GEOLOGY

of

BLUFF COVE

by

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PLATE ONE: Showing location of the Bluff Cove Area.

INTRODUCTION.

Bluff Cove is situated on the west side of the San Pedro Hills and lies about twenty miles south-west of Los Angeles. The area mapped includes Flat Rock Point to the north of Bluff Cove and Rocky Point to the south, a distance of about two and one-half miles (pl. 1). Only the sea cliffs were mapped, the hope being that from these cliffs the inland structures could be extrapolated.

I am indebted to Mr. D. J. Varnes, who worked with me constantly both in the field and in the office, and offered many valuable suggestions; and to my instructor, Dr. F.D.Bode.

The map is of the north half of the area. It is a hand drawn enlargement (x4) taken from the 1932 reprint of 1928 edition of the U.S.G.S. topographic map of the San Pedro Hills Quadrangle. The Geologic mapping was done by Brunton compass in 1939-40.

The topography of the area is one of rolling hills sloping to the ocean. The present sea cliffs, to which the mapping was confined, average about 150 feet high and afford good exposures. However, the lower parts of the cliffs are usually masked by landsliding.

SYSTEM	SERIES	GROUP	FORMATION	SYMBOL	COLUMNAR SECTION	AVERAGE THICKNESS (feet)	DESCRIPTION OF THE ROCK
QUATERNARY	RECENT		ALLUVIUM	Qls			Surface soil and landslide material.
	PLEIS-TOCENE		TERRACE	UNCONF. Qt UNCONF		0-50	Clay, sand, and pebbles. FOSSILS
TERTIARY	MIOCENE	MONTEREY	ALTAMIRA	Ma		?	Siliceous sh., diatomaceous sh., silty sh., fine ss. , lms.
				Mb		150	Basalt
				Ma		140	Diatomaceous & silty shale, ss.
				Mb		130	Basalt
				Ma		?	Sh. & ss.
		?	BRECCIA	? Mso		200 ?	Breccia of quartzite, gneiss, glaucophane schist, etc. in a clay matrix.

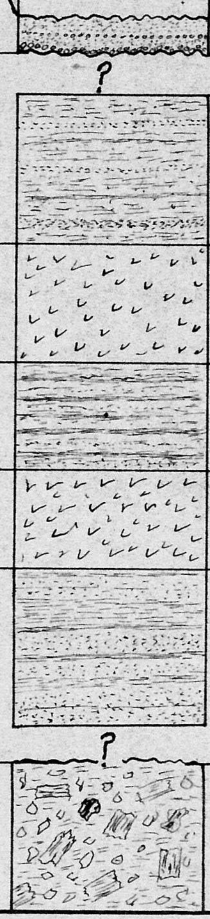

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PLATE THREE   Columnar Section

STRATIGRAPHY.

GENERAL:

The regional stratigraphy is incompletely known because only a small area was mapped. The area contains rocks of two periods, middle Tertiary (Miocene) rocks and Quaternary rocks. The period between the Tertiary and the Quaternary rocks is represented by a profound angular unconformity. The Tertiary rocks are divided into three formations: the Green Breccia, the Altamira Shale, and the Basalt. The Quaternary rocks consist of Pleistocene terrace gravels, Recent landslide materials, and Recent alluvium.

TERTIARY (MIOCENE):

The Green Breccia consists of angular cobbles of quartzite, hard green gneiss, and glaucophane schist; smaller, less angular pebbles of a dark basic rock; and a groundmass of a fine green silt or mud. Because of the angular character and green color of most of the rocks in the formation I have named the formation the Green Breccia. The formation shows no bedding or stratification. The only outcrop of this breccia is at Bluff Cove. Here the outcrop is about 250 feet square and has very irregular margins. The stratigraphic relations of this formation are very doubtful and are discussed in detail under "The Breccia Problem" (p.7). In the discussion I have concluded that the Green Breccia is probably of middle Miocene age.

