REPORT ON THE GEOLOGY OF

THE SAN PEDRO HILLS

Geology Dept.

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PREFACE

Work in the San Pedro Hills was very difficult on account of the scattered exposures, the great number of facies of each formation, and the lack of time to adequately study the fauna of each exposure. A study of the fossils found in each exposure is the only way in which more than a general idea of the areal geology may be obtained. The problem is really a paleontological problem, but offers a great deal of interest and a number of problems for the physiographer and the lithologist.

Frank W. Bell

SUMMARY

The San Pedro Hills Area is composed of Basement Complex overlain by a series of late Tertiary and Quaternary, marine sediments. There is a series of intrusive rocks forming sills and laccolithic masses in the vicinity of San Pedro Hill.

There is a great abundance of fossil material in the very late Tertiary and Quaternary beds, offering ample opportunity for the Paleontologist to accurately zone the different formations.

The folding is quite acute, but there has been no important faulting in the area.

INTRODUCTION

The area covered by this report is in the San Pedro Hills in the vicinity of the town of San Pedro. San Pedro is twenty miles south of Los Angeles, California, and is best reached via Western Avenue or Alameda Street from Los Angeles. The maps used were the advance sheet of the San Pedro Hills Quadrangle and the Wilmington sheet, which lie between 33°-42' and 33°-48' latitude and between 118°-12' and 118°-26' longitude. These maps are published by the United States Geological Survey, and, as the horizontal scale is 2000 feet to the inch, with five foot contour intervals, the maps form an excellent base for geological mapping.

This report covers the south and east slopes of the San Pedro Hills. The mapping was done as a senior thesis problem in fulfillment of requirements for the degree of B.S. at the California Institute, Pasadena, California. About twenty square miles of area were mapped.

The work was done on foot, a Brunton Compass being used for triangulations and for dips and strikes. The large number of streets and roads made it possible to use an automobile a great deal for general reconnaissance work.

About twenty days were spent in mapping the area.

TOPOGRAPHY AND DRAINAGE

The topography consists of a rather subdued, isolated group of hills, reaching an elevation of 1480 feet in San Pedro Hill. From the sea coast, the slopes rise rather abruptly in a series of terraces, the maximum rise being 1480 feet in a mile and a half, or a 14° slope.

The drainage west of San Pedro Hill is both to the north and south from a divide which trends about N 60° W and which is parallel to the coast. East of San Pedro Hill, the drainage is to the east. The divide between east and south drainages runs in a straight line between San Pedro Hill and Point Firmin.

There are a number of depressions in the area, most of which are due to the road fills built across canyons. In the north eastern corner of the area, there is a large shallow depression known as Bixby Slough. To the north and east of this slough, the country is very flat or only gently rolling.

VEGETATION AND EXPOSURES.

The shales are covered with a heavy growth of grass with very little brush. ~~The~~ brush is found, for the most part, on the ~~intrusive~~ exposures of intrusive rock and ~~on~~ sandstone ~~exposures~~.

The San Pedro formations are so sandy, that they will support practically no vegetation, except where the soil layer covers the underlying sands.

The thick soil mantle, which covers most of the country, even far up on the slopes, makes geologic mapping rather difficult. However, the numerous roads which have been cut through the hills offer excellent exposures at those points. Where this soil mantle does not cover the formations, very good exposures for this type of topography are found.

PHYSIOGRAPHY

The San Pedro Hills form a separate physiographic province. They are an isolated group of hills, which have beautifully developed marine terraces on their seaward slopes. These terraces are quite fairly evenly spaced, differing being about one hundred to two hundred feet difference in elevation. There are ~~either~~ seven or eight of ~~them~~ these terraces, and ~~they~~ the highest truncate run entirely to the top of the hills. The terrace surfaces dip southeast very slightly (toward San Pedro) and continue, at times, for long distances. The width is sometimes as high as a miles one and one-half ~~and a half~~. ~~A great~~ Many of the terraces are not continuous, as later terrace surfaces have been cut across them.

~~The origin of~~ These physiographic features had is without doubt marine in origin. They are very clearly not fault terraces, as the boundaries are sinuous, and there is no indication of offset in the beds underlying the terrace. They cannot be dip slopes as the strata stand in very varied angles below them. As marine deposits have been found on them, it is almost certain that they are marine in origin.

These features are quite recent, as the terraces have been disected very little, especially the lowermost ones. The process seems to be still going on. The Upper San Pedro Beds have been found only on the lower terrace level, which would place the age of the terraces as late Pleistocene.

