Seven of the test wells were drilled to explore the sediments of the Lompoc Terrace ground-water basin, three were drilled to explore the alluvium of Canada Honda, and one was drilled in the alluvium of the Santa Ynez River valley. Pertinent data on these test wells are summarized in table 3, and logs of all test wells and supply well 1 are given in table 5.

TABLE 3.—*Summary of data from test wells, Point Arguello Naval Missile Facility*

Well	USGS No. and location	Date completed	Depth (ft)	Approximate elevation of land surface (ft)	Interval perforated (ft)	Yield (gpm)	Drawdown (ft)	Static[1] water level (ft below land surface)	Remarks
1	7/35-30G1. 1.4 miles south of Surf, Calif., west of highway.	4-14-58	277	130	115-270	Not enough water for bail test.		97	
2	7/35-33R1. 2.2 miles up Lompoc Canyon from State Highway 150.	4-28-58	432	216	402-420	180	280	110	Cemented 425-432 ft.
3	7/35-28K2. 0.9 mile up Lompoc Canyon from State Highway 150.	5-15-58	315	89	22-23 46-48 60-63	5	(2)	14	Cased to 284 ft. Gravel-cement to 235 ft.
4	7/35-32N1. 0.75 mile up Bear Canyon from highway.	5-27-58	300	175	10-210	21	(2)	10	Fine sand when pumped. Cemented to 292 ft.
5	6/35-5F1. 1.3 miles up Bear Canyon from highway.	5-29-58	77	220	5-57	4	(2)	25	Cemented at 70 ft.
6	7/35-33J1. 1.75 miles up Lompoc Canyon from highway.	6-17-58	380	177	113-155 173-255	125	65	112	Casing damaged at 240 ft. 6 ft of preperforated 6-in casing set from 236-242 ft.
7	6/35-15J1. Canada Honda, near junction of Honda and La Salle Roads.	6-6-58	78	585	20-75	7	(2)	21	
8	6/35-16P1. Canada Honda, 1.4 miles northwest of Tranquillon Mountain.	6-12-58	76	400	20-68	10	(2)	18	
9	6/35-21D1. Canada Honda, 1.3 miles west northwest of Tranquillon Mountain.	6-16-58	59	380	14-17 30-55	5	(2)	17	
10	6/35-2D1. Canyon between La Salle and Lompoc Canyons.	7-7-58	475	289	250-470	20	107	215	Fine sand bailed.
11	7/35-22N2. Mouth of Lompoc Canyon between Highway 150 and railroad.	7-18-58	194	24	96-181	380	30	7	

[1] Date measured the same as date completed.
[2] Well was bailed dry during test.

GEOLOGY

The rocks and unconsolidated deposits exposed at the missile facility range in age from Jurassic to Recent. Their areal distribution is shown on plate 1 and their lithologic character, stratigraphy, and water-bearing properties are summarized in table 4. Detailed descriptions of the stratigraphic units are given by Dibblee (1950). The most promising ground-water supplies occur in the unconsolidated deposits that range in age from Pliocene to Recent.

