A GEOLOGIC REPORT ON THE PACOIMA AREA

by

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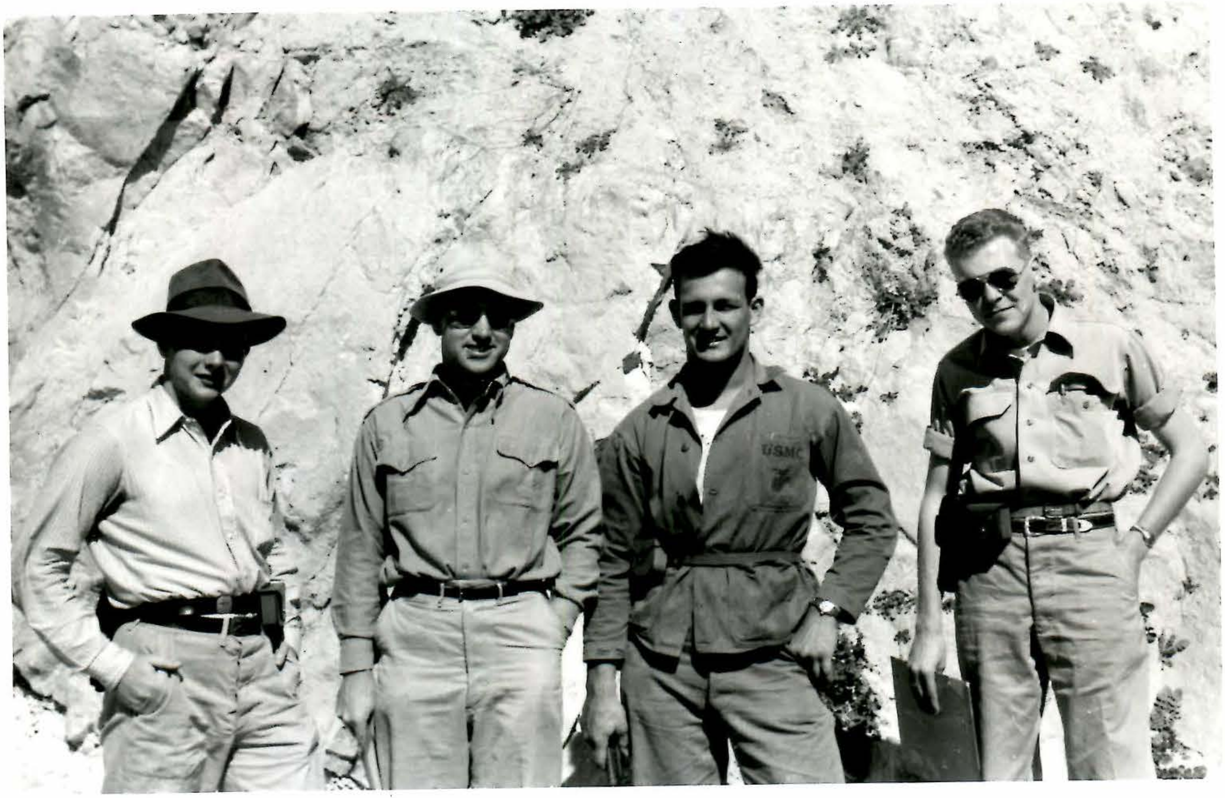
PACOIMA AREA



Outcrop of the Hansen Dam Formation

31 May 1947

Frontispiece

CONTENTS

CONTENTS

ABSTRACT

The region treated in the following report is a small area of about one square mile near Pacoima, California. It consists of a group of small hills that form the western abutment of the Hansen Dam. It is underlain by a section of intrusives, sediments, and extrusives, which may be subdivided into four groups.

The oldest rocks form the Dimebere complex of Jurassic (?) plutonic rocks, pegmatites, and schists. Lying unconformably on this is a series of alternating terrestrial sandstones and basalts of Tertiary age. These are unconformably overlain in turn by the Hansen Dam formation, a series of marine shales and sandstones correlated with the Temblor by the fossil content. Finally into these strata was intruded the Munglish andesite.

These strata form a shallow, plunging anticline, whose axis trends slightly east of north and lies in the center of the hills. The unconformities have been offset in several places by a series of faults apparently related to the anticline.

A complete outline of the geologic history is included in the report.

INTRODUCTION

Pacoima was chosen by the Division of Geological Sciences at the California Institute of Technology to offer the students experience in mapping an area containing both igneous and sedimentary rocks. In addition, it was selected because it presents a more complex structure than the previous problem (Sunland Field Problem). The authors feel that this is the definitive report on this area and that it can be used as a standard of comparison for future generations of student geologists at the California Institute.

The base map was an Ozalid print, prepared from a photostatic enlargement of portions of the Sunland and Pacoima quadrangles of Los Angeles county. The original scale was 1/24000, while the scale used on this problem was 1/6000, with a standardized contour interval of twenty-five feet. As a result of the enlargement the contours were greatly generalized; however, the original map was accurately prepared. Since the Pacoima quadrangle was mapped in 1927, many of the subsequent cultural features are not shown. This is especially true of the extensive quarrying, which is not indicated on the map. The geology was plotted by walking out contacts. Where this proved inadequate, the locations of the formations were determined by the mapping of outcrops, analysis of float, and "gopher hole" geology techniques. All lithological investigations were carried out in the field, rather than in the office. The age of one of the beds was approximately determined in the vertebrate paleontology laboratory from a specimen discovered by George P. Rigsby.

The authors wish to acknowledge the field assistance given by Messrs. R.H. White, R.J. MacNeill, and H.W. Menard. Very kind assistance was given by Dr. Chester Stock, the new Chairman of the Division, and his preparator, Mr. William Otto, by their preparation and identification of vertebrate fossil material found by George P. Rigsby. Dr. J. Wyatt Durham was extremely helpful in identifying the invertebrate fossils. All persons above are associated with the California Institute of Technology.

