THE GEOLOGY OF MOUNT WASHINGTON

A Thesis By

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INTRODUCTION

SIZE & LOCATION:

The scope of this report embodies the work done in an area of six and a half square miles in extent, which lies between the northern portion of Los Angeles and Highland Park, more specifically it is bounded on the north by the $34° 07'$ parallel of latitude, on the south by the $34° 5' 30''$ parallel of latitude, on the west by the $118° 14'$ meridian of longitude, and on the east by the $118° 12'$ meridian of longitude. The United States Geological Survey have made excellent topographic maps of this area on the scale of 1/24,000 with a contour interval of 25 feet on the more prominent topography and 5 foot contours on the more subdued portions. The area is covered by the southeast corner of the Glendale Quadrangle and the northeast corner of the Los Angeles Quadrangle.

ACCESSIBILITY:

Mount Washington is easily reached from any of the near by cities, Los Angeles, Pasadena, Glendale, Alhambra ets, by excellent paved highways. Not only do good highways lead to these hills but nearly all points in this region are accessible by automobile roads.

PURPOSE OF INVESTIGATION & ACKNOWLEDGMENTS:

This work was undertaken for the prupose of fulfilling the requirements for a degree of Bachelor of Science at the California Institute of Technology. The writer wishes to make acknowledgments to H. Smith for his suggestions and the interest he has shown in this work, to J.P.Buwalda for his suggestions, and to M.H. Sperling with whom he worked in the field.

PREVIOUS WORK:

The greater part of this area is covered by Ralph Arnold in U.S.G.S. Bulletin 309. However that work was done on a small scale map and was essentially of the reconnaissance nature; hence it was not of much help to the writer. In the summer of 1928 H.Smith, while working for the City of Los Angeles, spent three days in the Mt Washington Hills and his map was available. The area covered by C.L.Gazin in his report on "The Geology of the Northwestern Portion of the Alhambra Quadrangle" adjoins the writers area on the east and an attempt was made to correlate the stratigraphy with that proposed by Mr Gazin. Thus the formation names are taken from his report.

METHOD OF INVESTIGATION:

As a basis for recording field observations the U.S.G.S. maps previously mentioned were used. Locations for plotting the the geologic data were made by the intersection method, using a Brunton Compass, and by prominent topographic and cultural features. The field work was undertaken in two distinct steps; first, a rather detailed reconnaissance, which was made in an effort to become acquainted with the general stratigraphy and the main structural features; second, the more detailed mapping was done.

NATURE OF EXPOSURES:

The natural outcrops are very poor and it would have been well nigh impossible to complete a detailed map were it not for the excellent road cuts. These cuts were particularly abundant in all parts of the area except in the northwestern corner where the topography is more subdued.

GEOGRAPHY

Land Forms :

The topography of these hills has reached the stage characteristic of maturity in the physiographic erosion cycle. The original surface has been eroded away, the canyons are wide and V shaped, and the relief is maximun. Mount Washington with an elevation of 930 feet represents the highest point of the area. The fact that this hill has a height of approximately 530 feet above the bed of the Los Angeles River will give an idea of the maximum relief of the region. The general relief however is much less than that , being nowhere over 300 feet. In generalizing the topography one can say that the location of the erosion features have been determined largely by the structure.

Drainage:

The stream beds on the southwest side of the area and those on the southeast side take care of the major portion of the water run-off of these hills, and drain into the Los Angeles River and the Arroyo Seco respectively. The canyons followed by these streams are well marked and extend well in to the hills, while the canyons on the north side are negligible. However none of these stream beds carry water except immediately after a rain.

Natural Vegetation:

The more shaly portion of the hills are characterized by a scanty vegetation consisting chiefly of oats, grass and wild mustard. Where the sandstones have formed the soil the vegetation is much richer consisting of live oak, scrub oak, holly, chapparal, poison ivy, rushes in moist places and wild walnut trees in addition to that mentioned.

CULTURE:

As it was previously indicated this area is surrounded and traversed by numerous paved highways. Near the main roads the hills are already quite thickly settled, and the more remote parts are now being subdivided. A steam railway and an electric interurban follow the course of the Arroyo Seco, while the freight yards of the Southern Pacific Railway are located in the Los Angeles River bed south of the Mount Washington hills.

