THE GEOLOGY OF A PART OF SEMINOLE QUADRANGLE, LOS ANGELES COUNTY, CALIFORNIA

by F.E.Oder

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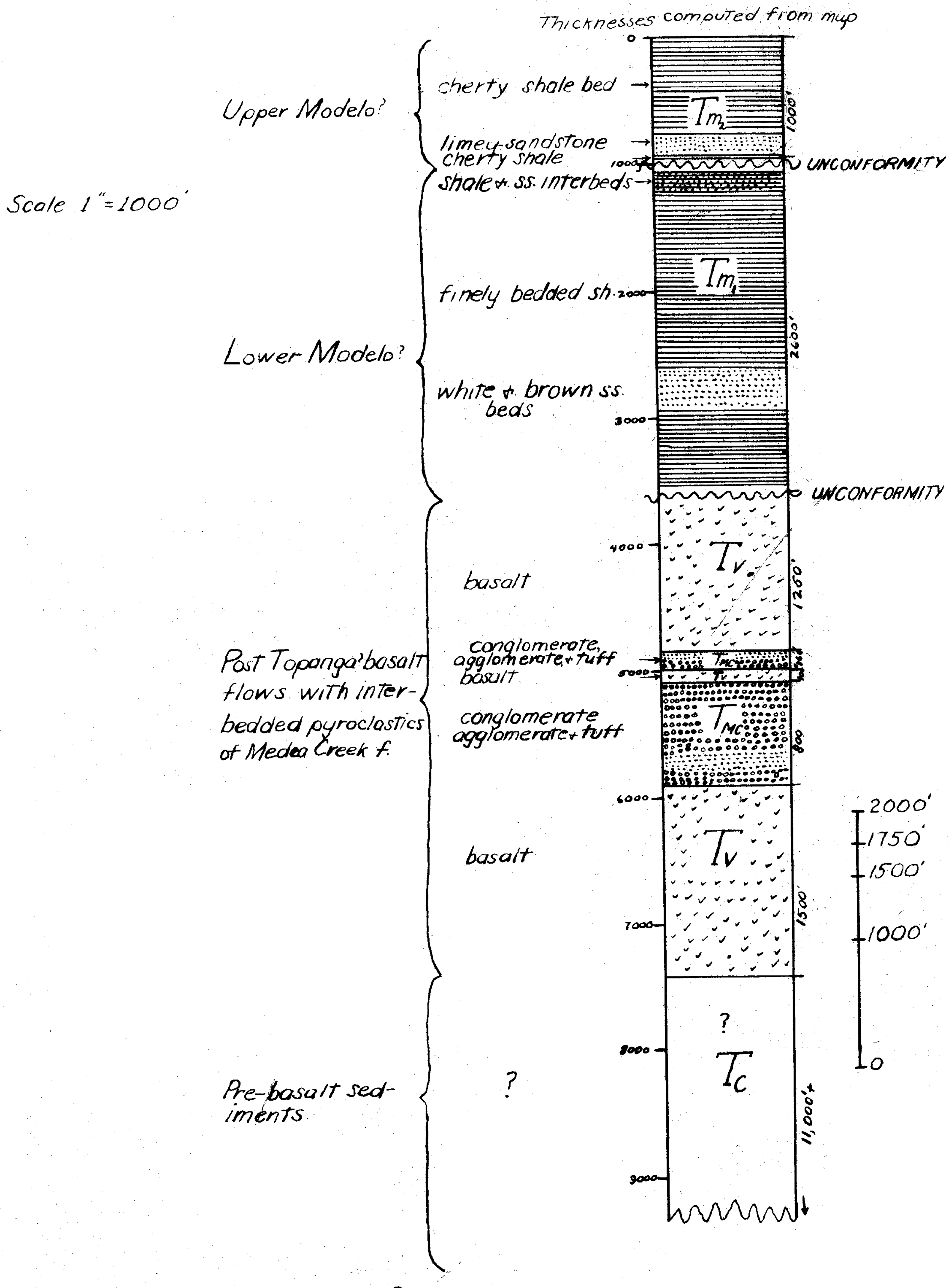
Introduction

The work was done in partial fulfillment of the requirements for a Senior Thesis problem at the California Institute of Technology. The area mapped lies roughly as a strip in the central portion of Seminole Quadrangle, Los Angeles County, California. It is bounded on the north by the Los Angeles - Ventura County line, on the east by a line drawn southward from the intersection of the east boundary of Rancho Las Virgenes and the county line, on the south by a line approximately two thousand feet south of the San Bernardino Base Line, and on the west by Medea Creek. The area described is approximately six and one-half square miles in extent. The field work was done in the spring of 1940 and took approximately eighty hours to complete.

Mapping was done by Brunton Compass on U.S.G.S. base maps photographically enlarged to a scale of one inch equals one thousand feet (1 / 12000).