GEOGRAPHY

The region mapped is a rectangular area measuring 5000 feet by 5500 feet, located on the border of the Sunland and Pacoima quadrangles at the west end of Hansen Dam, approximately 34°16' north latitude and 118°24' west longitude. The area is twenty-three miles from Pasadena along Foothill Boulevard, or from Los Angeles by San Fernando Road. Entirely surrounded by alluvium of the San Fernando Valley, these hills are outliers of the San Gabriel Mountains.

The maximum relief in the area is 250 feet. A triangulation point is located on Hill 1250, the highest peak in the problem area. The hills are well-rounded and are in an early mature stage of erosion, with the gentlest slopes on the north sides; they have a general trend of northeast-southwest.

Ordinary dendritic stream drainage is present, superimposed on the drainage of the San Fernando Valley, sloping gently to the south and controlled by the Tujunga Wash, which lies immediately southeast of the hills.

In a manner typical of Southern California, the southern part of the area is covered with greasewood. The northern part consists of cultivated, grassy slopes. A few trees have been planted by the W.P.A.; namely, a few palm trees on the northwest side, near a large quarry, and a variety of deciduous trees in a small valley on the southwest side.

Due to the gentleness of the slopes and the grassy cover, the entire northern half of the area is nearly devoid of exposures, except for an occasional roadcut. In the southern half of the region, however, extensive quarrying operations in the basement complex and basalts have left superaltive exposures. The steepness of the slopes, caused by differential erosion of the interbedded basalts and sandstones, also formed good outcrops.

The most predominant cultural feature of the circuit is Whitman Airport, located in the northwest section, running along Pierce Street. Other dominant features are the Forestry Station on the south and Hansen Dam on the east side of the mapped region. Remnants of a park started by the W.P.A. are present on the southwest side and in the basalt quarry in the northwest section. On the outskirts of the area are several shacks, in a sad state of repair, occupied by the peasants of the San Fernando Valley, who seem to spend their time raising flowers.

STRATIGRAPHY

Present in the area are well over 1700 feet of interbedded sediments, intrusives, and extrusives, overlying the Dimebere basement complex, which is composed of igneous and metamorphosed rocks. The formations may be divided into marine and land-laid strata; the lower sandstone and basalt comprises the non-marine section. There are two unconformities present in the region; the lower one separates the Dimebere basement complex from the interbedded sandstones and lavas -- the upper unconformity divides the the sandstones and lavas from the overlying marine sandstones and shales.

The Dimebere basement complex, the lowermost mappable bed in the sector, is so named as a testimonial to the stimulating moral and mental support received from the "gold" mining distributor for the local soda pop products. This formation covers the whole southern portion of the area. Due to the extensive quarrying carried on, the outcrops are perfect and nearly continuous. Since the formation is composed of plutonic igneous and metamorphic rocks, the thickness is undeterminable. Three major rock types are present in the complex: granitic rocks, pegmatites, and schists. The bulk of the complex is granitic, ranging in composition from granite to granodiorite. These rocks are generally medium grained and equigranular. At scattered localities near the upper contact, the granitic rocks grade into coarse biotite schists. In the two eastern quarries in the complex are found pegmatite dikes, composed of predominantly quartz and orthoclase minerals, with some muscovite and plagioclase. In places these rocks have been ground to a coarse gouge by the several faults that offset the upper contact. The rocks are highly jointed and fractured and the joints show movement and slickenslides in the vicinity of the faults; the joints seem to run parallel to the faulting in the complex. Judging from the coarseness of the texture of these rocks, they must represent deep seated silicic intrusions. The complex has been classified by Kew, Wagner, English, and Buwalda as Jurassic (?), but the age is undeterminable from the limited field relations. Fundamentally, the contact between the complex and overlying conglomerates and sandstones is an unconformity. This is demonstrated by two facts: 1) the contact runs parallel to the other sedimentary contacts in the area, and 2) typical lensing conglomerates, containing cobbles similar in lithology to the complex below, are present above the contact. However, in most cases where this contact is well exposed there is evidence of some movement along the unconformity. Furthermore, the contact is offset in three places by comparatively large faults, which form a considerable part of the total length of the contact. In one place an old soil seemed to be present immediately overlying the Dimebere complex.

The bed overlying the Dimebere basement complex has been called the Tivoli, in honor of the superior geologic information dispensed by the proprietor of the nearby beer joint of the same name. The Tivoli formation covers an irregular area immediately overlying the Dimebere across the southern portion of the mapped region. A few good outcrops of the bottom of the bed are present in the quarry faces, as is the lower contact. The outcrops on the whole are poor because of the poorly consolidated nature of the sidiments, forming a topographical saddle between the adjacent resistant and ridge-forming igneous formations. The thickness varies, due to the faulting and unconformable contact, over its extent and averages approximately 280 feet, as calculated from the map. The major portion of this formation consists of poorly sorted, coarse grained sandstone. Near the base the formation becomes conglomeritic, containing boulders up to nearly a foot in diameter. At the top the bed grades into an even grained, coarse sand with a few scattered pebbles and cobbles. The sand is predominantly quartz with small amounts of feldspar; the majority of the cobbles are granitic in composition. The sand grains are mostly sub-angular and are loosely cemented with silicious material. Their color is white, grading to red from hematite staining beneath the basalt. It is likely that the Tivoli formation is of terrestrial origin because of the poor sorting and the angularity of the grains. Probably the source of this bed is the basement complex. The contact seems to be conformable. It is impossible to discern precise angular relations of the sandstone and the overlying Glen Oaks basalt because both are very massive and show no bedding planes or flow structure. There is no reason to suspect an unconformity since both are apparently of terrestrial origin and there is no general angular discordance between this contact and the lower one. In the southeast section of the mapped area the Tivoli formation makes contact with the Pacoima basalt, and has the same relations to it as does the Glen Oaks basalt. The only way the age of the Tivoli may be judged is by the age of its tongue, the Sandwich sandstone, which is the youngest part of the whole formation. In the Sandwich sandstone a small fragment of an artiodactyl jaw was found by George P. Rigsby. This was considered by Dr. Chester Stock to be most probably a California oreodon. The specimen was not well enough preserved to identify even the genus, especially since very little is known about California oreodonts. However, the size of the teeth are nearly the same as those found in the Mint Canyon. The last of the oreodons are found in the Hemphillian stage, which is approximately lowermost Pliocene on the invertebrate time scale. All of the later known oreodons were larger than this form found in Pacoima. Since the overlying marine shales and sandstones are known to be of Temblor age (middle Miocene), and the age of the oreodon is undeterminable, it is quite possible that the Tivoli, and overlying basalts, is nearly as young as the marine sediments.