The cause of these features is found on the northern and western side of the hills. This boundary is a fault along

which intermittent uplifts have occurred. During the intervals between uplifts, these terraces were cut by the sea. As the terraces are found only on the seaward face, the uplift has been one of tilting and not an island uplift. This is also substantiated by the fact that the highest portion of the hills lies very close to the sea coast, with the more gradual slope going to the northward.

Landsliding is evidenced in the physiography on a large scale at Inspiration Point. Here the terraces are discontinuous, except for the lowermost one, the drainage ways cut down through the tops of ridges, the drainages are often reversed and even closed. The topography is very hummocky, and in one place, a hummock has a flat top, which is tilted sharply away from the coast. This may possibly be a remnant of a terrace, which came down from a higher level, being tilted back as it moved down.

Another less important landslide area may be seen at the San Pedro Golf Course, where closed drainages and hummocky topography are in evidence.

The divide between east and south drainages, which runs from San Pedro Hill to Point Firmin, is quite interesting. Its straightness suggests faulting, but as there are no exposures along the face, which is rather unusually steep for low topographic expressions seen in the hills, there is no most clear stratigraphic evidence for fault relations. There is some suggestion of faulting in the sea cliff at Point Firmin, which is discussed more fully under Structure with regard to this straight mountain face.

STRATIGRAPHY

The section is made up entirely of Tertiary and Pleistocene rocks, all of which are sedimentary, except for a series of intrusives. The entire sedimentary section is exposed in the face of Dead Man's Island.

The oldest formation exposed in the area is a complex of schists, and such, which have not been encountered in mapping.

The Miocene Modello

One & only in Modello

The Miocene Modello overlies the Basement Complex, and is composed of two series, the upper sandy series and the lower siliceous series. The nature of contact between these two is a matter of some doubt, but it is probably unconformable. The lower beds seem to "butt into" the overlying beds, There is a zone of fragmental material and a rather irregular contact. The overlying beds seem to dip less steeply than the underlying, but the difference is not more than five degrees, and, as accurate determinations of dip and strike were not obtainable, it is not certain that there is angular discordance.

The Upper Modello forms a cap only on the end of Point Firmin, as it dips off into the sea. The sandstones are massive, conglomeratic, some of the conglomeratic material resembling the San Onofre Breccia in that there are glaucophane schist fragments, which are quite large and angular. (See Plate VII fig. 2) However, this material is much better consolidated and less

fragmental than the San Onofre Breccia. It is truly a conglomeratic sandstone containing large slabs mixed in. The inclination of these particles and the schist slabs indicate that the material came from the west. That such material as this might have been deposited, there must have been high lying exposures of Basement Complex to the west which shed these carbonaceous, conglomeratic, sandstones, and sandy shales.

The lower Modello series is quite characteristic of the Modello in that it is made up of highly siliceous sediments, which are badly broken up and contorted. No fossils were found in either series, except fish scales and bone impressions found in the mud shales of the Upper or Point Firmin Modello. The upper Modello is about 75 feet thick and the Lower Modello is 3000+ feet thick.

The Modello Intrusives
(See Plate IX)

These intrusive rocks are composed of basic lavas, for the most part. There is little doubt that these igneous rocks are of intrusive origin, as the strata at the contact are baked badly both above and below the igneous rock. The contacts are very irregular, either cutting through the strata or running parallel to it in sills. This sill structure is plainly seen in the most westerly exposure mapped. In this exposure, a series of olivene basalts are interbedded with shale and sandstone. The sandstone is badly baked, both above and below the igneous rock; this would tend to indicate intrusive relations sill structure. Also the igneous rock has thin layers of

vesicular rock on either contact, which also indicates they were formed as sills. At times, the vesicles are filled with zeolites. In the most northerly exposure of igneous rock along the Palos Verdes Coast Road, the igneous material crops out only on the sides of the canyon, while the canyon bottom and the neighboring ridges are sediments, the bedding of which is parallel to the contact surface. At the southern edge of the same exposure, the strata "butt into" the igneous rock.

Where the baked shale at the contact is well exposed, a distinct crystalline texture and banding is seen in the shale. Of course, the banding may be primary, but as it does not show very well farther from the contact, the banding is probably secondary. As this contact was between the upper surface of the igneous rock and the overlying shale, it ~~offers~~ is an excellent argument for intrusive relations.