The formations within the area are middle Miocene basalt flows with interbedded pyroclastics overlain unconformably by Modelo shales and sandstones. The relief is slightly less than six hundred feet. Exposures are good, with the exception of the alluviated valley adjacent to Ventura Boulevard.

GEOLOGIC COLUMN



Stratigraphy

At no place in the area mapped was there a complete section which could be measured. The thicknesses shown in the Geologic Column have been calculated from the areal extent and average dip of the various formations. The total section has a calculated thickness of more than nine thousand feet.

Pre-Basalt Tertiary Complex

None of the formations under this heading out crop in the area mapped. They are seen in section (Plate II) only. The position of the complex in the sections was computed in order that the lower limit of the basalt might be determined. For the purposes of the computation the formations included are assumed to be all of those found lying between the Chico formation (Cretaceous) and the basalt (Miocene) in adjacent regions[1]. On the basis of the calculations these formations may have, in the area mapped, a total thickness of 11,700 feet. This thickness was calculated on the assumption that these formations, exposed in adjacent areas, continue underground across the area covered by this report.

The total thickness of formations lying in the complex in the locality of Simi Valley is approximately 12,000 feet[2]. In the Las Flores Quadrangle the thickness of the pre-basalt complex , as defined, is about 11,400 feet[3].

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1. W.S.W. Kew: U.S.G.S. Bulletin 753
   E.K. Soper: The Geology of the Central Santa Monica Mtns. Calif. Jour. Mines and Geol., April, 1938
2. W.S.W. Kew: op. cit.
3. E.K. Soper: op. cit.

The Simi Valley section was taken at a point approximately eight and one-half miles to the north of the area for which the pre-basalt complex thickness was calculated. The thickness of the complex in the Las Flores Quadrangle was determined in the vicinity of Saddle Peak, approximately eight and one-half miles southeast of the area in Seminole Quadrangle. Thus it may be seen that the position for which the thickness must be calculated lies roughly equidistant from the two places where the thickness of the complex is known. The calculated thickness can be then determined as the arithmetic average of the two known thicknesses, this giving the thickness of 11,700 feet.

It is further assumed that the basalt flows overlying the complex lie nearly conformably upon it. In the Las Flores Quadrangle at a point roughly seven miles to the southeast the basalt has a maximum thickness of 4000 feet[4]. In the Malibu Ranch five miles southwest of the Seminole Quadrangle area the basalt has a thickness of 4000 feet[5]. These facts and the approximate basalt thickness as seen in the sections (Plate II) would indicate that the basalt thickness in the area mapped is also about 4000 feet. If this be so it follows that the pre-basalt complex be folded in accordance with the basalt, the folding in which can be best seen in the Medea Creek pyroclastic beds. In order that they may lie at the same elevation in the basalt flow series it is seen that the pyroclastics must be synclinally folded in the vicinity of Ventura Boulevard, the fold axis running nearly parallel to the road.

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4. E.K. Soper: op. cit.
5. Vincent C. Kelly: M.S. Thesis, California Inst. of Technology

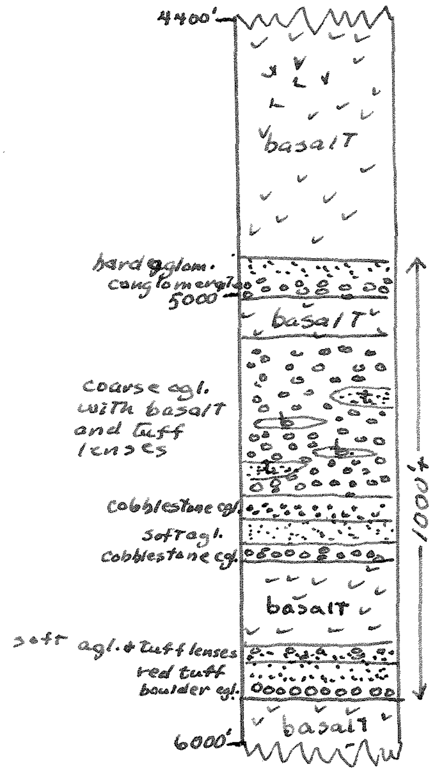
Post-Topanga? Basalt and interbedded pyroclastics

The total areal extent of the basalt flow-interbedded pyroclastic series totals approximately one and one-half square miles in the area mapped. Lithologically, the basalt is very similar to basalts found elsewhere in the Santa Monica Mountains. The basalt flows together with the interbedded pyroclastics have a total thickness of between 3900 and 4000 feet, this thickness being taken from both the average dip-thickness calculation and the constructed section. The lower 1500 feet is one continuous flow with interbedded pyroclastics in only small amounts. The presence of the pyroclastics are the strongest evidence of the flow nature of the lower 1500 feet.