<u>The Altamira Shale</u> was named by W. P. Woodring[1] when he differentiated the Miocene rocks of the San Pedro Hills. From paleontological evidence he determined the age of the Altamira as lower Monterey. In the Bluff Cove area the Altamira consists of fine-grained, soft, thin-bedded shale. The shale is a light cream color and often highly diatomaceous. Interbedded in this soft shale is cherty shale, porcelaneous shale, phosphatic shale, diatomite, tuff, sandstone and a little limestone. As the area mapped does not include either the bottom or the top of the formation and because of the difficulty of correlation across the Green Breccia, the thickness of the Altamira formation can not be determined. In the area mapped, 1500 feet of Altamira is exposed. The thickness of the Altamira may be less than this since there may be duplication of beds. (See Breccia Problem, p. 7.) Woodring, Bramlette, and Kleinpell[2] give 1045 feet as the thickness of the Altamira at the type locality and say that the base is concealed.

The relationship of the Altamira Shale to the Green Breccia is not known. In the discussion of the Green Breccia Problem (p. 7) I have concluded that the Altamira is probably younger than the Breccia. No late Tertiary formations are

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1- Woodring, W.P., San Pedro Hills: Internat. Geol. Cong., Guidebook 15, 1933.

2- Woodring, Bramlette, Kleinpell, Miocene Stratigraphy and Paleontology of Palos Verdes Hills, Calif.: Bull. A.A.P.G., vol.20, pp.125-149, 1936.

present in the Bluff Cove area. The Pleistocene terrace gravels lie with large angular unconformity on the Altamira.

The Basalt. Sills of basalt are intruded into the Altamira Shale. The basalt is generally massive and erodes easily, producing a fine red or yellow powder. The basalt contains small amygdales of quartz and calcite. The basalt formed as a sill and not as a flow since the shales above it are metamorphosed and contain apophyses of basalt up to five feet long.

The base and the top of the Basalt formation is a highly brecciated zone cemented with calcite. This brecciated zone is resistant to erosion and forms rocky points where it strikes the sea. Flat Rock Point (see pls. 4-5) was formed in this manner. Macdonald[3], working three miles south of Bluff Cove at San Vicente, described a similar formation as an intrusive Peperite intruded into a thin layer of unconsolidated Altamira sediments while they were collecting on a shallow sea floor. If Macdonald's conclusion is true, and the evidence he presents is quite convincing, then the basalt is contemporaneous with the Altamira Shale and of Monterey Age.

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3- Macdonald, G., An intrusive Peperite at San Pedro Hill: U. of C. Pub., vol.24, no. 12, 1939.

QUATERNARY:

Pleistocene. The Pleistocene is represented by a series of discontinuous marine terrace deposits. The area mapped contains four terraces. The four terraces are probably not contemporaneous as they lie at different levels. The terraces are covered by thirty to forty feet of sediments. The base of the formation is a boulder conglomerate (1½ ft. thick) which contains abundant Pleistocene molluscs. Above the conglomerate is a four foot bed of sand (also fossiliferous). Above the sand is another conglomerate bed and then interbedded sands and gravels to the top of the formation (pl.6).

Recent. There is a large landslide on the north side of Bluff Cove. It covers about eleven acres. Also many small landslides occur at the base of the sea cliffs in the area. A thin cover of Recent alluvium is present on the terraces and flatter slopes of the mapped area.

GEOLOGIC STRUCTURE.

My purpose in mapping the Bluff Cove area was to map the sea cliffs and from them to extrapolate the structures further inland. However, due to several complicating factors, several structures in the sea cliffs themselves could not be delineated and, therefore, no attempt has been made to extrapolate.

On the basis of contacts, dips and strikes, and outcrops; several structural features of the area have been discovered. Many structures of varying size (pl.8 and the map) are present. These structures are mainly folds with their axes striking N.70° W. in the north part of the area and East-west in the south part. However, most of these structures are minor and the region as a whole is one of relatively flat-lying beds. Starting at Rocky Point to the south and going north (pl.9) the general structure is a broad, flat syncline (strike E-W.) merging northward into an anticline at Bluff Cove (strike N.80° E.). The anticline is asymmetrical with its steeper side north. North of this (Flat Rock Point) is a syncline with a strike of N. 70° E. Superimposed on the flank of the Bluff Cove anticline is a small, minor syncline and anticline. (See pl. 2)

THE GREEN BRECCIA PROBLEM.