TABLE 4.—*Stratigraphic Units of the Point Arguello Naval Missile Facility*

	Geologic age	Stratigraphic unit	Thickness (ft)	Lithologic character	Water-bearing properties
Quaternary	Recent	Dune sand	0-50±	Windblown sand, in part actively drifting.	Unconsolidated, but probably above the zone of ground-water saturation.
Quaternary	Recent	Younger alluvium	0-200±	Gravel, sand, silt, and clay underlying the alluvial plains of the Santa Ynez River and tributaries; of fluvial origin, except in Lompoc Canyon where estuarine clay and silt are predominant; lower part underlying the Lompoc plain is predominantly gravel.	Unconsolidated; lower part constitutes the main water-bearing zone and is the principal source of water to the Lompoc plain; low permeability in smaller valleys.
Quaternary	Pleistocene	—Unconformity— Orcutt sand	0-300±	Sand, clay, and some gravel, predominantly nonmarine; locally includes indurated caps of eolian beach sand; locally may include beds equivalent to the Paso Robles formation of the eastern Santa Ynez Valley.	Unconsolidated; yields water to wells but is generally of low permeability.
Tertiary	Pliocene	—Unconformity— Careaga sand	0-1,000±	Fine- to medium-grained marine sand and some gravel; locally fossiliferous; poorly consolidated in exposures.	Unconsolidated where saturated with water; gravel zones are less permeable than those of the younger alluvium.
Tertiary	Pliocene	Foxen mudstone	0-800±	Compact claystone; not exposed at surface, but identified in some well logs.	Consolidated; probably would not yield water to wells.
Tertiary	Pliocene and Miocene	Sisquoc formation	0-3,000±	Diatomite and diatomaceous clay shale.	Consolidated; would not yield water to wells.
Tertiary	Miocene	Monterey shale	0-2,000±	Siliceous and diatomaceous shale and some limestone.	Consolidated; contains some water in fractures.
Tertiary	Miocene	Tranquillon volcanics of Dibblee (1950)	0-700±	Rhyolite and rhyolitic agglomerate and tuff; exposed in the area of Tranquillon Mountain.	Consolidated; fracture systems supply water to several small springs.
Tertiary	Miocene	—Unconformity— Rincon shale	1,500±	Bentonitic and siliceous brown to gray claystone.	Consolidated; would not yield water to wells.

TABLE 4.—*Stratigraphic Units of the Point Arguello Naval Missile Facility*—Con.

	Geologic age	Stratigraphic unit	Thickness (ft)	Lithologic character	Water-bearing properties
Tertiary—Continued		Vaqueros formation	300	Sandstone and conglomerate.	Consolidated; possibly would yield small amounts of water to wells.
		—Unconformity—			
	Oligocene and Eocene	Gaviota formation of Effinger (1935) and Sacate formation of Kelley (1943)	2,600±	Interbedded sandstone and shale and minor conglomerate beds.	Consolidated; thick sandstone units might yield some water to wells.
	Eocene	Cozy Dell shale member (Kerr and Schenck, 1928) of Tejon formation	700±	Gray and brown clay shale.	Consolidated; would not yield water to wells.
		Matilija sandstone member (Kerr and Schenck, 1928) of Tejon formation	1,000±	Thick bedded bluish-white sandstone and minor shale and conglomerate.	Consolidated; locally yields water in small quantities to wells south and east of the Missile Facility.
		Anita shale of Kelley (1943)	1,000±	Dark gray clay shale and minor beds of greenish-brown micaceous sandstone.	Consolidated; would not yield water to wells.
		—Unconformity—			
Jurassic and Cretaceous		Espada formation of Dibblee (1950)	4,000±	Dark greenish-brown silty shale and thin beds of sandstone.	Consolidated; would not yield water to wells.
		—Unconformity—			
Jurassic(?)		Honda formation of Dibblee (1950)	1,500±	Dark greenish-brown clay shale, thin beds of sandstone, and nodules of calcareous concretions.	Consolidated; would not yield water to wells.
		Franciscan formation (as used by Dibblee, 1950)	?	Dark greenish-gray coarse-grained serpentinized pyroxenite.	Consolidated; may contain some water in fractures.

CONSOLIDATED ROCKS (JURASSIC TO PLIOCENE)

The consolidated rocks exposed on the missile facility are predominantly of marine origin and range in age from Jurassic to Pliocene. They include all rocks older than the Careaga sand, and consist of a series of sandstone and shale units distributed throughout the southern half of the missile facility; volcanic rocks occur in the series near Tranquillon Mountain. Several springs in the area yield small amounts of water from the consolidated rocks, generally less than about 20 gpm (gallons per minute). Locally, sandstone, volcanic rocks, and brittle siliceous shale may yield small quantities of water from fractures or other openings. The most likely sources of small supplies of water from the consolidated rocks are fractures or other openings in the following formations: the Franciscan, the Matilija sandstone member (Kerr and Schenck, 1928) of the Tejon, the Sacate (Kelley, 1943), Gaviota (Effinger, 1935), and Vaqueros formations, the Tranquillon volcanics of Dibblee (1950), and the Monterey shale. The remainder of the consolidated rocks probably would not yield water to wells.