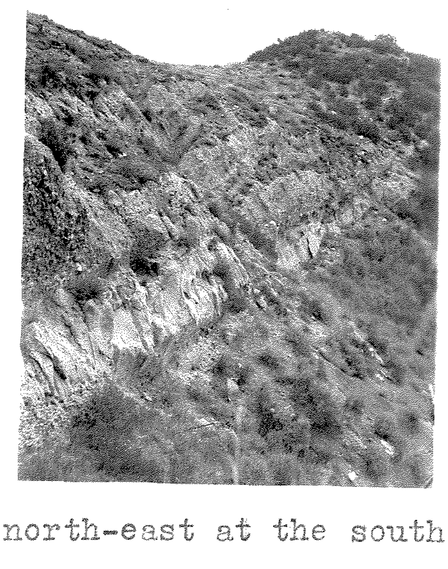
The next 1100-1200 feet are nearly all pyroclastic beds, named by the author "the Medea Creek pyroclastics" because of the exposures on Medea Creek. Small basalt lenses have a total thickness of from 100 to 200 feet. The pyroclastic thickness is made up of conglomerates, agglomerates and tuffs. It is suggested by the author that the conglomerates were formed in connection with volcanic mud flows related to the volcanism from which the basalt flows were derived. The conglomerate particles are somewhat rounded and show the following approximate composition:

Rock	% of total particles
grey basalt	90 ±
red basalt	5 ±
basement (granite, schist,etc.)	5 ±

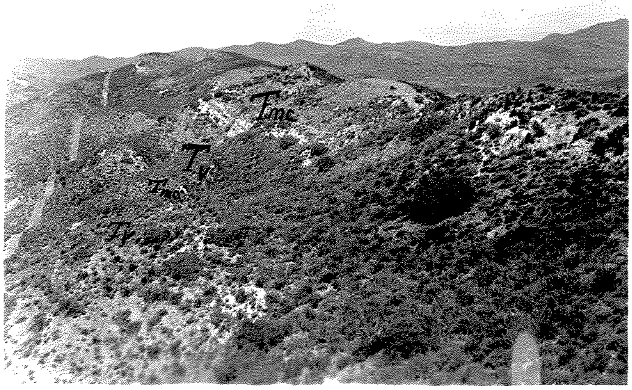
The deposits of the various pyroclastics show long lateral extension with short vertical extension. Some of the pyroclastics show lateral gradation in both particle size and composition. An average section through the 1100-1200 feet of Medea Creek pyroclastics would be the following:



Views of basalt and interbedded pyroclastics



Looking north-east at the south side of saddle between hills 1306 and 1261 on ridge formed by the pyroclastics.



Looking west from the north-west
flank of hill 1414 (3400 feet
S 28° E of Agoura P.O.)

Two types of agglomerate are found in the pyroclastics. One is hard with angular fragments in a fine-grained, silicified pyroclastic matrix. Fragment dimensions range from one-half to two inches. The other is composed of slightly rounded, angular particles scattered through a fairly soft, tufaceous matrix. This second type of agglomerate grades both laterally and vertically into a more completely tufaceous pyroclastic.

At the exposures along Medea Creek the pyroclastics are nearly all a boulder-breccia (large angular particles). A comparison with the average section of the pyroclastics on page six illustrates the lateral gradation of the series.

The upper 1250 feet of the basalt-pyroclastic series is similar to the lower 1500 feet. It is seemingly one large flow with discontinous pyroclastic lenses in a few places.

It is very likely that the basalt - pyroclastic series are of post-Topanga age since:

a. Much of the basalt in the Santa Monica Mountains is of this age[6].

b. It lies directly under the Modelo formation which itself is post-Topanga.

Modelo

The Modelo formation occupies about seven-tenths or four and one-half square miles of the area mapped. It unconformably overlies all of the older formations concerned. The formation has been mapped as two members which are separated by a slight angular discordance. The total thickness of the Modelo as exposed is approximately 3600 feet, the measurement taken from sections drawn from the surface data.

Lower member

The lower member of the Modelo has a thickness of approximately 2600 feet, and composes the part of the formation found south of Ventura Boulevard , and to some extent that found north of the boulevard. The greater part of the unit is composed of soft, finely laminated, marine shale. The rest is made up of narrow lenses of white and brown sandstone well distributed throughout the shale. The part of the lower member lying north of Ventura Boulevard contains a 300 foot thick band of white sandstone interbedded with brown sandstone and fine conglomerate. The upper 150 feet of the lower member consists of interbedded shales and sandstones.

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6. H.W. Hoots, U.S.G.S. Prof. Paper 165-C
   F.E. Oder, Senior Thesis Report # 1, Calif. Inst. Technology
   W.S.W. Kew, op. cit.

View showing outcrops of the cherty shale bed at the base of the upper Modelo member.

Upper member

An angular discordance exists between the lower and upper members of the Modelo. The upper member of the Modelo reaches a thickness of approximately 1000 feet, and composes to a large extent the part of the formation lying to the north of Ventura Boulevard. A bed of cherty shale, which thickens from 25 feet in the west to 100 feet in the east part of the area, marks the base of the upper member and serves as a useful marker bed. Just above the marker bed lies a 150 foot bed of soft, brown, limey sandstone. The rest of the section is composed of interbedded shales and sandstones, the shales predominating. Several cherty shales similar to the abovementioned marker bed are found at various levels in the upper member.

