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PALEONTOLOGY OF THE PLEISTOCENE OF POINT LOMA, SAN DIEGO COUNTY, CALIFORNIA*

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INTRODUCTION

The study of the fossils of the Point Loma Terrace deposits was undertaken primarily to determine the ecology of the fauna. The specimens were examined, identified, and their identifications checked by specialists in Pleistocene Marine Paleontology. The work was done by the author while a graduate student in the Division of Geological Sciences of the California Institute of Technology.

LOCATION OF THE AREA

The material for study was obtained from the lowermost marine terrace on the west side of Point Loma, a promontory of considerable length which extends into the Pacific Ocean in a north-south direction, protecting San Diego Harbor on the west. The entire southern half of the peninsula is a government military and naval reservation; the northern and broader half is largely a residential district of the city of San Diego.

COLLECTIONS AND METHOD OF STUDY

The material for study was collected by Dr. W. P. Popenoe, Curator in Invertebrate Paleontology, and Mr. David Scharf, graduate

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student, of the California Institute of Technology, on a collecting trip in 1930. A later trip for additional collecting was made in the winter of 1935-1936 by Dr. Popenoe and the writer.

The fossils were identified by the author, largely according to the nomenclature of Grant and Gale.[1] The identifications were checked by Dr. Popenoe, under whose supervision the work was conducted. Dr. U. S. Grant, Associate Professor of Geology, University of California at Los Angeles, checked the fossil list, edited the manuscript, and offered helpful suggestions. Mr. A. M. Strong, of Los Angeles, aided in the identification of the small gastropods; in addition he contributed, from his personal experience, data on the ecology of the forms.

REVIEW OF PERTINENT LITERATURE

There are few papers on the geology of the Point Loma area. No thorough geologic study has ever been published, although Messrs. U. S. Grant and L. G. Hertlein are now preparing a systematic study of the region. The only geologic report of significance is that of Ellis and Lee,[2] which contains a generalized geological map of Point Loma, indicating the distribution of the marine terrace deposits and their relations to underlying materials. No description of them is undertaken, nor are any paleontological data recorded.

A paper by Berry[3] includes a list of fossils from the "Coal Mine," on the west side of Point Loma, which contains thirty-one species. These "Coal Mine" fossils are identical in age with those listed in the present paper.

Stephens[4] briefly discusses the occurrence of fossils on the Pleistocene terraces, and gives a small faunal list.

GEOLOGIC SETTING OF THE TERRACE

The terrace material from which the fauna was collected lies uncon-

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[1] GRANT, U. S., and GALE, H. R. Catalogue of the Marine Pliocene and Pleistocene Mollusca of California and Adjacent Regions. Memoirs, San Diego Soc. Nat. Hist., Vol. 1, pp. 1-1036, 1931.

[2] ELLIS, ARTHUR L., and LEE, CHARLES H. The Geology and Ground Waters of the Western Part of San Diego County, California. U. S. Geol. Surv. Water Supply Paper 446, pp. 1-321, 1919.

[3] BERRY, S. STILLMAN. Fossil Chitons of Western North America. Calif. Acad. Sci. Proc., 4th ser., Vol. 11, pp. 399-536, 1922.

[4] STEPHENS, FRANK. Notes on the Pleistocene Deposits of San Diego County, California. Trans. San Diego Soc. Nat. Hist., Vol. 5, pp. 245-256, 1929.

formably on sediments of Cretaceous age, called "Chico" by Ellis and Lee.[5] These Cretaceous rocks are mostly very fine-grained cherty and marly shales, rather carbonaceous in places. A small fauna has been reported from them by Fairbanks.[6] Associated with the terrace deposits are gravels of continental origin, which mostly overlie, but occasionally interfinger with the terrace sediments.

The terrace materials themselves are moderately fine-grained brownish to yellowish sands, with some conglomeratic material and much marl. The best collecting was near the base of the terrace directly overlying the Cretaceous shale. Here the fossils were well-preserved in marls that surround huge boulders of the Cretaceous shale. These are products of marine erosion on an old shoreline along which the terrace materials were deposited.