On the other hand, the rock material itself is rather basic and coarse grained, which is not usually the case in intrusive rocks. However, this is not an impossible state for sill intrusions. The vesicular and amygdaloidal rocks would tend to indicate extrusive relations, but these zones are for the most part not more than a foot or so in thickness. Nevertheless, it is not impossible that some of the igneous rock is extrusive. The uppermost layer of igneous rock in the most westerly outcrop is more acid than the other, and the top is quite vesicular and brecciated. This may be a vein breccia as there has been a great deal of

But it is!

mineralization, with rather ~~quite~~ large veins of dolomite being formed. Another possibility is friction breccia, which has been cemented by later mineralization. This last possibility is perhaps the most likely, as the cementing material predominates and some of the particles are angular pieces of sandstone.

Considering the evidence as a whole, there is little doubt that ~~the majority~~ most of the rock is intrusive, with a bare possibility of extrusive relations. The included masses of limestone and sandstone, the vesicularity on both contacts and baking of surrounding rock would indicate intrusive deposition.

majority refers to members —

The Pliocene Saugus

At ~~the~~ Dead Man's Island, which is the type locality for the late Tertiary and Quaternary Beds of the San Pedro Hills, the contact between the Modello and Saugus is well exposed. The contact plane dips 15° N, and shows unmistakable signs of erosion. The evidences for nonconformity are listed below:

1. A thin, discontinuous layer of fragmental material separates the overlying and underlying material.

2. The larger pebbles of this fragmental material are composed of the limey underlying rock, and are full of borer holes. The pebbles are also well rounded.

3. The contact surface shows the same weathering as the present marine surfaces.

4. The contact surface in general is regular, but in detail is irregular.

5. Sharp change in character of sediments from a very hard, resistant limestone, which has been highly mineralized, to an only fairly well consolidated, unresistant, clayey sandstone.

6. Lower material is unfossiliferous; upper sandstone is richly fossiliferous. The fossil assemblage is made up of quite recent forms, very few being extinct.

7. There seems to be little evidence of bedding in the limestone, but indications of bedding in more shaly portions, show a dip much steeper than 15° toward the north.

The age of this Saugus series is as yet a question, as are most of the late Tertiary formations of the Los Angeles Basin. The reasons for correlation of the material with the Saugus are chiefly on the basis of Foraminifera, which are very similar to the faunal representatives taken from well borings of the Saugus of the Los Angeles Basin. According to the attached faunal list of Pelecypods and Gastropods, which was kindly furnished by Alex Clark, there are only three extinct species. Of course, Clark's work is not complete, but if the beds from which he has been collecting at Timm's Point are older than very late Pliocene or Pleistocene, one would expect to find more extinct species, even in a less exhaustive or complete collection than Clark has made. Besides the Foraminifera, which came from the lowermost bed at Timm's Point and the above mentioned molluscs, there are a great number of Bryzoans, Diatoms and Hexactinellid

sponge spicules.

In the canyon about a quarter of a mile south of the Standard Oil Tank Farm, there are beds very similar to the Timm's Point and Dead Man's Island Saugus, dipping north about 19°, which seem to continue up a small side canyon directly under and conformable with Lower San Pedro Deposits. This would also tend to indicate the close proximity of the Saugus to Pleistocene time. The Saugus is 500 feet thick on Dead Man's Island, and feathers out toward San Pedro Hill on the mainland.

The Lower San Pedro
(See Plate VI)

Above the Saugus at Dead Man's Island, with an angular unconformity of about 10°-13°, is a series of gray sands, which form the type section of the Lower San Pedro. In spite of the fact that this locality was chosen by Arnold as the type section, it is quite unique in that the exposures of Lower San Pedro on the mainland are entirely different in character. These beds are quite fossiliferous, the ~~characteristic~~ more common fossils being Venericardia ventricosa and Schizotherus nuttalli among the Pelecypods, and two species of Astracea known as undosa and inaequalis, Bursa californica and Euspira lewisii among the Gastropods. The fauna is quite definitely of Pleistocene age. This series is about 20 feet thick on Dead Man's Island and reaches a much greater thickness on the mainland, where it dips as high as 53°.

The Upper San Pedro

The marked unconformity, of the Upper and Lower San Pedro beds, is admirably exposed along Harbor Blvd., between O'Farrel and Dreifuss Streets in San Pedro and at Ninth and Beacon also in San Pedro. The evidences of non-conformity are:

1. An irregular contact.

2. Lenses of broken shells and fragmental rock on top of the contact, which seem to be pockets.

3. "Conglomerate" or fragmental rock shows initial bedding parallel to irregularities of the erosional surface.