The name of the Glen Oaks basalt, which overlies the Tivoli formation, is derived from the name of one of the main boulevards near the mapped area. This formation forms a twenty foot flow, extending from the alluvial contact on the west side and pinching out on the eastern hills. The outcrop of the bed seems to run due east and west. The exposures are fair along the extent of the bed. This is a basalt that is vesicular in the lower part. A considerable portion of the vesicles are filled with quartz and/or calcite. The size of the vesicles varies greatly in size -- the largest are upwards of an inch and the smallest are microscopic. Color varies from a rust to a bleached gray. The upper part is a dense, dark gray basalt with very thin and well defined red hematite stains running thru it. The stains are parallel with each other. Portions of this basalt bed are aphanitic while the actual grains may be seen in phenocrysts - - fine grained in part, aphanitic in part. Flow structure observed in some portions as evidenced by alignment of elongated visicles. The Glen Oaks basalt is an extrusive, as evidenced by vesicularity and absence of baking in the overlying beds. It is conformable with the enclosing sandstone as evidenced by the field relations and parallel contacts. As the Glen Oaks basalt is a lentil between the Tivoli and the Sandwich sandstone tongue, it must be of an age intermediate between the two.

The Sandwich sandstone is the next overlying formation. It is named from its character of being a "filling" between two basalt members. This sandstone formation extends across the area parallel to the Glen Oaks basalt and grades, at the eastern end, into the Tivoli formation, of which it is a tongue. The quarrying operations in the basalt in the western end of the area have extended the areal distribution of the sandstone in a peculiar manner. Windows extending into the Glen Oaks basalt and islands of the Pacoima basalt have been formed. Since the outcrops occur mostly on steep slopes, they are better than would be expected from such poorly consolidated material. The thickness of the bed is between ten and fifteen feet. In lithology the Sandwich sandstone is identical with the upper portions of the Tivoli formation. For the most part it is a well-sorted, medium to coarse grained, sub-angular, sandstone. It is composed principally of quartz with some feldspar. The upper few feet of the bed are heavily stained by iron, apparently leached from the overlying basalt. Since this tongue extends from the Tivoli formation, it can be assumed that the origin of the sands was the same as that of the Tivoli. Two facts attest to terrestrial deposition of these sands despite the fact that they are well-sorted. As has been pointed out a fragment of a land vertebrate (i.e. oreodon) was found in this bed. In addition, the formation is sandwiched between two basalts neither of which show evidence of under water extrusion. This could be accounted for as an accumulation of beach sand blown landward over the basalt. This possibility seems logical since the Sandwich sands are very similar to the basal sands in the Hansen Dam formation, overlying the Pacoima basalt. The basal Hansen Dam sandstone contains pelecypods and grades into shales of definitely mar~~e~~ine origin. This is an exceedingly interesting contact as it shows a gradation between sedimentary and extrusive igneous rocks. It is impossible to say where the sandstone ends and where the overlying basalts begin. This is apparently caused by the outflow of highly liquid lava over unconsolidated sands. Thus some of the lava seeps downward into the sands and a good deal of the sand is picked up by the lower parts of the flow. Discussed already under the Tivoli formation, the age and correlation of the Sandwich sandstone has previously been discussed under the Tivoli formation.

The Pacoima basalt, named from its outstanding lithologic features, is the next formation in the stratigraphic sequence. It forms the central section of the area and upholds the chain of the most prominent hills. It is exposed extensively along the southern rims of these hills and on their more gentle northern slopes. In addition, the westernmost quarry exposes a nearly complete vertical section of the formation. As calculated from the map, the thickness is about 140 feet. Laterally and vertically the lithologic characters of this basalt varies greatly. In places it is aphanitic and is totally devoid of phenocrysts or vesicles. This facies is usually black. Other portions are highly vesicular or amygdaloidal, the vesicles being filled with quartz, calcite, zeolites, and griffithite (?). In one locality, vesicles up to two inches in length were found. The phenocrysts may be either plagioclase or biotite, up to a millimeter in length. In some portions they form the mass of the rock. The color of vesicular and porphritic portions is purplish brown to a bleached tan. There is considerable limonite staining in the parts that have been leached. In the westernmost quarry the jointing was observed to be parallel to the lower contact. The Pacoima basalt is conformable with the Sandwich sandstone, so consequently is slightly younger. The Pacoima basalt is composed of a series of terrestrial flows. The feeder was not located in the area. Since the basalts show no evidence of under water extrusion and the overlying sandstone contains marine fossils, the contact between the two must be unconformable. This however, is not demonstrable by the field relations of these rocks. The overlying Hansen Dam formation is known to be of Temblor age by the identification of the pectens, and other pelecypods, by Dr. J. Wyatt Durham. The time interval represented by this hiatus is indeterminable since the age of the oreodon may be nearly the same.