In the sea cliff at Bluff Cove is a small outcrop of breccia. (See map.) Because of its lithology (p. 2) I have called it the Green Breccia. The Green Breccia is very similar lithologically to the San Onofre Breccia[4] of the San Onofre Hills, San Diego County. It has been suggested by several authors that the San Onofre Breccia was derived from the west from a former mountain mass that was located about at the position of the present Santa Catalina Island. The fragments in the Green Breccia are of the same peculiar composition and of the same peculiar shape as the fragments in the San Onofre Breccia. Therefore, as it is not likely that the unusual conditions necessary for the formation of these breccias (what these conditions were is not known) would be repeated twice in the geologic history of Southern California, I assume that the Green Breccia, like the San Onofre Breccia (dated by Ellis and Lee[5]) is of middle Miocene age.

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4- Ellis, A.J., and Lee, C.H., Geology and groundwaters of the Western Part of San Diego County, California: U.S.G.S., W.S.P. 446, p.57, 1919.
Woodford, A.O., The San Onofre Breccia: U. of C. Bull., vol.15, no. 7, pps. 182-205, 1925.

5- Ellis and Lee, idem.

The outcrop of the Green Breccia is about 250 feet square. It is exposed as shown in figure one. Plate six shows the contact between the Green Breccia and the terrace gravels. Plate seven shows the contact between the Green Breccia and the Altamira Shale to the north. The Altamira Shale meets the

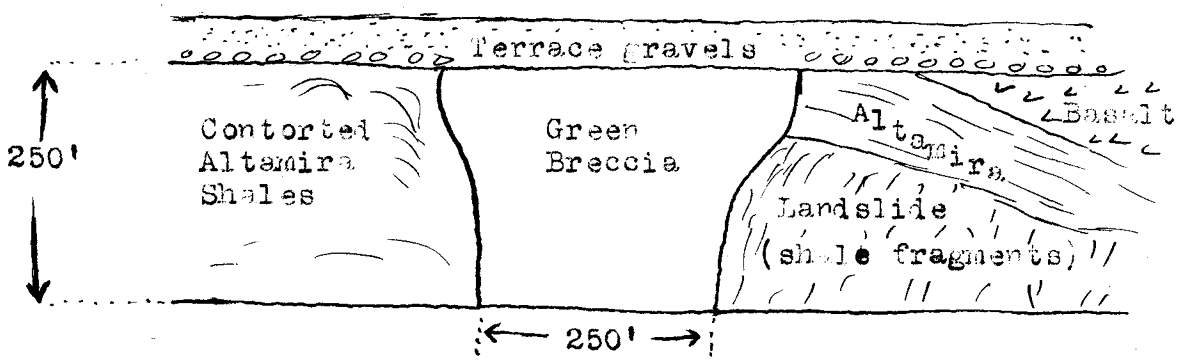

Fig. 1. Sea Cliff at Bluff Cove.

Green Breccia in a distinct angular unconformity at both contacts. The Altamira beds, where visible, strike into the contact with angles up to 90 degrees. The Altamira beds on the north side of the Green Breccia are highly deformed and the dips and strikes are very irregular and apparently without any structural control (pl.7).

The present position of the Green Breccia presents several unsolved stratigraphic and structural problems. In order to solve these problems two theories have been put forward: the fault theory and the anticline theory.

<u>The Anticline Theory</u>. Woodring, etc.[6] suggest that the breccia might be the lowest exposed bed of the anticline that runs through Bluff Cove (pl.9). Evidence in the favor of the anticline theory:-

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6- Woodring, Bramlette, and Kleinpell, op. cit.

(1) There is an anticlinal structure through this area. (See p.6, pl.9, and map)

(2) The Green Breccia is probably middle Miocene and older than the Altamira Shale (see p.7.)

Objections to anticline theory:-

(1) The contact between the Altamira Shale and the Green Breccia is not of the type that would be expected if the anticline theory were true. The presumably younger Altamira beds abut against the Green Breccia at large angles. (See p.8.)

(2) The contacts between the Altamira Shale and the Green Breccia dip into the postulated anticlinal axis instead of away from the axis as is normal for anticlines. (See map and fig. 1.)

(3) Two basalt sills are exposed on the north side of the postulated anticline and only one on the south side. (See map) The anticline theory does not account for the absence of a second basalt sill on the south side.