The Modelo formation was probably formed under shallow marine conditions. The shallow deposition is indicated by:

a. the lithology of the sediments

b. the occurance in places of ripple marks in the shales. Marine conditions of deposition ~~is~~ are indicated by the discovery of a marine pelecypod cast at X-2 (see Map) at a point on the southwest boundary of Rancho Las Virgenes, 4200 feet north of the San Bernardino Base Line.

The age of the upper[7] and lower[8] members of the formation has been given as upper middle Miocene (Modelo). No definite age determination could be made within the limits of the area mapped since no recognizable fossils were found.

The formation shows many fairly shallow folds. In the area south of Ventura Boulevard the south flanks of the anticlines tend to be steeper than are the north flanks (for further discussion see under Geologic Structure).

In the small exposure of the lower member in the north part of Cheeseboro Canyon, the shale of the bottom of the upper member shows organic material which may be due to an oil seep at this point.

Recent Alluvium

The valley lying to the north of Ventura Boulevard is well alluviated as are a few other small areas. Nowhere is the formation very thick.

Geologic Structure

Folds

Folds are the chief structural feature in the area. In general, the folding is moderate with axes trending in a northwest direction. In some places the highly incompetant shale beds

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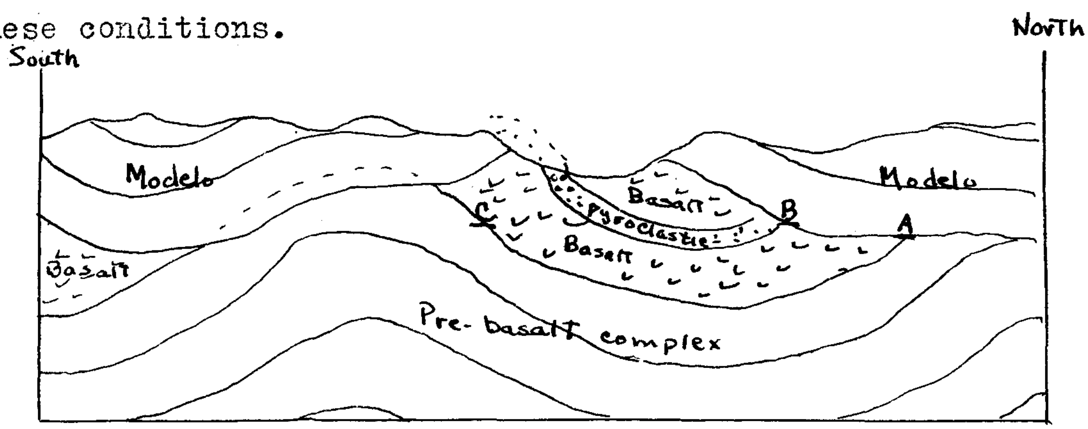
7. W.S.W. Kew: op. cit.
8. F.D.Bode - oral communication

of the Modelo show acute deformation. The larger folds in the Modelo are controlled by the competent sandstone beds in the upper part of the formation. The constructed geologic section indicates that both the pre-basalt complex and the basalt-pyroclastic series have undergone folding (see Plate II). A simple sketch will serve to demonstrate the necessity of the existance of this folding. Point A is determined by the total thickness of the pre-basalt complex. At the surface the Medea Creek pyroclastic beds have a dip of 50-60° N. In order that they remain in the same stratigraphic position, it follows that the pyroclastics be folded to a position such as seen at point B. Since it is assumed that the basalt-pyroclastic series has a constant thickness of 4000 feet, it follows that there must exist a pre-basalt complex-basalt contact at point C. Since the basalt has a large exposure south of the area mapped[9] and south of this lies the pre-basalt complex here dipping north[10], the pre-basalt complex and the basalt must be folded to accord with these conditions.



Sketch of typical section showing A,B,and C (above)

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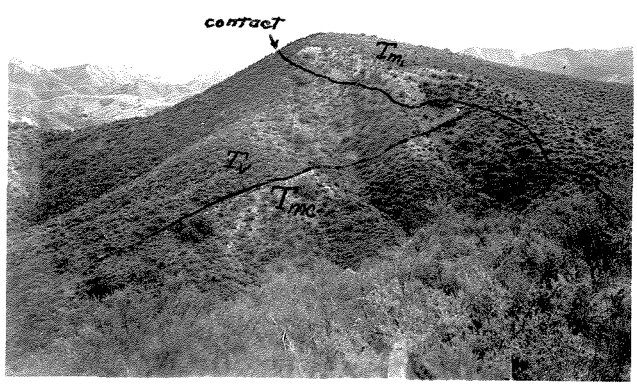
9. D.J.Varnes and D.H.Kupfer - oral communication
10. E.K.Soper:*op. cit.*

Unconformities

The area mapped is marked by two distinct unconformities in the stratigraphic column. They will be considered separately in chronological order.

