

THE PALEONTOLOGY AND STRATIGRAPHY OF THE  
PLEISTOCENE AT SIGNAL HILL, CALIFORNIA

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## INTRODUCTION

### Location

Signal Hill is located in the northern limits of the city of Long Beach, Los Angeles County, California, approximately two and a half miles north of the Pacific Ocean waterfront. It reaches an elevation of three hundred and sixty-four feet and is the highest point in a series of low-lying hills that extend from Seal Beach in Orange County, to the Dominguez Hills, approximately ten miles to the northwest. Signal Hill is a portion of the Long Beach oil field.

### Review of Literature

Arnold (1, pp 30-32) in his report on the marine Pleistocene at San Pedro, California, gave a brief but fairly detailed account of the Pleistocene stratigraphy and paleontology at Signal Hill. He listed a fauna of one hundred and sixty species from the "Upper San Pedro" formation (Palos Verdes sands), but he found no fossils in the underlying sands and gravels. However, Arnold considered this latter group to be equivalent to his "Lower San Pedro" formation (San Pedro sands). So far as I know this is the only published report that has a detailed account of the Pleistocene at Signal Hill.

Eaton (5, p 124) considered the Palos Verdes sands on Signal Hill as being equivalent in part to the warm-water Hall Canyon formation of Lower Pleistocene age rather Upper Pleistocene.

Grant and Gale (7, p 43) suggested that the "Upper San Pedro" on Signal Hill might possibly belong to the basal warm-water Las Posas zone instead of the Palos Verdes sands because the beds are deformed and there are two warm-water horizons in the Pleistocene instead of one.

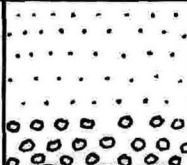
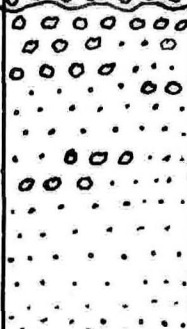
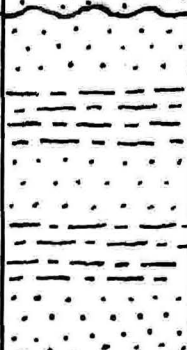
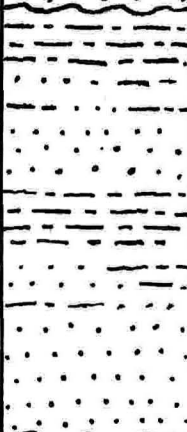
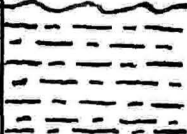
Professor Tieje (7, p 43) also suspected that the "Upper San Pedro" beds at Signal Hill belonged to the Las Posas zone.

#### Purpose of Report

I spent the summer of 1938 studying the stratigraphy and paleontology of the two Pleistocene formations exposed at Signal Hill. Special emphasis in this study was placed on the lower series of sands and gravels from which a large representative fauna was collected. Previous to this no fossils had been reported from this lower group of sediments. It seems desirable, therefore, to record the results of this investigation.

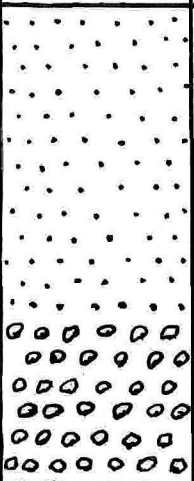
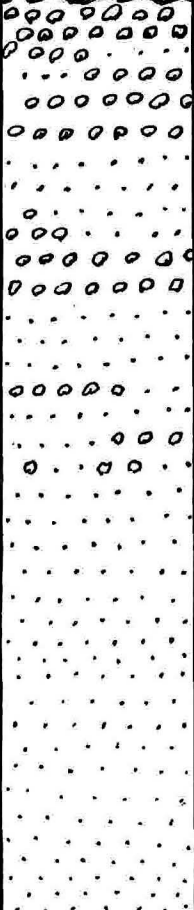
#### Acknowledgments

I wish to express my appreciation to Dr. W. P. Woodring of the United States Geological Survey for suggesting the problem and for criticism and advice. Dr. W. P. Popenoe, Curator of Invertebrate Paleontology at the California Institute of Technology, has had general supervision of this paper during its preparation. He has offered many valuable suggestions regarding the faunal relations and stratigraphy of the Signal Hill formations. Mr. H. Hollis Reamer and Mr. John W. Christensen of the California Institute of Technology have rendered valuable assistance in the field. The Golish collection of Recent shells and the collections from the Pleistocene of Southern California, both at the California Institute of Technology were found indispensable in making comparisons with the Signal Hill fossils.

AGE	FORMATION	COLUMNAR SECTION	THICKNESS	CHARACTER
UPPER PLEISTOCENE	PALOS VERDES SANDS		15' ±	Unconsolidated, marine, fossiliferous gravel overlain by gray sand.
LOWER PLEISTOCENE	SAN PEDRO SANDS		1000' ±	Unconsolidated, brown to gray silts, sands, and gravels.
UPPER PLEISTOCENE	PICO		1300' ±	Beds of semi-consolidated sands and shales.
LOWER PLEISTOCENE	REPETTO		2300' ±	Alternating beds of sand, sandy shale, and shale. Contains most of the oil producing horizons.
MIOCENE	?		?	Hard black shale beds, Oil bearing.