UNCONSOLIDATED WATER-BEARING DEPOSITS

CAREAGA SAND (PLIOCENE)

The Careaga sand underlies much of the northern half of the missile facility, but it is for the most part masked by a combination of dense vegetation, surface wash, and overlying formations that are similar to it. Generally the Careaga sand consists of two members—the Cebada fine-grained member and the Graciosa coarse-grained member (Woodring and Bramlette, 1950, p. 42). The lower (Cebada) member is an olive-gray very fine grained silty, somewhat indurated sand containing abundant fossil shells and lenses of fossiliferous gravel. The upper (Graciosa) member comprises a sequence of yellowish-brown medium- to coarse-grained unconsolidated sand locally pebbly. The contact between the two members generally may be identified easily in well cuttings—the olive-gray silty Cebada contrasts with the yellowish-brown coarse-grained sand of the Graciosa. According to Dibblee (1950, p. 46), the contact between the two members is marked by a persistent pebble bed at the base of the upper member; however, the pebble bed was not recognized in outcrop nor in the test drilling. In test well 4 the two members appear to intertongue.

The Cebada member is exposed on the southwest side of Bear Creek west of test well 5, where it is in contact with the underlying Sisquoc formation. A fossiliferous gravel bed, presumably part of the Cebada member, crops out about four-tenths of a mile west of La Salle Canyon. The Cebada member was penetrated in test wells 2, 3, 4, 5, 6, and 10, in well 7/35–33M1, and in supply well 1 (7/35–33J2). The Cebada is about 400 feet thick at well 7/35–33M1 (a wildcat oil well). A fossiliferous gravel was tapped in the Cebada in test well 2, supply well 1, and in well 7/35–33M1. Computations based on the position of the gravel in these wells indicate that it strikes N. 20° E. and dips 5° W.

The Graciosa member was not recognized in any exposures; however, it was found in test wells 3, 4, and 6, supply well 1, well 7/35–33M1, and possibly in test well 1. The base of the Graciosa member, as defined by test well 3, supply well 1, and 7/35–33M1, strikes S. 70° E. and dips about 1° S. The thickness of this member is estimated from well logs to be about 200 to 300 feet.

More is known about the water-bearing characteristics of the Careaga sand than most of the other formations at the missile facility. Seven of the test wells penetrated varying thicknesses of the unit. Within the Lompoc Terrace basin the lower member of the Careaga sand, the Cebada, probably contains a considerable amount of stored water; however, the low permeability of this fine-grained deposit makes the extraction of water difficult. Test well 2 and supply well 1 penetrated a bed of fossiliferous gravel in the Cebada member, and