The earliest unconformity is that between the basalt-pyroclastic series and the overlying Modelo (lower member). The unconformable relations of the two formations can be best seen at a point some 2000 feet southeast of the Agoura Post Office. The unconformity is seen in the overlap of the basalt-pyroclastic series by the shale beds of the lower member of the Modelo. The pyroclastic beds strike N 75° W and dip 50-60° to the north. Overlying them are the shale beds which strike N 40° E and dip 26° to the south. If the age of the basalt-pyroclastic series is correctly assumed to be post-Topanga (lower middle Miocene), the time lapse represented by the unconformity can not be very great.



View looking east from east-west ridge formed by pyroclastics at hill of elevation 1300+' , showing overlap of the Modelo on the basalt-pyroclastic series.

The second, later unconformity occurs as a slight angular discordance between the upper and lower members of the Modelo formation. The best indications of the discordance are found in the following measurements made along the contact between the upper and lower members of the Modelo:

locality	shale marker bed at base of upper member		uppermost bed in the lower member	
	strike	dip	strike	dip
1.	N 70°W	25°N	N 80°W	45°N
2.	N 20°E	17°N	N 6° E	25°N

Locality 1 is N 70° W from hill 1336 a distance of 500 feet. Locality 2 is 4250 feet north of Ventura Boulevard just adjacent to the eastern boundary of Rancho Las Virgenes.

Since the unconformity is between the upper and lower members of the Modelo formation it is probable that the time lapse represented is small.

Faults

The only faults in the area are minor and do not contribute to the general structure of the region. Displacements as well as continuities of trace are short for all faults mapped.

Geologic History

The first episode was the formation of a pre-Chico (Cretaceous) marine deposition basin in which the formations up through and including the basalt-pyroclastic series were deposited more or less unconformably[11]. This was followed by gentle warping and gentle folding into the shallow marine basin in which the Modelo was de-

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11. W.S.W. Kew; Op.cit.

posited. During Modelo time there was further movement which led to the slight angular discordance between the upper and lower members of the Modelo. Since Modelo time there has been uplift together with severe deformation in the form of folding.

There is much indication that the later forces came from the southeast. This is found in the fact that there is a tendency for the south flanks of the anticlines in the Modelo to be steeper than are the north flanks of the same anticlines.

The later deformation was followed or accompanied by mineralization (by silica solutions) of some localities. This feature is especially noted along the contacts between the pyroclastic beds and the basalt flows, as well as along the contacts of the basalts and the lower member of the Modelo formation.

Subsequent erosion has given the area its present topographic relief. Active erosion is indicated in the steeply cut southern face of the main series of pyroclastic beds.

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Introduction

The work entailed in mapping the geology of Black Butte was done in partial fulfillment of the requirements for a Senior Thesis problem at the California Institute of Technology. This desert butte has its center located at the intersection of the first parallel north of the San Bernardino Base Line and a north-south line at the longitude 117°43'30" west of the Greenwich Meridian, and covers an area of approximately three-quarters of a square mile. The field work was done in April of 1940 and required approximately twenty-five hours to complete.

Mapping was done by Brunton Compass on U.S.G.S. base maps photographically enlarged to a scale of one inch equals five hundred and sixty-three feet (1/6760).

The rocks found within the area are an igneous series together with a very small amount of metamorphosed sedimentary rock which is apparently present as inclusions in one member of the igneous series. This igneous series, together with the metamorphics, have been intruded by later dikes of aplite, pegmatite, quartz, amd aplite-pegmatite. Since the intrusion of the dikes there has been minor faulting followed by mineralization chiefly in the form of epidotization.

The butte is roughly oval in plan view with the long axis of the oval extending in a northwest direction. Towards the southeast end there is a narrow projection extending east-south-east. The butte is a mountain remnant projecting out from the alluviated floor of the Mojave Desert here formed by the ends of fan deposits extending from the base of the San Gabriel to the south. Rising steeply from the alluvial desert floor Black Butte has a relief of five hundred feet. Seen from a distance the butte appears dark colored due to the extensive doating by "desert varnish" of the boulders of the gabbro-diorite intrusive which cover a large part of the surface.

In general, exposures were very poor and pertinent information is obscured. The mapping of the dikes was best accomplished by first determining their actual presence and character at the few existing exposures, and then following the traces of their courses by observation from a not too distant vantage point.

View of Black Butte taken from 7000' N 30° W of the 3584' triangulation point.

Petrology

Pelona Schist Series?

These are the old metamorphics found in two small patches within the limits of the gabbro-diorite member of the igneous series. The total areal exposure of the metamorphics is less than fifty square feet. The larger of the two recorded exposures lies approximately one hundred feet south east of the know of the butte which has an elevation of 3454 feet. It has an areal exposure of approximately forty feet. This exposure, in which the metamorphics are striking approximately east-west and are nearly vertical, shows the following section from south to north:

(a) 4' of a metasedimentary gneiss composed of finely bedded primary? limestone and metamorphosed tuff[1].