SUMMARY

The chief elements of geologic interest are listed as follows:

1. The rocks outcroping in these hills are shales and sandstones of Puente Age.
2. The structure is one of intense folding and faulting.
3. The course of the Arroyo Seco has been determined by the position of a fault.

GEOLOGY

STRATIGRAPHY

GENERAL COMMENTS:

At no place in this region does the base of the section of sedimentary rocks lie exposed. The 3200 foot thickness that outcrops, represents a series of concordant strata, composed cheifly of interbedded shales and sandstones. The lower two thirds of this section, shows a change from predominantly sandstones to predominantly shales. These shales and sandstones were differentiated in mapping, neither by a distinct litholgic change nor by an unconformity, but one which was difficult to establish because of the nature of the section. Another consideration that adds to the inaccuracy of these contacts is the gradation of material along the strike of the beds. That is to say, the sandstone grades into shale from N.W. to S.E. indicating that the source of materal was from the N.W.

These shales are overlyn concordantly by an upper sandstone. However this contact is a definite one, as it was mapped along the basal conglomerate of the sandstone.

The lower sandstones were called the Omaha Sandstones, the shales the Rose Hill Shales, and the upper sandstones the El Sereno Sandstones after the nomenclature proposed by C.L. Gazin.

OMAHA SANDSTONES:

This formation has the greatest areal extent of the rocks that were mapped. These strata form the limbs of the large syncline in the southern portion of the area and a complete uninterrupted section is well exposed on the south limb of this structure.

As it has already been mentioned this formation consists chiefly of sandstones interbedded with shales, which becomes more predominantly shaly as one goes up in the section. These beds aggregate a thickness of 2200 feet of which approximately 400 feet are shaly material, the remaining 1800 feet are sandstones.

The particles of the sandstone are angular, subangular to rounded, medium in size and composed of quartz, feldspar, biotite and muscovite grains, stained by limonite, and cemented by limonite and clay material. The rock is not hard but[15] sufficiently well indurated to maintain vertical walls in the road cuts. When fractured it has an uneven surface and the break occurs around the grain. The sands colored grey to pale buff on fresh surface, weather to a dull light grey. These massive sandstones form beds varying in thickness from 6" to 10 and 12 feet, they are well washed and show very little sorting or lamenation. In the upper part of the section the sand loses partially its arkosic character and becomes more predominantly quartzose at the same time becoming finer.

The shale members vary in composition from soft sandy grey shales to harder buff colored arenaceous, calcareous shales and to extremely hard buff colored cherty shales which often form tracable chert reefs. All of these shales show fine laminations and the bedding is never more than one foot thick the average width of bedding is about 2 inches.They weather to almost the same deep buff color although the sandy shales weather to a more greyish buff than do the others.

Plant remains ,fish scales ,and fish impressions were the only kind of fossils found in this formation.

In several places in this section of rocks ,soft white chalky beds were found having a general thickness of about4" -8" and composed chiefly of calcium carbonate with fine elastic material.

Figure 1.

This photograph shows the interbedded character of the Omaha Sandstones. As this exposure occurs near a fault the strata show drag.

ROSE HILL SHALES:

This formation, which has in this area a thickness of about 600', is best exposed in the northern portion of the hills on the east side of the Arroyo Seco and on the northwest side of Mt. Washington. As its relaton to the underlying Omaha Sandstone is one of concordance and gradational change, petrologically it is similar to those shales described as belonging to the Omaha Sandstone series. That is to say, this shales series is composed of alternating arenaceous, arenaceous calcareous, calcareous and cherty shales interbedded with a few relatively thin sandstones. In general this division of the section shows a greater percentage of cherty shales than do the shales found interbedded in the Omaha Sandstones.

W.A.English comes to the conclusion that the most probable source of this siliceous material was from silica rich river waters, rather than from volcanic ash or siliceous organisms (such as radiolarians or diatoms). To the writer his conclusion seems quite a likely one, especially in the case of the siliceous rocks in this area. Several samples were submitted to K.E.Lohman for study but he could not find the skeletal remains of either diatoms or radiolarians. Neither, were any beds of volcanic ash material observed in the field.

These shales contain a large number of hard chert concretions, These masses vary in size from a few inches up to tens of feet in greatest dimension.

Plant remains and fish scales were the only type of fossil material that could be found in these rocks.

Figure 2.

