Dunne

20th FALL FIELD FROLIC
DEPARTMENT OF GEOLOGICAL SCIENCES
CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

STRATIGRAPHIC CLUES
TO THE
TECTONIC ORIGIN
OF THE
SOUTHERN COAST RANGES

by

EUGENE FRITSCHE

with assistance from

PETER WEIGAND, DOUG YULE, and HERB ADAMS

AUGUST 21-24, 2002

2002 FALL FIELD FROLIC ROAD LOG
DEPARTMENT OF GEOLOGICAL SCIENCES
CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

DAY 1, Wednesday, August 21

Directions to Stop 1 - Proceed north on Interstate 405 North, merge with Interstate 5 North, and go to the Templin Highway offramp. Turn right (east) on Templin Highway and go **1.2 mi** to its intersection with the Old Ridge Route. Stop 1 is in the near vicinity of this intersection.

Directions to Stop 2 - Return on Templin Highway to Interstate 5 North and turn right (north) onto Interstate 5. Exit the interstate at Quail Lake Road and turn left (west). Cross under the interstate and turn left (south) at the T-intersection with Peace Valley Road. Go **0.6 mi** to Stop 2, a roadcut on the west side of the road.

Directions to Stop 3 - Go back north on Peace Valley Road to Quail Lake Road and turn right (east). Follow Quail Lake Road eastward until it merges with Highway 138 and continue on Highway 138 eastward to the Old Ridge Route. Turn right (south) on the Old Ridge Route and go **2.1 mi** to Stop 3, which is a roadcut exposure of the Sandberg thrust fault on the west side of the road.

Directions to Stop 4 - Return northward on the Old Ridge Route toward Highway 138. Somewhere along the Old Ridge Route where there is a good view of the Antelope Valley and the mountains to the north, we will pause for Stop 4.

Directions to Stop 5 - Continue northward on the Old Ridge Route and turn left (west) at its intersection with Highway 138. Proceed west on Highway 138 to its end and merge onto Interstate 5 North. Follow Interstate 5 North to the Frazier Park exit. At the end of the Frazier Park offramp, turn left (west), go under the interstate and follow Frazier Mountain Park Road past Frazier Park to Lake of the Woods. From Frazier Park on westward the field trip route follows the San Andreas fault. At a Y-intersection in Lake of the Woods bear right (north) onto Cuddy Valley Road. As you pass the intersection, read your odometer or **set your trip odometer to 0.0 mi**. At **4.1 mi** is a junction with West Tecuya Mountain Road. Pull off to the right for Stop 5.

Directions to Stop 6 - Continue westward on Cuddy Valley Road. At **4.8 mi** (from Lake of the Woods) is a road on the right to Camp Bethany Pines. At **4.9 mi** the road crosses the San Andreas fault. Look for a pressure ridge formed along the fault on the left side of the road. At **5.2 mi** is another Y-intersection. Bear right (north) onto Mil Potrero Highway. The San Andreas fault is crossed again at **5.5 mi**. At **8.3 mi** pull off the road into a parking spot on the left side. Here at Stop 6 we will walk back along the road for **0.1 mi** to see the Whitiner Tree, the largest tree in southern California, which is growing on the trace of the San Andreas fault.

STOP 1

Stratigraphically we are standing in the upper part of the Marple Canyon Sandstone Member, the lowermost unit of the Ridge Basin Group. We are near the transition between marine beds stratigraphically below us and nonmarine bed above us, exposed in the russet-colored outcrops along the Old Ridge Route to the north of Templin Highway (Figure 2). Deformed beds near this transition are conspicuous (Figure 24).

Figure 24. Slump-folded strata at the junction of Templin Highway and Old Ridge Route (Marple Canyon Sandstone Member). These rocks are interpreted to be slope deposits.

Marple Canyon Sandstone Member

The Marple Canyon Sandstone Member of the Ridge Route Formation is well exposed at Templin Highway–Old Ridge Route junction (Figure 25). The nonmarine- marine transition in Ridge Basin occurs in this unit at approximately the intersection of the two roads. Marine rocks crop out along the Old Ridge Route south of Templin Highway and contain marine mollusks and foraminifers indicating moderate water depths. Slope facies and channel and interchannel turbidites are exposed here. The slope facies consists of large-scale sequences of slump-folded strata, slide blocks, and faults (growth faults) cut and filled by channels and bounded by laterally continuous strata (Figure 24). Composite channel deposits consist mainly of sandstone which form laterally discontinuous thinning- and fining-upward sequences. Graded beds, displaced mollusks, dish structures, sole marks, and Bouma intervals are common. Associated with the channel sequences are interchannel deposits of mudstone and thin-bedded sandstone. These deposits wedge-out laterally and are highly slump folded and locally brecciated. Many of the sandstone interbeds are graded and contain rip-up clasts, dish structures, and are interpreted as turbidites forming from overbanking processes from major distributary channels. They are deposited in interchannel areas adjacent to the channels.

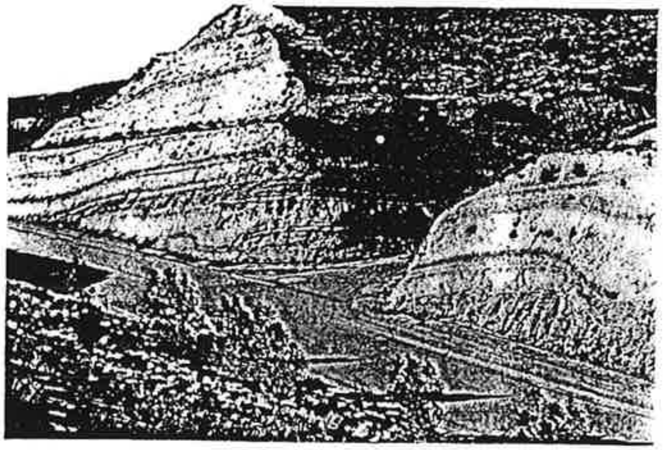


Figure 25. Upper Marple Canyon Sandstone Member at Templin Highway/ Old Ridge Route junction. The rocks are deltaic and braided-fluvial facies overlying slope deposits.

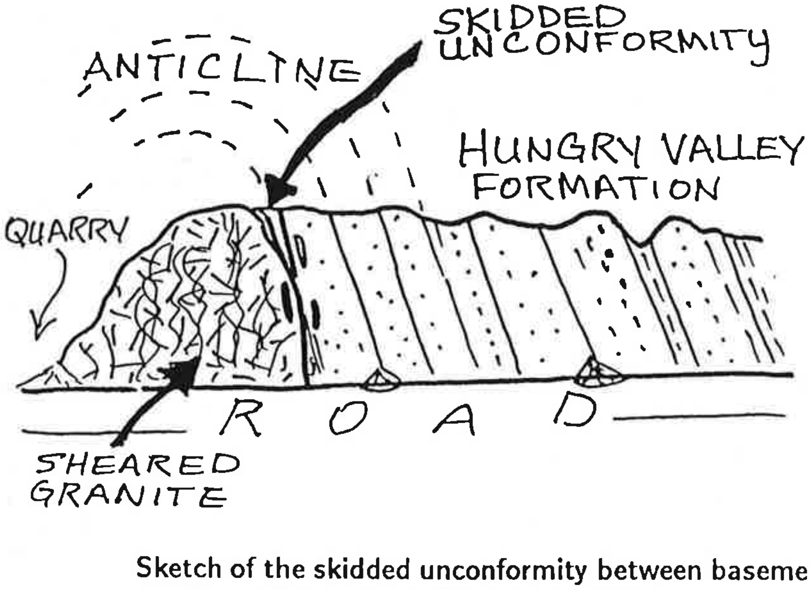
Overlying the marine rocks is the nonmarine fluvial-deltaic sequence of the upper part of the Marple Canyon Sandstone Member (Figure 25). It is well exposed along the Old Ridge Route north of Templin Highway. It consists of interbedded sandstone and mudstone which form laterally continuous beds interpreted to be deltaic deposits. Vertebrate remains, nonmarine mollusks and ostracodes, and charophytes occur in this upper section. Trough- and planar-cross bedding, climbing ripples, parallel laminae, and scour channels are common. Overlying these continuous beds is a thick interval of conglomeratic sandstone and conglomerate. These units are highly cross bedded and contain numerous channel lags. They are interpreted to be braided-fluvial deposits. These fluvial-deltaic deposits mark the start of nonmarine sedimentation in Ridge Basin and apparently prograded over deeper-marine deposits as the basin filled.