<u>The Fault Theory</u>. If a high-angle fault is postulated on the north side of the Green Breccia, several of the problems involved are solved. The north side of the fault is Altamira shale which is younger than the Green Breccia on the south side of the fault. Therefore, the side with the older beds (the south side) must have moved up. Evidence in favor of the fault theory:-

(1) The north part of the Green Breccia consists of a finer, more powdery material than the rest of the formation. This material may be gouge. (See right half of plave seven.)

(2) The Altamira beds on the north side of the Green Breccia are very severely contorted. (See pl.7.) Such contortion may be contributed to movement on the fault.

(3) If the north contact of the Green Breccia and the Altamira is a fault contact, this fact might explain the irregular manner in which the contact cuts across the Altamira beds. (See p.8 and fig.1.)

(4) The presence of two basalt sills on the north side of the breccia and of only one on the south side is not an anomaly if a fault is present in the Green Breccia.

(5) The syncline "a" in the structure section (pl.2) can be considered as a drag fold. Assume that the faulting occurred after the deformation of the region into the synclines and anticlines shown in plate nine. Assume that anticline "b" (pl.2) is the same anticline as shown in plate nine. Then the movement along the postulated fault dragged the formerly south-dipping beds (on the south limb of anticline "b") up until they dipped north. Thus syncline "a" (pl.2) was formed.

Objections to the fault theory:-

(1) The minimum displacement on the fault (as calculated from the structure section, pl.2) permitting correlation of the beds on opposite sides of the fault is about 1500 feet. Such a large displacement would usually produce a wider gouge zone than is present in the Green Breccia. However, this objection is very weak as many large faults have very narrow gouge zones.

(2) The fault theory offers no explanation of the direction of dip of the south contact of Green Breccia and Altamira Shale. Normally this contact would dip south as shown in plate two, but actually it dips north. (See map.)

GEOLOGIC HISTORY.

Assuming a fault in the Green Breccia (pps.7-10), the following is an outline of the geologic history of the Bluff Cove area. The accuracy of this history is subject to all restrictions mentioned in the foregoing report. All doubtful steps are preceded by a question mark (?).

STEP	TIME	EVENT
1-		Submergence.
2- ?	Middle Miocene.	Deposition of San Onofre Breccia.
3-	Upper Miocene.	Deposition of Altamira Shale and contemporaneous intrusion of basalt sills.
4-	Pliocene or early Pleistocene.	Uplift of area and folding of Tertiary sediments. Erosion.
5- ?	After step 4 and before step 6.	Faulting along Green Breccia fault.
6-	Before step 7.	Erosion of part of the Altamira Shale.
7-	Pleistocene	Sporadic uplift and cutting of marine terraces. Deposition of terrace gravels on these terraces.
8-	Recent	Cutting of present sea cliffs by waves and landsliding of parts of these cliffs.