(b) 10-15" sill of vein quartz.

(c) 3' of a finely laminated, micaeous, metasedimentary schist.

(d) 8" sill of aplite.

(e) 3-4' of micaeous schist similar to above.

The second and smaller exposure was found approximately 600 feet N 8° W of the triangulation point at the 3584 foot elevation. It has an areal exposure of less than ten square feet. The rock here exposed is very similar to the metasedimentary gneiss of the first exposure, and has an approximately north-south strike with a nearly vertical dip.

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1. I.C.Campbell: Oral communication as to probable composition of rock.

The age of the metamorphics is possibly, according to Dr. Ian Campbell[2], close to that of the Pelona Schist Series which is pre-Cambrian[3].

Igneous Series

Gabbro-Diorite

This rock composes the cap portion of Black Butte, and has an areal exposure of approximately one-quarter mile. The reason for calling the member a "gabbro-diorite" comes from the fact that its composition shows a large variation which lies nearly with these limits. The individual types within these limits were too poorly defined to warrent separation in the mapping. The actual range of composition of the gabbro-diorite is from a true anorthosite to a true hornblendite. Facies found between these limits include: melagabbro, gabbro, diorite, and diorite?-pegmatite. The most common facies seems to be a rock of gabbroic composition. The gabbro-diorite has suffered much hydrothermal alteration in the form of epidotization along joint cracks and fault planes, the epidote replacing to some extent the hornblende in these places.

The gabbro-diorite shows two smaller bodies in the quartz-monzonite (on the map, bodies both south of the first parallel north - near the word "NORTH") which may be either dikes or xenoliths (see under Geologic Structure).

Quartz Monzonite

This rock is the "basement" rock of Black Butte, and has an areal exposure of approximately one-half square mile. The basis for calling the rock a quartz-monzonite (or adamellite) comes solely from an examination of hand specimens, since nowhere was any of this member found which was fresh enough for a slide to be made. The hand specimen

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2. I. Campbell: oral comm. 3. Simpson: Geol. of the Eliz. Lake Quad. C.J.M.G

shows the following approximate composition:

orthoclase feldspar	35 %
plagioclase "	35
quartz	30

With the exception of the southeast end of the butte, the quartz-monzonite is topographically exposed below the gabbro-diorite. The south-eastern half of the projection from the butte to the southeast is composed of quartz-monzonite cut by aplite dikes. The author offers the suggestion that this contact between the gabbro-diorite and the quartz-monzonite is continuous with that to the northwest, and with that to the southwest, thus limiting the gabbro-diorite to a roughly ellipsoidal body taken in plan view.

Dike Rocks

Four distinct types of dike rocks are noted in the geology of Black Butte. They consist of aplite, pegmatite, quartz, and aplite-pegmatite varieties. They will be considered separately.

Aplite dikes

Aplite dikes make up the majority of the dikes which cut the earlier rocks at Black Butte. They show a range in width of from six inches to nearly one hundred feet, with an average width of approximately ten feet. In many places it is to be noted that they occur in groups with parallel orientation (for a discussion of this occurence see under Geologic Structure). The dike rock is a typical aplite, both in composition and in grain size, showing a predominance of orthoclase feldspar over plagioclase feldspar together with an abundance of quartz. The high percentage of orthoclase gives the dike rock a pinkish hue. In a few places along the dike boundaries the effects of epidotization can be observed.

Pegmatite dikes

Second in number of occurences among the dikes are those of pegmatitic texture. Their width is more uniform than that of the aplite dikes, averaging about five feet. A typical composition for the pegmatite dikes would be the following:

orthoclase	50 %
quartz	35
biotite	15

The grain size in these dikes is exceedingly large with some of the orthoclase crystals reaching a length of two inches. It is to be noted that the pegmatite dike outcropping in the saddle between elevations 3584 and 3454 (see map) appears to grade laterally southward to a dike of aplite texture. The pegmatite dikes show no such parallel grouping as is observed in the case of the aplite dikes.

Quartz dikes

In a few places quartz dikes or veins of quartz cut the gabbro-diorite, quartz-monzonite, and Pelona schist Series. In general, they are usually less than a foot in width. An exception to this rule is the large quartz dike lying 2300 feet N 8^{o} W of the 3484 foot triangulation point which has an average width of five feet. The dike material is white, massive quartz showing limonite stains in a few places. Prospects have been made in a few places along the quartz dikes but, apparently, with no profitable results.

Aplite-pegmatite dikes

Two dikes which cut Black Butte show local variation between aplite and pegmatitic texture. One is located on the hill of elevation 3454 feet, the other approximately 300 feet northwest of the 3584 triangulation point. There is no regularity in textural variation.

