DAVID BLOOM

Field Trip No. 8

STRATIGRAPHY AND STRUCTURE OF THE AREA BETWEEN OCEANSIDE AND SAN DIEGO, CALIFORNIA: GEOLOGIC ROAD LOG

by

M.P. Kennedy
California Division of Mines and Geology
and
G.W. Moore
U.S. Geological Survey
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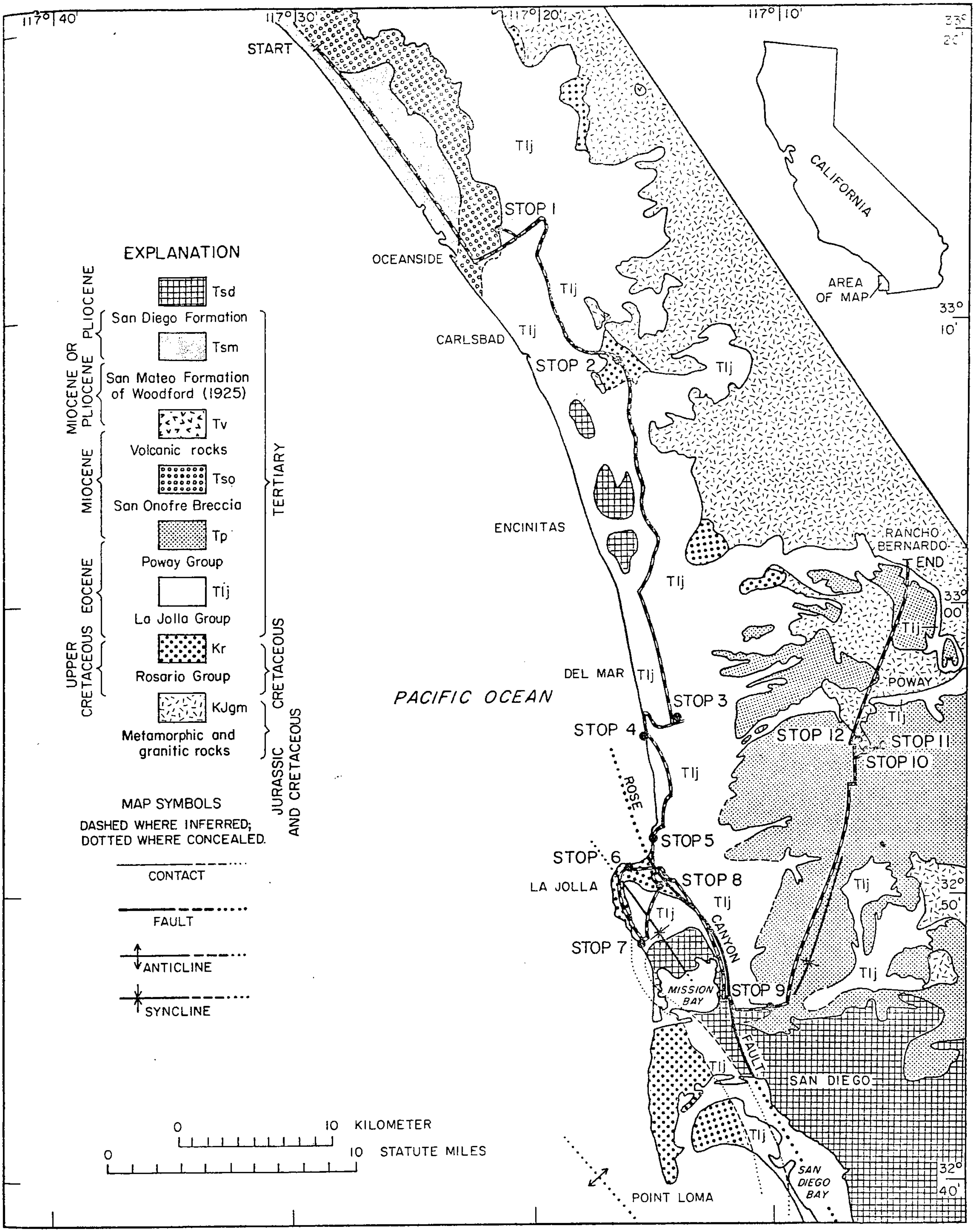

Figure 1. Field-trip route and index map of the bedrock geology between Oceanside and San Diego, California. Quaternary deposits not shown. Geology after Boss and others, 1958; Kennedy, 1967-1969; Weber, 1963.

INTRODUCTION

This road log begins on the coast at a highway viewpoint within Camp Pendleton Marine Corps Base, about 10 miles north of the center of the city of Oceanside, and, after passing through the north part of San Diego, ends in San Diego's Rancho Bernardo district (Fig. 1). A total of 12 stops provide an opportunity to examine strata of Jurassic, Cretaceous, Eocene, Miocene, Pliocene, and Pleistocene ages. The Upper Cretaceous and Eocene rocks are discussed under recently proposed new and revised names (Kennedy and Moore, 1971). Along the route of the field trip in San Diego, special attention is directed toward the Rose Canyon fault, considered by some investigators to be an extension of the active Newport-Inglewood fault zone. During the preparation of this road log, we have benefited by advice from David Bukry and John G. Vedder.

ROAD LOG

Miles

0.0 Start field trip from Interstate 5 viewpoint, maintained by California Division of Highways, at Camp Pendleton, approximately 6 miles south of the San Onofre nuclear generating station. The viewpoint is on a Pleistocene terrace cut on Woodford's (1925) San Mateo Formation of Miocene or Pliocene age, which dips gently southwestward in sea-cliff outcrops. San Onofre Mountain, the highest point on the ridge directly to the north, is the center of the type region for the San Onofre Breccia of middle Miocene age. This formation, which dips about 20 degrees toward the sea, contains blue-schist fragments derived from the Catalina Schist. The San Onofre Breccia lies above a basement of metamorphic and granitic rocks unlike that of its clasts, however, and the blue-schist is believed to have been derived from the west side of the offshore Newport-Inglewood fault zone.

2.2 Outcrop of San Mateo Formation of Woodford (1925) to the west.

2.6 Quaternary terrace material in railroad cut to the east. The foothills are underlain by the San Onofre Breccia, which in this area directly overlies Eocene rocks. The numerous tracks at the side of the freeway have been made during Marine Corps tank maneuvers.

6.6 White tower to the west is a navigational aid for aircraft.

7.2 Santa Margarita River. Extensive flooding on this river in February 1959 cut the freeway and removed newly completed bridges that had been built for it. Exposures of the San Onofre Breccia can be seen in river cuts upstream.

9.8 San Luis Rey River.

10.5 Take freeway exit to Mission Avenue (State Highway 76).

10.6 Turn east on Mission Avenue. The road crosses a Pleistocene marine terrace.

11.8 Road descends into the valley of the San Luis Rey River. The San Onofre Breccia occurs in the first road cuts to the south, followed, farther along, by Eocene rocks below.