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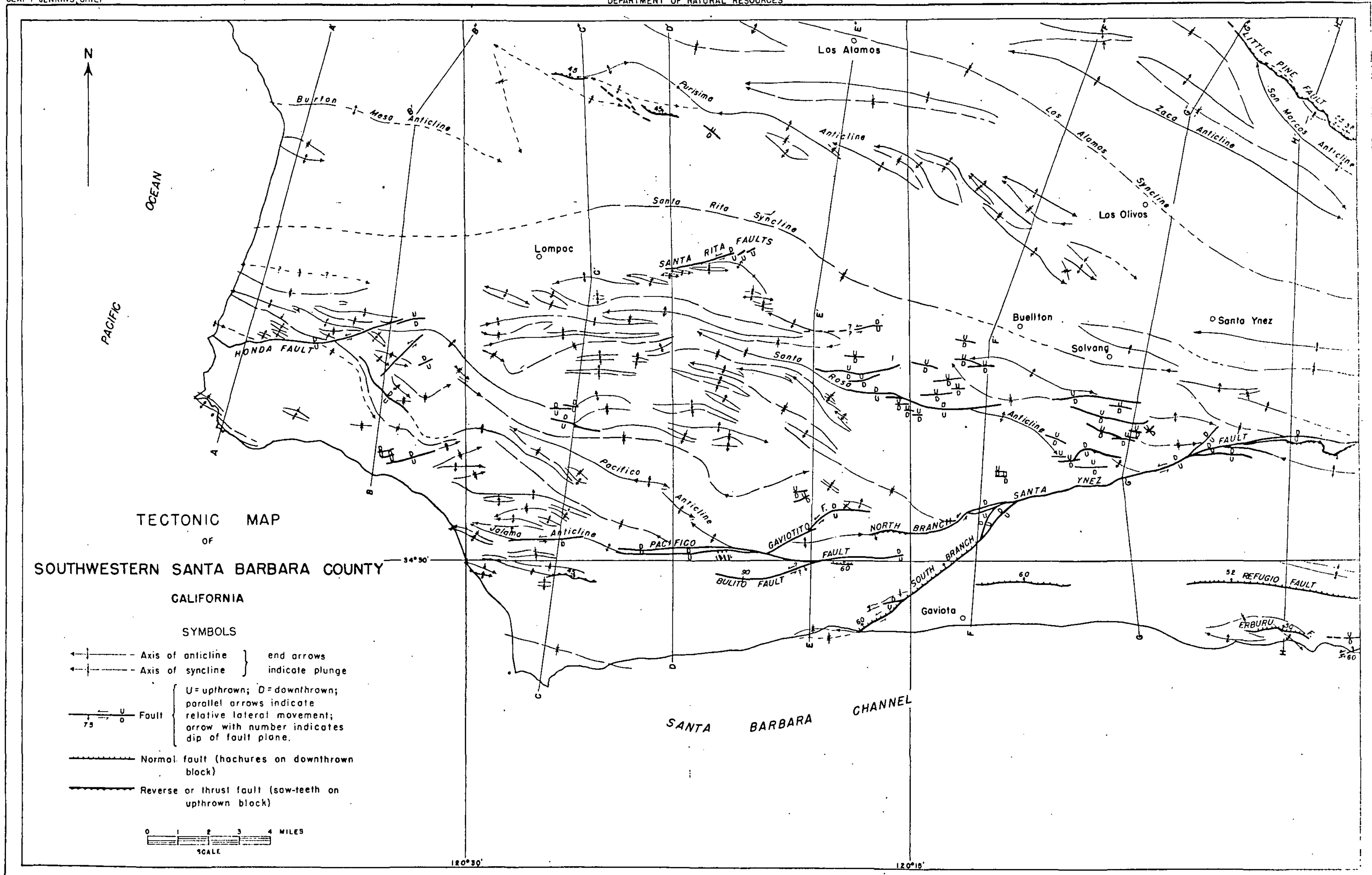