A typical road cut exposure of the Rose Hill Shales.

EL SERENO SANDSTONES:

These sandstones beds concordantly overlie the Rose Hill Shales, and are separated from them by a well defined contact, represented by a basal conglomerate. The only exposure of this basal bed is found near a hill top on the north part of the area. It shows a bed about two feet thick, composed of subangular shale pebbles, varying in size from 1 to 6 inches, embedded in a sandy matrix. Above this bed one finds about 100' of well washed quartzoes sand composed of subangular, medium sized quartz grains with a little feldspar and biotite. These beds are poorly indurated, colored a whitish grey, and weather to a deep buff color. The sandstones are followed by an alternating series of conglomeratic quartzose sandstone, and red sandstone beds. The conglomerates are composed of typical beach pebbles and boulders of schist granite, quartz, feldspar, andesite and pegmatite varying in diameter from one half inch to 12 inches. The matrix is a quartzose sand. In composition the red sandstones bed are essentially equivalent to the other sandstones, but have been deeply stained by limonite and hold this color in both fresh and weathered surfaces. The thickness of these strata aggregate approvimately 500 fett.

The El Sereno Sandstone that outcrops in the southern part of the area shows a marked lithologic dissimilarity to the material previously discussed ~~above the Rose Hill Shale~~. An excellent exposure of this material can be seen on the North Broadway roadcut just west of Mission Road. This exposure shows it to have the same arkosic character as the Omaha Sandstones, but differs from them in the following; it has a darker buff color when fresh, and a greyish buff color when weathered. It shows better sorting and lamination, the particles are less angular, the bedding is finer, the sands are much better washed and are in general less well indurated than are the Omaha Sandstones.

The cross bedding and shingling of pebbles in the conglomerate indicate a source of deposition from the north. The evidence seems to point to the conclusion that the part exposed on the north side is a littoral deposit which grades south ward into deposits formed in the deeper water.

QUATERNARY ALLUVIUM:

This stratigraphic division is confined to the soil in situ and the recently deposited sands and river gravels.

AGE and CORRELATION:

Sand molds and impressions of invertebrate fossils were found about 100 feet above the base of the El Sereno Sandstones, but the nature of these remains was such that their determination was impossible. Based on the correlation of these beds by Arnold (1) they are a part of the Puente Formation. As classified by English (2) the Puente Formation is equivalent to the upper part of the Monterey group, which would place the Puente in the middle and upper Miocene of the standard time scale. C.L. Gazin (3) places everything stratigraphically above the El Sereno Sandstones as upper Puente and everything below them as lower Puente. If one follows this classification the section as here represented is lower Puente and is probably upper middle Miocene in age.

STRUCTURE

GENERAL CONDITIONS:

The general structure of this particular area exhibits an extreme complexity. In addition to two major folds and several major faults there are a series of minor faults and small folds. On the east side of the Arroyo Seco neither do the areal pattern nor the structural relations match to a large degree with the work done by C. L. Gazin (3) in the northwest corner of the Alhambra Quadrangle. Nor does the structure or stratigraphy match on either side of the Arroyo Seco, thus the conclusion that the stream has followed a zone of structural failure.

The relations between the faulting and the folding is not particularly clear, although in some cases it is apparent. The efforts on the part of the writer to generalize this relation have not meet with a large degree of success. One rather obvious conclusion is that the stronger sandstones show a less degree of folding and shattering than do the more incompetent shales.

MAJOR FOLDING:

There are in this area two major folds the syncline to the south and the syncline to the north. The former occurs in the Omaha Sandstone Series and is asymmetrical in character. The beds on the south limb have an average dip of about 48 , those on the north limb an average dip of about 22 . This fold has a general trend of north 65 degrees west, but it is cross faulted twice in the western portion with a consequent displacement of the axis in the magnitude of 100 to 200 feet. With the exception of the two faults mentioned above the south limb of this syncline shows no other effects of shattering. On the other hand nearly all of the area to the north of this structure is a mozaic of fault blocks. It is difficult to ascertain the cause for this difference in the behavior of the rocks under the deforming stresses. It is probable that the north side represents an arching effect which has failed because of the lack of supporting material. However the lack of direct evidence in support of this theory makes it merely an assumption. Although the lower sandstone beds have nearly everywhere the same competence the shales are very weak and it is highly probable that this weakness may to a large degree account for the shattering of these beds under the same forces which caused the folding in the stronger sandstones.