4. "Conglomerate" contains pebbles with borer holes.

5. Lower beds dip from 3° to 16° East, while upper beds are horizontal.

Quaternary Alluviam

Above the horizontal Upper San Pedro and with unconformable relations, is a layer of dark brown to black soil. [See Plate XII (fig.1.)] This soil is slightly fossiliferous in places, and at Dead Man's Island has pockets of shells, which are possibly kitchen midden material, as the shells are almost all of one kind and some are broken. However, this is only hypothetical. Are they all edible species?

Besides this soil there is distinctly land laid alluviam and beach sands, which were all mapped as Quaternary Alluviam.

STRUCTURE

General Considerations

There has been quite a little considerable tilting in the San Pedro Hills, probably due to the movements in the fault running along the northern boundary of the hills and into the sea at the west border. The shales have suffered greatly on account of their incompetance. Consequently, the Miocene strata stand at all angles, filled with small faults and folds. Even the Lower San Pedro Beds at one point have been tilted 53°. It is interesting that all the post-Miocene beds in the vicinity of San Pedro dip northeast, while the dips in the Lower San Pedro Beds, S.S.E. of Harbor City, are to the S.E.

There has been no major faulting, except for that mentioned above, as the shales have not the competance to permit stresses to accumulate sufficiently. But shales to faint.

Landsliding has taken place on a very large scale.

Folding

There are ~~thousands of~~ a great many folds in the shales, ranging all the way from several tens of feet across to a mile or so. Besides those shown in the cross section B'B, there is a series of folds which show in the sea cliffs. All these folds plunge into the ocean, the axes on the east side of Point Firmin trending about N 20° W, and those on the south coast trending almost north and south.

The entire system of folds seem to make up an anticlinorium, the apex of which is San Pedro Hill. This folding is due to two causes, namely, the tilting of the whole block on which the San Pedro Hills lie, and the intrusion of the dolerites.

The date of folding ranges throughout the Tertiary and into the early Pleistocene. As the Upper San Pedro Beds lie practically horizontal, there has been little movement outside of uplift since Lower San Pedro time.

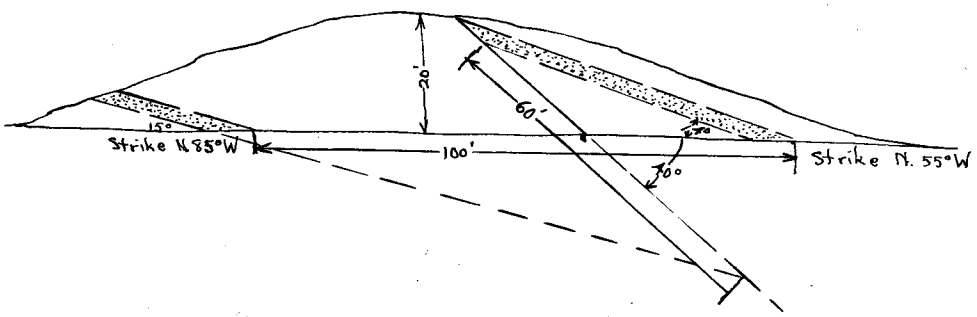
Landsliding

Landsliding has taken place on such a large scale, that areas almost a square mile in area have been moved down the slope. Such is the case of the large landslide at Inspiration Point. This landslide has been discussed under Physiography, and as no further study was made of this area, it needs only to be mentioned here. The same holds true for the San Pedro Golf Course Landslide, which is much smaller than the one at Inspiration Point. It is interesting to note that where the Palos Verdes Road has cut through the ridges, the down hill cut nearly always dips toward the hill, regardless of the dip on the opposite side of the road. This is due to slumping of the isolated mass on the down hill side.

Faulting

Faulting is of very minor importance, only one being encountered which was large enough to mention. See sketch.

Road Cut in Palos Verdes Coast Road near Modello - Lower San Pedro Contact.



There is a possibility of fault relations in a line of hills connecting San Pedro Hill and Point Firmin. This fault possibility is only based on scanty physiographic evidence, and is discussed under "Physiography". There is evidence, on the very end of Point Firmin, of a small fault, the displacement of which is about 5', which ends in a syncline, as shown by dips and striker taken on reefs along the beach. This may be a continuation of the hypothetical fault mentioned above.