COMPLETE COLUMNAR SECTION OF THE FORMATIONS AT SIGNAL HILL

FIG 1

AGE	FORMATION	COLUMNAR SECTION	THICKNESS	CHARACTER
UPPER PLEISTOCENE	PALOS VERDES SANDS		15'±	Unconsolidated, gray, micaceous, sand.
				Unconsolidated, fossiliferous, basal gravel.
LOWER PLEISTOCENE	SAN PEDRO SANDS		75'±	Brown, unconsolidated gravels with subordinate beds of brown and gray sands. No silts.
				Series of brown and gray sands with subordinate beds of brown silts and gravels.
				Brown, fossiliferous silts with subordinate beds of gray sand. No gravels.

DETAILED COLUMNAR SECTION OF PLEISTOCENE FORMATIONS AT SIGNAL HILL  
FIG. 2

## STRATIGRAPHICAL NOMENCLATURE

Before proceeding with a discussion of the geology of Signal Hill it is perhaps advisable to give a brief discussion of the stratigraphical nomenclature used in this report.

Arnold (1) used the terms "Lower San Pedro" and "Upper San Pedro" for his formations of Lower and Upper Pleistocene age. Kew suggested in work for the United States Geological Survey, the names "San Pedro" and "Palos Verdes" for Arnold's "Lower and Upper San Pedro" formations. These have been accepted by the United States Geological Survey and, accordingly, will be used in this report.

## STRATIGRAPHY

## General Statement

The rocks exposed at the surface on Signal Hill are composed of loosely consolidated marine sands and gravels. They are divisible into two formations; (1) the Palos Verdes sands of Upper Pleistocene age and (2) the San Pedro sands of Lower Pleistocene age. The Lower Pleistocene sands are found in oil wells at all depths down to 1000 feet. No formations older than the San Pedro sands are known from surface exposures, but subsurface data show the Lower Pleistocene to be underlain unconformably by the Pico formation of Upper Pliocene age, approximately 1300 feet thick which in turn is unconformably underlain by the Lower Pliocene Repetto formation which is approximately 2300 feet thick at Signal Hill, and which contains most of the oil-producing horizons. These Pliocene sediments are more consolidated than the Pleistocene and consist of alternating beds of sand, sandy shale, and shale. Some of the wells below a depth of 5000 feet have entered a hard black shale which is believed to be Upper Miocene (2). The columnar section (Fig. 1) shows this succession in more detail.

## San Pedro Sands

The San Pedro sands in the Signal Hill area consist of a series of fairly well-bedded, though locally cross-bedded, loosely consolidated marine silts, sands, and gravels. They are gray-colored when fresh but because of the many local brownish pockets and lenses, and the general tendency to weather out with a brown color, the series is easily distinguished by its brown color from the overlying gray Palos Verdes sands. The fragments vary from silt size up to four or five inches in diameter. The majority of these pebbles are well-rounded, slightly weathered, and of an assortment that seems to indicate their derivation from a possible quartz diorite region. A few rounded pebbles of shale were found in the coarser beds. The lithology of these fragments is very similar to the Miocene shale beds exposed in and around San Pedro. On the north slope of Water Tank hill (Fig. 4), in a small ravine about 200 feet east of the lowermost oil well is an outcrop of a well-consolidated gray silt - almost a shale. In lithology it closely resembles a portion of the Miocene shale exposed on the Palos Verdes Hills, but because of its stratigraphic position it is believed to be a consolidated lens of the San Pedro sands.

Although a good deal of lensing occurs, as is natural in a gravel and sand series, the San Pedro as a whole at least in the exposed portion, is fine-grained in the lower portion and coarsest in the uppermost part. This is the reverse of normal order of deposition but it may be explained by the fact that the surrounding uplands were probably undergoing initial diastrophic disturbances preparatory to the great Pacific Coast Pleistocene revolution.



On Water Tank hill the San Pedro sands are finer-grained and more firmly consolidated than on Signal Hill proper.

An exceedingly fossiliferous silt lense was found in the lower part of the exposed San Pedro in the old reservoir cut (Fig. 4).

The exposed portion of the San Pedro sands on Signal Hill is approximately 75 feet thick. As indicated in a previous paragraph, the well core evidence tentatively places the thickness of the Lower Pleistocene succession of which the San Pedro sands are a part at about 1000 feet. Whether this section belongs to the San Pedro sands entirely, is not known.

The San Pedro sands are the core of Signal Hill and thusly outcrop on all sides of the hill, whereever an artificial cut or a small ravine has cut through the overlying Palos Verdes sands. The dips are variable but are usually steep, ranging from 15 to 40 degrees. In general, at any given point, the beds dip in the same direction as the slope of the hill.