From Link, M. H., and Wood, M. F., 1987, Ridge basin field trip guide, *in* Link, M. H., ed., Sedimentary facies, tectonic relations, and hydrocarbon significance in Ridge basin, California: Society of Economic Paleontologists and Mineralogists, Pacific Section, book 51, p. 49-61.

STOP 2

Skidded Unconformity & Hungry Valley Formation

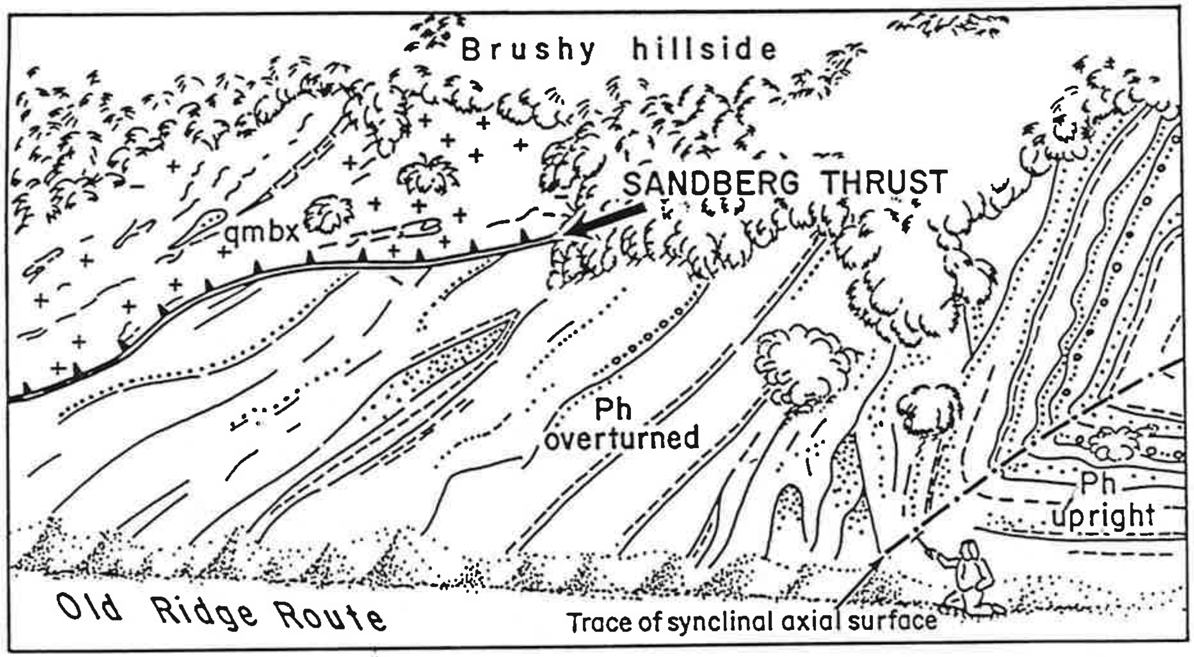
Roadcuts along Peace Valley Road, west of the interchange between Interstate 5 and Highway 138, expose deformed sandstone, conglomerate and shale of the Hungry Valley Formation, lying unconformably upon granitic basement (Figure 12). The unconformity is characterized by about 1 ft (0.3 m) of gouge and is now a zone of tectonic movement. It is interpreted as a skidded unconformity, or a zone of detachment that can be traced westward and then southward and eastward all the way around the northwestward plunging end of an anticline (Crowell, 1975, 1982). The core of the anticline consists of granite that is sheared and locally pulverized. In the roadcut the skidded unconformity is nearly vertical, and Hungry Valley beds to the north have been disrupted and at places torn into phacoids. Sedimentary structures, including trough cross bedding and conglomerate-clast imbrication, indicate that the source of these sediments was to the north, across the present location of the active San Andreas fault zone, only 1.5 mi (2.4 km) to the northeast. The pebbles show that the source consisted mainly of granitic, gneissic, and volcanic rocks. The canyon south of the anticline exposes a sedimentary breccia interpreted as coarse debris deposited along the hanging-wall lip of a buried strand of the Liebre fault zone (Crowell et al., 1982, Plates 1 and 2).



Sketch of the skidded unconformity between basement rocks and the Hungry Valley Formation.

From Link, M. H., and Wood, M. F., 1987, Ridge basin field trip guide, *in* Link, M. H., ed., Sedimentary facies, tectonic relations, and hydrocarbon significance in Ridge basin, California: Society of Economic Paleontologists and Mineralogists, Pacific Section, book 51, p. 49-61.

STOP 3



Syncline beneath the Sandberg "slust." Note the axial surface is inclined to the south.

Sandberg Thrust

Basement rocks have been thrust upon sandstone and conglomerate of the Hungry Valley Formation in the Bald Mountain area (Figures 4, 5). The low-angle thrust is well exposed in several road cuts for over one-half mile (1 km) north of the Oakdale Canyon Guard Station at the intersection of the Old Ridge Route with Pine Mountain Road (Highway N2). Here shattered and sheared granitic rocks and gneisses have been emplaced upon deformed Hungry Valley beds by processes that probably involve a combination of both tectonics and downslope gravity sliding. The Sandberg thrust has been cut, sliced, and dismembered by displacements along the San Andreas fault zone, and pieces of it are exposed over a distance of three miles (5 km) (Figure 4). Its exposed deeper parts dip steeply to the south, whereas the upper parts dip more gently and at places bend over and grade into landslides. Local exposures suggest that it is a combination of a thrust and a slide and has been referred to as a "thride" or "slust" by Crowell (1975, 1982). Sandstone and conglomerate beds beneath the Sandberg thrust are overturned at one of the places we will examined on the field trip. The axial surface of the syncline beneath the thrust is inclined to the south indicating north vergence (Figure 5).

From Link, M. H., and Wood, M. F., 1987, Ridge basin field trip guide, *in* Link, M. H., ed., Sedimentary facies, tectonic relations, and hydro-carbon significance in Ridge basin, California: Society of Economic Paleontologists and Mineralogists, Pacific Section, book 51, p. 49-61.

STOP 3

(Comments by Peter Weigand)

Evidence for 160 km Offset along the Southern San Andreas Fault

Distinctive bodies of monzogranite to quartz monzonite in the Liebre Mtn. region near Gorman and on the opposite side of the San Andreas fault in the Mill Creek region of the San Bernardino Mtns. appear to be fragments of a formerly continuous pluton that has been severed by the fault. The two bodies share numerous features. 1) presence of characteristic K-feldspar megaphenocrysts (average lengths = 16 mm); 2) groundmass of plagioclase, quartz, and hornblende ± biotite; 3) Triassic intrusive ages (215 Ma from U-Pb on zircon); 4) same modal and chemical compositions; 5) initial $^{87}Sr/^{86}Sr$ ratios of 0.7096; and 6) Late Cretaceous thermal event (75-70 Ma).

Frizzell, V. A., Jr., Mattinson, J. M., and Matti, J. C., 1986, Distinctive Triassic megaporphyritic monzogranite: Evidence for only 160 km offset along the San Andreas fault, southern California: Journal of Geophysical Research, v. 91, p. 14,080-14,088.

