstone Dam. It is the most continuous fold in the area and has an average dip of 60° for both limbs (Fig.24).

South of the syncline are mapped four small folds, none of which are important. They are all easily recognized in the fied, but seem to terminate eastward toward the lava. They are, in general, symmetrical, with the flanks averaging 40° in dip.

This area of minor flexures is followed on the south by two major folds. The most northerly is an asymmetrical anticline with the steeper south limb dipping 45° to 50°. On the south it is paralleled by an asymmetrical syncline. Both of these folds can be traced nearly three miles westward from the shale-lava contact.

The most southerly fold of this group is a small questionable anticline which apparently has affected the lavas as well as the shales. A small

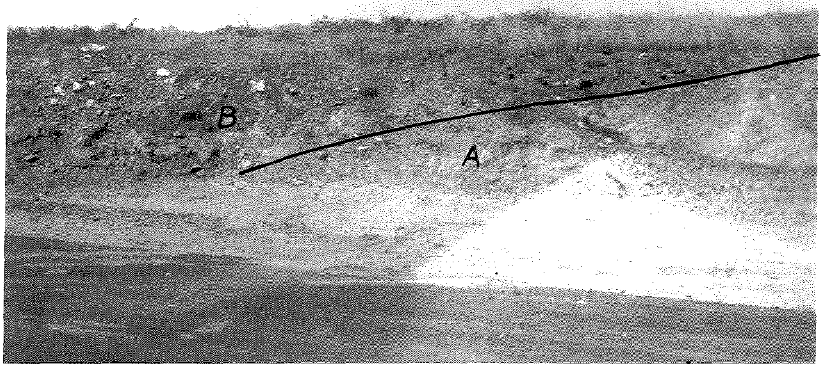


Fig.25 Small patch of shale protruding through lava at western end of Puddingstone Dam. Folding has enabled erosion to strip off overlying lava and expose the underlying shale.
A=shale
B=lava

anticline in the lava at the western end of Puddingstone Dam has exposed a few hundred square feet of underlying shale, and formed an island of sediments protruding through the extrusives (Fig.25). Undoubtably other folds are present throughout the region described in this report, but due to unreliability of attitudes and scarcity of outcrops only the above described have been definitely mapped.

Faulting

The major fault in the area has been termed the Buzzard Peak fault. Its linear extent is not definitely known, but it can be accurately traced eastward from a point one mile SW of Buzzard Peak, to the alluvium of the San Jose Wash. Its presence beneath this thin covering of unconsolidated gravel is definitely shown by variations in the water levels of wells drilled along the southern border of the hills. Well log data kindly offered by Mr.R.Eckis has enabled the writer to extend this fault eastward until, in the region north of Pomona, it passes beyond the area. Its western termination is questionable, for as soon as its trace passes beyond the middle Puente conglomerate and enters the upper Puente shale evidence for its presence cannot be found. It may turn slightly northward and continue down the canyon traversed by Cameron Avenue, but as detailed investigation shows little disturbance in that region, this is unlikely. Since the San Jose anticline terminates near the western end of this fault a more likely explanation is that the stresses producing faulting in the eastern portion of the area produced folding in the western portion.

The fault plane is nowhere exposed, and the present escarpment is of a fault line type; therefore little accurate data upon dip, direction of movement, amount of movement, etc. can be obtained. However, the following can be stated.

1. Presence of a fault is indicated by upper Puente shale striking beneath 2000 or more feet of middle Puente sandstone, and by a zone of fractured

and crushed shale and conglomerate, extending the length of the upper shale-middle sandstone contact.

2. The fault has a vertical displacement of at least 2,700 feet, for this thickness of middle Puente has been exposed.

3. The fault plane dips northward at a large angle. The trace of the shale-conglomerate fualt contact indicates a northward dip of at least 80° to 85°.

4. The fault is therefore of the revesse type with the northern block overriding the southern one.

5. Compressional forces were active in producing the fracture and subsequent movement.

6. Horizontal movement was probably of very minor importance, for if this were not the case the fault trace should continue some distance beyond the western border of the conglomerate.

7. The fault is post-upper Puente in age as evidenced by its displacement of the upper Puente shale. (Evidence will later be presented which will probably correlate this faulting with the early Pliocene orogenic movements.)

Another important fault enters the area just north of Puddingstone Dam, traverses several thousand feet of lava, and then terminates in the shale. Construction of the dam has excluded forever the possibility of determinating the charcter of this fault or of its movement. Its presence is indicated by the wide zone of fractured, slicken-sided lava, a depp, narrow, straight canyon, and major disturbance during the Long Beach earthquake of March 11, 1933. This latter evidence is the more interesting for it may have some bearing on the hypthesis which utilizes an eathquake shock as a trigger force to set in motion faults in the shaken area.