## Palos Verdes Sands

Resting unconformably on the tilted brown San Pedro beds at Signal Hill is a gray stratum of exceedingly fossiliferous, unconsolidated, marine gravel. The matrix varies from fine sand grains to pebbles three inches in diameter. Most of these pebbles are fresh, subangular to well-rounded, and of a heterogeneous assortment. However, no fragments of Miocene shale which are common to the Palos Verdes sands at San Pedro were found in the Signal Hill localities. The fossils are well-preserved and may easily be removed from the matrix by hand. The gravel stratum varies from three inches to about two feet in thickness.

Overlying the fossiliferous gravel is a massive deposit of fine, gray, micaceous, unconsolidated sand. No fossils were found in it. The sand varies from two to over ten feet in thickness. It thickens to the south and west where it replaces or overlies the basal gravel. Arnold (1, p 32) suggests that the 41 feet of sand exposed in the sea cliff at Long Beach is a continuation of the Palos Verdes exposed on Signal Hill. Because of a covering of vegetation and a city ordinance against excavation this statement could not be verified. It is probably a continuation, however, because of the fauna reported by Arnold and the dip in that direction on the south side of Signal Hill.

The basal gravel is fairly uniform in character wherever exposed except in the Cherry Avenue cut (Fig. 4) where the pebbles are more weathered and the fossils are semi-cemented together by calcium carbonate - a coquina-like mass. The overlying sands are remarkably uniform in color, texture, composition, and structure wherever they are found in the Signal Hill region.

The Palos Verdes sands at Signal Hill can always be easily recognized by its lithology and faunal content.

The Palos Verdes sands are absent from the northwest side of Signal Hill. This absence is probably due to erosion and possible patchy deposition of the sediments. On the east slope of Water Tank hill in a dump are Palos Verdes sediments and fossils. However, they are not in place and most likely were dumped there after being hauled from some other locality. Outside of this occurrence, the Palos Verdes sands are not present on this hill.

The dips are gentle and closely follow the slope of the hill both in direction and amount.

Overlying the Palos Verdes sands are about two to over twenty-five feet of dark brown sandy soil, the thickest part being on the crest of Signal Hill.

## PALEONTOLOGY

## Fauna Collected From The San Pedro Sands

## Gastropoda

*Amphissa columbiana* Dall*A. reticulata* Dall*A. ventricosa* Arnold*Bittium asperum* Gabb*B. catalinense* Bartsch*B. larum* Bartsch*B. ornatissimum* Bartsch*B. rugatum* Carpenter*Bursa californica* Hinds?*Calliostoma canaliculatum* Martyn*C. costatum* Martyn*Cancellaria tritonidea* Gabb*Clathurella conradiana* Gabb*Conus californicus* Hinds*Crepidula adunca* Sowerby*C. excavata* Broderip*C. nummaria* Gould*C. onyx* Sowerby*C. princeps* Conrad*Epitonium indianorum* Carpenter*Fusinus barbarensis* Trask*Mangelia hecetae* Dall and Bartsch*Mitrella carinata* Hinds var. *gausapata* Gould*M. tuberosa* Carpenter*Moniliopsis incisa* Carpenter*Nassarius mendicus* Gould

*N. mendicus* Gould var. *cooperi* Forbes  
*N. perpinguis* Hinds  
*Natica clausa* Broderip and Sowerby  
*Neptunea tabulata* Baird  
*Neverita alta* Dall  
*N. reclusiana imperforata* Dall  
*Olivella pedroana* Conrad  
*Polinices lewisii* Gould  
*Sella montereyensis* Bartsch  
*Surculites carpenterianus* Gabb  
*Terebra albocincta* Carpenter var. *pedroana* Dall  
*Tritonalia barbarensis* Gabb  
*T. lurida* Middendorff  
*T. poulsoni* Carpenter  
*Trophon eurymata* Dale  
*T. multicostratus* Eschscholtz  
*T. pacificus* Dall  
*Turbonilla pedroana* Dall and Bartsch  
*Turcica coffea* Gabb  
*Turritella cooperi* Carpenter

#### Pelecypoda

*Botula diegensis* Dall?  
*Cardita ventricosa* Gould  
*Clementia subdiaphana* Carpenter  
*Corbula luteola* Carpenter  
*Cryptomya californica* Conrad  
*Gari edentula* Gabb  
*Laevicardium corbis* Martyn  
*L. quadragenarium* Conrad

- Lucina acutilineata* Conrad  
*L. californica* Conrad  
*L. nuttallii* Conrad  
*L. tenuisculpta* Carpenter  
*Macoma calcarea* Gmelin  
*M. inquinata* Deshayes  
*Nucula castrensis* Hinds  
*Nuculana taphria* Dall  
*Panope generosa* Gould  
*Pecten hastatus* Sowerby  
*P. islandicus* Muller var. *hindsii* Carpenter  
*P. islandicus* Muller var. *jordani* Arnold  
*P. latiauratus* Conrad  
*P. multirugosus* Gale  
*P. stearnsii* Dall  
*P. sp.*  
*Pododesmus macroschisma* Deshayes  
*Psephidia cymata* Dall  
*P. ovalis* Dall  
*P. salmonea* Carpenter  
*Saxicava artica* Linnaeus  
*Schizothaerus nuttallii* Conrad  
*Solen sicarius* Gould  
*Thracia undulata* Conrad  
*Yoldia scissurata* Dall  
 Scaphopoda  
*Dentalium neohexagonum* Sharp and Pilsbry