The Hansen Dam formation overlies the Pacoima basalt. It received its name from the well-exposed section in the road cut next to Hansen Dam. This formation covers the northern half of the area. Beside the three road cuts, there are no good outcrops. These beds, up to the point they disappear under the alluvium, have a measured thickness of about 1200 feet. A large part of this area was cultivated at some time and is covered with a large growth of grass. This fact together with the gentleness of the slopes accounts for the scarcity of outcrops. The basal portion, a distinct mappable member, is a thick bed of medium to fine grained, sub-angular to sub-rounded, feldspathic, quartz sandstone. The color is white, and it is friable except where calcareously cemented. Thickness of this portion of the formation is fifty to seventy-five feet. The rest of the section above this bed is a series of interbedded shales and sandstones. All of the beds are either white or buff. Some of the individual beds are well-cemented but the majority of the individual beds are only fairly well-cemented, and offer little resistance to erosion, as is evidenced by the lack of ridges on the slopes of this portion of the area. The shales immediately above the basal sandstones are extremely well bonded with a silicious cement. Some of the hardness near the andesite is probably due to baking by the igneous body. A typical section of the Hansen Dam formation is exposed in the road cut next to the Hansen Dam. It consists of interbedded sandstone and shale. The sandstone beds are mostly thick and massive, ranging in thickness from one to five feet. Although the sandstones are of nearly uniform composition, consisting mostly of quartz with some biotite, some are well-cemented wheras others are feldspathic and friable. The silicious shale beds are thinly bedded and fractured; they also contain some biotite, which yields a brown limonitic stain on weathering. Some of the shales are well-sorted and others are quite sandy. The beds contain concretions around which the laminae seem to bend. Approximately in the middle of the section is a four foot bed of massive clay. When wet it has the appearance of cheap, yellow-green laundry soap, and can be scratched with a fingernail; when dry it is white and becomes somewhat harder. In water it swells and spalls off, which leads the authors to believe that it has bentonite in its composition. These beds were deposited under marine conditions, probably a fairly shallow basin. The bentonitic material was possibly derived from a volcanic ash that was either deposited on the water or was washed to sea by stream action. Evidence for shallow water are the pelecypods and arthropod scales. The upper contact is not visible because the formation disappears under the alluvium. These beds have been correlated with the Temblor by their molluskan faunal assemblage:

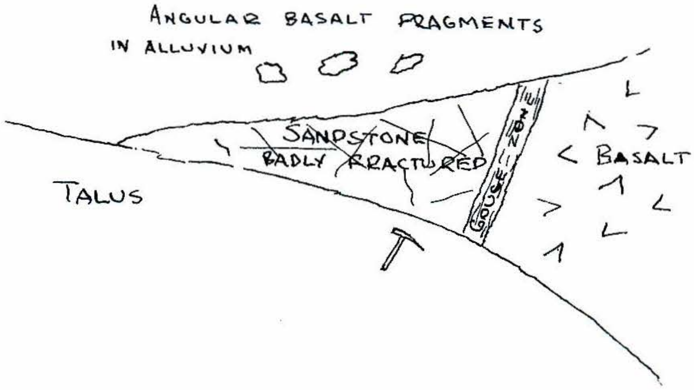
Pecten andersoni Arnold	Nemocardium sp.
Nassarius sp.	Dentatium sp.
Nuculana ochsneri (Anderson and Martin)	

The Munglish andesite is the uppermost bed in the area. Its name was derived as an acrostic by taking the first two letters from each of the authors' last names and trying to make something fairly euphonious out of it. This dike has an outcrop of about 20 feet by 100 feet on the south slope of Hill 1250. Exposures are fair and the eastern contact can be traced in detail. The andesite varies considerably over the outcrop. Most of it is a blue-gray color with thin stringers of phenocrysts. These stringers have dimensions of one by ten millimeters. Most of the phenocrysts are plagioclase. Some of the andesite is aphanitic and gray, while other portions are slightly vesicular; the vesicles are filled with chalcedony. This is an intrusive dike, apparently near the surface due to the presence of vesicles in some of it. The contacts cut the sediments at about 30°; the long dimensions of the dike strike N45°W. The sediments above and below it are baked, proving the intrusive nature of the body. Since it is intruded in Temblor rocks it must be of post-Temblor age.

GEOLOGIC STRUCTURES

The Pacoima area is underlain by a series of sediments and volcanic strata dipping in a generally northerly direction. The dip becomes more shallow towards the north, being approximately 50° at the contact with the basement complex, and between 15° and 17° in the northernmost exposures of the Hansen Dam formation. The dip also flattens to the east and the west. Thus it may be seen that the hills are situated on the nose of a shallow anticline plunging north. The axis trends slightly east of north and lies approximately in the saddle between Hill 1300 and Hill 1250. In the region of the saddle the crest becomes much sharper, causing the trend of the beds to arch sharply towards the north. This broad anticline is complicated locally by minor crenulations and folds on the flanks. In addition, possibility of a synclinal axis trending approximately northeast - southwest, lying north of the anticlinal axis, is indicated by the anomalous dips on Hill 1100, the northernmost hill in the region.