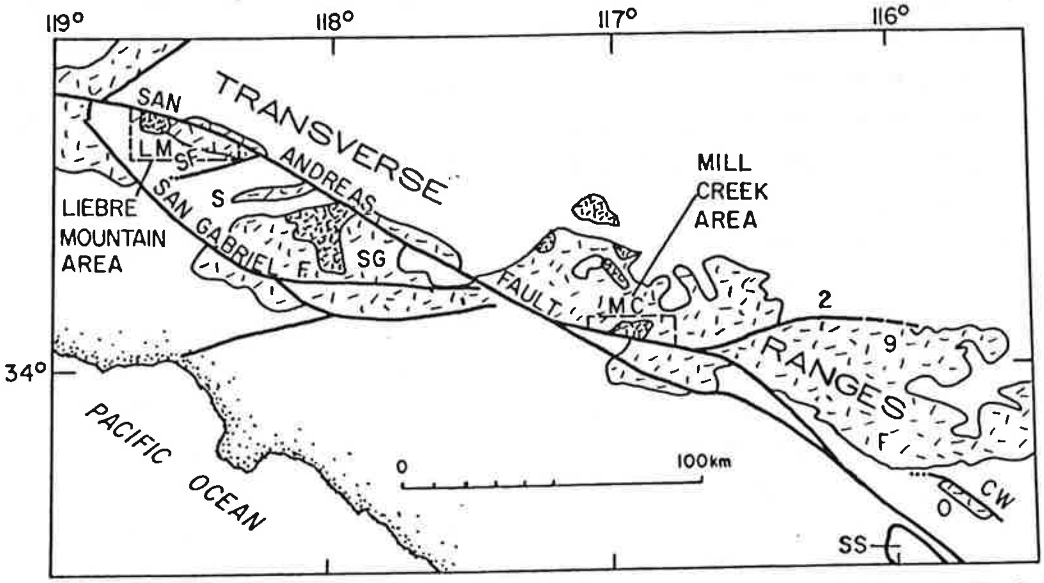


Fig. 1. Map showing areas underlain by granitoid rocks (shown by pattern), Transverse Ranges, California. Mill Creek and Liebre Mountain areas indicated by dashed boxes shown in more detail in Figure 2. Localities underlain by the various monzonitic bodies shown by heavier granitic pattern. O, Orocopia Mountains; LM, Liebre Mountain; MC, Mill Creek; S, Soledad basin; SG, San Gabriel Mountains; SS, Salton Sea; 2 and 9, the Twentynine Palms quartz monzonite offset by Pinto Mountain fault; CW and SF, major segments of Clemens Well–Fenner–San Francisquito fault of *Powell* [1981].

STOP 4

(Comments by Peter Weigand)

THE NEENACH-PINNACLES VOLCANIC FIELD - TORN APART AND DISPLACED 315 KM BY THE SAN ANDREAS FAULT

The San Andreas fault is probably the most famous fault in the world. Considerable evidence suggests that the fault in central California represents about 295 to 325 km of offset (Huffman, 1972; Matthews, 1973a; Ross, 1984; Graham and others, 1989). Primary among the rock units considered offset by the fault are the Neenach Volcanics, located adjacent to and NE of the San Andreas fault in the western Mojave Desert between Palmdale and Gorman, and the Pinnacles Volcanics, the centerpiece of Pinnacles National Park, located adjacent to and SW of a strand of the fault east of Monterey and south of San Juan Bautista (Fig. 1). These 24- to 22-Ma (million year old) volcanic units are considered among the most robust of the offset rock units (Dickinson, 1996; Irwin, 1990; Atwater, 1989).

Several types of geologic features have been offset by the San Andreas fault in central California (Fig. 2). These include granitic country rock, sedimentary depositional complexes, volcanic rocks, and other paleogeographic features. These displaced features provide a means to document the amount of offset as well as the history of offset. Unfortunately, many displaced features have poorly defined margins, are dated only approximately, or are not adjacent to the fault, so that palinspastic restoration of fault movement typically entails uncertainties of tens of kilometers and millions of years since the beginning of displacement (Matthews, 1976; Graham and others, 1989).

The Neenach-Pinnacles correlation provides some of the most conclusive documentation of large scale, lateral displacement on the San Andreas yet documented in central California for several reasons (Matthews, 1997). 1) A precise distance of separation can be determined because both areas are adjacent to traces of the fault, thus eliminating the necessity of interpretive projection into the fault. 2) The volcanic nature of the rocks makes them potentially suitable for accurate radiometric dating. 3) Ten different rock units, each with distinctive petrologic features, are common to both areas, thus reducing the likelihood of chance occurrence.

Neenach Volcanics

The Neenach Volcanics mostly lie on private land, which makes access difficult. Wiese (1950) and Dibblee (1967) included the volcanic rocks in regional studies. Following early suggestions that the volcanic rocks in the Neenach and Pinnacles areas were once adjacent, Matthews (1973b) mapped the volcanic rocks. He found eight units to consist of calc-alkaline andesite, dacite, and rhyolite flows interbedded with pyroclastic and volcaniclastic rocks, very similar to those in Pinnacles National Monument. In contrast to the situation at Pinnacles, however, contacts between units are obscured, making it difficult to reconstruct the stratigraphy. As at Pinnacles, the volcanic rocks at Neenach rest nonconformably on Cretaceous granitic rocks and are overlain unconformably by the upper Miocene Santa Margarita Formation (Wiese, 1950). Matthews (1973b) estimated that the volcanic pile attains a thickness of about 1.4 km. The southern exposures of the Neenach Volcanics are truncated by the San Andreas fault; five minor exposures of these volcanic rocks crop out as fault slivers along the fault a few kilometers to the northwest near Gorman. Based on older K-Ar dates and more recent Ar-Ar dating, the Pinnacles and Neenach Volcanics erupted between about 24 and 22 Ma. (Matthews, 1973b, Weigand and Matthews, in prep.).