PLATES

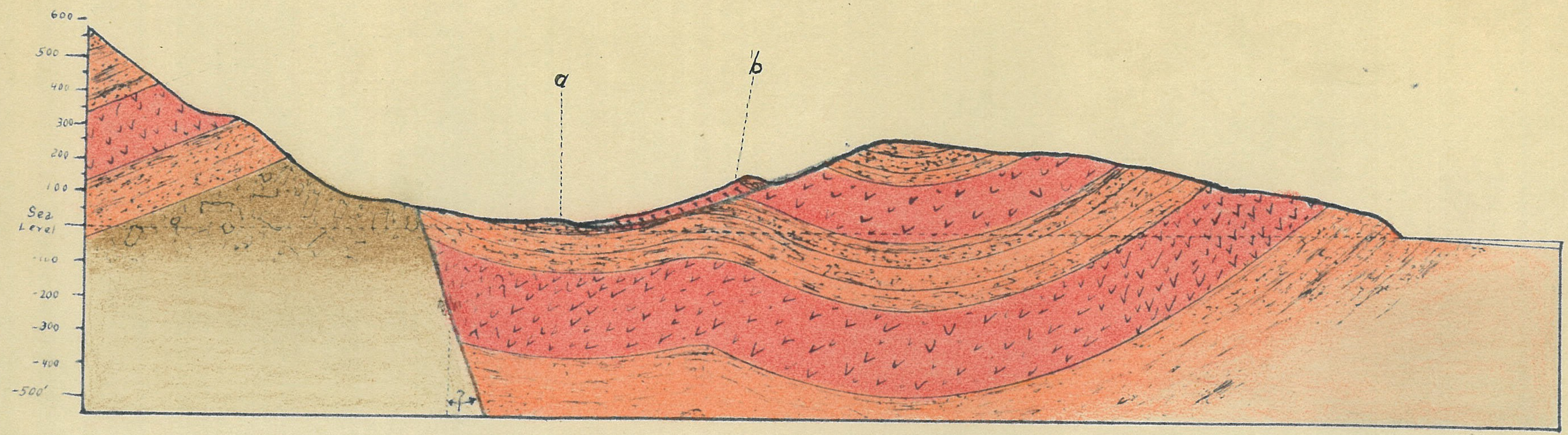


PLATE TWO

STRUCTURE SECTION A-A'

BLUFF COVE

PALOS VERDES CALIFORNIA

Scale 1" = 500'

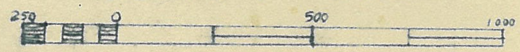


PLATE FOUR: Looking N60E across Bluff Cove toward Flat Rock Point. Note the large landslide area in the center of the picture. The terrace sloping gently seaward has dropped until it now slopes steeply landward.

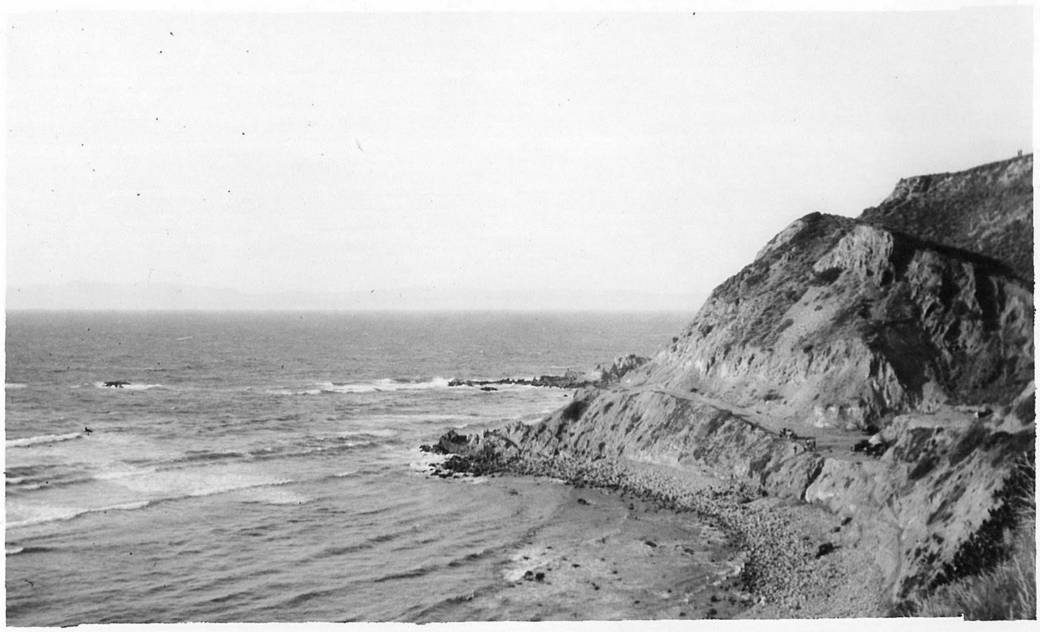


PLATE FIVE: A close up of the landslided block of Plate Four. Note how the basalt beds form rocky reefs and points where they strike the ocean. This view shows one in the foreground and a second (Flat Rock Point) in the background.

PLATE SIX: About 25 feet of horizontal terrace gravels overlying the Green Breccia Formation. The basal conglomerate is highly fossiliferous.

PLATE SEVEN: The north contact of the Green Breccia. The Altamira Shale member to the left shows a sharp fold. Drag?

PLATE EIGHT: Sea cliff 1000 feet north of Rocky Point (Looking N25E). The picture shows the complex minor structures of the Altamira Shale and at the same time illustrates the general horizontal character of the region as a whole. Sandstone beds striking out into the water and dipping north can been seen on the left.