## Faunal Summary - San Pedro Sands

Total number of species.....	77
Gastropoda.....	45
Pelecypoda.....	31
Scaphopoda.....	1
Species living at San Pedro.....	55
Percentage of fauna.....	71
Species living only north of San Pedro.....	12
Percentage of fauna.....	16
Species living only south of San Pedro.....	6
Percentage of fauna.....	8
Species having greatest range north of San Pedro.....	14
Percentage of fauna.....	18
Species having greatest range south of San Pedro.....	4
Percentage of fauna.....	5
Species extinct.....	3
Percentage of fauna.....	4
Species of questionable habitat.....	3
Percentage of fauna.....	4

## Faunal Relations - San Pedro Sands

The strata in which the fossils of the San Pedro sands at Signal Hill were found, were laid down in relatively shallow water. The medium-grained, tan and gray sands in which they were found are similar to the sediments which are being deposited in depths from ten to twenty-five fathoms off Long Beach at the present time. The fauna of the San Pedro sands is a cool-water fauna. This is evidenced by the higher percentages of cold-water affinities than warm. 16% of the species are now living only north of San Pedro and 18% of those that range north and south of San Pedro have a more pronounced range north than south. This is at quite a variance with the 8% obtained for the forms now living only south of San Pedro and 5% for those with a pronounced southerly range. The presence of the southern forms in the San Pedro sands indicates a temperate climate, probably somewhat similar to the present climate of the Pacific Northwest. That this cool temperate aspect was climatic rather than facies is shown by the relatively constant ratio between northern and southern forms wherever the San Pedro sands are found.



## Fauna Collected From The Palos Verdes Sands

## Gastropoda

- Acanthina spirata* Blainville  
*Acmaea insessa* Hinds  
*Acteon punctocaelatus* Carpenter  
*Amphissa columbiana* Dall  
*A. versicolor* Dall  
*Bulla punctulatus* Adams  
*Calliostoma canaliculatum* Martyn  
*C. gemmulatum* Carpenter  
*C. tricolor* Gabb  
*Calyptraea mamillaris* Broderip  
*Cerithidea californica* Haldeman  
*Conus californicus* Hinds  
*Crepidula adunca* Sowerby  
*C. crepidula lessoni* Broderip  
*C. excavata* Broderip  
*C. nummaria* Gould  
*C. onyx* Sowerby  
*C. sp.*  
*Crucibulum spinosum* Sowerby  
*Diodora aspera* Eschscholtz  
*Epitonium indianorum* Carpenter  
*Lacuna unifasciata* Carpenter  
*Lora sp.*  
*Lucapinella callomarginata* Carpenter  
*Mangelia hecetae* Dall and Bartsch  
*M. variegata* Carpenter  
*Megatebennus bimaculata* Dall

*Melampus olivaceus* Carpenter  
*Melanella hastata* Sowerby  
*M. micans* Carpenter  
*Mitrella carinata* Hinds  
*M. carinata* Hinds var. *gausapata* Gould  
*M. tuberosa* Carpenter  
*Moniliopsis incisa* Carpenter  
*Nassarius californianus* Conrad  
*N. cerritensis* Arnold  
*N. fossatus* Gould  
*N. mendicus* Gould  
*N. mendicus* Gould var. *cooperi* Forbes  
*N. perpunguis* Hinds  
*N. tegula* Reeve  
*Neverita alta* Dall  
*N. reclusianus imperforata* Dall  
*Olivella biplicata* Sowerby  
*O. pedroana* Conrad  
*Polinices lewisii* Gould  
*Purpura festiva* Hinds  
*P. nuttallii* Conrad  
*Retusa carinata* Carpenter  
*R. culcitella* Gould  
*Tegula ligulata* Menke  
*Terebra albocincta* Carpenter var. *pedroana* Dall  
*Tricolia compta* Gould  
*T. pulloides* Carpenter  
*Tritonalia lurida* Middendorff  
*T. poulsoni* Carpenter  
*Turbonilla pedroana* Dall and Bartsch