PETROGRAPHY

The Miocene Modello

The predominating rock of the Lower Modello is an almost white to brown siliceous shale. Besides this siliceous shale, there are a great variety of rocks composing the Lower Modello section which are listed below.

1. Cherts, which are black or brown in color, and which have a good conchoidal fracture. These rocks are often laminated. On soaking this laminated chert in hydrochloric acid, the alternate layers etch out indicating alternate laminae of limestone mixed with the chert.

2. Limestones are quite abundantly exposed in the area, often showing distinct reefs, which are unusually continuous across the topography, taking into consideration the incompetancy of the remainder of the section. There are cherty limestones, which are grayish black in color and arenaceous limestones of dark reddish brown to black color. The arenaceous limestones are laminated.and are unfossiliferous.

3. Sandstones are also quite abundant, and like the limestones form reefs.

4. The remaining types of rocks are shales of the mudstone, arenaceous and diatomaceous varieties. The diatomaceous shale is white, with a very low specific gravity, soft and laminated. The diatom content runs as high as 98%.

The upper or Point Firmin Modello is made up of dark colored conglomeratic sandstones, light colored sandy shales,

and ordinary sandstones with the other characteristic rocks of the lower Modello represented, but not in important quantities. The sandstone is frequently found saturated with petroleum. The conglomeratic sandstones are rather unique in that they, at times, resemble brecciated material. In addition to the large amount of well rounded particles, there is a great amount of very angular pebbles in this rock. These pebbles are composed of shale, feldspar, quartz, schist, older conglomerate and igneous rocks. The sandstones of this series show a great deal of cross bedding. Even the contacts between adjacent strata are quite irregular. The beds are very massive with the cross bedding showing up as very coarse lamination within the bedding planes.

The Miocene Intrusives

The intrusives of this area, especially the more easterly exposures, are very badly weathered. In fact, the decomposition has gone so far that the material resembles a loosely consolidated, arkosic sandstone. The weathered material is brown in color, and appears to be coarsely crystalline. The most westerly exposures show more fresh rock and more clearly the texture, which, for the most part, is aphanitic.

The following descriptions show the character of the intrusives very well:

Spec. No:- A-1

Location:- Palos Verdes Coast Road east of San Pedro Hill.

Description:- Fine grained, phaneric texture, medium

dark brown, badly weathered rock, containing plagioclase, biotite, olivene (pyroxene or horneblende).

Name:- Dolerite

Spec. No:- A-2

Location:- Most westerly intrusions, near inspiration rock with sedimentary rock.

Description:- Specimen shows magmatic differentiation, the core being greenish in color and the shell being reddish brown. The shell rock is of fine, phaneric texture and contains orthoclase and plagioclase as major elements with quartz and augite as minor elements. This shell is typical of most of the surrounding rock and is more acid than the lower part of this exposure, and also more acid than other exposures. The core is aphanitic, porphrytic with phenocrysts of plagioclase. The ground mass is light greyish green and salic. Weathering effect?

Name:- Andesite or Latite (?)

Spec. No:- A-4

Location:- The most northerly intrusion on the Palos Verdes Coast Road, east of San Pedro Hill. Most of the rock in the exposure is like A-1.

Description: The rock is of aphanitic, porphrytic texture. The ground mass is very femic. The color is very dark, blackish green.

Name:- Olivene Basalt.

Spec. No:- A-7

Location:- Northern contact of intrusive with shale in Inspiration Point exposure.

Description:- Rock is a breccia with very angular particles of lava and sandstone cemented by dolomite and calcite. There is more cement than particles.

Name:- Friction Breccia.

The Pliocene Saugus

This material is a soft, clayey sandstone, indistinctly bedded, and is a very massive, homogeneous rock. One bed is made up almost entirely of foraminifera.

The Lower San Pedro

The Lower San Pedro at Dead Man's Island is a massive, gray, fairly coarse sandstone. It weathers in caves and shelves, the outer portions of which are supported by sandstone pillars, which resemble stalactites to some extent. On the mainland the Lower San Pedro is made up of well bedded grey sands, brown clayey sands, and massive calcareous sandstones or unresistant limestones. The brown clayey sands show a great deal of cross bedding. The Lower San Pedro beds are, for the most part, poorly consolidated.

The Upper San Pedro

The upper San Pedro is composed of light grey to brown, unconsolidated sands and very limey beds of shells,

resembling very coarse, unconsolidated coquina. In the northern part of the area, the brown sands become very coarse and granular, and are unique in that the granules are all the same size, the material being uncemented.