12.5 Turn left at stop light onto Airport Road.

12.9 Oceanside Airport. Continue on paved road down the river valley.

13.2 Turn left on gravel road toward switchbacks leading to St. Charles Priory high on the bluff.

13.5 Bear north to the priory.

13.6 **Stop 1.** Typical exposure of the middle Miocene San Onofre Breccia containing angular to subangular clasts of blue–schist, vein quartz, and metavolcanic rocks (Fig. 2). This exposure of the San Onofre Breccia and its blue-schist clasts is one of the farthest from the Newport-Inglewood fault zone, known in this area. The clasts here average only about 5 centimeters in diameter but closer to the off-shore fault, the clasts may be as much as 10 meters in diameter. A minor fault trending N 25 W and dipping 60° NW cuts the formation here. The rock is stained reddish brown near this fault. Turn around and return to Highway 76 via Airport Road.

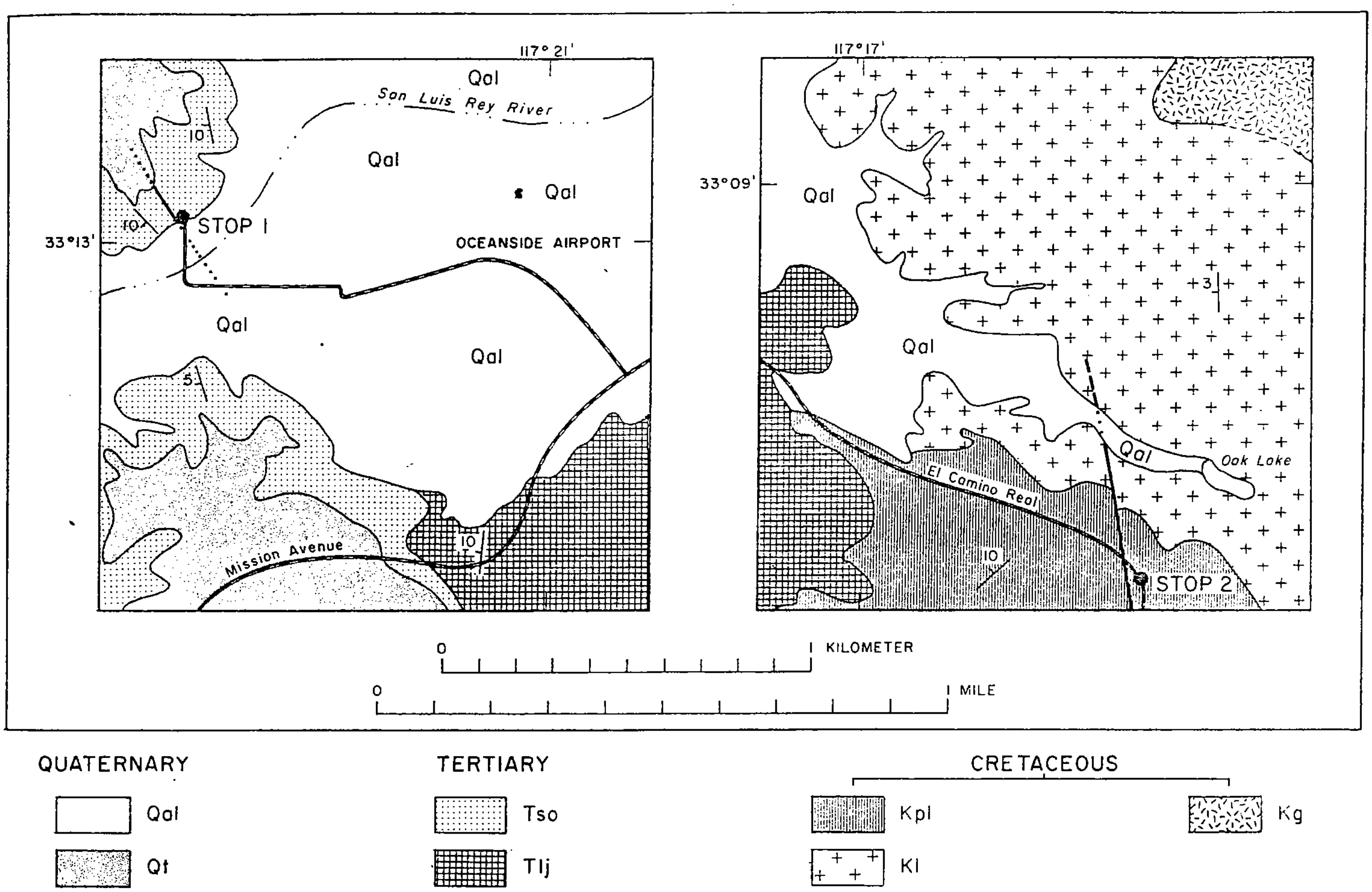

Figure 2. Geologic maps for Stops 1 and 2. Geologic units: Qal, Quaternary alluvium; Qt, Quaternary terrace deposits; Tso, San Onofre Breccia; Tlj, La Jolla Group; Kpl, Point Loma Formation; Kl, Lusardi Formation; Kg, granitic rocks.

14.1 To the south, the west-dipping Eocene-Miocene contact follows the canyon crossed by Highway 76—the hill to the east being Eocene and that to the west Miocene. To the north, the matching contact is marked by grassy hills to the east and rough brushy hills to the west.

14.7 Turn left at stop light on Mission Avenue (Highway 76).

15.2 Light colored exposures on hill slope to south are underlain by the La Jolla Group of Eocene age.

16.0 Turn south on El Camino Real, the Royal Highway, a road begun by Father Junipero Serra in 1769 to connect the California missions between San Diego and San Francisco.

17.5 White sandstone typical of the La Jolla Group in this area. This sandstone is quarried about ½ mile to the east for plaster and specialty sand.

18.7 Overview of the valley of Buena Vista Creek. The lagoon to the west is Buena Vista Lagoon, a major sanctuary for migratory waterfowl. The rolling hills on the flanks of the valley are underlain by the La Jolla Group.

19.2 Crossing Highway 78. Continue south on El Camino Real.

21.7 Crossing minor valley. The outcropping rocks of the La Jolla Group in this area were formed in a lagoonal setting and have produced many vertebrate fossils, including crocodiles, rodents, and artiodactyls.

22.5 The hills to the east are underlain by Upper Cretaceous, quartz diorite of the Southern California batholith. The valley and hills to the west are underlain by the La Jolla Group.

23.8 Excellent exposures of fossiliferous Upper Cretaceous rocks of the newly named Point Loma Formation, middle formation of the Rosario Group (Kennedy and Moore, 1971). These exposures will be examined on foot from Stop 2. The post-batholithic Rosario Group is divided into three formations, which are from base to top, the Lusardi Formation, the Point Loma Formation, and the Cabrillo Formation.