*T. torquata* Gould  
*T. tridentata* Carpenter  
*Turritella cooperi* Carpenter  
*Volvulella cylindrica* Carpenter  
 Pelecypoda  
*Amiantis callosa* Conrad  
*Anomia peruviana* d'Orbigny  
*Apolymetis biangulata* Carpenter  
*Chama pellucida* Sowerby  
*Corbula luteola* Carpenter  
*Crassinella branneri* Arnold  
*Cryptomya californica* Conrad  
*Cumingia lamellosa* Sowerby  
*Donax californicus* Conrad  
*D. gouldii* Dall  
*Dosinia ponderosa* Gray  
*Laevicardium procerum* Sowerby  
*L. quadragenarium* Conrad  
*L. substriatum* Conrad  
*Lima dehiscens* Conrad  
*Lucina nuttallii* Conrad  
*Macoma indentata* Carpenter  
*M. moesta* Deshayes var. *acolasta* Dall  
*M. nasuta* Conrad  
*M. secta* Conrad  
*Mactra californica* Conrad  
*M. elegans* Sowerby  
*M. hemphilli* Dall  
*M. nasuta* Gould  
*M. planulata* Conrad

*Mya cancellata* Conrad  
*Nucula exigua* Sowerby  
*Nuculana taphria* Dall  
*Ostrea lurida* Carpenter  
*Pecten gibbus* Linnaeus var. *circularis* Sowerby  
*P. latiauratus* Conrad  
*P. multirugosus* Gale  
*Periploma planiuscula* Sowerby  
*Petricola carditoides* Conrad  
*P. denticulata* Sowerby  
*Pholas gabbi* Tryon  
*Pitar squelidus* Sowerby  
*Pododesmus macroschisma* Deshayes  
*Pseudochama exogyra* Conrad  
*Sanguinolaria nuttallii* Conrad  
*Schizothaerus nuttallii* Conrad  
*Semele decisa* Conrad  
*S. pulchra* Sowerby  
*Tagelus californianus* Conrad  
*Taras parilis* Conrad var. *sericatus* Reeve  
*Tellina bodegensis* Hinds  
*T. buttoni* Dall  
*T. meropsis* Dall  
*Tivela stultorum* Mawe  
*Veneropsis staminea* Conrad  
*V. staminea* Conrad var. *lacinata* Carpenter  
*Venus fluctifraga* Sowerby  
*V. gnidia* Broderip and Sowerby

*V. purpurissata* Dall

*Volvella recta* Conrad

*Yoldia cooperi* Gabb

Scaphopoda

*Dentalium neohexagonum* Sharp and Pilsbry

Crustacea

*Balanus concavus* Bronn

*Cancer* sp.

## Faunal Summary - Palos Verdes Sands

Total number of species.....	119
Gastropoda.....	60
Pelecypoda.....	56
Scaphopoda.....	1
Crustacea.....	2
Species living at San Pedro.....	91
Percentage of fauna.....	76
Species living only north of San Pedro.....	2
Percentage of fauna.....	1
Species living only south of San Pedro.....	17
Percentage of fauna.....	14
Species having greatest range north of San Pedro.....	5
Percentage of fauna.....	4
Species having greatest range south of San Pedro.....	31
Percentage of fauna.....	26
Species extinct.....	2
Percentage of fauna.....	1
Species of questionable habitat.....	3
Percentage of fauna.....	2

### Faunal Relations - Palos Verdes Sands

The fauna of the Palos Verdes sands at Signal Hill is southerly in character and represents a fauna that today is living several hundred miles south of San Pedro. Not only is there a relatively large percentage of the species now living only south of San Pedro (14%), but also many of those that are living at San Pedro have a much greater range to the south (26%) than the north (4%). Those northern forms present are very few and rare. The fauna probably lived in semi-tropical waters as evidenced by the presence of such forms as Retusa carinata, Bulla punctulatus, Calliostoma gemmulatum, Laevicardium procerum, and Mactra hemphilli.

The assemblage of forms present in the Signal Hill Palos Verdes sands indicates a fauna that would be found on a low, sandy coast.

In the following check list of fossils from the Pleistocene at Signal Hill, the specific and generic nomenclature generally follows that of Grant and Gale (7). The exceptions to this rule were that of Venus purpurissata Dall, Amphissa reticulata Dall, Crepidula crepidula lessoni Broderip, Neverita alta Dall, and N. recluziana imperforata Dall. V. purpurissata, A. reticulata, and C. crepidula lessoni are not listed. Grant and Gale (7, p 802) state that N. alta and N. recluziana imperforata are the same species. However, the specimens found on Signal Hill are distinct. Accordingly, the classification of Dall is used.

The present range of species was also taken from Grant and Gale (7). The letter R indicates that a species is rare in a given locality, there having been three or less specimens found. The letter C denotes common (4 to 10 specimens), and the letter A indicates that 10 or more specimens were found per locality. In the column marked "Living" species now found living only south of San Pedro are indicated by an S. Species living only north are designated by the letter N. Species that range north and south are indicated by an X. Xn means a very pronounced northern range as compared with that of the south; Xs is vice versa. E indicates that the species is extinct.