The maximum height of the terrace above sea level is about 100 feet (to the north) and the minimum twenty-five feet (to the south).

RELATION TO OTHER TERRACES

The position of the Point Loma terrace indicates that its uplift was produced by the last diastrophic movement of the southern coast,[7] since it is the lowest terrace exposed, and has, in part, at least, been destroyed by marine processes since the last diastrophism. This is further indicated by the fact that at least three older terraces have been recognized by Ellis and Lee,[8] and more by other workers. While no positive correlation of this lowermost terrace can be made with the terraces to the north and south, the fact that the Point Loma terrace shows a marked local increase in elevation from the south toward the north where it approaches the elevation of the La Jolla terrace of Hanna,[9] which he has shown to be the lowest exposed in the La Jolla Region, may be indicative of a similar age for the Point Loma and La Jolla terraces. Hanna, however, suggests correlation of his La Jolla terrace with the Chula Vista terrace of Ellis and Lee.[10] The Chula Vista terrace is, however, not the lowest one mapped by

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5 Op. cit., p. 51.

6 FAIRBANKS, HAROLD W. The Validity of the so-called Wallala Beds as a Division of the California Cretaceous. Amer. Jour. Sci., 3rd ser., Vol. 45, pp. 473-478, 1893.

7 ELLIS and LEE (op. cit.), and others, have shown that a slight submergence, producing the embayments of the San Diego coastal area, was the last diastrophic movement. This movement is not recorded in the Point Loma terrace.

8 Op. cit., p. 25, and plate VI.

9 HANNA, MARCUS A. Geology of the La Jolla Quadrangle, California. Univ. Calif. Pub., Bull. Dept. Geol. Sci., Vol. 16, pp. 187-246, 1926.

10 Op. cit., p. 26, and plate VI.

Ellis and Lee, but is the next to the lowest. From the account of Ellis and Lee, it seems that the Nestor terrace, said by them to have an elevation of from twenty-five feet to 100 feet above sea level, is more nearly the equivalent of the Point Loma terrace. This correlation is also suggested by Gale.[11]

The correlation of terraces in the region is complicated by the inability to trace terraces directly from one geographic locality to another, and by local warping known to have taken place in the Point Loma and adjacent blocks.

CLIMATIC INFERENCES FROM THE FAUNA

Analysis of the fauna as a whole, and of each locality collection, was undertaken in an effort to determine climatic and temperature variations which are known to have taken place in the Pleistocene in other west coast localities.[12] Considering all those forms living only as far south as San Diego as dominantly *northern* forms and thus indicative of cooler water, and those ranging only as far north as Santa Barbara as *southern* forms and thus indicative of warmer water, one finds a consistently high percentage (64-65%) of the forms (for the whole fauna and for each locality) which indicate neither warm nor cold water (on the basis outlined above) and which are of wide geographic range. The balance is almost equally divided among northern and southern forms. The general percentages for the entire fauna are: northern, 16.6%; southern, 19.2%; intermediate, 64.1%. Thus a temperate water condition is indicated. This is additional evidence for each fauna coming from the same horizon in the lowermost terrace, as well as evidence for the water temperature having been essentially the same as today at the time the forms were deposited.

The absence from the fauna of such forms as *Chione gnidia, Dosinia ponderosa,* and *Turritella goniostoma,* which are found in other terraces of the San Diego region, and which do not live today[13] on the San Diego

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11 GALE, H. R., in Grant and Gale. Op. cit., p. 64.

12 BAILEY, T. L. Lateral Change of Fauna in the Lower Pleistocene. Bull. Geol. Soc. Amer., Vol. 46, pp. 489-502, 1935. CLARK, ALEX. The Coolwater Timms Point Pleistocene Horizon at San Pedro, California. Trans. San Diego Soc. Nat. Hist., Vol. VII, pp. 25-42, 1931. WOODRING, W. P. Fossils from the Marine Pleistocene Terraces of the San Pedro Hills, California. Amer. Jour. Sci., Vol. XXIX, pp. 292-305, 1935.