24.1 Stop 2. Park at top of hill. This stop will include visits to the Lusardi and Point Loma Formations (Fig. 2). To get to the base of the exposures, start from the beginning of the driveway of the Madonna Hill Guest Home, go through the wire gate to the east, and walk toward a concrete standpipe about 100 meters to the east. The granitic boulders near the standpipe are not basement rock but are clasts within the Lusardi Formation, the basal conglomerate of the Rosario Group. Walk down the steep recently bulldozed track to see the section. This rock conforms to an old definition of an arkose: "A sandstone which looks like a granite" (Oriel, 1949). A layer of sandy claystone about half way down the track makes clear the true nature of the rock. The basal contact with underlying granitic rock lies on the opposite slope and will not be visited. The trace of the contact between conglomerate of the Lusardi Formation and fossiliferous shaly rock of the overlying Point Loma Formation passes approximately under the standpipe. It trends across the field below the Madonna Guest House to intersect the road at the base of the main exposures of the Point Loma Formation. Retrace steps back to the road and examine the Point Loma Formation in the road cut along El Camino Real. *Watch for cars.* An ammonite about one meter in diameter, which was found here in 1969, is now in the San Diego Museum of Natural History. Maestrichtian foraminifers and coccoliths have also been collected here (Bandy, 1949; D. Burky, written commun., 1969).

Continue south on El Camino Real.

24.9 Airport Road. Continue south.

27.1 The valley ahead is underlain by the La Jolla Group. The green-colored sandy claystone in this area belongs to one of the formations of the La Jolla, the Delmar Formation, of middle Eocene age. The reddish soil on the hills to the east has formed on the Santiago Peak Volcanics of Late Jurassic and Early Cretaceous (?) age.

28.4 Typical exposure of green mudstone of the Delmar Formation. A north-trending fault in the valley ahead displaces Eocene rocks such that the west side is down. Oysters and other mollusks can be collected from the lagoonal Delmar Formation, which crops out in the road cuts along the valley.

31.2 Encinitas Boulevard. Continue south on El Camino Real.

31.3 Excellent exposures of the Torrey Sandstone of middle Eocene age in the road cuts. Interesting sandstone structures are well exposed at this place, including cannonball concretions and massive cross bedding. The Torrey Sandstone is believed to be ancient beach and dune sand associated with a former barrier beach.

33.3 San Elijo Lagoon is on the south side of the road.

33.7 Near the base of the hill to the north, green rocks of the Delmar Formation can be seen directly overlain by massive sandstone of the Torrey. The Delmar contains oysters and other molluscan fossils here.

34.2 Interstate 5. Turn right onto freeway, heading south toward San Diego.

35.1 The road cuts expose the Torrey Sandstone.

36.8 Del Mar racetrack to the west.

37.3 San Dieguito River. Deltaic terraces on the valley floor to the east interfinger with the marine upper Pleistocene Bay Point Formation of Hertlein and Grant (1939).

39.1 On the left are the first of the Torrey Pines—trees indigenous to only a few square miles here and on Santa Rosa Island.

39.9 Take Carmel Valley Road exit from freeway.

40.2 Turn toward the east on Carmel Valley Road.

40.4 Turn north on El Camino Real.

40.5 **Stop 3.** Park at roadside (Fig. 3). Cross on foot the concrete drainage ditch directly opposite from the Shell gasoline station. Richly fossiliferous inland exposure of Hertlein and Grant's (1939) upper Pleistocene (Sangamon) Bay Point Formation. Despite its young age of approximately 100,000 years, this formation is rather extensively jointed here and has a gentle dip to the south that may be tectonic. A northeast-trending fault passes through the sand quarry that lies on the opposite side