Nine faults of over seventy feet displacement have been mapped in the area. Starting in the southwest corner, the faults have been lettered counterclockwise to facilitate the discussion. Fault A has a trend of N75°W and dips 75° to the south. It is well exposed in the southwestern granite quarry, where it has a gouge zone two feet wide. The apparent displacement is 225 feet, with the south side moving west with respect to the north side. Fault B trends N25°E and dips 64° to the west. It is well exposed in the middle quarry where it has a six-foot gouge zone and a considerable shatter zone on either side. The face of the fault is shown clearly on the quarry wall and the slickensides indicating the direction of the last movement plunges 41° to the southwest. Many of the joints in the quarry show some indication of movement in the same direction. Fault B is a right hand fault with an apparent displacement of 220 feet. Fault C trends N15°W and dips 36° to the east. It has a complex shatter zone with ten feet of gouge and slices exposed in the easternmost granite quarry. It is a left hand fault with an apparent displacement of 250 feet. Faults B and C bound a block which has moved about 200 feet north with respect to the surrounding blocks. Fault D trends N77°E but its dip is unknown. The interpretation of this contact as a fault is derived from the fact that it trends at an angle considerably different from the general trend of the beds in this region and that it makes a distinct angle with another portion of the contact, which is parallel to the trend of the bed. Apparent displacement on this right hand fault is 400 feet; however, this figure is only approximate since the intersection of the fault with the southern continuation of the contact cannot be definitely located in the field. Fault E trends N40°E, dip unknown. This part of the contact is known definitely to be a fault because it also displaces the contact between the basal sandstone of the Hansen Dam formation and the overlying shales. This is a right hand fault with an apparent displacement of 200 feet. Fault F trends N30°W, probably dipping steeply to the west. This fault is based on threefold evidence, 1) the apparent thickness of the basal sandstone of the Hansen Dam formation is increased by more than half in this area, 2) a calcareously indurated, slightly fossiliferous ridge in this sandstone has been apparently repeated, and 3) there is a small break in the lower contact of this sandstone in the position where a normal fault, which would account for the above factors, would pass through. Calculating from the dip of the beds and the shortest horizontal distance between the two similar ridges, the displacement perpendicular to the plane of the beds is about seventy feet. Fault G trends N85°W, and dips 41° to the north in the gully, where very little slickensides or gouge is present. The apparent displacement has been extended by movement along Fault F. Correcting for the extension, the apparent displacement is probably about 200 feet. Fault H trends N30°W, but the dip is unknown. The existence of this fault cannot be definitely demonstrated but the authors feel that it is probably there because of the unduly large northward jog in the contact, which is difficult to explain entirely by means of folding. In addition, the displacement of the sandstone and basalt in the saddle of Hill 1175 is directly in line with the probable trend of this fault. Since most of the displacement on the upper contact of the Pacoima basalt is due to folding, the only measure of the apparent displacement of the fault is that evidenced by the movement of 150 feet on the lower contact of the Glen Oaks basalt, on Hill 1175. Fault I trends N20°E and dips 80° to the west. This fault is exposed in the northern end of the basalt quarry where it has some interesting relations as illustrated by the sketch:



The slickensides indicate that the last movement was essentially horizontal with a slight dip to the south. This will correlate the segment of sandstone with the Sandwich sandstone and the basalt overlying it with the Pacoima basalt. Movement indicates that this is a left hand fault, with a displacement on the order of 100 feet. Although the faulting in this area need not necessarily be related to the folding of the strata, a very definite hypothetical relationship can be demonstrated between the two. Three faults can be attributed to the forces responsible for the uplifting of the anticline. As has been pointed out, Faults B and C form an uplifted block or a horst. Fault H appears to have been due to failure along the excessively steep portion of the anticline in response to the folding forces. Most of the other faults, namely A, D, E, and F could be interpreted as gravity faults normally found in the crest and flanks of an anticline due to partial collapse of the structure. The system of Faults D-E-F-G form a series of downdrop slices and extend the upper unconformable contact of the Pacoima basalt towards the east, giving the Pacoima formation a greater apparent thickness on the eastern side of the area. Fault I is nearly a strike-slip fault along which a block contained between Faults I and H rotated counterclockwise. Subsequent tilting of the entire structure has probably occurred in accordance with the general northward tilting of the formations in this area against the San Gabriel Fault. However, the relation between the folding and faulting in the Pacoima area and the movement along the San Gabriel Fault cannot be proven within the limited field region.

There are two major unconformities in the mapped area. One separates the "Jurassic" crystalline rocks, the Dimebere complex, from Tertiary sediments and lavas; the other separates the terrestrial basalts and sandstones from the marine "Temblor", the Hansen Dam formation. The evidence for the existence of the unconformable nature of these contacts has been discussed under the section on "Stratigraphy". The former may be classed, according to M. P. Billings' definition, as a nonconformity, whereas the latter, since it is parallel to the strata and probably represents a recognizable interval of time, may be classed as a disconformity. One of the unique structural features in the Pacoima area is the andesitic dike on the south side of Hill 1250. The intrusive nature of this volcanic is demonstrated by the baking of the sediments both above and below the body, and by the way in which it transects the shale and sandstone strata. The lateral extent of the body is unusually short, 100 feet, compared with its thickness of twenty feet, but no indication of truncation by faulting was discovered. This point of the intrusion was probably fairly near the surface, because portions of the andesite were decidedly vesicular. Although no other intrusive was found in the area, float of a similar lithology was discovered in nearby scattered sections, indicating probable presence of other related igneous bodies.

GEOLOGIC HISTORY

The history of the formations present in the Pacoima area lends itself to division into four stages:

First stage

The earliest event of the geologic history of this area, which can be ascertained from the rocks present, was the metamorphism of pre-existent rocks and the intrusion of the granitic mass. Kew, Wagner, Buwalda, and English consider this to have happened in Jurassic (?) time. The granitic mass was further intruded by pegmatites. A period of erosion took place and brought these intrusions to the surface. A considerable interval of time elapsed before further deposition. The hiatus indicated by the stratigraphic break represents at a minimum all of Cretaceous and Eocene time.

Second stage

The next observable event was uplift and erosion, resulting in the deposition of the coarse Tivoli sediments. These deposits appear to be terrestrial. This stage is marked by the extrusion of basalt and interbedding of "beach" sands. The Pacoima basalt probably represents a series or succession of flows as evidenced by the change in lithology. As has been pointed out, this stage is possibly Temblor. The end of the stage is marked by subsidence and marine invasion.