The column marked Las Posas (7, p 42) include the species common to Signal Hill and the calcareous beds and marls exposed at Lomita Quarry, Hilltop Quarry and Second Street, San Pedro. The list of Las Posas fossils was taken from Clark (§, Check List). The next four columns belong to the Timms Point horizon. Deadman Island and Second Street are locality names while Zone 1 and Zone 2 are the two faunal zones present at the type locality at Timms Point, San Pedro. Species common to these localities and those of

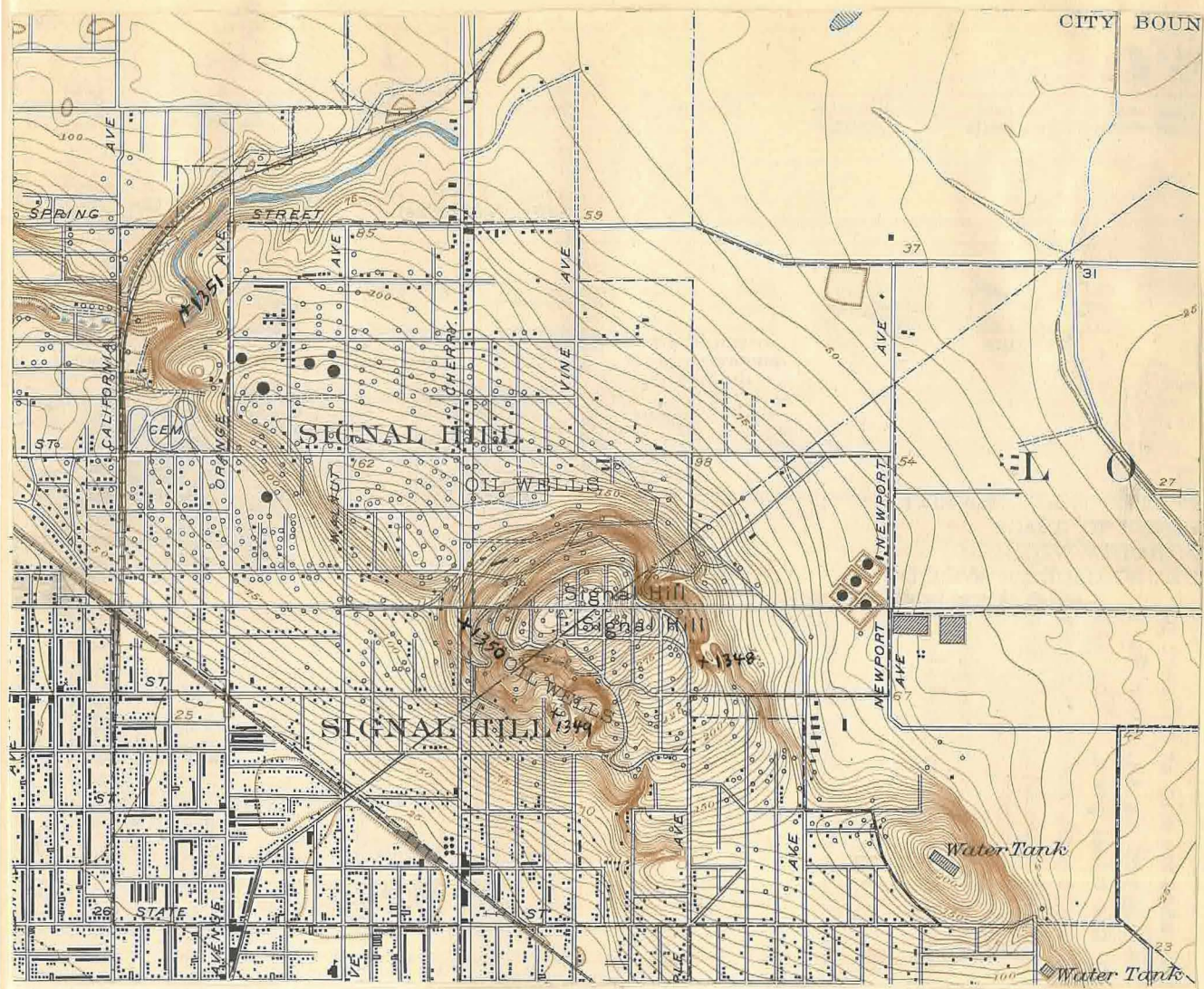


Signal Hill are accordingly listed under their proper headings. These fossils were also taken from Clark's check list. The San Pedro sands are subdivided into the three, Deadman Island, San Pedro Bluffs, and Nob Hill, localities around San Pedro in which they are exposed. Arnold's (1, Check List) lists were consulted for Deadman Island and San Pedro Bluffs, while Oldroyd was used for Nob Hill. Cherry Avenue, Hill Street and Temple Avenue, and Raymond Avenue are the three localities on Signal Hill at which the Palos Verdes sands outcrop. Crawfish George's, and the San Pedro Bluff - the lumber yard of Arnold (1, p 27) are the localities in which the Palos Verdes sands are exposed in the San Pedro region. The Fossils present in the two latter localities were taken from Arnold (1, Check List).

## COLLECTING LOCALITIES

The following is a list of California Institute of Technology collecting localities at Signal Hill.