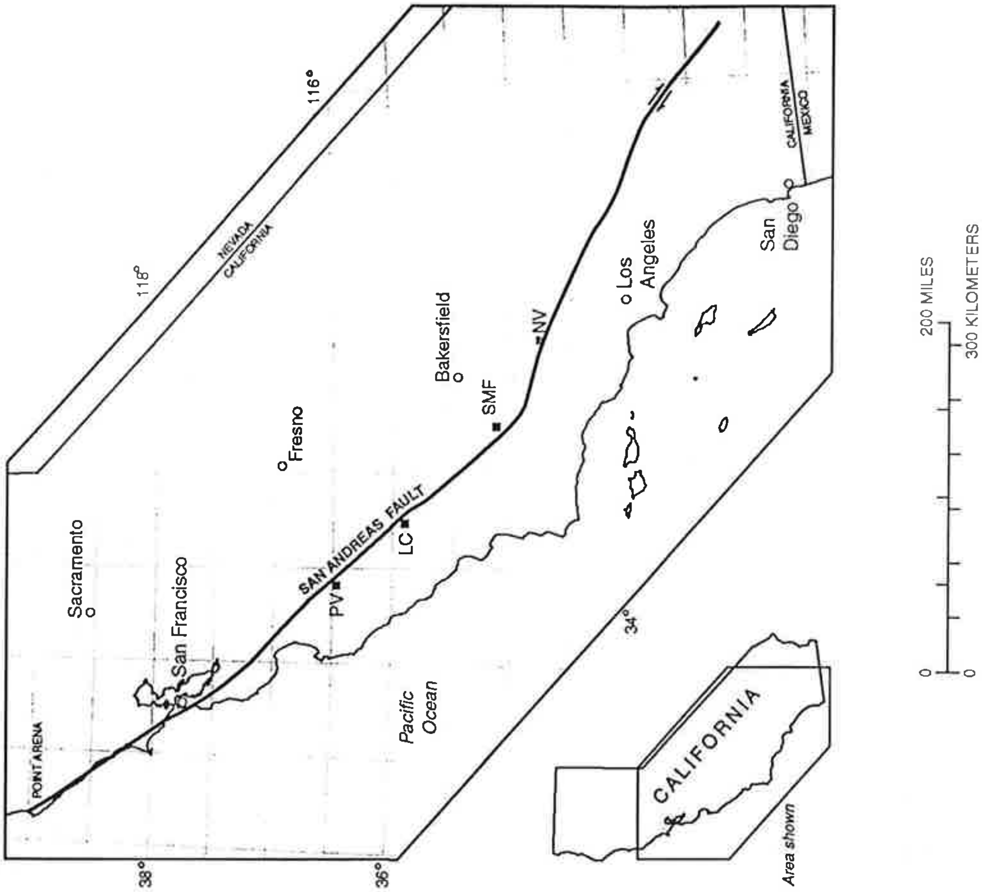


Figure 7. Map showing approximate locations of units in central California offset related to the Neenach (NV) and Pinnacles (PV) Volcanics; SMF = clasts in the Santa Margarita Formation, LC = volcanics of Lang Canyon at Parkfield. Map modified from Stanley and others (2000).

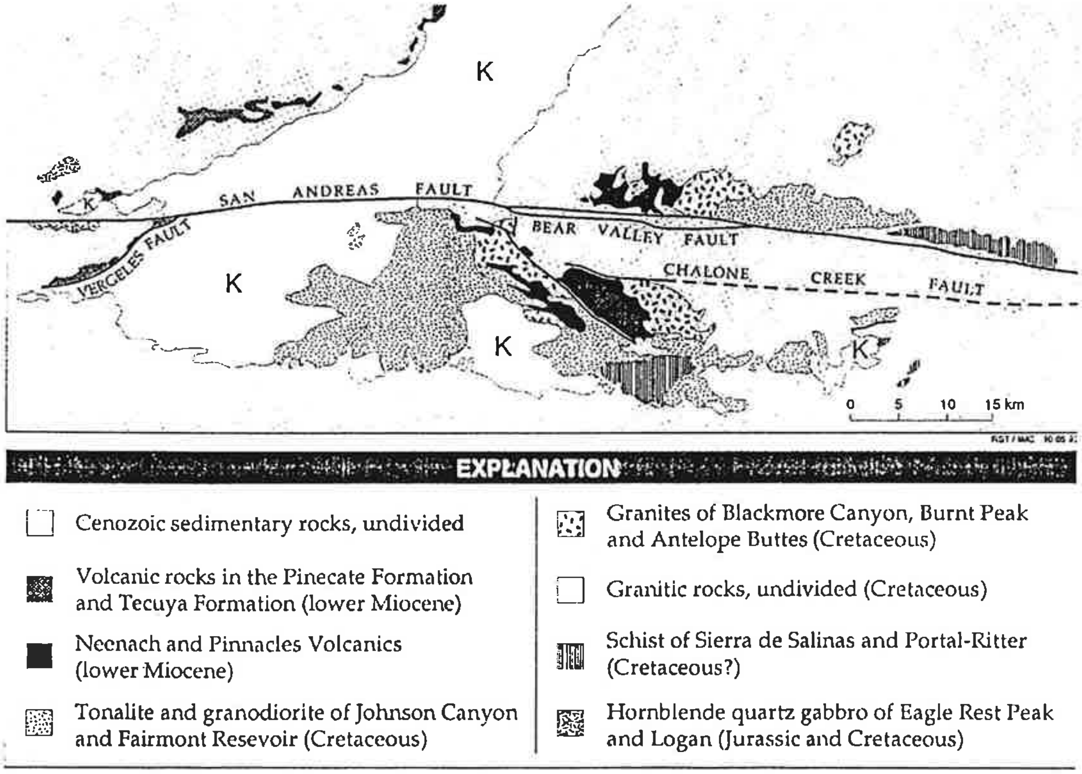
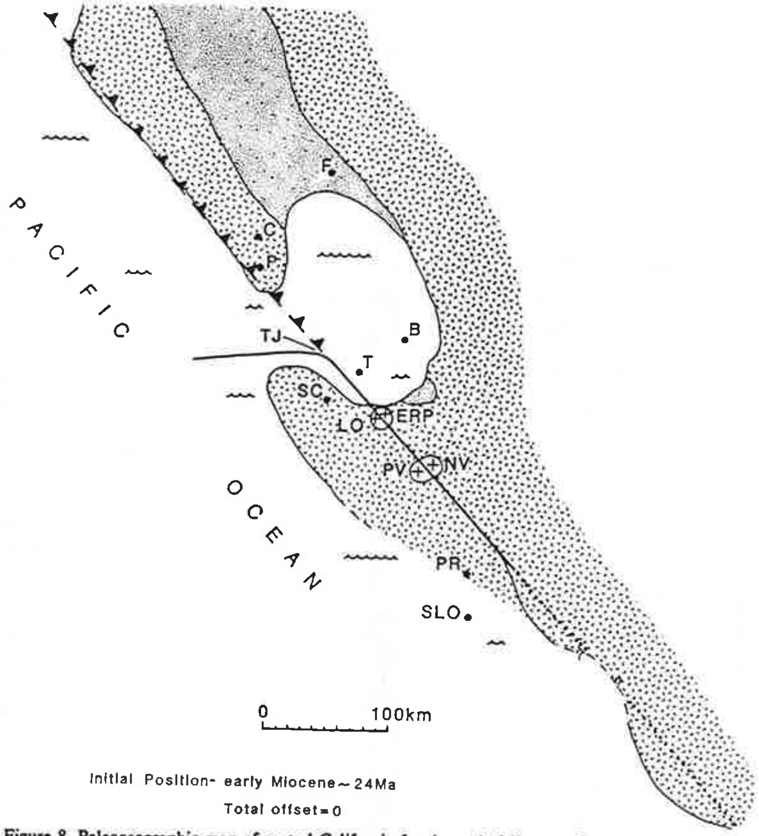


Figure 2. Geologic map showing palinspastic reconstruction of the Neenach and Pinnacles Volcanics and other rock units. The main mass of the Pinnacles is placed opposite the Neenach Volcanics. Crystalline basement rocks of the Johnson Canyon, Burnt Peak, and Fairmont Reservoir bodies, which bear distinctive sphene crystals, are correlated. Granitic rocks that bear salmon-pink K-spar phenocrysts, the Bickmore Canyon and parts of the Burnt Peak and Fairmont Reservoir bodies are also correlated. (Modified from Sims, 1993, and Ross, 1984.)

Four figures showing the possible offset history of the central San Andreas fault.