Third stage

This stage is the period during which the marine deposition of the Hansen Dam formation occurred. The different facies of this formation (see frontispiece) possibly indicate an undulating sea. Bentonitic material being present might indicate an association between the extruding basalts and the Hansen Dam sediments; the bentonite could have been formed by volcanic ash falling upon the sea. The first part of the period shows very little difference from the preceeding stage; the lithology of the sand is practically the same. Following this the deposition of finer sediments is seen. Further inundation, uplift, sea cliff erosion, or a similar process could be responsible for this deeper water deposition. The sands are not diatomaceous and the condition of the water must have been such that few invertebrates could exist, as indicated by the small number of fossils recovered from this formation. Some cyclic arrangement, possibly climatic, may be responsible for the alternation of different beds. The rate of deposition is not known.

Fourth stage

The beginning of the stage is marked by uplift. Since a reasonable relationship can be demonstrated between the anticline and the faults, "Munglish" hypothesises the simultaneous occurrence of the faulting and folding. The relationship between the forces responsible for the uplift and the folding and faulting cannot be proven, but it is quite possible that they are related. Chances are the andesite was intruded immediately after or together with the faulting, etc. because the orogenic forces would have assisted this intrusion. Regional tilting probably followed the above orogeny because it is known that it was associated with the San Gabriel Fault, along which there has been much recent movement. This in turn was followed by erosion, and at the present day the region is in a mature stage of erosion.

DISTRIBUTION OF LABOR

The field work and report writing was done collectively in "bull-session" form. In addition to the general party cooperation on the report proper, extra credit is due Eugene M. Shoemaker for his extensive and admirable work on structural and age problems.

Compilation of map data, columnar section, and overlay:

Eugene M. Shoemaker

Inking and coloring of map:

Patrick N. Glover

Lettering of map, cross-sections, and overlay:

William R. Muehlberger

Revision of report and typing:

Fred H. Nicolai

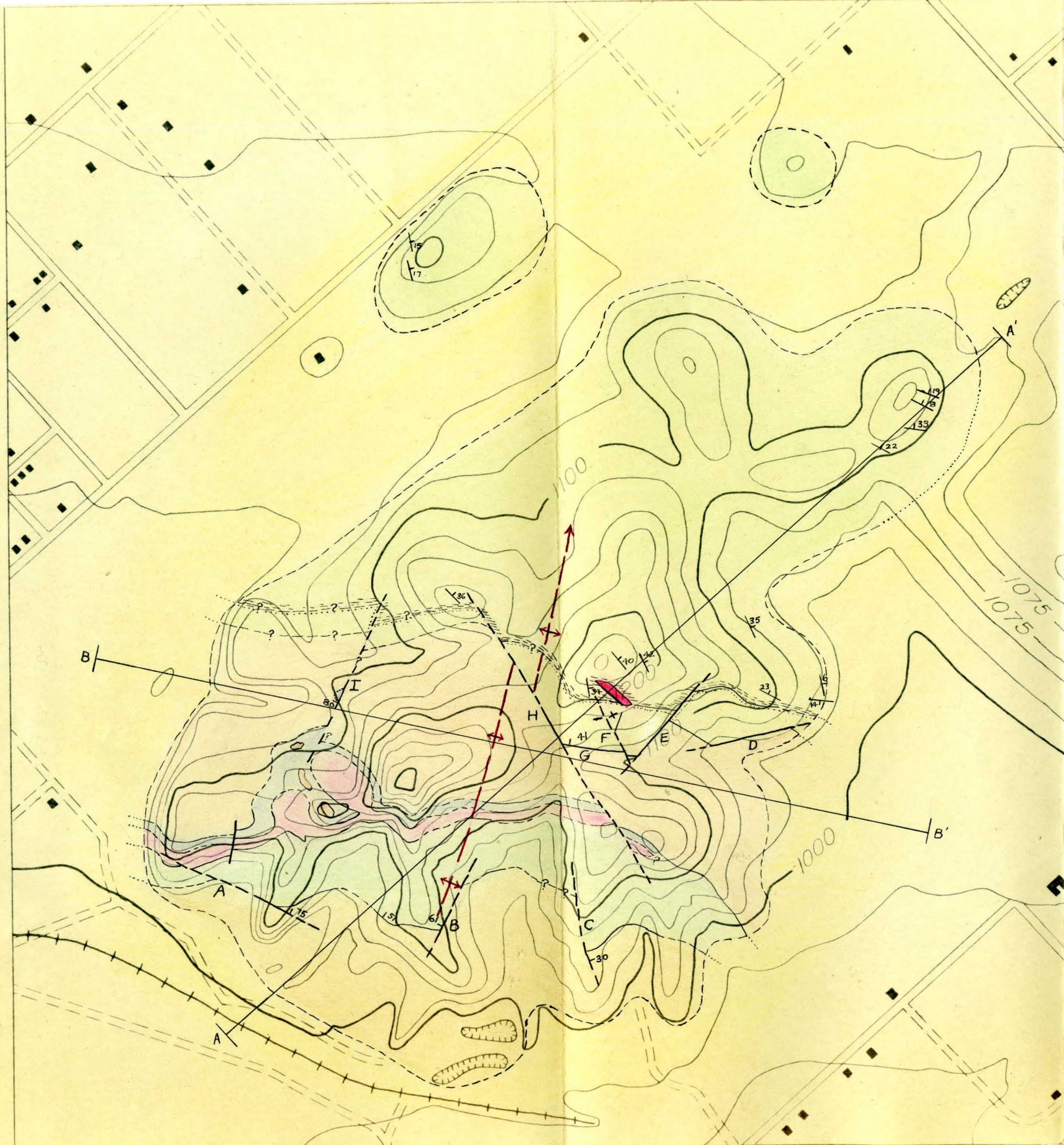
APPENDIX

a. Office map

b. Columnar section

c. Cross-sections

d. Overlay



LEGEND

SEDIMENTARY ROCKS

Quat.
- Alluvium

Miocene
- Hansen Dam fm.
- Sandwich sandstone
- Tivoli fm.