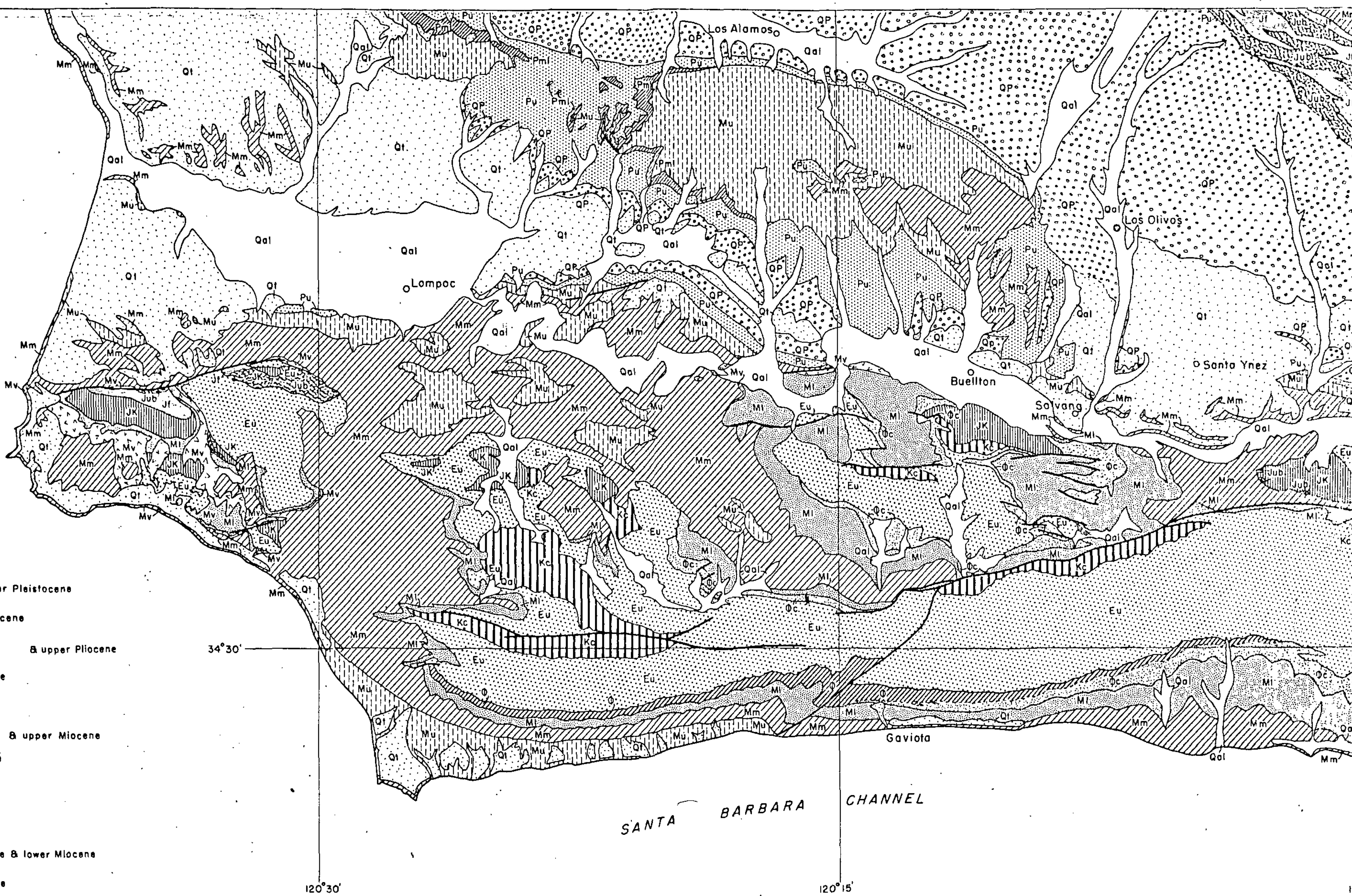
BULLETIN 150
PLATE 7