The presence of the Puddingstone Dam fault, was known to the builders of the structure, and an earth-filled dam, faced with large slabs of concrete was therefore built, for such a structure would stand minor fault movements.

These large concrete slabs are merely laid on the sloping face of the earth filling and are free to move with respect to one another. The Long Beach

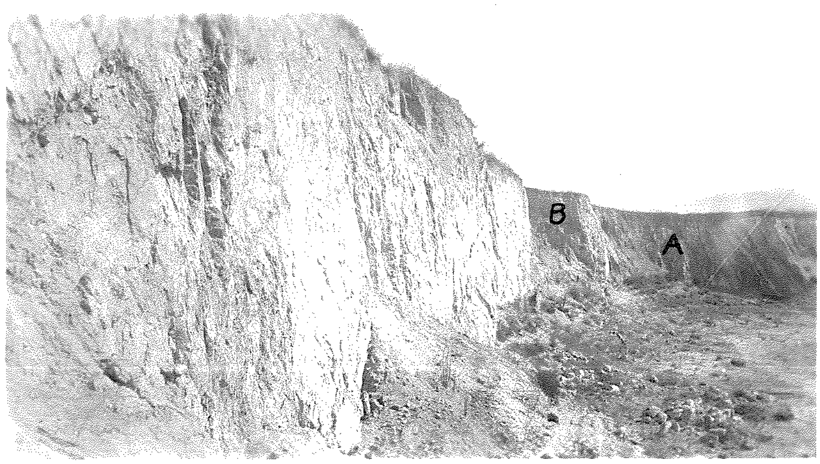


Fig.26 Plane of small strike fault exposed by excavations for Puddingstone Dam. Looking east along north face of reservoir.
A=Badly crumpled shale (hanging wall)
B=Lava (foot wall)

quake directly or indirectly caused these blocks to be relatively displaced as much as one inch. This movement was confined to that part of the dam under which the trace of the fault passes.

The shifting of the blocks may have been due to a minor movement on the Puddingstone Dam fault or to the phenomenon of amplification of movement due the presence of a zone of crushed and brecciated rock. A hurried examination of the region below the dam revealed no evidence of actual displacement on the fault, and the writer therefore concluded that the jostling of the blocks was due to amplification of movement at this point. However, only a hurried examination was made and detailed work in the area may uncover evidence of minor movement on the fault itself.

Excavations for the Puddingstone Dam have exposed a small strike fault whose plane dips 85°S. Striations attest a nearly vertical movement, and drag folding indicates compressive forces with elevation of the south shale block (Fig.26).

A small cross fault displaces the plunging

Fig.27 One of the four small faults at the summit of Pomona Road. (This view also illustrates the alteration referred to on page 25, and the gradational nature of the middle sandstone-upper shale contact).

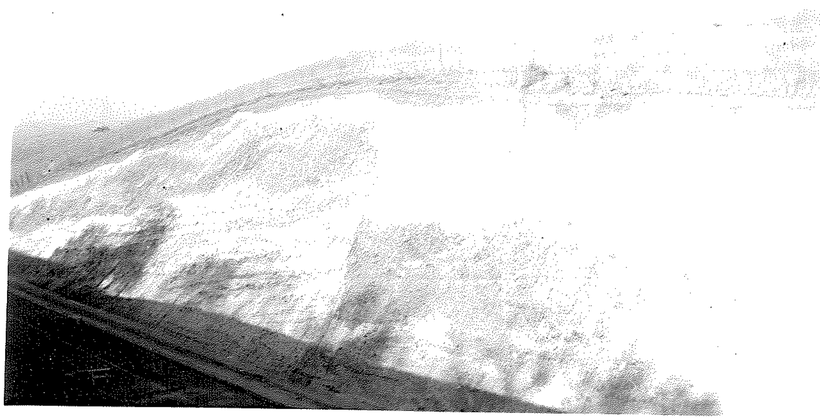


Fig.28 Another of the small faults at the summit of Pomona Road, and also illustrating the alteration of the conglomerate along the contact.

anticline which traverses the nearly isolated hills east of Puente. The trace of the fault plane suggests a nearly vertical fault, and southward displacement of the eastern portion of the anticlinal axis, as well as an elevation of the eastern block indicates oblique slip movement. The throw of the fault cannot be ascertained, but the *heave* is at least 500 feet. Northward this fault rapidly dies out for there is no displacement of the shale member occupying the crest of the hills. It can definitely be traced southward to the alluvium where its trace is concealed by a thin mantle of unconsolidated sediments.