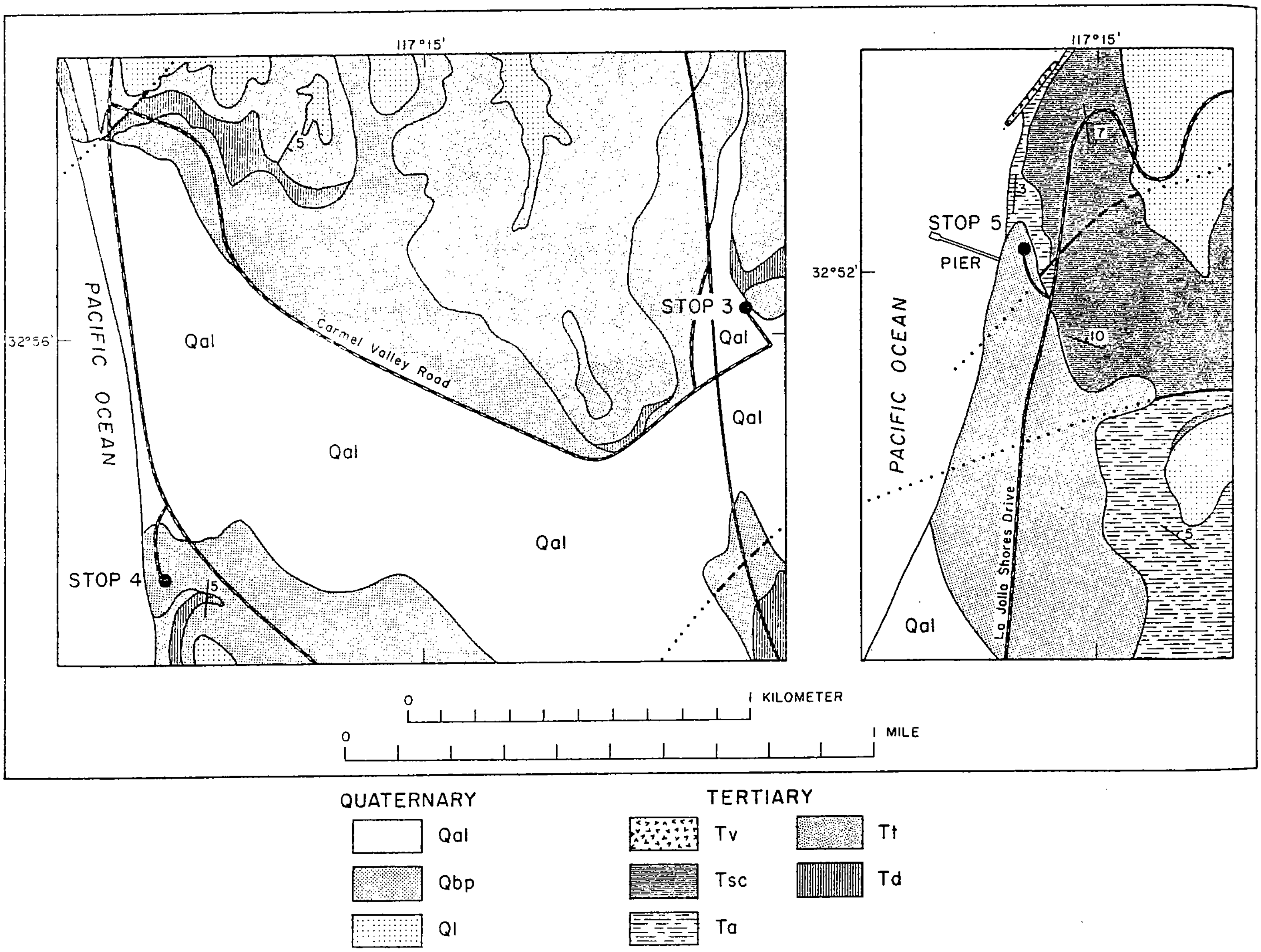

Figure 3. Geologic maps for Stops 3, 4, and 5. Geologic units: Qal, Quaternary alluvium; Qbp, Bay Point Formation of Hertlein and Grant (1939); Ql, Lindavista Formation of Hanna (1926); Tv, Tertiary volcanic rocks; Tsc, Scripps Formation; Ta, Ardath Shale; Tt, Torrey Sandstone; Td, Delmar Formation.

of the valley to the south.

Turn around and return to Carmel Valley Road.

40.7 Pass under Interstate 5. Continue straight on Carmel Valley Road.

41.4 Light-colored Torrey Sandstone to the north is capped here by reddish-brown deposits of the lower Pleistocene Lindavista Formation of Hanna (1926).

42.0 The road follows near the contact between the Torrey Sandstone above and the Delmar Formation below.

42.2 Junction with coast highway. Turn south. Several small faults cut the Torrey Sandstone in the road cut to the north.

43.1 Turn right into Torrey Pines State Park.

43.3 **Stop 4.** Park in parking lot (Fig. 3). Take stairway to the beach. The gradational contact between greenish oyster-bearing rock of the Delmar Formation and light-brown cavernously weathered massive sandstone of the Torrey are well exposed in the cliff to the south. The type locality for the Torrey Sandstone is on the road that continues up the hill toward Torrey Pines State Park headquarters. Age and facies relations of the newly named Eocene formations within the La Jolla and Poway Groups are shown in Figure 4.

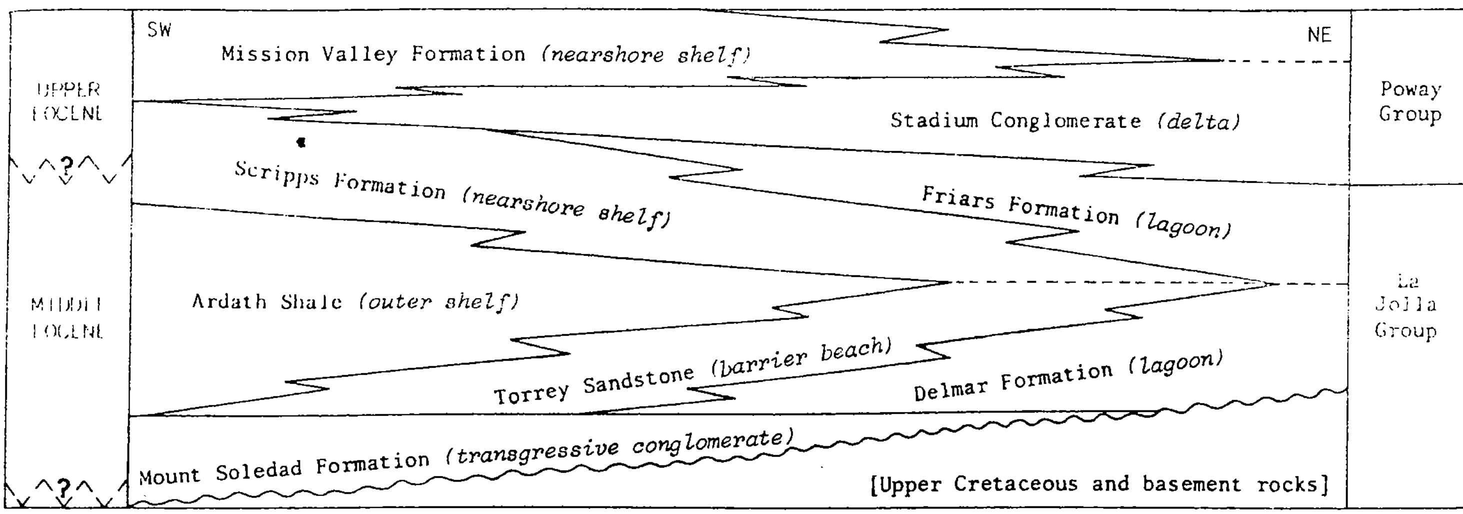

Figure 4. Facies relations and inferred depositional environments of Eocene formations in the San Diego coastal area (after Kennedy and Moore, 1971).

Torrey Pines State Park contains nature trails featuring the pines and is well worth a side excursion. The skyline to the south consists of Mount Soledad on the east and La Jolla on the west. The deposits under the steps to the beach contain a Quaternary molluscan fauna.

Return to coast highway and turn south up the hill.

43.8 Some of the largest specimens of Torrey pines growing on massive exposures of the Torrey Sandstone.

44.3 A fault in the Torrey Sandstone can be seen, along which reddish-brown deposits of Hanna's (1926) Lindavista Formation of early Pleistocene age have been down-dropped into a minor graben. This is the same fault that passes to the south of the upper Pleistocene locality at the Shell gasoline station at Stop 3, which can be seen to the northeast.

45.2 Torrey Pines Golf Course. Continue straight.

45.9 Headquarters of Gulf General Atomic to the east.

46.4 Genesee Avenue. Turn west.

46.7 Salk Institute to the west. Continue straight.

47.2 University of California, San Diego.

47.6 La Jolla Shores Drive. Turn west at stop light.

48.8 U.S. Fishery-Oceanography Center.

48.9 Headquarters of Deep Sea Drilling Project on east side of road.

49.1 Turn west on Discovery Way into the parking lot of the Scripps Aquarium-Museum.

49.2 **Stop 5.** Park in parking lot (Fig. 3). Take the aquarium steps and path to the beach. The path ends on a concrete ramp directly north of Scripps Pier. The bedrock at this place consists of the La Jolla Group of Eocene age, and the rocks exposed north of the beach ramp at the base of the cliff belong to the formation representing the most seaward facies of the La Jolla Group, the Ardath Shale of middle Eocene age. Sausage-shaped sandstone bodies on the beach between the ramp and pier are minor folds produced by submarine sliding.