ECONOMIC GEOLOGY

There is not a great deal which is of economic importance in the San Pedro Hills. The Miocene intrusive rocks, which have been badly weathered, have been quite extensively quarried for road building purposes. The diatomaceous material, found quite abundantly in the Miocene shales, is not in workable deposits, although some of it is very rich in diatoms, running as high as 98% diatoms. Near Lomita, there are a few quarries, where highly fossiliferous material is being excavated for fertilizer.

A wild cat well has been drilling on Point Firmin where, in the upper sandy series of the Miocene shales, a great deal of oil soaked sandstone appears in the sea cliffs.

There is quite a little mineralization in the shales. Barite and dolomite are found in abundance, but not in workable deposits. However, mine shafts have been dug on the south slope on the lowermost terrace, which have apparently been for the purpose of working these deposits.

HISTORICAL GEOLOGY

The history of the San Pedro Hills has been quite eventful. The first event, for which evidence is seen in the area mapped, is the subsidence of the area, and the deposition of the rather thick section of Modello Shales. Following the deposition of the Lower Modello, there was a slight erosional interval in which deposition of the siliceous material ceased. Following this, came the deposition of the Point Firmin Modello, the material coming from exposures of basement complex, which were rather close at hand, as the material is quite coarse and fragmental.

As the Lower Modello is highly mineralized, the upper not being mineralized, the intrusion of the dolerites probably took place at the close of Lower Modello time. However, it seems that the erosional interval between the two would have been much greater if this were the case.

Following the deposition of the Upper Modello came a period of uplift and erosion, with tilting and possibly folding of the shales.

Following this event, came the subsidence in late Pliocene or early Pleistocene time which permitted the deposition of the Saugus beds. These beds were probably laid down in a quiet marine lagoon, as inferred from the character of the sediments, which indicated quiet deposition, and the fact that the fauna is not a deep water group.

Then in Pleistocene time, the land mass was again lifted up and ~~all~~ the Saugus was eroded away, if ~~there was~~ more existed in this vicinity, except the small area near Timm's Point.

The events then took place very rapidly with folding, tilting, and erosion taking place in each break of the stratigraphic interval. With the subsidence of the land mass in Middle or Lower Upper Pleistocene, the Lower San Pedro beds were laid down on the eroded edges of the Saugus beds. Then came uplift, tilting, and further folding, followed by subsidence and deposition of the Upper San Pedro. Then came a series of seven or eight uplifts of the San Pedro Hills area in Late Pleistocene, which resulted in the succession of marine terraces mentioned under "Physiography". During the latter of these terrace forming intervals, the Upper San Pedro Beds were deposited in a thin sheet on the terraces and quite thickly in the basin north of San Pedro. The last terrace has but recently been lifted up from the sea, and a new terrace is probably in the process of construction at present.

INVERTEBRATE FAUNA

TIMMS POINT "PLIOCENE"--BY ALEX CLARK

ECYPODA

	Range
Acila castrensis (Hinds)	Bering Sea to San Diego
Leda taphria Dall	Bodega Bay to Lower Calif.
Yoldia ensifera Dall	Alaska to San Luis Obispo
Chlamys jordani (Arnold)	Extinct
Chlamys hastatus (Sowerby)	Monterey to San Pedro
Chlamys caurinus (Gould)	Wrangell, Alaska to Siletz Bay, Oregon
Monia macroschisma (Deshayes)	Bering Sea to Lower Calif.
Modiolus sp.	
Thracia trapezoides Conrad	Extinct.
Pandora (Kennerlia) grandis Dall	Bering Sea to Oregon
Venericardia ventricosa Gould	Alaska to Coronado Islands
Venericardia barbarensis Stearns	Santa Barbara to San Diego
Thyasira gouldi Phillipi	Bering Sea to San Diego
Diplodonta orbella Gould	Bering Sea to Gulf of Calif.
Phacoides californicus (Conrad)	Crescent City to Lower Calif.
Phacoides annulatus (Reeve)	Alaska to Coronado Islands
Cardium (Trachycardium) quadragenarium Conrad	Santa Barbara to Lower Calif.
Cardium corbis Martyn	Santa Barbara to San Diego
Protocardia centrifilosa Carpenter	Bodega Bay to Lower Calif.
Saxidomus nuttallii Conrad	Baulinas Bay, Calif. to San Diego
Marcia subdiaphana (Carpenter)	Alaska to Santa Barbara
Marcia kennerlyi Reeve	Alaska to Carmel Bay, Calif.
Macoma sp.	
Semele rubropicta Dall	Alaska to Tiajuana
Solen sicarius Gould	Vancouver Is. to San Quentin Lower Calif.
Panomya ampla Dall	Bering Sea to Victoria, B. C.
Panope generosa solida Dall	Straits of Fuca to San Francisco
Mya truncata Linnaeus	Arctic Ocean to Puget Sound