The syncline in the northern portion of the area occurs in Rose Hill shales. This also is an asymmetrical fold, but with a N-E trend. The beds on the southeast limb dips steeper by 20 than those on the opposite limb.

The other folds of this area seem to be of very minor importance and are probably in the most part the result of fault movements accompained by a consequent buckling of the strata. Although on the north side of Mount Washington there are several anticlines in the separate fault blocks that may be correlated as the same fold that has been displaced by cross faulting.

Figure 3.

The picture illustrates the manner in which the shale members are contorted near a fault zone.

FAULTING:

The fault relations may best be discussed by first making a general subdivision of the area into a series of major fault blocks and then a more detailed consideration of the various minor fault systems. With this plan in mind the writer has divided the area into five main blocks listed below with a discussion of each block.

1. That part of the area east of the Arroyo Seco which shows no structural continuity with the part west of the Arroyo Seco. The necessity of explaining this discontinuity, as has been previously indicated, leads to the conclusion that the Arroyo Seco follows a structural feature, namely, a fault.

The main structure of this block is one major fault tending about north 75 degrees west, and two minor faults. As exposed in a road cut on its western extremity, the fault (see figure4) has a south dip of about 40 degrees and the drag folds (an overturned syncline to the north and an overturned anticline to the south) indicate the movement to have been of a reverse nature but it was impossible to estimate the amount of displacement. As one follows the fault eastward one finds that the fault plane tends more nearly to approach the vertical until at the very east end it becomes vertical. Although the writer did not trace this structure further than the edge of the map a study of Mr Gazins' report seems to indicate that eastward this structure changes to the axial plane of the principle anticline of that area.

The other two faults found here are of a vertical nature and probably owe their origin to the major fault discussed above.

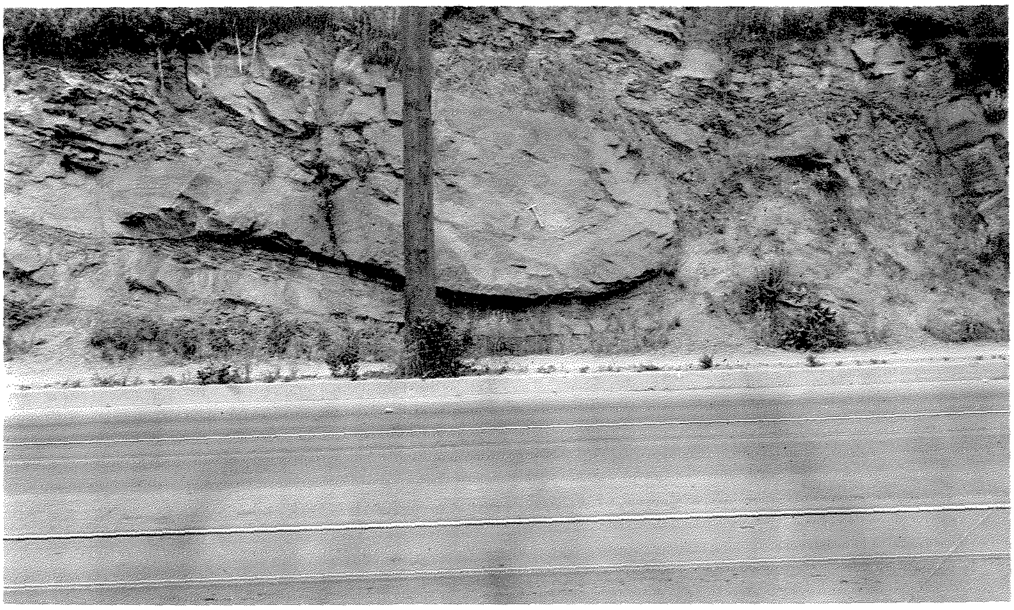

Figure 4.

For explanation see text page 20.

2. The southwest block of the area to the west of the Arroyo Seco will next be considered. It is bounded on the east by the Arroyo Seco fault, on the north by the main fault crossing Mount Washington about 900 feet south of the summit, and on the west by the fault up Division Street.

The characteristic feature of this block, namely, the prominent syncline has already been discussed. The faults appear to be vertical except the easternmost fault on the syncline. This particular fault has a north dip of 80 degrees and the drag shows a reverse movement.