The contact between the La Jolla Group and the overlying upper Pleistocene Bay Point Formation of Hertlein and Grant (1939) lies about 1 meter below the concrete outfall pipe on the cliff about 100 meters north of the beach ramp. A very well indurated conglomerate lies in the basal part of the 100,000-year-old Bay Point Formation north of the pipe. Near this place, excellent examples of submarine sliding can be seen in the Eocene bedrock. About 200 meters north of the beach ramp, directly below the jutting edifice of the Institute of Geophysics and Planetary Physics, the basal 4 meters of the cliff consists of partly contorted siltstone of the Ardath Shale, and the remainder of the cliff consists of sandstone and conglomerate of the Scripps Formation of middle and late Eocene age.

The promontory about 500 meters north of the ramp, directly below the U.S. Fishery-Oceanography Center, is held out by a columnar-jointed Miocene basaltic-andesite dike. A whole-rock potassium-argon analysis of this rock, which shows some evidence of wall-rock assimilation, gave an experimental age of 10.9 ± 1.1 million years (J.W. Hawkins, personal commun., 1970).

Return to parking lot. A visit to Scripps Aquarium is well worth the extra time. Leave parking lot and return to main road.

49.4 Turn and drive south along the La Jolla Shores Drive. The Rose Canyon fault, the principal fault passing through the city of San Diego, comes ashore at the bay ahead after having passed through the head of La Jolla Submarine Canyon. The fault trends through the saddle to the east. It will be seen during later parts of the field trip.

50.4 Turn west on Torrey Pines Road. The Rose Canyon fault passes approximately under this intersection, and Cretaceous rocks are faulted against Eocene.

50.6 Dipping Cretaceous rocks of the Point Loma Formation in roadcuts to the east.

Both foraminifers and coccoliths in these outcrops indicate a stratigraphic position near the Campanian-Maestrichtian boundary (Sliter, 1968; Bukry and Kennedy, 1969). This part of the Rosario Group is at approximately the same stratigraphic position as the rocks seen at Stop 2 along El Camino Real.

51.1 Turn west on Prospect Street, following scenic-drive markers.

51.4 Bear northwest at fork onto Cave Street and drive toward La Jolla Cove.

51.5 La Jolla sea cave. Tunnel access is through curio shop.

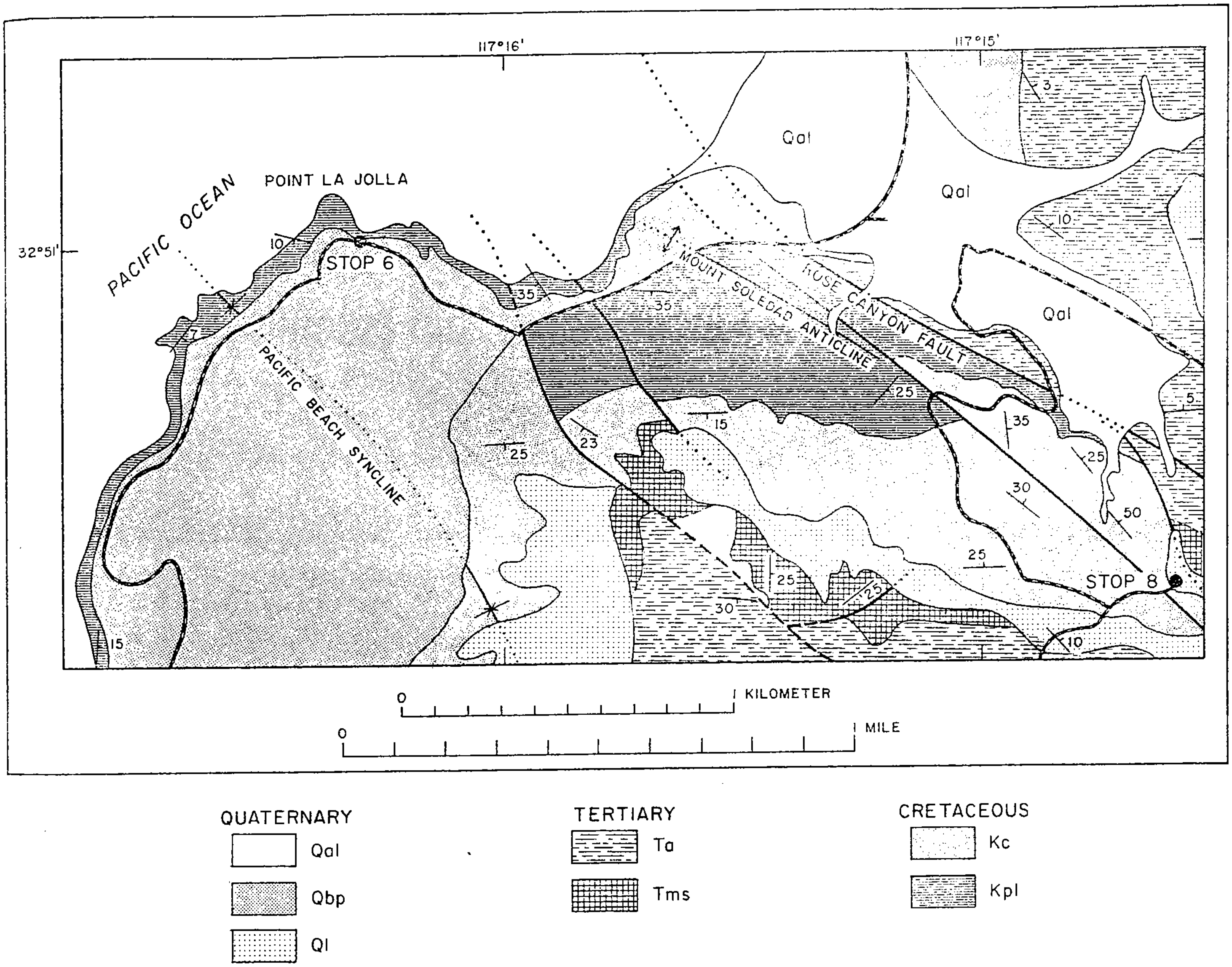

Figure 5. Geologic map for Stops 6 and 8. Geologic units: Qal, Quaternary alluvium; Qbp, Bay Point Formation of Hertlein and Grant (1939); Ql, Lindavista Formation of Hanna (1926); Tsc, Scripps Formation; Ta, Ardath Shale; Tms, Mount Soledad Formation; Kc, Cabrillo Formation; Kpl, Point Loma Formation.

51.6 **Stop 6.** La Jolla Cove (Fig. 5). Park on street. Take walkways on the street level past the La Jolla Shuffleboard Club to Point La Jolla, which is directly west of the Cove Beach. The terrace level at the top of the point is overlain by the basal part of the Bay Point Formation of Hertlein and Grant (1939). Late Pleistocene (Sangamon) fossils can be found above the point.