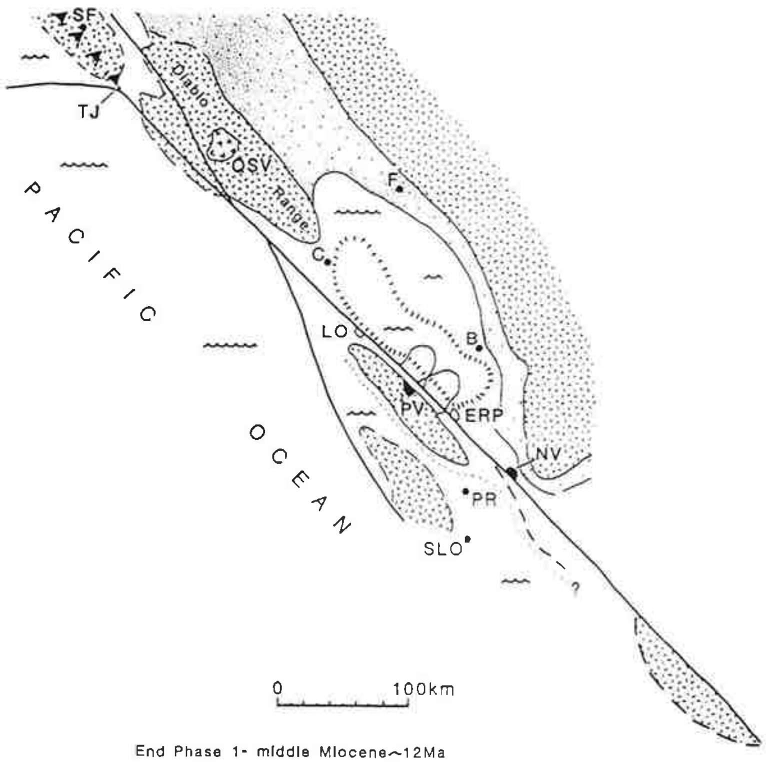
Sims, J. D., 1993, Chronology of displacement on the San Andreas fault in central California: Evidence from reversed positions of exotic rock bodies near Parkfield, California, *in* Powell, R. E., Weldon, R. J. II, and Matti, J. C., eds., The San Andreas fault system: Displacement, palinspastic reconstruction, and geologic evolution: Boulder, Colorado, Geological Society of America Memoir 178, p. 231-256.



Initial Position- early Miocene~24Ma

Total offset=0

Figure 8. Paleogeographic map of central California for the early Miocene after the eruption of the Neenach/Pinnacles and Tecuya/San Juan Bautista Volcanics. Shorelines and depositional units taken from Bartow (1987), Perkins (1987) and Graham and others (1989). C = Coalinga; B = Bakersfield; ERP = gabbro of Eagle Rest Peak; F = Fresno; LO = gabbro of Logan; NV = Neenach Volcanics; P = Parkfield; PR = Paso Robles; PV = Pinnacles Volcanics; QSV = Quien Sabe Volcanics; SC = Santa Cruz; SF = San Francisco; SLO = San Luis Obispo; SV = Sonoma Volcanics; TJ = Mendocino triple junction.



End Phase 1- middle Miocene~12Ma

Offset this Phase~95km

Total Offset~95km

Figure 9. Paleogeographic map of central California for the early Miocene after the eruption of the Neenach/Pinnacles and Tecuya/San Juan Bautista Volcanics. Shorelines and depositional units taken from Bartow (1987), Perkins (1987) and Graham and others (1989). C =Coalinga; B = Bakersfield; ERP = gabbro of Eagle Rest Peak; F = Fresno; LO = gabbro of Logan; NV = Neenach Volcanics; P = Parkfield; PR = Paso Robles; PV = Pinnacles Volcanics; QSV = Quien Sabe Volcanics; SC = Santa Cruz; SF = San Francisco; SLO = San Luis Obispo = SV = Sonoma Volcanics; TJ = Mendocino triple junction. Phase 1 of the evolution of the San Andreas fault began with strike-slip movement following eruption of the (composite) Neenach-Pinnacles Volcanics and the volcanic rocks in the Tecuya Formation. The end of Phase 1 is placed at the time flow-banded rhyolite clasts first occur in the Santa Margarita Formation in the southern Temblor Range. The age of the Santa Margarita is here considered to be ~12 Ma. The time span of Phase 1 is about 10 m.y. The amount of slip is 95 km. Thus the minimum slip rate for Phase 1 is 9.5 mm/yr.

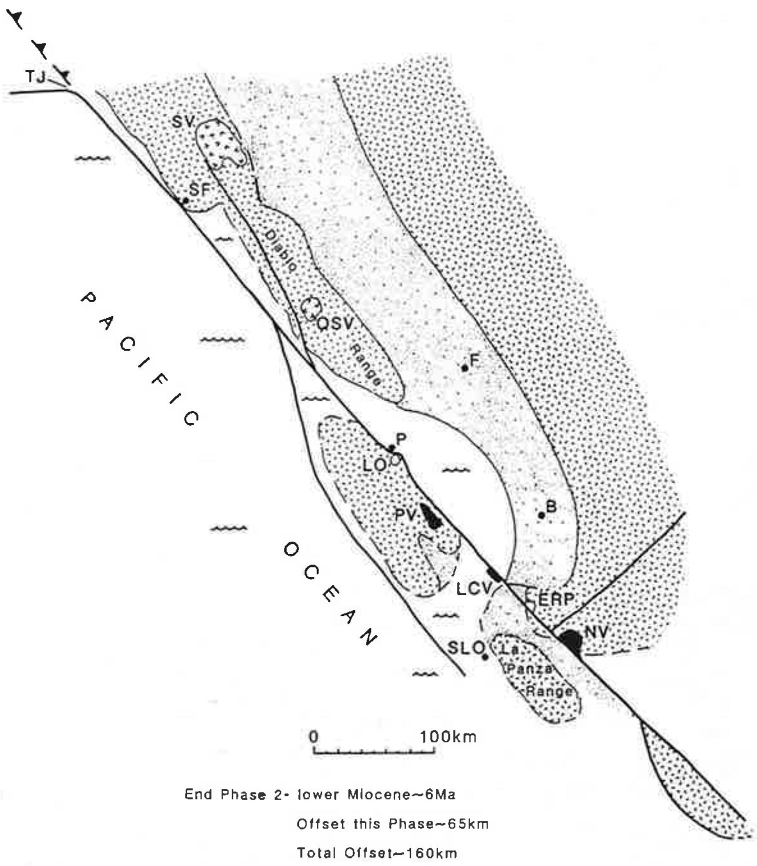


Figure 11. Paleogeographic map of central California for the early Miocene after the eruption of the Neenach/Pinnacles and Tecuya/San Juan Bautista Volcanics. Shorelines and depositional units taken from Bartow (1987) and Perkins (1987). C = Coalinga; B = Bakersfield; ERP = gabbro of Eagle Rest Peak; F = Fresno; LO = gabbro of Logan; NV = Neenach Volcanics; P = Parkfield; PR = Paso Robles; PV = Pinnacles Volcanics; QSV = Quien Sabe Volcanics; SC = Santa Cruz; SF = San Francisco; SLO = San Luis Obispo; SV = Sonoma Volcanics; TJ = Mendocino triple junction. Phase 2—strike-slip movement is transferred to a new segments of the San Andreas and the older segment occupied during Phase 1 becomes inactive. The new segment severs the sliver composed of the now designated volcanic rocks of Lang Canyon from the Neenach Volcanics. The distance between the Pinnacles Volcanics and the volcanics of Lang Canyon remains constant. The end of Phase 2 is chosen as the time of slivering of the Gold Hill sliver from Logan body about 7 m.y. ago. The distance between the Logan unit and Gold Hill unit at the end of stage 1 is 65 km. This stage is estimated at about 7 m.y. long. Thus the minimum slip rate for Phase 2 is 8 mm/yr.