EXPLANATION

	FORMATION	ORIGIN	AGE
Qal	Alluvium	continental,	Recent & upper Pleistocene
Qt	Orcutt sand, terraces	"	Middle Pleistocene
QP	Paso Robles formation	"	Lower " & upper Pliocene
Pu	Careaga sand	marine	Upper Pliocene
Pml	Foxen claystone	"	Middle "
Mu	Sisquoc formation	"	Lower " & upper Miocene
Mm	Monterey shale—upper " " lower	"	Upper Miocene Middle "
Mv	Tranquillon volcanics	"	Lower "
Ml	Rincon claystone Vaqueros formation	" "	" " " "
Φc	Sespe formation	continental	Upper Oligocene & lower Miocene
Φ	Alegria formation	marine	Upper Oligocene
Eu	Gaviota formation Socate " Cozy Dell shale Matilija sandstone Anita shale Sierra Blanca limestone	" " " " " "	Lower Oligocene Upper Eocene " " Middle Eocene " "
Kc	Jalama formation	"	Upper Cretaceous
JK	Espada formation	"	Lower Cretaceous & Upper Jurassic
Jf	Honda shale Franciscan formation	" "	Upper Jurassic " "
Jub	Serpentine	intrusive	Upper Jurassic

AREAL MAP SHOWING GENERALIZED GEOLOGY OF

SOUTHWESTERN SANTA BARBARA COUNTY, CALIFORNIA

0 5 10 Miles
SCALE

Geology by T.W. Dibblee

USGS Circ. 797 Vandenburg Study

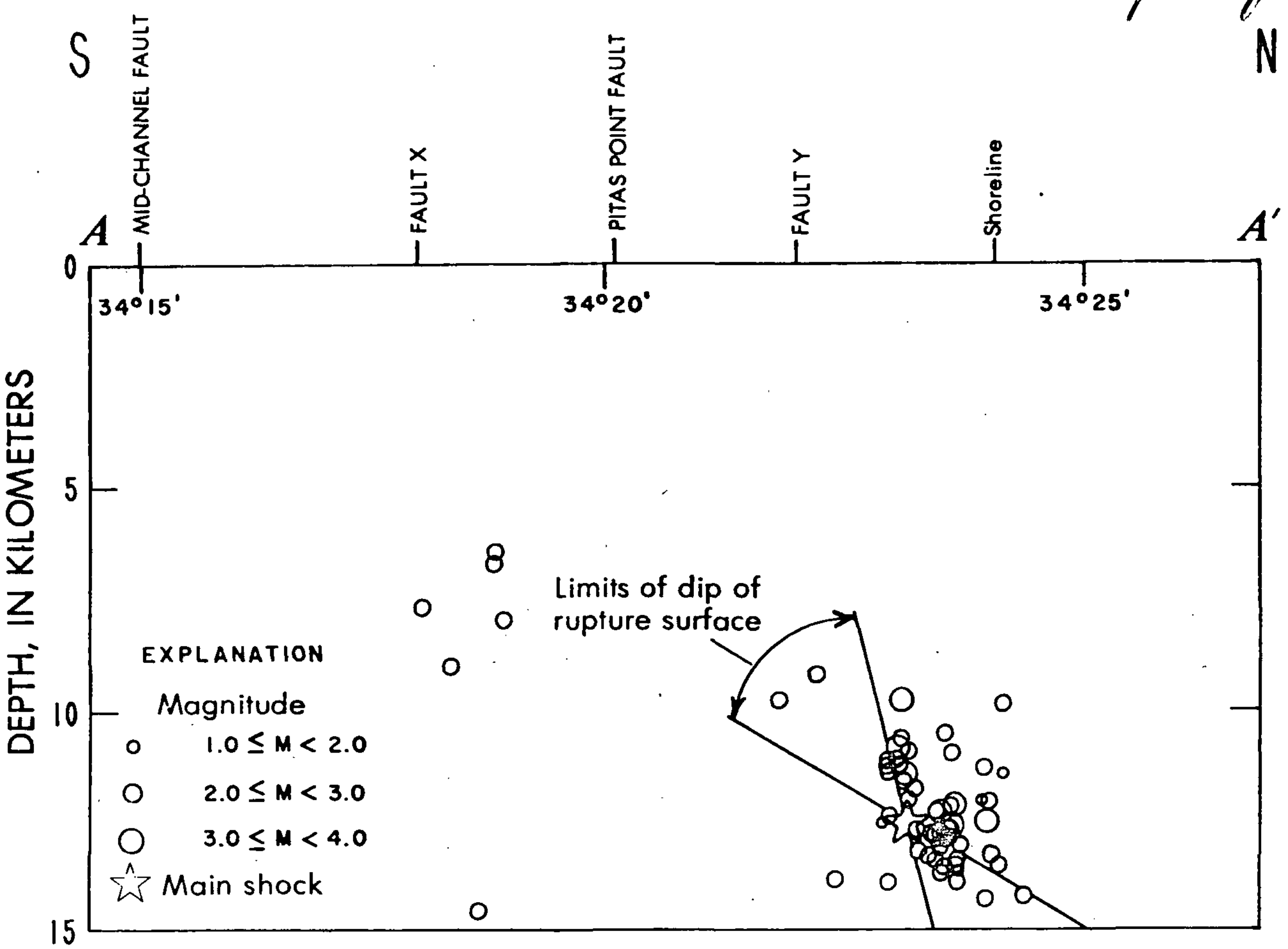


Figure 5.—Cross section of area of figure 3, showing hypocenter distributions and faults.

the Santa Barbara Channel was located in the same general area as the March-April 1978 swarm and included a magnitude 5.2 event (fig. 1) (Sylvester and others, 1970). However, this swarm was not followed by any larger earthquake. Therefore, it is not clear that earthquake swarms are reliable precursors to larger earthquakes in the Santa Barbara Channel.