The rocks making up the tip of Point La Jolla belong to the Point Loma Formation, the middle formation of the Rosario Group. Good examples of flame structure, contorted beds caused by submarine sliding, and sandstone concretions occur at the point. An impression of the rate of wave erosion on relatively hard rocks is indicated by the concrete channels around drainpipes that are now etched into bas-relief. Emery (1941) has studied the frequency distribution of dated inscriptions cut into the rock at this place and has estimated that the rate of erosion is about 1 centimeter in 20 years.

Continue following the scenic-drive markers south along the coast.

51.8 Turn west on Coast Blvd. This is approximately the axis of the Pacific Beach syncline. The rocks along the coast consist of the Point Loma Formation. The flat terrace is believed to be associated with a stand of sea level that existed during the Sangamon interglaciation.

52.8 Turn south on La Jolla Blvd.

54.6 Bird Rock Avenue. Continue south on La Jolla Blvd.

55.5 Turn west on Tourmaline Street.

55.6 **Stop 7.** Tourmaline Surfing Park (Fig. 6). Follow walkway to beach. The cliffs directly south of the parking lot consist of the San Diego Formation of Pliocene age. The rocks are richly fossiliferous, and the large scallop *Patinopecten healeyi* (Arnold) is especially prominent in these outcrops (Moore, 1968). After examining the San Diego Formation, walk toward the northwest along the beach down through the section exposed on the nose of the Pacific Beach syncline. Directly north of the parking lot, the top third of the cliff consists of mollusk-bearing Bay Point Formation of Hertlein and Grant (1939), marked at the base by a boulder gravel. The middle third consists of the San Diego Formation, and the lower third is the basal transgressive unit of the La Jolla Group, the Mount Soledad Formation. Walk north along the beach about 300 meters until exposures of conglomerate occur on the cliff. The upper conglomerate, which is about 2 meters thick and contains clasts of grayish-red porphyritic rhyolite welded tuff ("Poway clasts"), is the basal conglomerate of the Eocene Mount Soledad Formation. A conglomerate below belongs to the Upper Cretaceous Cabrillo Formation, uppermost formation of the Rosario Group. The Cretaceous rocks in San Diego generally lack the red welded tuff clasts and contain dark-colored volcanic clasts as well as fresh granitic ones.

Return to parking lot and then to La Jolla Blvd.

55.8 Turn north on La Jolla Blvd.

55.9 Turn east on Turquoise Street.

56.1 Turn north on La Jolla Mesa Drive.

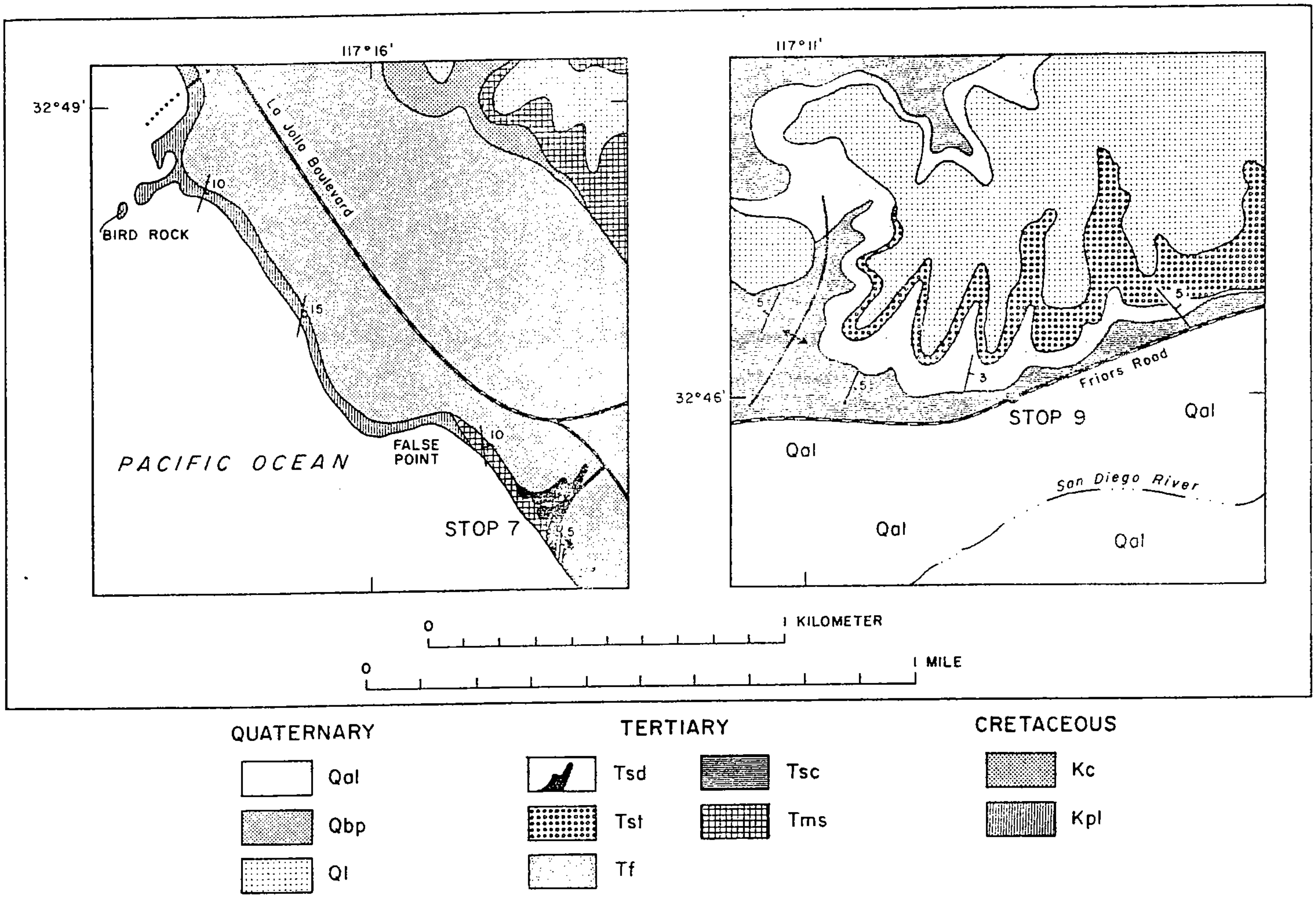

Figure 6. Geologic maps for Stops 7 and 9. Geologic units: Qal, Quaternary alluvium; Qbp, Bay Point Formation of Hertlein and Grant (1939); Ql, Lindavista Formation of Hanna (1926); Tsd, San Diego Formation; Tst, Stadium Conglomerate; Tf, Friars Formation; Tsc, Scripps Formation; Tms, Mount Soledad Formation; Kc, Cabrillo Formation; Kpl, Point Loma Formation.