"PLIOCENE" FAUNAL LIST (Continued)

GASTROPODA

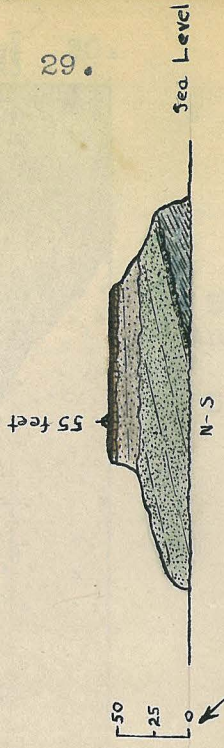
	Range
Acmaea incessa Hinds	Trinidad, Calif. to Magdalena Bay, Lower Calif.
Acteocina eximia (Baird)	Kodiak Is. to Puget Sound
Alectreon cooperi (Forbes)	Puget Sound to San Diego
Antiplanes perversa (Gabb)	Alaska to San Diego
Anachis sp. cf. A. minima Arnold	Extinct
Bittium asperum Gabb	Extinct
Calliostoma canaliculatum Martyn	Alaska to San Diego
Calyptraea sp.	
Chlorostoma montereyi Kiener	Baulinas Bay to Santa Barbara
Conus californicus Hinds	Farallones Is. to Lower Calif.
Heilprinia barbarensis (Trask)	Oregon to San Diego
Neptunea tablatus (Baird)	British Columbia to San Diego
Oenopota sp. a.	
Oenopota sp. b.	
Olivella biplicata Sowerby	Vancouver Is. to Magdalena Bay, Lower California
Pseudomelatoma sp. a.	
Pseudomelatoma sp. b.	
Turritella cooperi Carpenter	Monterey to San Diego
Turritella jewetti Carpenter	Santa Barbara to Salina Cruz, Mexico
Columbella gausapata Gould	Alaska to San Diego
Turcica caffea Gabb	San Pedro to Cape San Lucas
Margarita pupilla Gould	Bering Sea to San Pedro--San Diego in deep water.
Astraea inequalis Martyn	Vancouver Is. to San Pedro

FORAMINIFERA FROM LOWERMOST SAUGUS BEDS--TIMM'S POINT

Collected by Frank Bell

Biloculina bradyi Schlumberger
Bulimina sp.
Cassidulina several species--undetermined
Cibicides lobatus (d'Orbigny)
Cibicides fletcheri Galloway and Wissler
Cibicides tenuimargo Brady
Cibicides sp.
Fissurina sp.
Globergerina sp.
Globorotalia grandis Galloway and Wissler
Lagena sp.
Nonion incisa Cushman
Nonion scapha (Fitchel and Moll)
Nonion sp.
Nonionella auris d'Orbigny
Orbulina universa d'Orbigny
Polymorphina sp.
Quinquiloculina vulgaris d'Orbigny
Quinquiloculina akneriana d'Orbigny
Quinquiloculina sp.
Rotalia subtenera Galloway and Wissler
Sigmoilina sp.
Textullaria barettii Jones and Parker
Textullaria gramen d'Orbigny
Themeon crispus (Linne')
Triloculina several species--undetermined
Uvigerina farinosa Hankten
Uvigerina peregrina Cushman
Virgulina sp.
Several other undetermined genera and species

PLATE I



CROSS SECTION OF DEAD MAN'S ISLAND

Showing section containing entire succession of beds in the San Pedro Hills Area.

Scale:—

GENERALIZED CROSS SECTION
Showing succession of beds in the vicinity of San Pedro, California.

Scale - 1000 feet equals 1 in.

DETAILED CROSS SECTION
Showing relations between Upper and Lower San Pedro beds.

Scale - 100 feet equals 1 in.