Figures 27 and 28 illustrate two of the four small faults that may be seen at the summit of Pomona Road. These faults form a conjugate system with alternate blocks being elevated. Movement was principally vertical, and approximately 15 feet in magnitude.

Figure 29 shows a minor fault which is well exposed in the first canyon west of the summit of Pomona Road. It occurs in the conglomerate of the middle Puente sandstone member. The fault plane

Fig.29 Small fault in the conglomerate of the middle Puente member. (In first canyon west of the summit of Pomona Road).

is nearly vertical, and striations indicate a slight dip slip movement. It is of small linear extent dying out northward soon after the crest of the ridge is reached,and passes southward into the alluvium.

Origin

Determination of the forces effecting the region and their origin is a problem in itself, but enough evidence has been found to make the following generalizations.

1. The forces producing folding and faulting acted in a S-SE direction, and originated to the north of the area. The above statement is based on two definite evidences. First, all structural features are roughly parallel to one another and to the edge of the hills which strike N70°E. Secondly, the small displaced, overturned anticline just east of Puente has been shoved southward, as well as overturned southward, clearly showing forces acting from the notth toward the south. Assuming that these forces were perpendicular to the present structural trend we may postulate that they acted in the direction S20°E.

2. The forces were of a compressional nature. This is definitely proven by the presence of many sharp folds, and the predominance of high angle reverse faults.

3. The forces causing faulting, especially along the present Buzzard Peak fault, acted through the underlying crystalline rocks and not through the sediments. Definite proof of this statement is lacking, but it seems impossible to assume that beds as incompetent as the upper Puente shales could transmit forces strong enough to produce the 2,500 plus feet displacement recorded on the Buzzard Peak fault.

4. Forces probably originated in the region of the San Gabriel fault and are due to the elevation of the San Gabriel mountains. Hereagain proof is meager and lies in the fact that the San Gabriels eperienced orogenic disturbances at the same time that the San Jose Hills were being folded and faulted, and farther that the structure of the San Jose Hills parallels the two major faults bounding the San Gabriel mountain mass.

GEOLOGIC HISTORY

The following is a summary of the previously discussed evidence upon which has been based the interpretation of the Geologic History.

Proof of granitic intrusions and subsequent erosion of the country rock cover as well as the intrusives themselves, is found in the extreme eastern portion of the area, where the "basement complex" outcrops. Alternate submersion, deposition, elevation and erosion of pre-middle Miocene beds is clearly evidenced in the Puente Hills region. Here a long succession of Tertiary and pre-Tertiary formations outcrop, enabling one to determine the geologic history of that region since Triassic time. In the San Jose Hills area no beds of pre-middle Miocene age outcrop, but they may be represented at depth.

The actual history begins with the deposition of the middle sandstone member of the Puente series. Its relation to underlying beds is unknown for its base is nowhere exposed.

The upper shale member of the Puente conformably overlies the middle sandstone. The contact is gradational and probably represents a gradual decrease in elevation of the origin, possibly combined with a slight deepening of the basin of deposition.

Lava overlying the shale member attests that volcanic activity followed deposition of a part of the upper shale member. A dacite flow rests on the "basement complex" and is the oldest extrusive in the region. It is overlain by a complex series of basalt-andesite flows, which toward the east are definitely subaerial, but the presence of glassy borders and a rudimentary pillow structure indicates that the western portion is submarine.

Following the extrusion of the lavas slight subsidence may have taken place, for unconformably overlying this material is the remainder of the upper Puente shale.

In other areas local movements occurred at the end of Miocene time, but in the San Jose Hills the Pico (?) conformably overlies the diatomite of the upper Puente shale. Due to the sudden change from shale to conglomerate we may postulate a major change in the source of the sediments, but no evidence is present indicating change in the basin of deposition.

Diastrophism occurred late in Pliocene time, as indicated by folding and faulting of all pre-Pleistocene sediments in the area. This orogenic disturbance is in all probability correlated with the well recognized post-Fernando deformations that affected the Coast Ranges and Sierra Nevadas and is believed to mark the end of the Pacific Coast Tertiary.

In Pleistocene times erosion of the then rugged San Jose Hills proceeded, with the formation of large fans. The remnants of these now form the Quaternary Terraces common along the north side of the area.

The most recent movement has been general uplift, now followed by dissection of the terraces, erosion of the hills, and deposition of valley fill and alluvium.

The geologic history of the San Jose Hills may be chronologically presented in the following outline.

1. Intrusion of granitic rocks forming the "basement complex".

2. Erosion of material covering the intrusives, and erosion of the intrusives themselves.

3. Alternate submersion, deposition, elevation, and erosion of possible pre-middle Miocene sediments, present in the area at depth, but not outcropping.