56.4 The roadcut to the west consists of sandstone of the Mount Soledad Formation.
56.7 Pleistocene gravel.
56.9 Contact between Hanna's (1926) lower Pleistocene Lindavista Formation and the La Jolla Group in the west roadcut.
57.2 Turn east on La Jolla Scenic Drive. Follow the signs to the top of Mount Soledad.
58.2 Nautilus Street. Continue north.
58.5 Television towers.
58.6 Turn east toward Easter Cross.

58.8 **Stop 8.** Easter Cross (Fig. 5). From the parking lot, Scripps Pier can be seen to the north. The skyline to the east consists of granitic rocks of the Southern California batholith. The near body of water to the south is Mission Bay, whose position is controlled by the actively sinking Pacific Beach syncline. The highland to the south is the Point Loma Peninsula, underlain by Cretaceous rocks on the northeast flank of the offshore Point Loma anticline, which is approximately parallel with the Pacific Beach syncline. Directly beyond Point Loma, Mexico's Coronados Islands can be seen on a clear day. They are underlain in part by Miocene rocks similar to the San Onofre Breccia. Table mountains on the skyline in mainland Mexico are capped by Miocene volcanic rocks. The broad house-covered terrace to the east at an altitude of about 100 meters is underlain mainly by Eocene rocks of the La Jolla Group and the Poway Group. The upper surface is a wave-cut terrace of early Pleistocene age. It is capped by reddish-brown deposits of the Lindavista Formation of Hanna (1926).

Walk about 30 meters down the fire road that extends east from the cross. A high roadcut down the mountain in the foreground to the northeast consists of a cross section through beach deposits of early Pleistocene age that make up part of the Lindavista Formation. These deposits are about 30 meters higher than the general level of the terrace. This elevation is believed to be related to Pleistocene deformation along the Rose Canyon fault, which passes through the saddle between our position and the beach deposits (Peterson, 1970). The fault extends from the bay south of Scripps Pier, through the saddle, then to the south along Interstate 5 freeway in Rose Canyon at the base of the mountain. Beyond the mouth of Rose Canyon, it is aligned with the freeway along the east side of Mission Bay, and finally passes toward Mexico under the arch of the San Diego-Coronado Bridge, which can be seen just west of San Diego's downtown skyscrapers.

Continue back to the junction with the main road.

59.1 Turn north on La Jolla Scenic Drive.

59.3 Folded and faulted rocks within the Cabrillo Formation of Late Cretacesous age.

60.2 Approximate crossing of the Rose Canyon fault.

60.4 Turn east and enter onto Ardath Road. The Rose Canyon fault follows a short distance to the southwest of this road.

61.2 The roadcut in lower Pleistocene beach deposits seen from the top of Mount Soledad lies to the northeast.

61.7 Take Interstate 5 southward toward downtown San Diego. The lower part of the opposite bank of Rose Canyon consists of the Ardath Shale. The upper part is the Scripps Formation.

62.5 The Rose Canyon fault crosses the freeway approximately here.

63.0 The fault passes under the large steel buildings to the east. The rocks on each side near the fault are vertical.

63.4 The prominent light-green outcrop to the east consists of Cretaceous rocks. They are separated from Eocene conglomerate on the slope above by a minor fault strand within the ½-kilometer wide fault zone.

63.5 The dipping conglomerate on the west side of the freeway belongs to the Mount Soledad Formation of early (?) and middle Eocene age.

63.8 Overpass.

64.3 The light-colored outcrop in a roadcut on the far side of the railroad track contains overturned rocks of the Pliocene San Diego Formation near the trace of the Rose Canyon fault.

64.9 Mission Bay.

66.7 Take Tecolote Road exit from Interstate 5.

66.9 Turn east on Tecolote Road.

67.3 Turn south on Morena Blvd. For those interested in Pleistocene deposits, an excellent exposure of the Bay Point Formation of Hertlein and Grant (1939) lies on Tecolote Road about 100 meters east of this turn. This exposure is richly fossiliferous, lies very near the Rose Canyon fault, and some investigators believe this 100,000 year old deposit has been disturbed by the faulting.

67.7 Stoplight. Continue south.

67.8 Turn east on Napa Street.

68.0 Turn east on Friars Road. We are now in Mission Valley, through which flows the San Diego River. The cliffs on the south side of the river consist of the Mission Valley Formation of late Eocene age.

68.5 The first good bedrock exposures on the north side of the road consist of marine mollusk-bearing rocks of the Scripps Formation. The lighter colored crossbedded rocks ahead constitute the Friars Formation of middle and late Eocene age, the uppermost formation of the La Jolla Group (see Fig. 4). The road trends toward the axis of the Mission Valley syncline to the east and hence passes upward in the Eocene section. The conglomerate overlying the white sandstone of the Friars Formation is the Stadium Conglomerate of middle(?) and late Eocene age, the basal formation of the Poway Group.

69.1 **Stop 9.** Contact between the Friars Formation and the Stadium Conglomerate (Fig. 6). The conformable nature of the contact is clearly shown. The Stadium Conglomerate contains red "Poway clasts," and one interesting recent hypothesis (Merriam, 1968) suggests that they were derived from the east side of the Elsinore and related faults, at a time prior to strike-slip fault movement when their source, presumed now to be in Sonora, Mexico, lay directly adjacent to the present area of western San Diego County.

Vertebrate fossils have been collected from both the Friars Formation and the Stadium Conglomerate near here. Some sandstone lenses also contain marine fossils, so this sequence and adjacent formations must have been formed where Eocene conditions alternated between marine and non-marine.

69.4 The contact between the Friars Formation and Stadium Conglomerate crosses Friars Road here. Continue east on Friars Road.

70.1 Overpass over U.S. Highway 395.

70.2 Turn north on U.S. 395 (California 163).

70.3 The Stadium Conglomerate is rather poorly indurated, and it is extensively mined for gravel in such quarries as the one to the east.

70.6 Good exposures of sandstone lenses within the Stadium Conglomerate.

71.1 Mission Valley Formation of the Poway Group. This sandstone contains late Eocene ("Tejon Stage") molluscan fossils, whereas the principal fossil beds of the La Jolla Group are of middle Eocene age ("Domengine Stage").