3. The block adjoining block number 2 on the north east side is bounded on the east by the Arroyo Seco fault, on the north by the fault following Avenue 50, and on the west by the fault by Division Street. The fault common to both blocks 2 and 3 is vertical and is well marked by excellent structural and physiographic evidence, such as change in the attitude of strata, fault gouge, drag, discontinuity of beds, canyons following the trend of the faults and fault gaps.

This block is characterized by a number of faults previously discussed, cut off by a series of vertical cross faults of a general northest trend.

The undecipherable structural complexity of the rocks directly north of the Southwest Museum has lead to the generalization of these features in mapping.

4. Block number 4 is sperated on the southeast by a vertical fault with a northeast trend which roughly follows Division Street. Another vertical fault effects the separation of this block from the low lying hills to the north; along this structure most of

the elevation of the hills has taken place.

Approximately in the center of this block a peculiar 50 degree north dipping, dip slip strike fault has been mapped. This may correspond to the axis of the anticlines mapped to the east of this place. Drag relations as shown in an exposure indicate reverse movement (see figure 5), but by a consideration of the stratigraphic relations in which Rose Hill Shales have been faulted down into contact with the underlying Omaha Sandstones the writer is of the opinion that the net movement has been of a normal nature. Although there has been a reversal of this movement.

Another fault gives evidence of having experienced this same type of movement. A new road cut in the large canyon directly southwest of McCallen Heights gives an excellent exposure of this fault. As seen in this exposure the shale beds to the south of this fault show a drag which indicates a reverse fault while those beds in intimate relation to the fault surface show a change in direction of drag indicating a normal fault. However the stratigraphic relations in this case show that the net movement must have been of the reverse type.

These two instances give evidence for two periods of action of the deforming forces with an accompanying change in the direction of forces.

5. The low lying hills in the extreme north side of the area are here classed as the fifth block. They are structurally inconsistant with the rest of the area having in general a north-east strike compared with the consistent northwest trend found elsewhere in the area.

The occurence of a syncline has already been mentioned.

Figure 5.

This shows the fault discussed on page 23.

Interruptions by faulting has occured in the east side of this block by two vertical faults trending northwest. In addition the El Sereno Sandstones are faulted down into contact with the Rose Hill shales along a vertical east-west fault by a movement of about 100 feet. Sequence of faulting as shown in the areal pattern is, first, the east-west movement and then that in the north-south direction.

HISTORICAL GEOLOGY

Geologic history in this region prior to middle Miocene time is of course not recorded. After the invasion of a depositional basin by the Puente sea the only variations were those which would cause the alternation from sandstone to shale. The changes in depositional conditions that would cause these flucuations are either a deposit further from shore, a change of the direction of deposition, or a change in the rate of erosion. In the case of the Omaha Sandstones the latter was probably the cause. Deposition of the Rose Hill Shales undoubtedly resulted from an increased depth caused by an advancing sea, also to the increase of silica content of the river water. The end of Rose Hill time was marked by a recession of the sea and erosion of some of the Rose Hill Shales. The margin of the El Sereno Sea was then somewhere in the region near York Boulevard. The source of this material was from the north, probably dervied from mountains in the vicinity of the present San Gabriels.

Thruout Fernando time the region was a low lying land mass. If one accepts the theory that the end of Pliocene time was marked by a period of deformation which continued thruout Pleistocene it was then that the present structure and physiograply were developed. Two distinct periods of application of deforming forces were noted in the discussion of structure. However their time relations are obscure and cannot be discussed.

Some of the higher members of the Puente group are missing here, wether this is because they were not deposited, or because they have been eroded is only a matter of conjecture.

PHYSIOGRAPHY:

As in all mountains, the topographic forms of these hills are the product of two forces, uplift and erosion. The weakening of zones by faulting and the consequent increase of susceptibility of these zones to erosive agents have largely determined the stream channels. The Los Angeles River is purely an antecedent stream. Although the stream that has cut the present Arroyo Seco surely existed before the uplift of this region, it has cut it's channel along a fault zone.