4. Deposition of middle Miocene conglomerate (middle Puente).

5. Deposition of a portion of the upper Miocene shales (upper Puente).

6. Extrusion of dacite lava flow and intrusion of the "basement complex" by this material.

7. Extrusions of basaltic-andesitic lava flows.

8. Slight submersion and continued deposition of shales.

9. Deposition of lower Pliocene conglomerate (Pico (?) formation).

10. Faulting and folding producing general uplift.

11. Formation of Quaternary terraces.

12. Slight general uplift.

13. Erosion and deposition of alluvium and valley fill.

PHYSIOGRAPHY

Due to long erosion the present Puente Hills bear little resemblance to the hills of the original uplift. Physiographic forms seem related almost entirely to the hardness of the beds and various structural features. A divide, centrally located between the northern and southern borders of the hills, traverses the area from east to west. From Buzzard Peak westward to the edge of the alluvium, this divide is formed by the steeply dipping limbs of the San Jose anticline. From Buzzard Peak eastward to the extrusive lavas, a series of peaks was originated by the San Jose fault which has elevated the middle sandstone member over 2,500 feet. From the western border of the extrusives eastward to the alluvium, headward erosion of streams has formed a continuation of the major divide.

The several rock types in the area each give rise to a characteristic topographic form. The shale weathers into low rolling hills, convex upward and rounded on top. The sandstone members form protruding ledges, and where relatively thick, steep cliffs.

A typical bad land topography is developed in the conglomerates. Due to the soft, unconsolidated nature of the material small steep canyons are formed, whose walls sometimes reach an angle of 65°.

Due to faulting, the conglomerate in the Buzzard Peak region is deeply eroded, especially on the southern side where the fault line scarp forms one flank of the hills. The extrusives weather to steep narrow canyons and sharp rugged peaks, forms characteristic of semi-arid erosion of this type of rock.

Streams are both of consequent and subsequent types, the former being more abundant. The subsequent streams are principaaly controlled by the difference in hardness of the shale and sandstone members. Numerous examples of this stream type may be seen on the accompanying geologic map. In two localities are found streams whose course is controlled by an easily eroded fault zone. One of these coincides with the small cross fault which has displaced the anticline traversing the isolated hill just east of Puente. The other occupies a crushed zone running southeast from the summit of Pomona Road.

Saddles are common along the Buzzard Peak Fault and are due, not to recent movement, but to rapid erosion of the crushed material.

Bounding the area on three sides is the flat lying plain of the San Gabriel Valley. This unconsolidated material has completely burried such features as the San Jose anticline, Buzzard Peak fault, etc. and no topographic evidence for their presence can be seen.

ECONOMIC CONSIDERATIONS

For a number of years most geologists have accepted the theory that oil, or at least oil in California, has had an origin in the decay of myriads of microscopic organism called diatoms. The presence of skeletal remains in most of the producing zones is an important argument in favor of this theory. A counter argument is brought by those bellieving in an origin from decayed vegatable matter. They strongly believe that the mid-continent and eastern fields disprove the diatom theory, for in these fields no skeletal remains are found.

In spite of the latter argument the former theory seems to explain exceedingly well most Southern California fields, and therefore it has a practical application.

In the San Jose Hills a thick section of upper and middle Puente is known to be present and is probably underlain by beds of lower Puente age. Dispersed throughout this series are thick beds of diatomaceous shale and it is logical to assume that oil has accumulated in structurally suitable regions.

However, most of the major anticlines have been given what appear to be, sufficient tests, and only traces of oil were found. Many of these folds are plunging but do not appear to have closure, a possible explanation for the lack of oil. It may therefore be concluded that the region is barren of oil, and future drilling is wasted effort.

At one time the Featherstone Quarry mined diatomaceous earth, and employed it in the manufacture of tile, pipe, conduit, etc., but operation ceased several years ago.

In certain areas in the granitic rocks decomposed gravel is obtained. It is used as a foundation for roads, walks, etc. and is of little or no economic importance.

BIBLIOGRAPHY

Davis, E.F. The Radiolarian Cherts of the Franciscan Group. Univ. of Calif. Dept. of Geo. Bull. vol.11, 1918.

English, W.H. Geology and Oil Resources of the Puente Hills Region, Southern California. U.S.G.S. bulletin 768, 1926.

Edwards, E.C. Unpublished Thesis, California Institute of Technology, 1933.

Hoots, H.W. Geology of the Eastern Part of the Santa Monica Mountains, Los Angeles County, California. U.S.G.S. Prof. Paper 165-C, 1931.