REFERENCES CITED

Allen, C. R., St. Amand, P., Richter, C. F., and Nordquist, J. M., 1965, Relationship between seismicity and geologic structure in the southern California region: Seismol. Soc. America Bull., v. 55, p. 753-797.

Eaton, J. P., 1969, Hypolayer—a computer program for determining hypocenters of local earthquakes in an earth consisting of uniform flat layers over a half-space: U.S. Geol. Survey open-file report, 155 p.

Ellsworth, W. L., Campbell, R. H., Hill, D. P., Page, R. A., Alewine, R. W., III, Hanks, T. C., Heaton, T. H., Hileman, J. A., Kanamori, H., Minster, B., and Whitcomb, J. H., 1973, Point Mugu, California, earthquake of 21 February, 1973, and its aftershocks: Science, v. 182, p. 1127-1129.

Geiger, L., 1912, Probability method for the determination of earthquake epicenters from the arrival time only (translated from Geiger's 1910 German article): Bull. St. Louis Univ., v. 8, p. 56-71.

Hamilton, R. M., Yerkes, R. F., Brown, R. D., Jr., Burford, R. O., and De Noyer, J. M., 1969, Seismicity and associated effects, Santa Barbara region, pt. D of Geology, petroleum development, and seismicity of the Santa Barbara Channel region, California: U.S. Geol. Survey Prof. Paper 679, p. 47-68.

Healy, J. H., 1963, Crustal structure along the coast of California from seismic refraction measurements: J. Geophys. Res., v. 68, p. 5777-5787.

Hileman, J. A., Allen, C. R., and Nordquist, J. M., 1973, Seismicity of the southern California region: Contribution no. 2385, Div. of Geological and Planetary Sciences, California Institute of Technology.

Lee, W. H. K., Bennett, R. E., and Meagher, K. L., 1972, A method of estimating magnitude of local earthquakes from signal duration: U.S. Geological Survey open-file report, 28 p.

Lee, W. H. K., Eaton, M. S., and Brabb, E. E., 1971, The earthquake sequence near Danville, California, 1970: Seismological Society of America Bulletin, v. 61, p. 1771-1794.

Lee, W. H. K., and Ellsworth, W. L., 1975, Earthquake activity in the Santa Barbara Channel region, in Draft environment statement, Oil and gas development in the Santa Barbara Channel outer continental shelf off California: U.S. Geological Survey, p. II-80 - II-137.

Lee, W. H. K., and Lahr, J. C., 1975, HYPO71 (Revised): A computer program for determining hypocenter, magnitude, and first motion pattern of local earthquakes: U.S. Geological Survey Open-file Report 75-311, 114 p.

Lee, W. H. K., Yerkes, R. F., and Simirenko, M., (in press), Recent earthquake activity and focal mechanisms in the western Transverse Ranges, California: U.S. Geological Survey Circular 799A.

Richter, C. F., 1958, Elementary seismology: San Francisco, W. H. Freedman and Company, 768 p.

Stierman, D. J., and Ellsworth, W. L., 1976, Aftershocks of the February 21, 1973 Point Mugu, California earthquake: Seismological Society of America Bulletin, v. 66, no. 6, p. 1931-1952.

Sylvester, A. G., Smith, S. W., and Scholz, C. H., 1970, Earthquake swarm in the Santa Barbara Channel, California, 1968: Seismological Society of America Bulletin, v. 60, p. 1047-1060.

Yeats, R. S., Lee, W. H. K., and Yerkes, R. F., (in press), Geology and seismicity of the eastern end of the Red Mountain fault, Ventura County, California: U.S. Geological Survey Professional Paper.

Yerkes, R. F., and Lee, W. H. K., (in press), Late Quaternary deformation in the western Transverse Ranges, California: U.S. Geological Survey Circular 799B.

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