The low lying hills on the north side of Mount Washington represent an old dissected degradational terrace cut perhaps by the stream that cut the Arroyo Seco. If this is the case, and it probably is, we have here an excellent case of stream piracy. The revival of the stream could be caused by two events, either an elevation of the source and a consequent increase in the degrading action of the stream, or the uplift of the Mount Washington Hills. To have cut thru its own fan as this stream has done nearer the head it must have been revived at the source. This probably accounts for the formation of these terraces in these hills.

ECONOMIC GEOLOGY:

Economic posability of the geologic material in these hills are essentially negative. Although the production of the Los Angeles oil field is obtained from rocks of Puente Age (1) the time has long since passed when drilling was allowed within the incorporated limits of Los Angeles. Nor is the structure especially favourable for the accumulation of such deposits. Furthermore the lithology is unfavourable for any other type of mineral resources.

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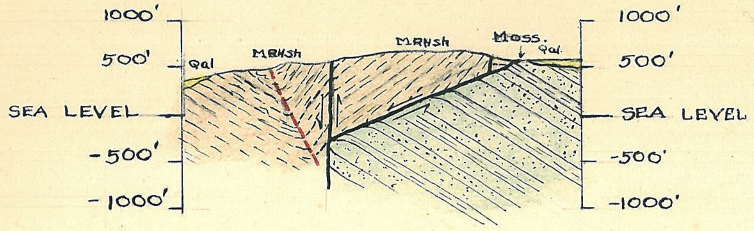
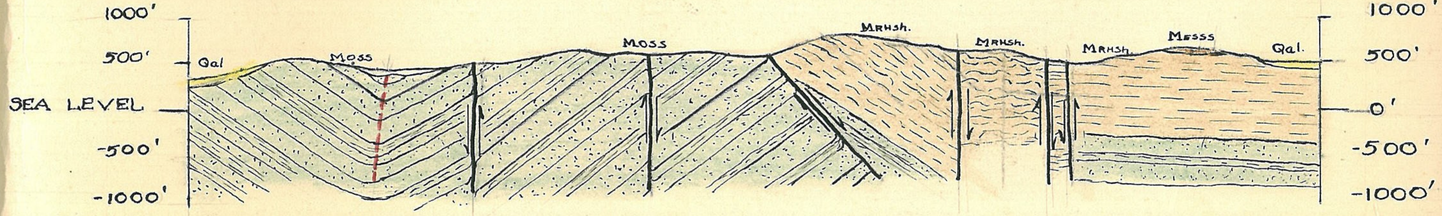
STRUCTURE SECTIONS



Section along line A-A'



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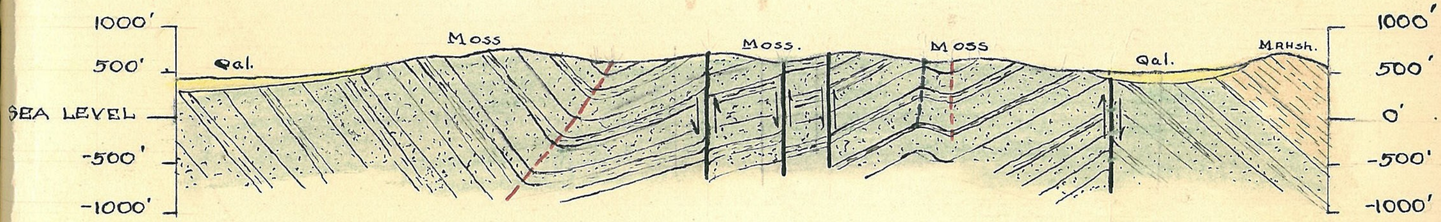
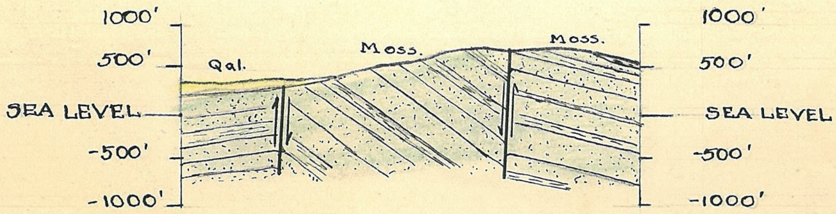


Section along line C-C'



Section along line D-D'

Scale. Vertical = Horizontal = 1/24000

MESSS El Sereno Sandstones

MRHSh Rose Hill Shales

Moss Omaha Sandstones.

Plate I