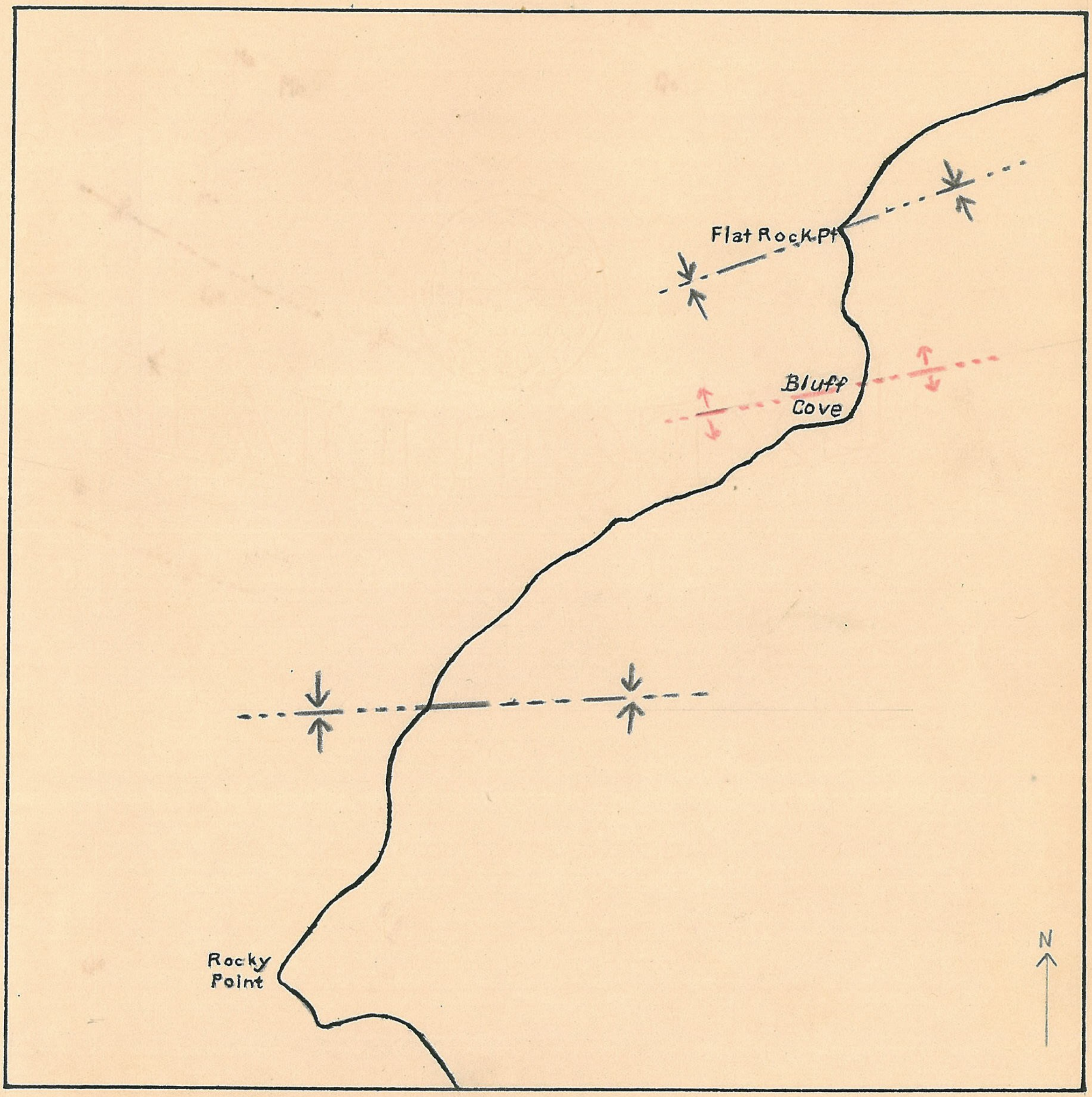
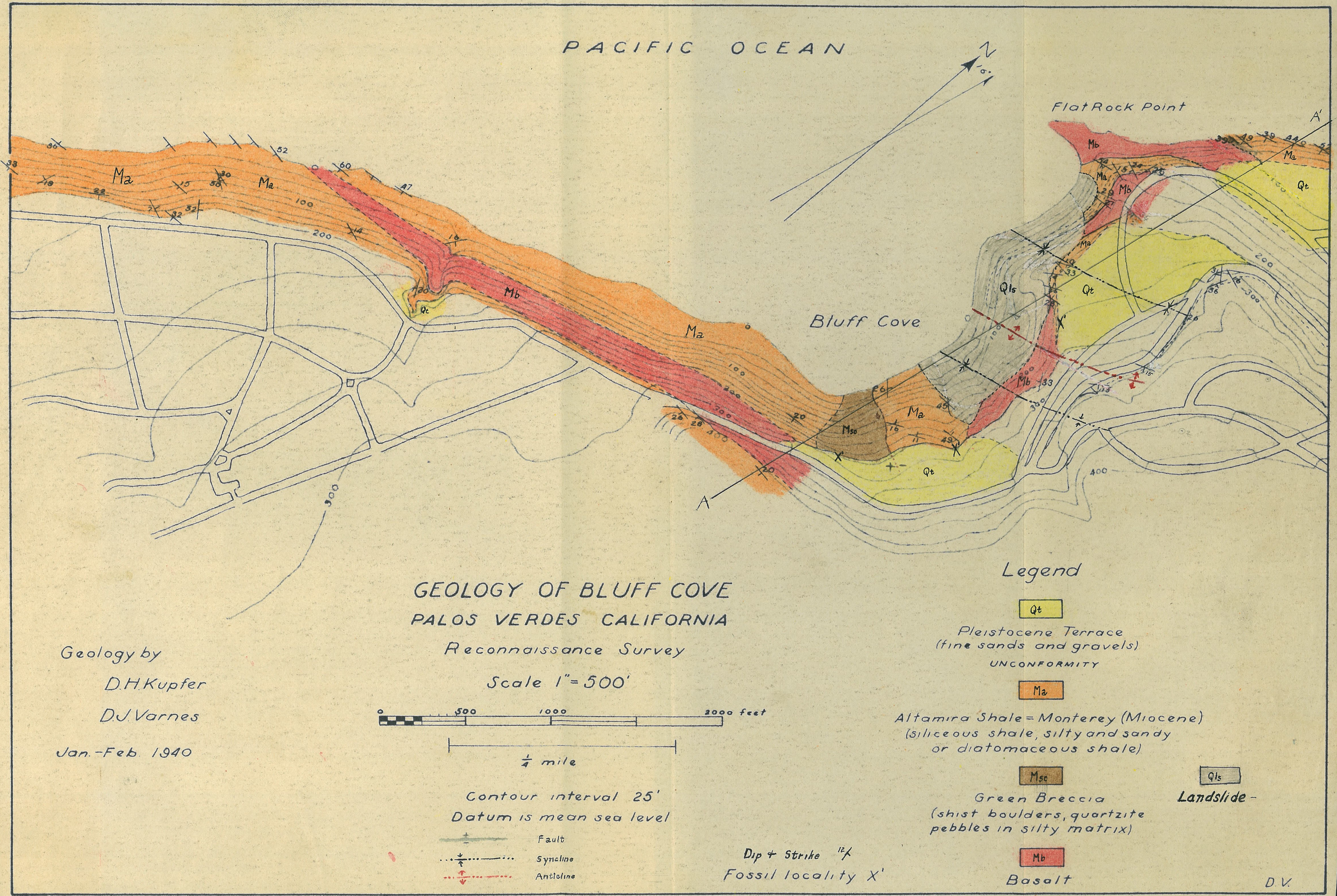


PLATE NINE: Major structures of Bluff Cove.


PACIFIC OCEAN
N
Flat Rock Point
A'
Bluff Cove
A
Ma
Mb
Msc
Qt
Qls
100
200
300
400
GEOLOGY OF BLUFF COVE
PALOS VERDES CALIFORNIA
Reconnaissance Survey
Scale 1" = 500'
0 500 1000 2000 feet
1/4 mile
Contour interval 25'
Datum is mean sea level
Fault
Syncline
Anticline
Dip + Strike
Fossil locality X'
Geology by
D.H. Kupfer
D.J. Varnes
Jan.-Feb. 1940
Legend
Qt
Pleistocene Terrace
(fine sands and gravels)
UNCONFORMITY
Ma
Altamira Shale = Monterey (Miocene)
(siliceous shale, silty and sandy
or diatomaceous shale)
Msc
Green Breccia
(shist boulders, quartzite
pebbles in silty matrix)
Qls
Landslide -
Mb
Basalt
D.V.