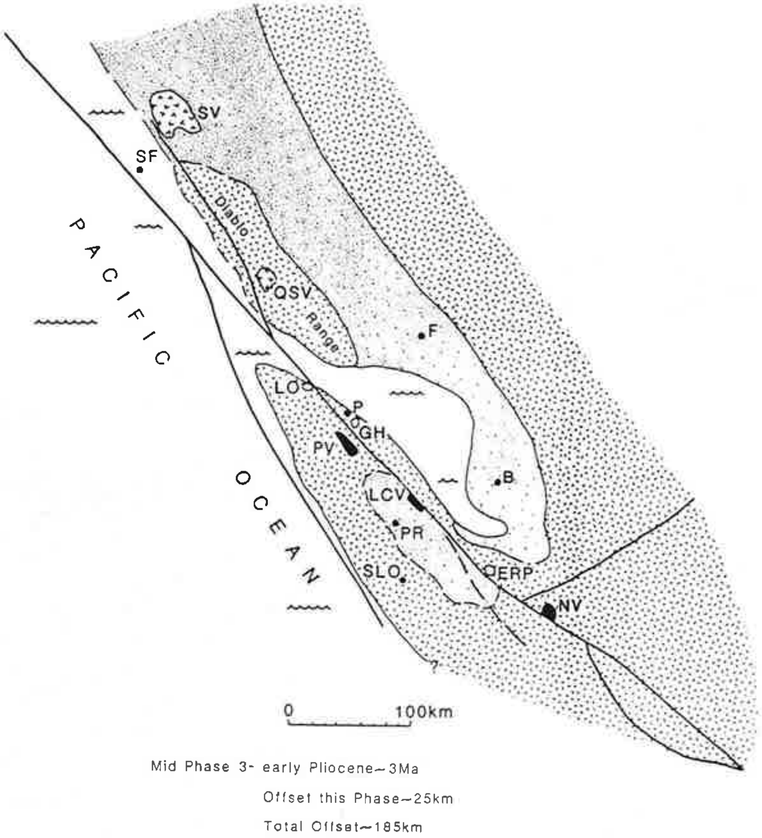
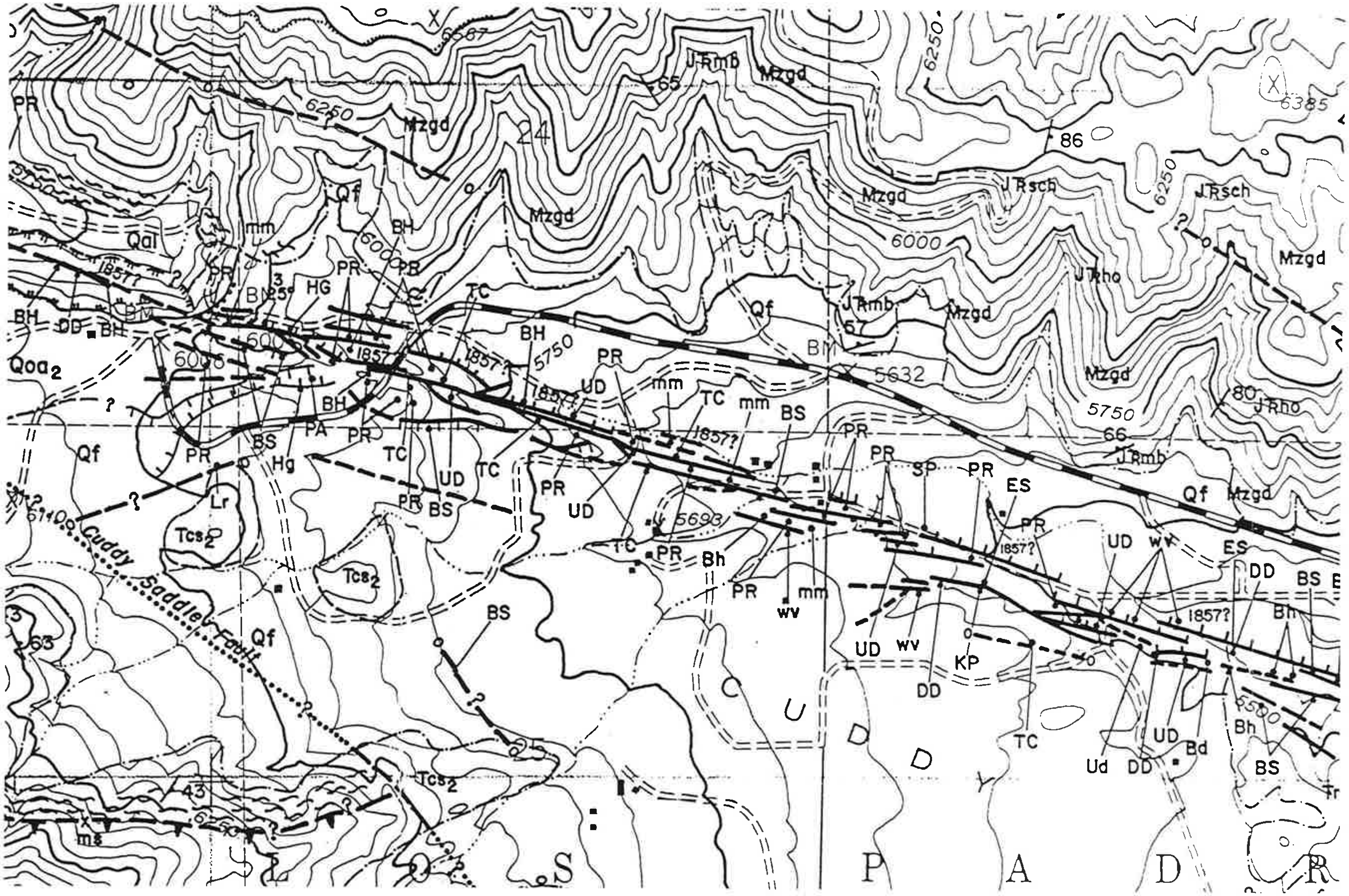


Figure 12. Paleogeographic map of central California for the early Miocene after the eruption of the Neenach/Pinnacles and Tecuya/San Juan Bautista Volcanics. Shorelines and depositional units taken from Bartow (1987), and Perkins (1987). C = Coalinga, B = Bakersfield, ERP = gabbro of Eagle Rest Peak, F = Fresno, LO = gabbro of Logan, NV = Neenach Volcanics, P = Parkfield, PR = Paso Robles, PV = Pinnacles Volcanics, QSV = Quien Sabe Volcanics, SC = Santa Cruz, SF = San Francisco, SLO = San Luis Obispo, SV = Sonoma Volcanics, TJ = Mendocino triple junction. Phase 3—follows the slivering off of the Gold Hill block. Right-lateral movement continues to the present time. The distance between the Pinnacles Volcanics and the volcanic rocks of Lang Canyon remains the same as does the distance between the gabbro of Logan and the Pinnacles Volcanics. The distance from the Gold Hill unit to the present location the gabbro of Logan is 165 km, which is also the distance required to bring the volcanic rocks of Lang Canyon to its present position. This phase is estimated as being about 5 m.y. Thus the slip rate for Phase 3 is 33 mm/yr. See text for discussion.