The age of the igneous series of Black Butte is possibly the same as that mapped by Simpson[4] in the Elizabeth Lake Quadrangle twenty miles to the east. The age of the Elizabeth Lake Quadrangle igneous series has been given as Jurassic.[5] In the Elizabeth Lake Quadrangle the basement rock is a quartz-monzonite as is the basement rock at Black Butte. The Elizabeth Lake Quadrangle igneous series also shows other basic rocks similar to those found at Black Butte (the gabbro-diorite for example).

Geologic Structure

Two possible explanations can be brought forth for the interpretation of the field observations at Black Butte. Either the gabbro-diorite was intruded into the quartz-monzonite as a dike, or the gabbro-diorite occurs as pendents in a later intrusion of quartz-monzonite. In the author's opinion the latter view is the more plausible one.

One possible evidence for the view that the gabbro-diorite was intruded into the quartz-monzonite lies in the presence of stringers of gabbro-diorite in the quartz-monzonite. These might be interpretted as feeder-dikes to the main body of the gabbro-diorite. The weathered condition of the exposures made it impossible for the author to determine whether or not the borders of the small bodies of gabbro-diorite showed chilling effects. Since these small gabbro-diorite bodies can not be traced to the main body of the gabbro-diorite, it is very possible that, in place of being feeder-dikes, they may be xenoliths of the gabbro-diorite included in the quartz-monzonite. Additional evidence for the post-quartz-monzonite nature of the gabbro-diorite lies in the

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4. Simpson: Geology of the Elizabeth Lake Quad., C.J.M.G. '34
5. " " " " " " " " "

extremely variable nature of the gabbro-diorite. This might indicate that the gabbro-diorite is a small body intruded into the quartz-monzonite.

For the case that the gabbro-diorite is a roof pendent in a later intrusion of quartz-monzonite there is more evidence which, however, is less direct. First, the bodies of gabbro diorite lie in the quartz-monzonite. The general appearance of these bodies strongly suggests that they are xenoliths rather than feeder dikes. The reasons for this view come from the lack of linear continuity of the small gabbro-diorite bodies. Stronger evidence comes from a consideration of the normal igneous series: In general, the more basic rocks preceed the more alkaline rocks in a series of intrusion.[6] Since the aplite, pegmatite-et-al dikes are normally the last part of the intrusion cycle and follow the alkaline rocks, and since aplite dikes can be traced across the boundary between the gabbro-diorite and quartz-monzonite, it seems best to conclude that, in this case, the basic rock existed prior to the alkaline.

Corroborating evidence comes from the position of the Pelona Schist Series: Since these old metamorphics are found only as inclusions in the gabbro-diorite the author believes that the gabbro-diorite inruded the Pelona Schist Series and was later intruded by the quartz-monzonite (in the same igneous series).

A likely explanation for the possibly concentric relations between the two major igneous bodies of Black Butte is found in the theory of "cauldron subsidence" [7]. According to this theory the

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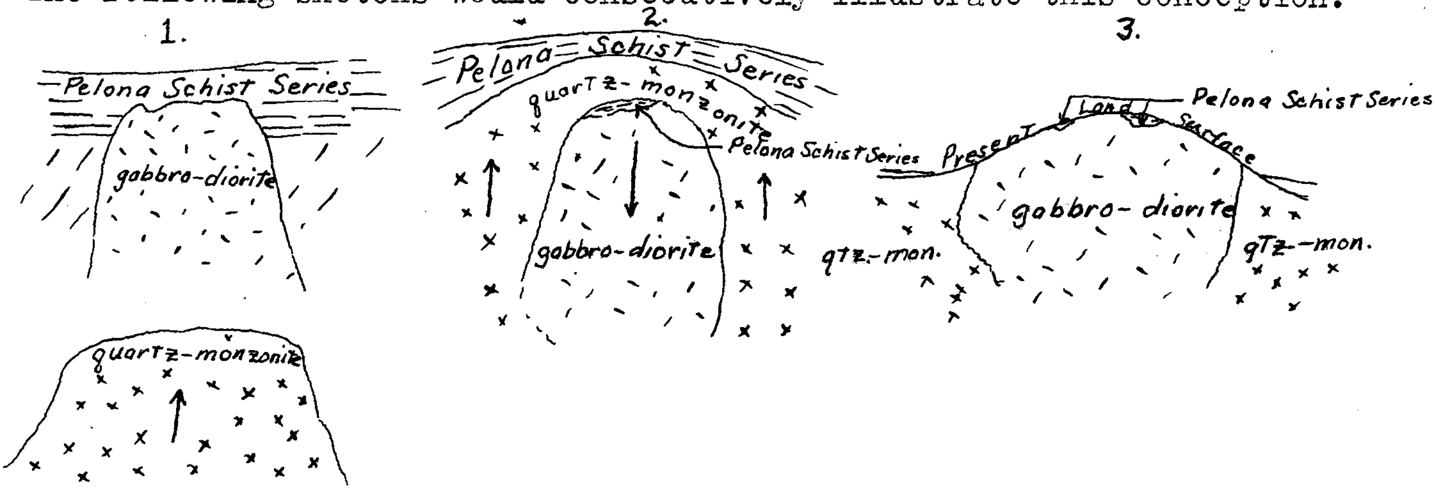
6. I. Campbell - oral communication
7. "Cauldron Subsidence at Mt. Ascutney" Bull. G.S.A. v.51, 1940