- 1348 In a large oil well cut, 100 feet N 45 E of the northeast corner at the intersection of Hill Street and Temple Avenue.
- 1349 West end of the south face of a low hill on the east side at the north end of Raymond Avenue.
- 1350 The west face of a road cut on the east side of Cherry Avenue; 75 feet north of the Cherry Avenue and East 23rd Street intersection.
- 1351 In the base of a hill cut, 15 feet north of the center point of the top of the north side of the westernmost old cement reservoir between California and Orange Avenues on the west and east, and Willow and Spring Streets on the south and north, respectively.



MAP SHOWING THE COLLECTING LOCALITIES AT

SIGNAL HILL

FIG. 4

## CORRELATION

## General Statement

Before proceeding with a discussion of the correlation of the Pleistocene at Signal Hill with the Pleistocene at San Pedro, a brief description of the stratigraphy at San Pedro seems in order.

The basal marine Pleistocene strata of the San Pedro region are the calcareous beds and marls exposed at Second Street, Hilltop Quarry, and Lomita Quarry. Grant and Gale (7, p 42) refer these beds to the Las Posas zone and they contain a warm-water fauna. Overlying the Las Posas zone unconformably is the Timms Point zone, the beds of which are exposed at Timms Point and at Second Street. Clark (8, p 41) recognizes two zones in this horizon; a lower which contains a transitional fauna and the upper which has a decidedly cool-water fauna. Grant and Gale (7, p 42) consider this horizon to be a separate formation, but Dr. W. P. Woodring of the United States Geological Survey, suggests in a personal communication that the Timms Point horizon is merely a deep water facies of the overlying San Pedro sands. Unconformably above the Timms Point beds are the San Pedro sands with their more temperate-water fauna. This horizon is exposed at Second Street and at Nob Hill. Truncating this entire Lower Pleistocene section are the Palos Verdes sands of Upper Pleistocene age. The beds are exposed at many places around San Pedro, a few of which are Crawfish George's, Beacon Avenue, and around the San Pedro Bluff. The fauna is decidedly a warm-water one.

The entire section was formerly exposed on Deadman Island in Los Angeles harbor before the island was blasted away in the process of harbor improvement.

## San Pedro Sands

A correlation will now be attempted between the Lower Pleistocene beds on Signal Hill and those of the San Pedro region. The correlation is based on the following points of evidence:

- 1 Total percentage of Signal Hill species present in the various horizons in the San Pedro district.
- 2 Signal Hill species found only at Signal Hill and one locality around San Pedro.
- 3 The percentage of abundant Signal Hill forms present abundantly in the other horizons.
- 4 Percentage of extinct species.
- 5 Cool or warm-water character of the fauna.
- 6 Similarities in the faunas as indicated by comparison with the California Institute of Technology Southern California Pleistocene collections.

(1) Total percentage present in other horizons.

Las Posas zone.....	53
Deadman Island (Timms Point horizon).....	39
Second Street (Timms Point horizon).....	36
Zone 1 at Timms Point.....	63
Zone 2 at Timms Point.....	43
Deadman Island (San Pedro sands).....	71
San Pedro Bluffs (San Pedro sands).....	45
Nob Hill (San Pedro sands).....	52

The above results suggest that the Signal Hill Lower Pleistocene deposits are equivalent either to the San Pedro sands or the Timms Point horizon. The Las Posas zone can be disregarded although it has a fairly high percentage of species present at Signal Hill. The characteristic Las Posas fauna lived in warm-water;

the Signal Hill fauna in cool-water. Furthermore, the characteristic Las Posas forms are not present at Signal Hill.

(2) Signal Hill species found only at one locality.

Deadman Island (Timms Point horizon).....	00
Second Street (Timms Point horizon).....	1
Zone 1 at Timms Point.....	11
Zone 2 at Timms Point.....	2
Deadman Island (San Pedro sands).....	18
San Pedro Bluffs (San Pedro sands).....	5
Nob Hill (San Pedro sands).....	5

This limits the possibilities to Zone 1, Timms Point, and Deadman Island, San Pedro sands. The other four localities can be neglected because of their low values.

(3) Percentage of abundant Signal Hill species abundant in Zone 1, Timms Point, and Deadman Island San Pedro sands.

Zone 1 at Timms Point.....	22
Deadman Island (San Pedro sands).....	34

It will be noticed that the Deadman Island San Pedro sands percentage values are highest throughout these three points of evidence, and thus suggest that the Signal Hill Lower Pleistocene is equivalent to the San Pedro sands. For further verification of this evidence the extinction values were consulted. Clark (8, p 32) reported the Timms Point extinction as being 8.8%. The Signal Hill fauna is in sharp contrast to this in being at 4% which in turn, is nearer that of the San Pedro sands. As a final check, the California Institute of Technology Southern California Pleistocene collections were studied. These collections show that the characteristic Zone 1 Timms Point fossils, such as Turritella jewettii, Pecten caurinus, Thracia trapezoides, Nuculana minuta praecursor, Protocardia

centifilosa, Cardita barbarensis, were not found on Signal Hill.