STOP 5



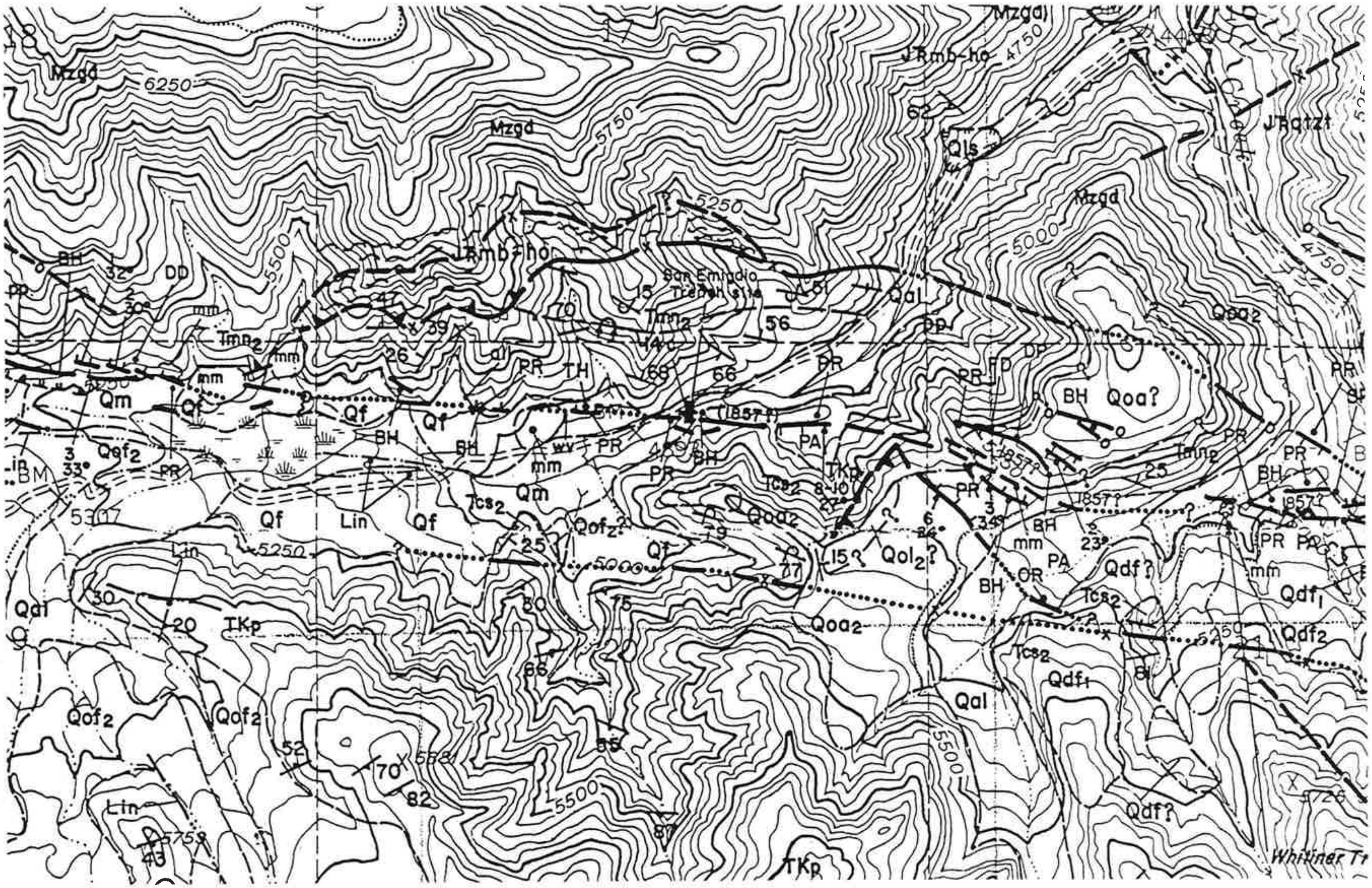
From Davis, T. L., and Duebendorfer, E., 1987, Strip map of San Andreas fault western big bend segment: Geological Society of America, map and chart series MC-60, scale 1:31,682.

Directions to Stop 7 - Continue westward on Mil Potrero Highway. At **6.2 mi** park off the right side of the road near Ward Drive. Walk to the roadcut just ahead for Stop 7.

Directions to Stop 8 - Continue westward on Mil Potrero Highway. At **6.9 mi** turn right (north) onto Nesthorn Way. At about **7.1 mi** park for Stop 8.

Directions to Fritsche cabin - Return to Mil Potrero Highway and turn left (east), then almost immediately right (south) onto San Moritz Drive, and immediately right (west) onto Mil Potrero Frontage Road. The address is 15520 Mil Potrero Frontage Road.

STOPS 6, 7, and 8



From Davis, T. L., and Duebendorfer, E., 1987, Strip map of San Andreas fault western big bend segment: Geological Society of America, map and chart series MC-60, scale 1:31,682.

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DAY 2, Thursday, August 22

Directions to Stop 9 - At the Fritsche cabin, note odometer mileage or **set trip odometer to 0.0 mi**. Travel west on Mil Potrero Highway past Pine Mountain Club to Apache Saddle, where the Mil Potrero Highway meets Cerro Noroeste Road. Bear right (north) and follow Cerro Noroeste Road past the road to Caballo Camp. At **6.0 mi** pull off at a wide cleared area on the right side of the road for Stop 9.

Directions to Stop 10 - Continue northward on Cerro Noroeste Road past the Los Padres National Forest boundary to **15.5 mi** and park on the right side of the road for Stop 10. In the roadcut on the left side of the road is the conformable contact between the Oligocene, nonmarine Simmler Formation and the Oligocene to lower Miocene, marine Soda Lake Shale Member of the Vaqueros Formation. Overlying these two formations in angular unconformity is the Pliocene, nonmarine Quatal Formation.

Directions to Stop 11 - Continue northward on Cerro Noroeste Road to **19.0 mi** and park on the right side of the road for Stop 11. Walk westward through the gate to the Wildlife Refuge to the top of the hill for an overview of the Sierra Madre, Cuyama Valley, and Caliente Range.

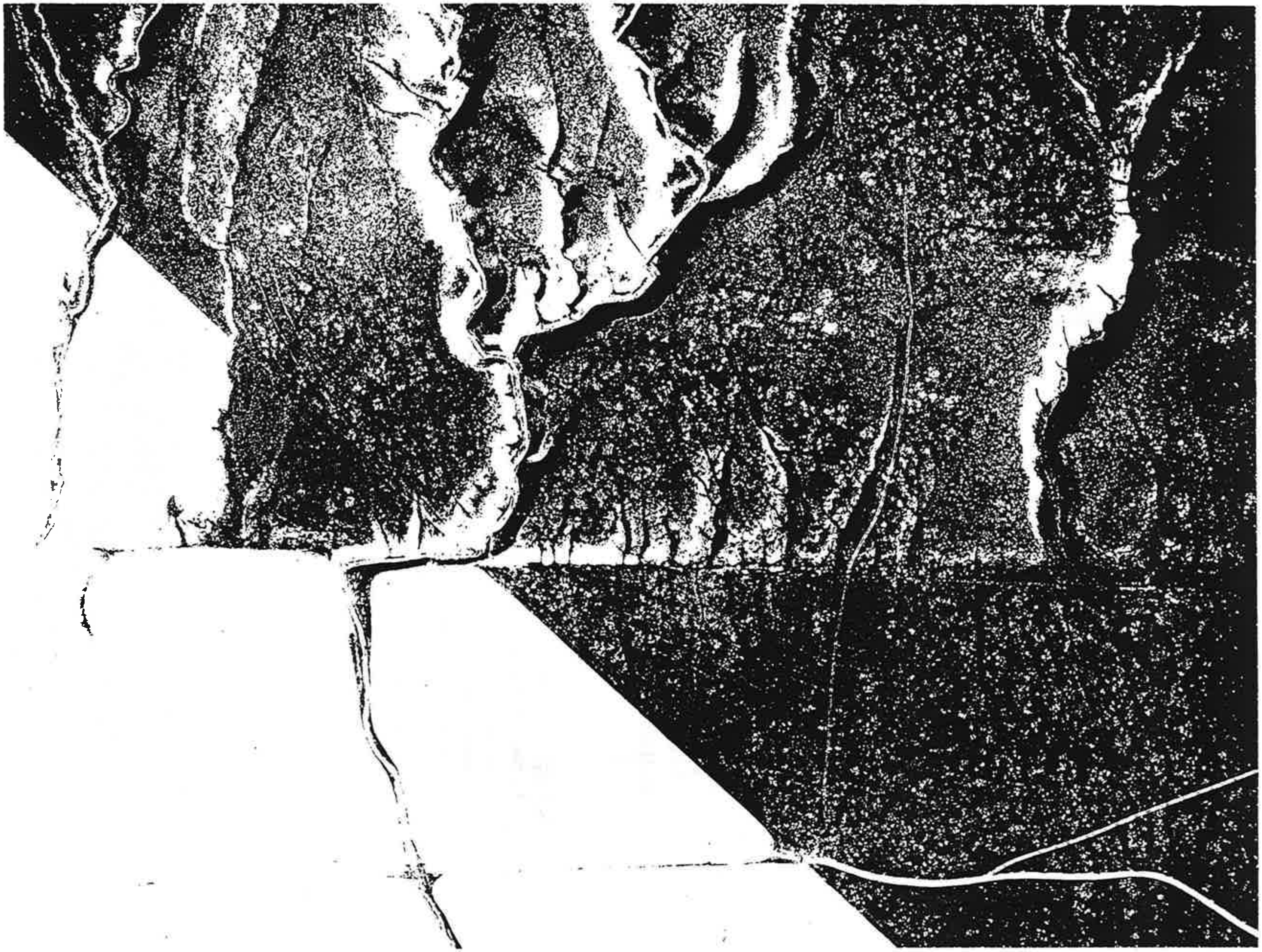
Directions to Stop 12 - Continue northward on Cerro Noroeste Road to its intersection with Highways 33 and 166 at **24.9 mi**. Turn right (east) on Highway 33/166 and go **0.2 mi** to Soda Lake Road. Turn left (north) on Soda Lake Road. Follow Soda Lake Road to Elkhorn Road and turn right (northeast) on Elkhorn Road. Stay on Elkhorn Road for **31.5 mi**, at which point you will find a parking area on the right with explanation signs that describe the San Andreas fault features at Wallace Creek. This is Stop 12.