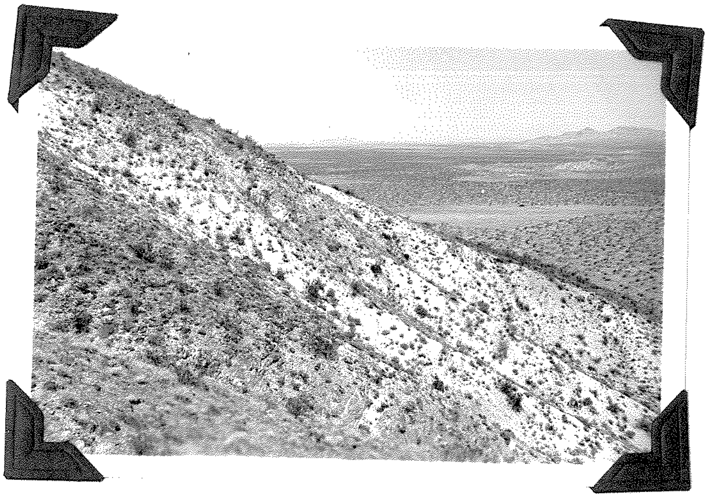
gabbro-diorite should intrude the Pelona Schist Series with a roughly dome-like form, and should be followed by the intrusion of a bysmalith of quartz-monzonite along a ring dike formed around the gabbro-diorite. The following sketchs would consecutively illustrate this conception.



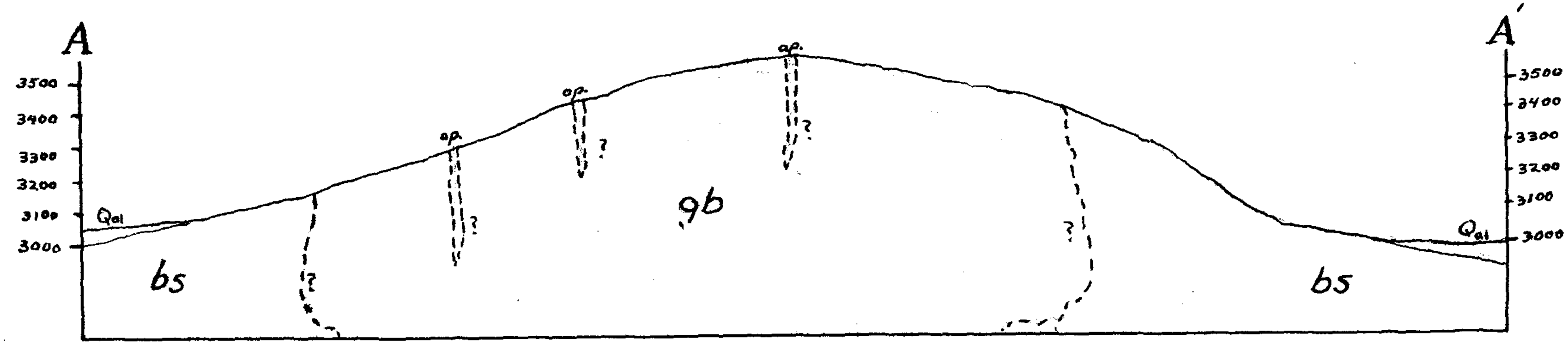
The orientation of the dikes, in general suggests that they were intruded along two sets of joint planes in the older igneous rocks. If this is so, it follows that the joint systems were imposed on both the gabbro-diorite and the quartz-monzonite.

Faulting in Black Butte is of minor importance and is post dike intrusion in age, since those dikes mapped have, in a few places, been offset by the faults.

The final modification of the structure of Black Butte was in the form of mineralization (epidotization). That the time of the mineralization followed that of the dikes is indicated by the occurance of secondary epidote in places along the margins of some of the dikes. The mineralization appears limited to the gabbro-diorite. This is probably due to the fact that the alteration has acted by a replacement of the hornblende which is an important constituent of the gabbro-diorite. The hydrothermal epidote is observed chiefly alon fractures in the gabbro-diorite such as joints and minor faults.



View along the north flank of Black Butte showing, for this area, exceptionally good exposures of both gabbro-diorite and quartz-monzonite.



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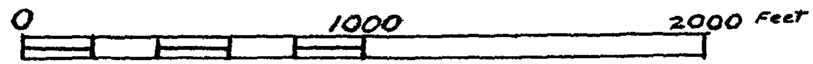

for legend see map

GEOLOGY OF BLACK BUTTE

F.C.E. Oder