IGNEOUS ROCKS

Plio.?
- Munglish andesite

Miocene ?
- Pacoima basalt
- Glenoaks basalt

Juras.?
- Dimebere complex

GEOLOGY OF THE PACOIMA HILLS, CALIFORNIA

GEOLOGY BY =

P.N. Glover
W.R. Muehlberger
F.H. Nicolai
E.M. Shoemaker

FIELD WORK =

Started = March 1947.
Finished = May 1947.

N

16°

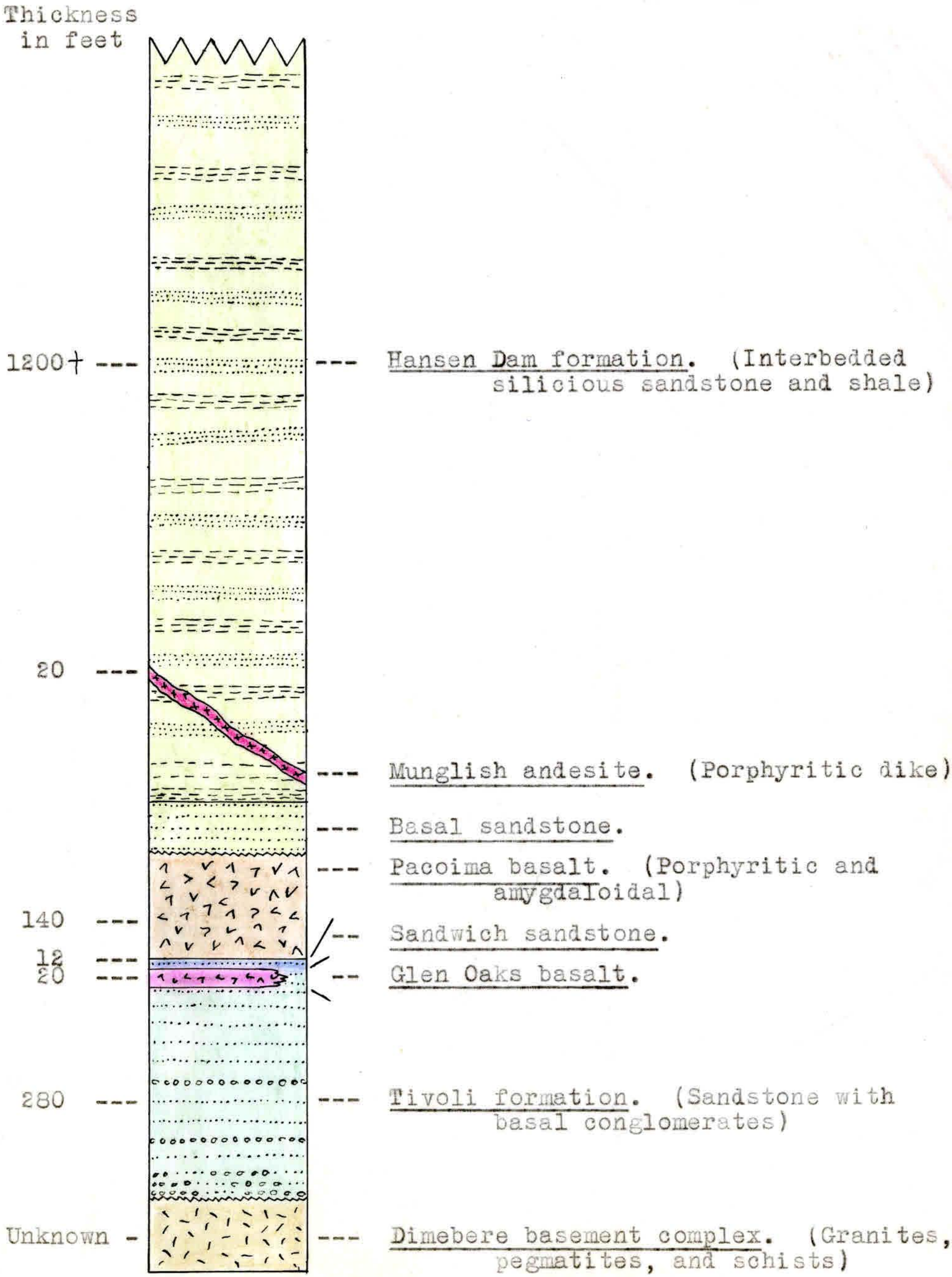