On the other hand, the Signal Hill species closely resemble those of the San Pedro sands at Deadman Island. Hence, all this evidence leads to the conclusion that the exposed Lower Pleistocene deposits on Signal Hill are equivalent to the San Pedro sands horizon of the San Pedro region, and equivalent in facies to the San Pedro sands formerly exposed on Deadman Island.

Each of the points of evidence used in this correlation by itself is not conclusive, but when the six give the same trend, fairly accurate and safe conclusions can be drawn.

## Palos Verdes Sands

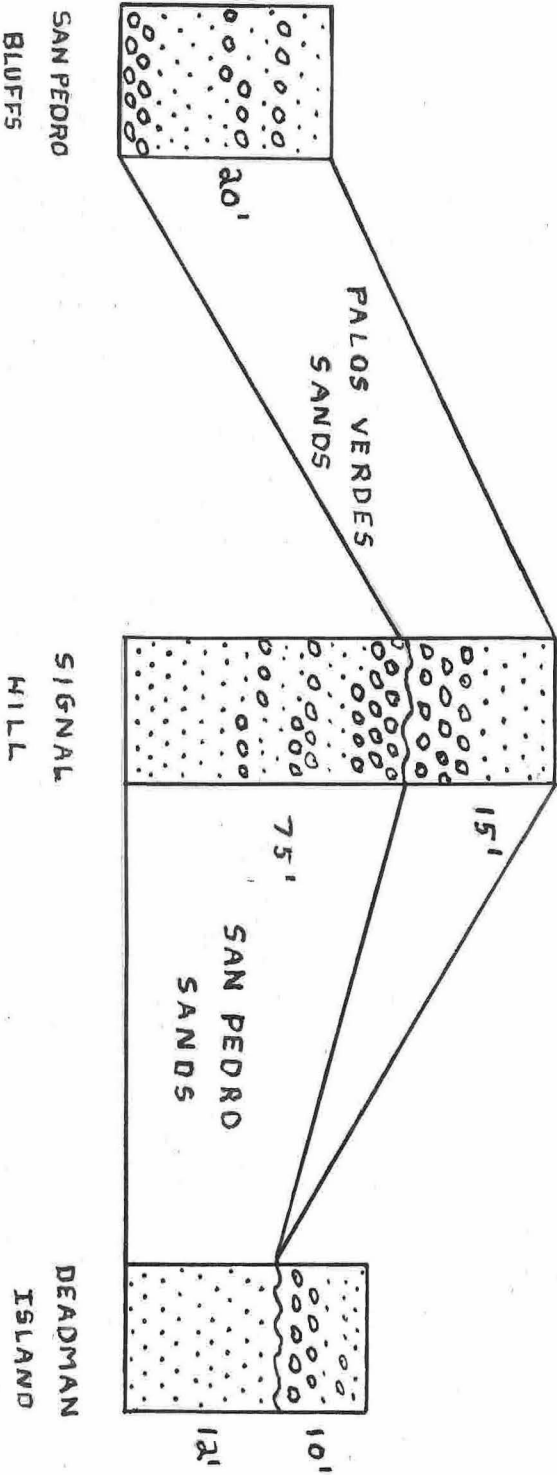
The warm-water deposits which overlie the San Pedro sands are equivalent to the Palos Verdes sands of Upper Pleistocene age in the San Pedro region. The fauna is also of probably the same facies as that found in the San Pedro bluffs near the old lumber yard of Arnold's report (1, p 27). The evidence for this correlation is based on the remarkable similarities in the species present at both localities and the similar sub-tropical aspect of the two faunas.

At first a possible correlation might be attempted between the Signal Hill Palos Verdes sands and the beds of the warm-water Las Posas zone because of the warm-water aspect. However, Dr. W. P. Woodring (7, p 40) has shown that the Las Posas at San Pedro underlies beds that are equivalent to the sands and gravels that underly the warm-water beds on Signal Hill.

No long-range correlations were attempted but from the collection of Spanish Bight, San Diego, fossils at the California Institute of Technology, it is evident that the Signal Hill fauna is very similar to it. Hence, it is considered to be of the same facies.



# CORRELATION CHART



## SUMMARY

Lower and Upper marine Pleistocene sediments are exposed on Signal Hill. The exposed portion of the Lower Pleistocene consists of silts, sands, and gravels with the coarser sediments being at the top of the section. A cool-water fauna of 77 species was collected. The faunal assemblage of the Lower Pleistocene is characteristic to that of the San Pedro sands horizon. It is equivalent in facies to the fauna contained in the San Pedro sands which were formerly exposed on Deadman Island.

Unconformably overlying the San Pedro sands on Signal Hill, are the Palos Verdes sands. They consist of a fossiliferous, basal gravel, and on overlying unfossiliferous, gray, micaceous sand. A warm-water fauna of 119 species was collected. The fauna is equivalent in facies to that found the San Pedro Bluffs, San Pedro, California, and at Spanish Bight, San Diego.

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