13 Professor Grant informs me that *Dosinia ponderosa* has been reported living in San Diego Bay today, but that this report is probably based upon fossil specimens which were thought to be Recent dead individuals.

coast, but live farther south, indicates that some change of water temperature (lowering) took place between the deposition of the upper terraces and those of Point Loma. Furthermore, the mean annual surface temperature of the seas where the above forms now live is respectively 63, 63, and 64 degrees Fahrenheit, while the mean annual surface temperature of the waters at San Diego is 62 degrees F.,[14] in which today live most of the forms found in the faunal list.

Gale[15] points out that the Nestor terrace, in which he includes the Point Loma terrace, contains warm water faunas like those of the Palos Verdes terraces. The data presented above show that the Point Loma terrace contains faunas indicative of temperatures like those of today, and not warmer. Since the faunas from which the temperature conditions were inferred by Gale, lived on the bay side of Point Loma, and on the landward side of San Diego and Mission bays, where they would have been protected from open ocean influences, one might expect warmer water facies in equivalent faunas on the landward side of an island separated from the mainland by a shallow coastal lagoon or strait, such as Point Loma was known to have been during the Pleistocene, prior to the last uplift.[16]

The presence of one specimen of *Tegula montereyi* in the collection, which is typically a northern form, and which has not been reported living farther south than the Santa Barbara Islands, would be of great significance in indicating a cooler water temperature, if other supporting evidence were forthcoming. The presence of so many facts indicating present day temperature conditions at the time of deposition, is strongly suggestive of the fact that *Tegula montereyi* of this fauna is a reworked or washed-in form; or, that its geographic range in the Pleistocene was greater than today.

In studying the geographic distribution of the fauna of the Point Loma terrace, Stephens[17] states that of those forms found: "Some have a southern distribution occurring now rarely or not at all this far north. More have a northern habitat."

The present survey, involving almost three times as many species as listed by Stephens, does not support this interpretation, since as many

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14 Temperatures from data compiled by U. S. Grant.
15 GALE, H. R., in Grant and Gale. Op. cit., p. 64.
16 STEPHENS, FRANK. Op. cit., p. 248-49.
17 Op. cit., p. 249.

southern as northern forms were found in the fauna; in fact, a few more southern than northern.[18]

Thus it is seen that temperatures closely similar to those found today prevailed in this area and that no temperature variations of warm and cool water facies (either lateral or vertical) are indicated by this fauna.

SUMMARY OF THE ECOLOGIC FEATURES OF THE FAUNA

The fauna contained in the collection examined by the writer comprises a total of 102 species. Of these more than ninety per cent are living today on exposed coasts, in shallow water, near shore, generally between tides. None of the forms present are extinct. Ten per cent of the species whose habitat indicates deeper water or bay conditions are of large depth range in general. Assuming that the physical conditions and paleogeography at the time the forms lived were essentially as today, it seems reasonable to suppose that the bay forms were washed outside onto the outer coasts by the currents, and were deposited with the shore fauna.

A few forms, such as *Astrea inaequalis, Calliostoma turbinum, Diadora aspera, Tegula montereyi, Tritonalia interfossa,* and *Mitra idae,* which appear in the faunal list, generally are thought to be of deeper water habitat. They may be present in the fauna because they were washed up from deeper water. Some of them appear to be water-worn.

AGE OF THE TERRACES

Since the Nestor terrace bevels the Pliocene San Diego formation,[19] its post-San Diego age is unquestioned; and since the Nestor is either older than or equivalent to the Point Loma terrace, the Pleistocene age of the Point Loma terrace is strongly suggested. That this terrace is the result of the latest uplift of the region has already been shown.