71.4 The highway attains the level of the Lindavista terrace.

72.6 Typical reddish-brown exposures of the lower Pleistocene Lindavista Formation of Hanna (1926).

75.5 Red and white checkered water tower.

77.6 San Clemente Creek.

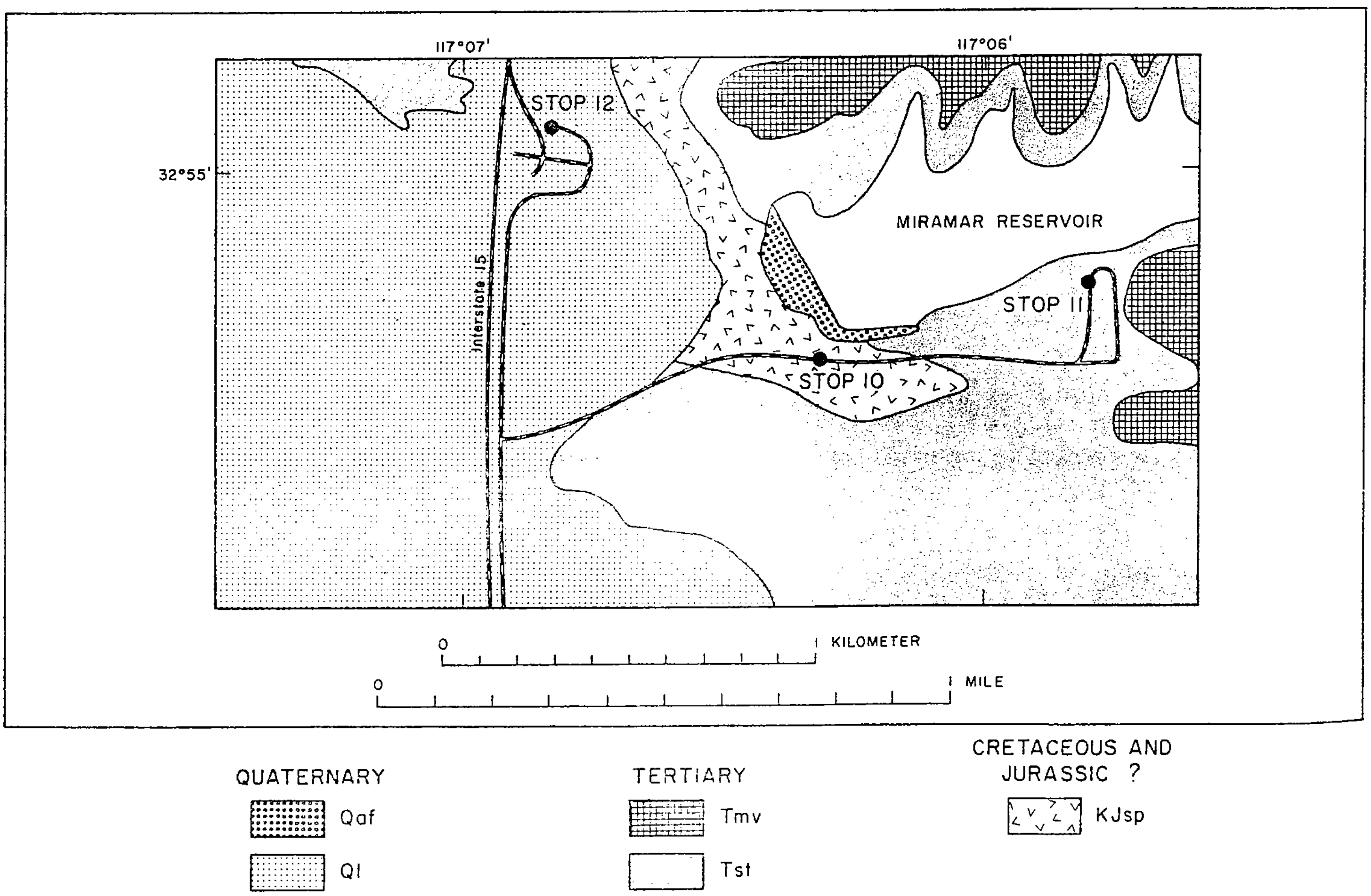

Figure 7. Geologic map for Stops 10, 11, and 12. Geologic units: Qaf, Quaternary artificial fill; Ql, Lindavista Formation of Hanna (1926); Tmv, Mission Valley Formation; Tst, Stadium Conglomerate; KJsp, Santiago Peak Volcanics.

77.9 The Lindavista terrace ends to the east where it intersects a presumed wave-cut scarp cut into rocks of the Poway Group.

79.1 Take Pomarado Road exit.

79.4 Turn east on Pomarado Road.

79.5 Turn north on road to Miramar Dam.

80.1 Exposures of the Lindavista Formation of Hanna (1926) in the roadcuts.

80.7 Turn east on road to Miramar Reservoir.

81.3 **Stop 10.** Mafic volcanic and volcanoclastic rocks of the Santiago Peak Volcanics of Late Jurassic and Early Cretaceous(?) age (Fig. 7). Slate and sandstone are interbedded with the volcanic rocks, and about 8 kilometers to the northwest Fife and others (1967) found this formation to contain belemnites and the Late Jurassic (Tithonian) clam *Buchia piochii* (Gabb).

Continue toward east.

81.8 Enter gate and turn left at fork of road into visitor parking lot. In January 1971 the gate was being kept open only on week days from 10 a.m. to 2 p.m.

82.0 **Stop 11.** Parking lot of water-filtration plant (Fig. 7). The exposure at the top of the hill above the filtration plant consists of the Mission Valley Formation of late Eocene age. A large variety of fossils occur at this locality including shark's teeth, echinoids, mollusks, foraminifers, and coccoliths. The molluscan fossils belong to the "Tejon Stage". This unit rests here on basement, owing to onlap of the Eocene formations toward the east.

82.2 Return to junction and pass out of gate.

83.3 Turn north on frontage road.

83.8 Road junction to west. Continue straight on road to north.

83.9 **Stop 12.** One of the farthest exposures from the coast of an early Pleistocene beach deposit (Fig. 7). It laps onto the basement which consists here of the Santiago Peak Volcanics. This exposure contains several beds that are very rich in heavy minerals.

Turn around and drive toward the south.

84.0 Turn west on Mira Mesa Blvd.

84.1 Turn north on U.S. Highway 395 (Interstate 15).

84.5 Basement contact crosses highway.

85.1 Typical exposures of the Santiago Peak Volcanics.

86.8 Contact between Santiago Peak Volcanics and La Jolla Group.

87.0 Contact between La Jolla Group and Poway Group above crosses road.

87.6 The hills on the east side of the road are underlain by quartz diorite of the Southern California batholith. Black Mountain on the west side of the road is underlain by the Santiago Peak Volcanics.

88.6 Rolling grass-covered hills to east are underlain by the Mission Valley Formation.

90.5 Contact between Stadium Conglomerate and Mission Valley Formation. The Stadium is about 20 meters thick here.

90.9 Approximate contact between the Stadium Conglomerate of the Poway Group and distinctive green sandstone and mudstone near the top of the La Jolla Group below.

91.9 Overpass at which Interstate 15 crosses Rancho Bernardo Road.

End of field trip. Interstate 15 continues north to Riverside. To return to Interstate 5 toward Los Angeles, turn west on California 78 in Escondido, about 7 miles to the north.

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