500 0 500

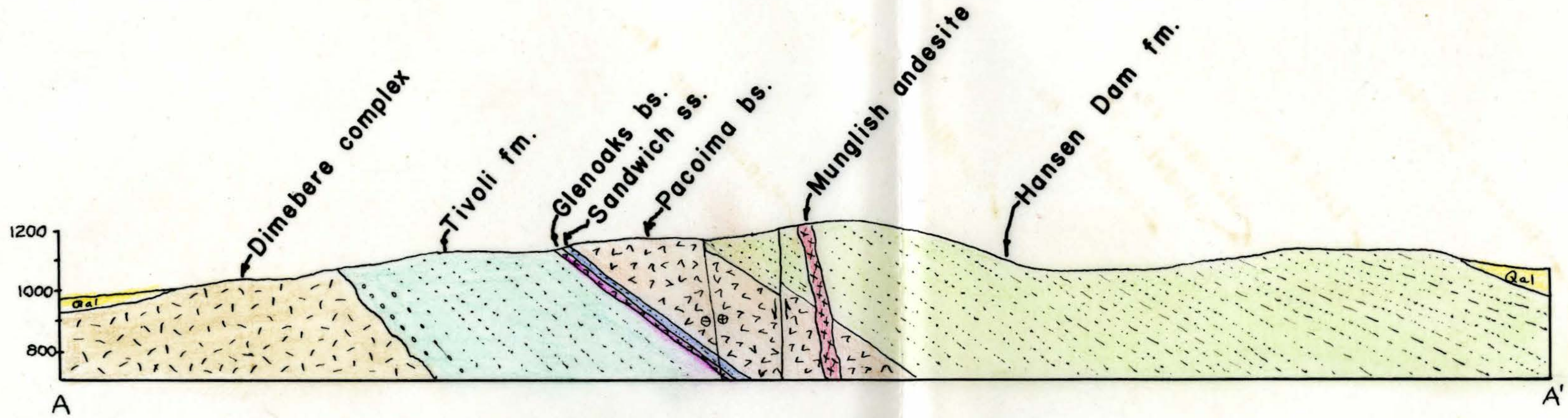
Scale 1/6000

Contour interval = 25 feet

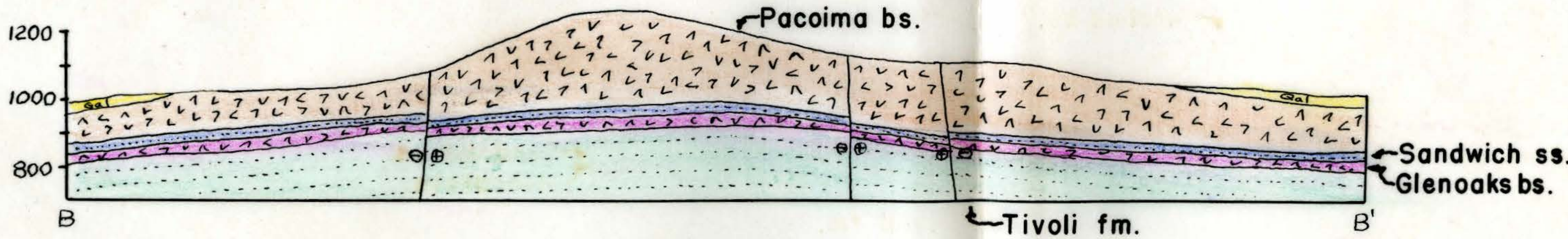
COLUMNAR SECTION

Scale: 1" - 200'

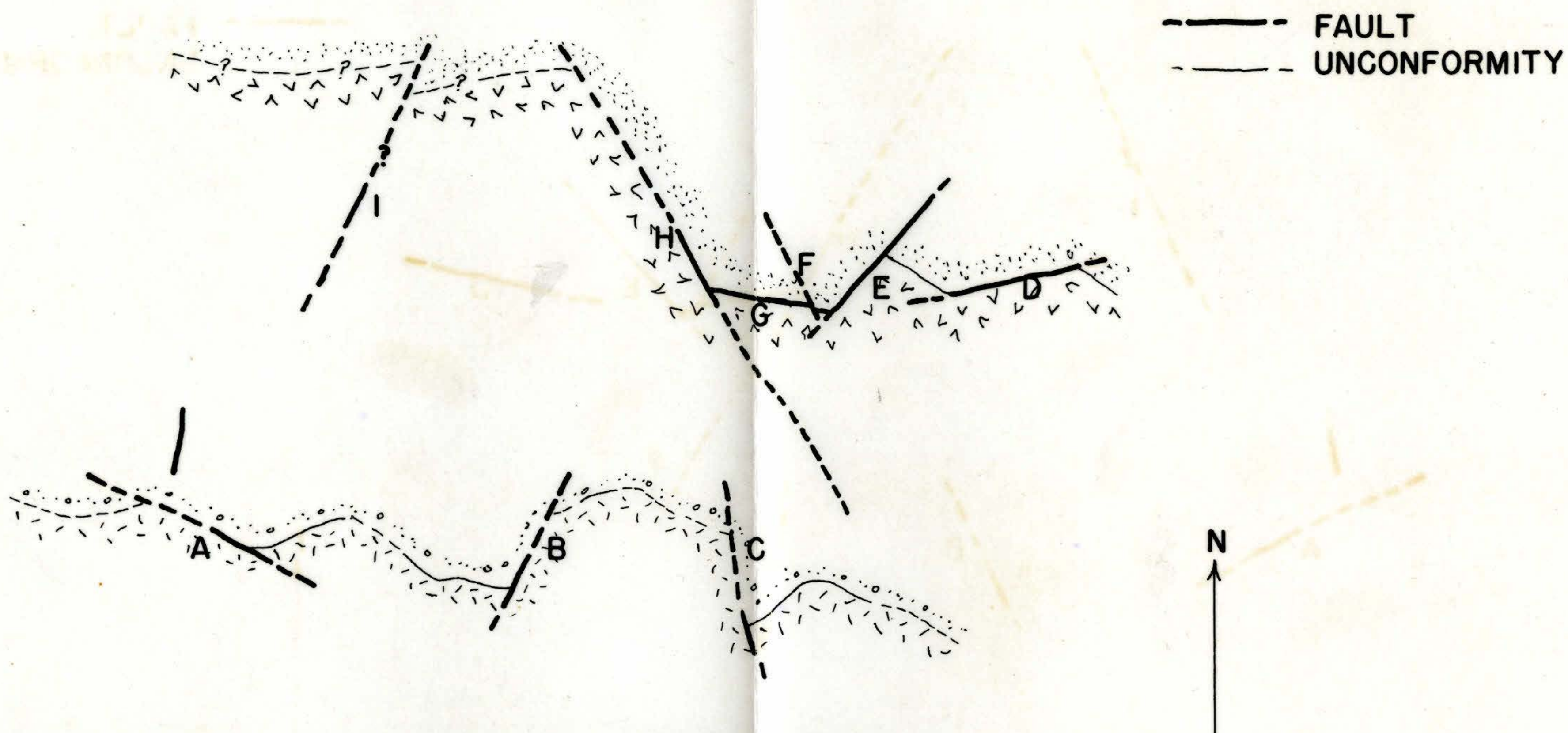




SECTION A-A'



SECTION B-B'



OVERLAY OF FAULTS AND UNCONFORMITIES

E. M. S.
W. R. M.