The very youthful stage of erosion of the Point Loma terrace, which is incised with few, small, V-shaped, steep gradient arroyos, entering the sea at discordant elevations, indicates a brief lapse of time since the exposure of this lowermost terrace. Terraces to the south and east of

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18 Professor Grant informs me that many of the smaller gastropods in the collections of Mr. Stephens were identified for him by the late Mr. Tom Oldroyd, who, being much more familiar with the northern microscopic fauna than the southern, unconsciously assigned several doubtful specimens to northern forms which were probably really west Mexican species with which he was unfamiliar.

19 ELLIS and LEE. Op. cit., p. 25.

Point Loma show much later physiographic stages. Thus a late Pleistocene age is indicated.

From a faunal standpoint, the Pleistocene age is supported by the fact that no extinct species are present in the fauna, and by the distinctly recent aspect of the faunal suite.

SUMMARY

The fauna of the Point Loma terrace in San Diego County, California, consists of over 100 species. The ecology of the species indicates an open, exposed coast, with shallow water, largely inter-tidal habitat. The age of the fauna is Pleistocene, probably late Pleistocene. The climatic conditions at the time the forms lived were similar to those found in the area today.

(For list of species and collecting localities, see following pages.)

CHECK LIST OF PLEISTOCENE FOSSILS, POINT LOMA PENINSULA

KEY TO ECOLOGIC FEATURES OF THE FAUNA

(A) On rocks, or in sand, between high and low tides, on reefs and moss.
(B) Along rocky shores and beaches, in the reach of the surf.
(C) Bay form; brackish water; tidal flats.
(D) Fairly deep water, on rocky bottom.
(E) On big kelp.
(F) On shells of *Tegula funebralis*.
(G) On eel grass, lettuce, and seaweed.
(H) Parasitic on star-fish and sea cucumbers.
(I) Nestler.
(J) Borer.

NAME	LOCALITIES KEY[20]							RANGE KEY[21]			
GASTROPODS	768	769	771	1185	1186	1187	1188	M	P	Pl	R
(A) Acanthina lugubris (Sowerby)	R	C	P	R		P	C			X	X
(A) Acanthina spirata (Blainville)	C									X	X
Acmaea sp.	A										
(A) Acmaea digitalis (?) textilis (Gould)	P										
(E) Acmaea insessa (Hinds)		C	A	C	R	P			X	X	X
Acmaea instabilis (Gould)				R							
(B) Acmaea (?) limatula (Gould)	R	C	A	C	P	C				X	X
(A) Acmaea mitra Eschscholtz in Rathke	A	C					C		X	X	X
(B) Acmaea paleacea Gould	C									X	X
(B) Acmaea scabra (Gould)	A	A		C	R		C			X	X
(B) Aletes squamigerus Carpenter	C	C	C	C			C			X	X
Amphissa sp.		C	R								
(A) Amphissa versicolor Dall	C									X	X
(A) Astrea (Pachypoma) inaequalis (Martyn)		R						X	X	X	X
(A) Astrea (Pomaulax) undosa (Wood)	P	R	R							X	X
Bittium sp.	C	P									
Calliostoma sp.	P										
(E) Calliostoma canaliculatum (Martyn)	P						P		X	X	X
(D) Calliostoma (?) turbinum Dall		P									
Chiton sp.	P			P							
(C) Cerithidea californica (Haldeman)			A						X	X	X
(A) Conus californicus Hinds	C	C	R	C		P	R		X	X	X
Crepidula sp.		P									
(A-D) Crepidula aculeata (Gmelin)	C	C	R	R			P		X	X	X
(F) Crepidula adunca Sowerby	A	R	P	C			R		X	X	X
(A-D) Crepidula lingulata Gould	C	P							X	X	X
(A-D) Crepidula nummaria Gould	R								X	X	X
(C) Crepidula onyx Sowerby			P					X	X	X	X
(D) Diodora aspera (Eschscholtz in Rathke)	P	P	R	P						X	X
Epitonium sp.		P									
(B) Epitonium (Nitidiscala) tinctum (Carpenter)	C								X	X	X
(A) Fissurella volcano Reeve	A	A	A	A	C	C	A	X	X	X	X
Fusinus sp.		R									
(A) Fusinus kobelti (Dall) variety monksae (Dall)	R	C	P			P	R		X	X	X
Gadinia sp.		P	P	R							
(B) Gadinia (?) reticulata (Sowerby)	C							X	X	X	X
(A) Haliotis cracherodii Leach	R	P	C	P			R			X	X
(B) Haliotis corrugata Gray	R								X	X	X
(A) Haliotis rufescens Swainson			P						X	X	X
(A) Haminoea virescens (Sowerby)	R	R							X	X	X
Hipponyx sp.			P	R							
(A) Hipponyx antiquatus (Linnaeus)	C	C							X	X	X
(A) Hipponyx tumens Carpenter	C	C	C	C			C			X	X