LEGEND:-

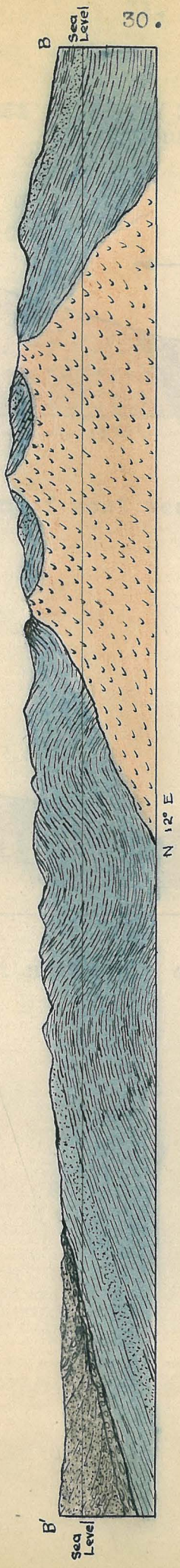
Miocene Modello
- sandstones
- limestones
- cherts
- siliceous shale
- mud shale
- diatomaceous shale

Pliocene(?) Saugus
- clayey sandstone

Pleistocene
Lower San Pedro
- sandstones
- clayey sands

Pleistocene
Upper San Pedro
- sands
- coquina
- soil

PLATE II



GENERALIZED CROSS SECTION
Showing structure of Modello shales and intrusive relations.

Scale 2000 feet equals 1 inch.

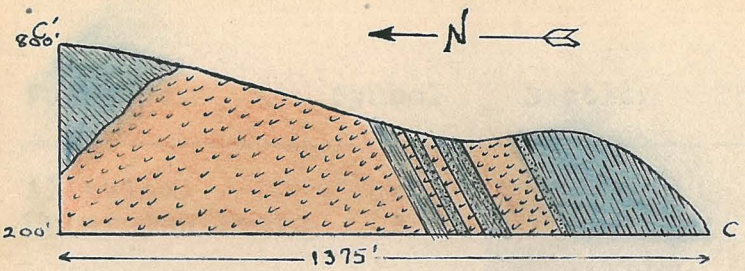
LEGEND:-

Miocene Modello Shales (Lower series)

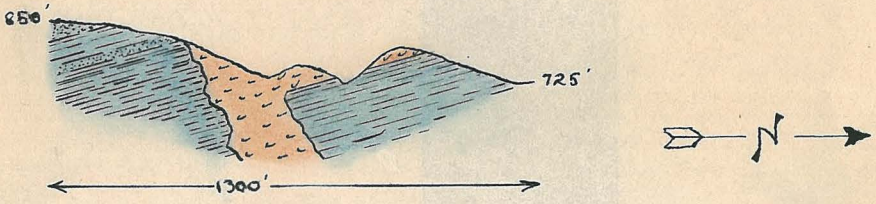
Miocene Modello Intrusives

Lower San Pedro Sediments

CROSS SECTIONS SHOWING SILLS
In Intrusive Dolerite



Section of most westerly intrusive exposure



Section of most northerly exposure on Palos Verdes Coast Road

LEGEND:-

Intrusive

Modello sediments

PLATE IV

COLUMNAR SECTION -- SAN PEDRO HILLS AREA - CALIFORNIA

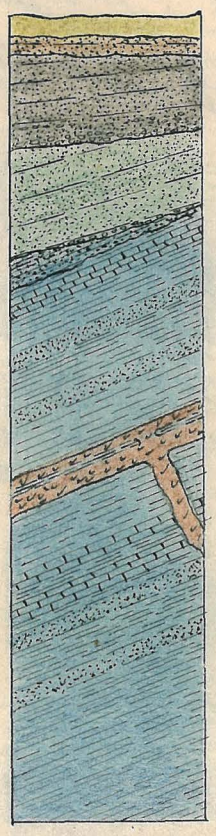
Formation	Symbol	Section	Thickness	Age
Alluviam	Qal			
Upper San Pedro	USP		50' ±	Quaternary
Lower San Pedro	LSP		500'±	
Saugus	PSg		500'±	Pliocene ?
Modello	MMo		3000'+	Miocene

Fig 1. Intrusive Contact with baked Modello Shales
Palos Verdes Coast Road

Fig. 2. Intrusive contact with Modello Limestone
Showing included masses and dikes
Palos Verdes Coast Road near San Pedro
Golf Course

Fig. 1. Section cut into Lower San Pedro clayey sandstones.

Fig. 2. Same as above

PLATE VII

Fig. 1 . Old erosional surface of Upper San Pedro now covered by Quaternary Alluviam.

Fig. 2. Large sandstone boulder from the Point Firmin Modello, showing large fragment of schist near head of geology hammer.