[20] P—Present; R—Rare (2 - 5); C—Common (5 - 20); A—Abundant (20+).
[21] M—Miocene; P—Pliocene; Pl—Pleistocene; R—Recent.

GASTROPODS (Continued)	768	769	771	1185	1186	1187	1188	M	P	Pl	R
(B-A) Homalopoma carpenteri (Pilsbry)	A	C		C		R	P		X	X	X
(A) Hyalina (Hyalina) californica (Tomlin)		C								X	X
(A) Hyalina (Cystiscus) jewettii (Carpenter)	A	R								X	X
(?) Ischnochiton sp.			P								
(G) Lacuna (?) unifasciata Carpenter		R								X	X
(B) Littorina scutulata Gould	A	A	A	A	A		A			X	X
(B) Macron lividus (A. Adams)		R								X	X
(A) Mangelia (Mitromorpha) filosa (Carpenter)	P									X	X
(A) Mangelia (Mitromorpha) gracilior (Hemphill in Tryon)	C									X	X
(H) Melanella (?) rutila (Carpenter)	P									X	X
(D) Mitra idae Melvill			R	R		P	P		X	X	X
(B) Mitrella carinata (Hinds) variety gausapata (Gould)	A	A		C	P		R	X	X	X	X
(B-C-D) Nassarius (Schizopyga) mendicus variety cooperi (Forbes)		C	R	P				X	X	X	X
(E) Norrisia norrisii (Sowerby)	C	R	C	P	R	A	P			X	X
(A) Olivella biplicata (Sowerby)	C	C	R	C		R	A		X	X	X
(C-D) Retusa (Acteocina) culcitella (Gould)	R								X	X	X
Spirotropis (Antiplanes) sp.		R									
(A) Tegula (Chlorostoma) aureotincta (Forbes)	R									X	X
(B) Tegula (Chlorostoma) funebralis (A. Adams)	A	A	C	A	C	C	A		X	X	X
(D) Tegula montereyi (Fischer in Kiener)		P								X	X
Tegula (Promartyn) pulligo Martyn		R	R								
Tritonalia sp.	P										
(D) Tritonalia foveolata (Hinds)	R	P								X	X
(D) Tritonalia interfossa (Carpenter)	C	R								X	X
Trophon sp.	P										
(B) Truncatella californica Pfeiffer		R								X	X
(B) Truncatella stimpsoni Stearns		R								X	X
Turbonilla sp.	C	P									
PELECYPODS											
Barbatia (Acar) pernoides (Carpenter)	P									X	X
(I) Cumingia lamellosa Sowerby	A	A	C	C	P	C	C			X	X
(D) Glans carpenteri (Lamy)	A	A	P	C	R	C	R			X	X
(A) Hinnites multirugosus (Gale)			P						X	X	X
(D) Irus lamellifer (Conrad)		P		P			P		X	X	X
(B) Kellia suborbicularis (Montagu) variety laperousii (Deshayes)		P									
Lacuna sp.	R										
(C) Leptopecten latiauratus (Conrad)	P	P							X	X	X
(D) Lucina californica Conrad	C	C	A	A	A	A	C		X	X	X
(B) Mytilus (Mytilus) californianus Conrad	P	R								X	X
(C) Ostrea lurida Carpenter		R						X	X	X	X
(A-B-C) Pecten (Aequipecten) bellilamellatus Arnold	P								X	X	X
(A-B-C) Pecten (Aequipecten) circularis Sowerby		R	A						X	X	X
(J) Pectricola carditoides (Conrad)	R	R	C	R					X	X	X
(D) Platydon cancellatus (Conrad)			P	P				X	X	X	X
(D) Pododesmus macroschisma (Deshayes)			P						X	X	X
(D) Psephidia lordi (Baird) variety ovalis Dall		C							X	X	X
(A) Pseudochama exogyra (Conrad)		P	R	R			P		X	X	X
(B) Saxicava arctica (Linnaeus)	P							X	X	X	X
(B-C) Saxidomus nuttalli Conrad						P		X	X	X	X
(B) Semele decisa (Conrad)			R							X	X
(B) Semele rupicola Dall				R						X	X
(A) Septifer bifurcatus (Conrad)	A	A	C	C		P	C			X	X
(B) Tellina (?) meropsis Dall	C									X	X
(A-B) Venerupis (Protothaca) staminea (Conrad)	C	C	A	A			C	X	X	X	X
(B) Venus (Chione) succinta Valenciennes		P	P					X	X	X	X
OTHER FORMS											
Barnacle fragments	P										
Coral fragments	P										
Echinoid fragments	P						P				
Tetraclita squamosa (Bruguiere)	P										

FOSSIL LOCALITIES (C. I. T.)

768. Yellow fossiliferous marl from marine terraces about 100 feet above sea level, and about 100 yards southwest of the intersection of Ladera and Cordova Streets, and about 4 miles N12°W of the lighthouse on Point Loma, San Diego County, California. Sept. 22, 1930. Popenoe and Scharf.

769. Marine terrace 100 feet above present sea level, exposed on west side of Point Loma peninsula and about two miles N17½°W of the lighthouse on Point Loma, San Diego County, California. Pleistocene marls just above Eocene-Pleistocene contact. Sept. 22, 1930. Popenoe and Scharf.

771. Marine terrace about 100 feet above present sea level along ocean front on west side of Point Loma peninsula, about 100 yards north of the north boundary of Fort Rosecrans Military Reservation and about 3.1 miles N13°W of the lighthouse on Point Loma, San Diego County, California. Marls just above Eocene sandstones. Sept. 22, 1930. Popenoe and Scharf.

1185. Marine terrace about fifty feet above present sea level, exposed on west side of Point Loma peninsula, and about 200 yards south of the south boundary of the Theosophical Society grounds, on the Fort Rosecrans Military Reservation. Nearly on the contact between the terrace deposits and the Cretaceous. Point Loma peninsula, San Diego County, California. February 8, 1936. Popenoe and Webb.

1186. Marine terrace about fifty feet above present sea level, exposed on west side of Point Loma peninsula, and about three-tenths of a mile south of the south boundary of the Theosophical Society grounds, on the Fort Rosecrans Military Reservation. Nearly on the contact between the terrace deposits and the Cretaceous. Point Loma peninsula, San Diego County, California, February 8, 1936. Popenoe and Webb.

1187. Marine terrace about fifty feet above the present sea level, exposed on the west side of Point Loma peninsula, and about one-half mile south of the south boundary of the Theosophical Society grounds, on the Rosecrans Military Reservation. Nearly on the contact between the terrace deposits and the Cretaceous. Point Loma peninsula, San Diego County, California. February 8, 1936. Popenoe and Webb.

1188. Marine terrace about fifty feet above the present sea level, exposed on the west side of Point Loma peninsula, and about eight-tenths of a mile south of the south boundary of the Theosophical Institute grounds, on the Fort Rosecrans Military Reservation. Nearly on the contact between the terrace deposits and the Cretaceous. Point Loma peninsula, San Diego County, California. February 8, 1936. Popenoe and Webb.