Directions to Stop 13 - Reset your trip odometer to 0.0 mi and proceed northward on Elkhorn Road. At **0.8 mi** the road crosses the San Andreas fault and at **3.4 mi** from Stop 12 is an intersection with 7-Mile Road. Turn right (northeast) on 7-Mile Road and go 0.3 mi to an intersection with Carrisa Highway (Highway 58). Note the mileage on your odometer or **set your trip odometer to 0.0 mi**. Turn left (west) on Carrisa Highway and follow it for **36.3 mi**. At this point, bear to the right (northwest) onto La Panza Road. At **46.2 mi** the road intersects with Highway 41. Cross Highway 41 and continue northeastward on Creston Road. Stay on Creston Road to Paso Robles. At **59.3 mi** cross the Salinas River and the Highway 101 freeway. At **59.7 mi** turn right (north) on Spring Street and at **60.6 mi** turn left (west) on 24th Street. At **60.7 mi** turn right (north) on Vine Street and park on the right side of the road by the high school football field. The roadcut on the left side of the road is an exposure of the Plio-Pleistocene, nonmarine Paso Robles Formation, which is the focus of interest at Stop 13.

STOP 9

From Davis, T. L., and Duebendorfer, E., 1987, Strip map of San Andreas fault western big bend segment: Geological Society of America, map and chart series MC-60, scale 1:31,682.

STOP 12



STOP 12

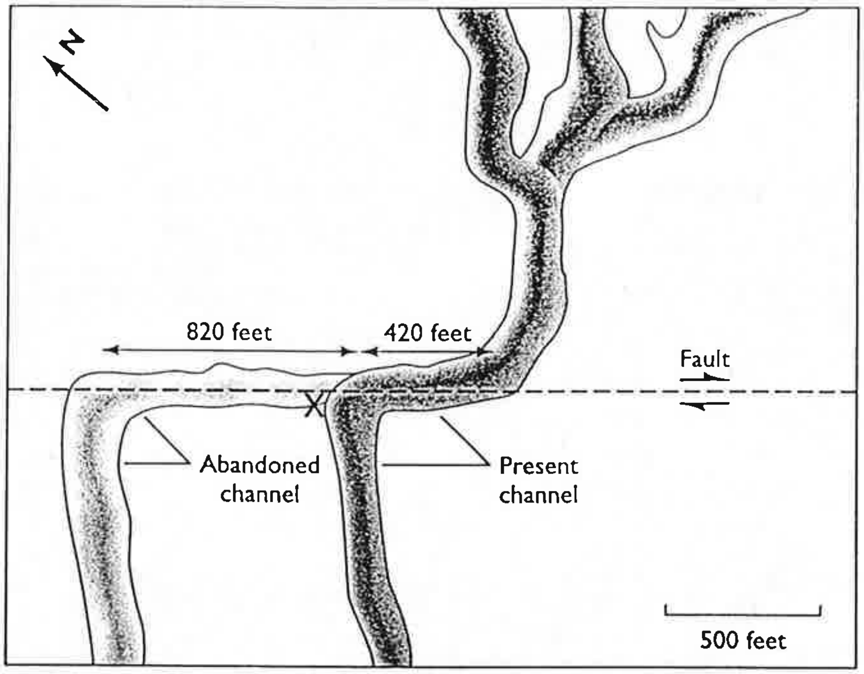


Diagram of Wallace Creek showing the current and abandoned channels and the site where samples for carbon dating were found (marked X*). (Based on a drawing by R. Wallace)*

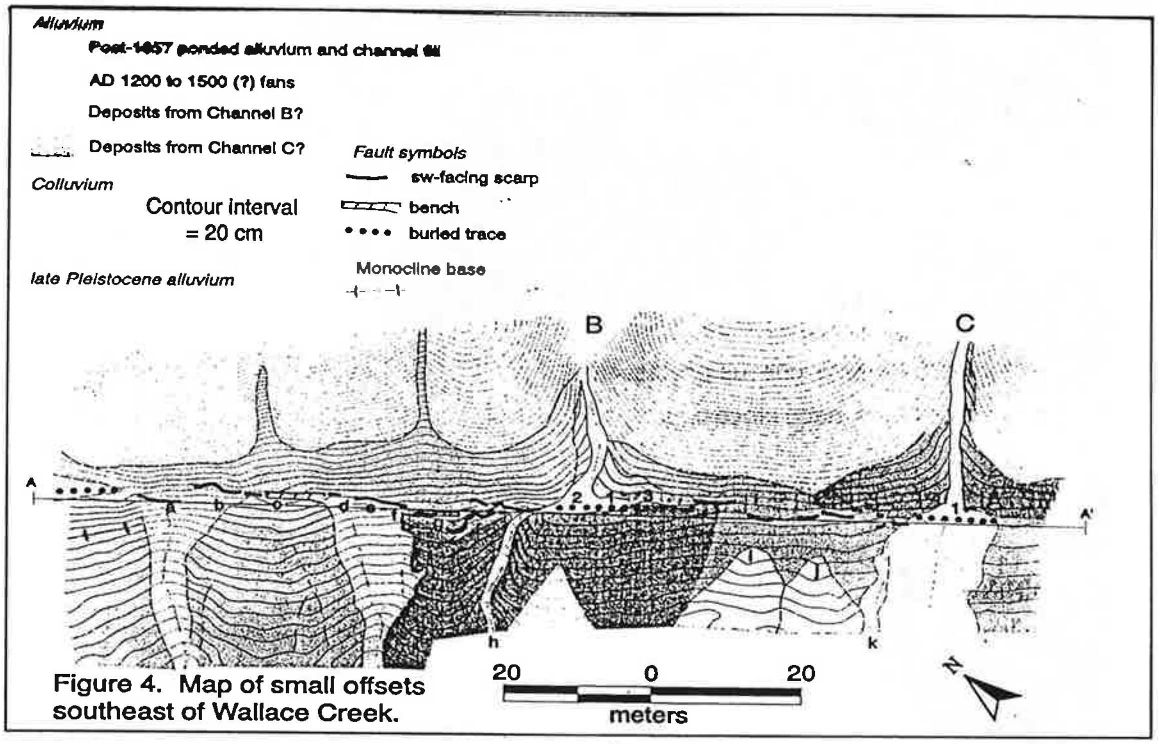


Figure 4. Map of small offsets southeast of Wallace Creek.

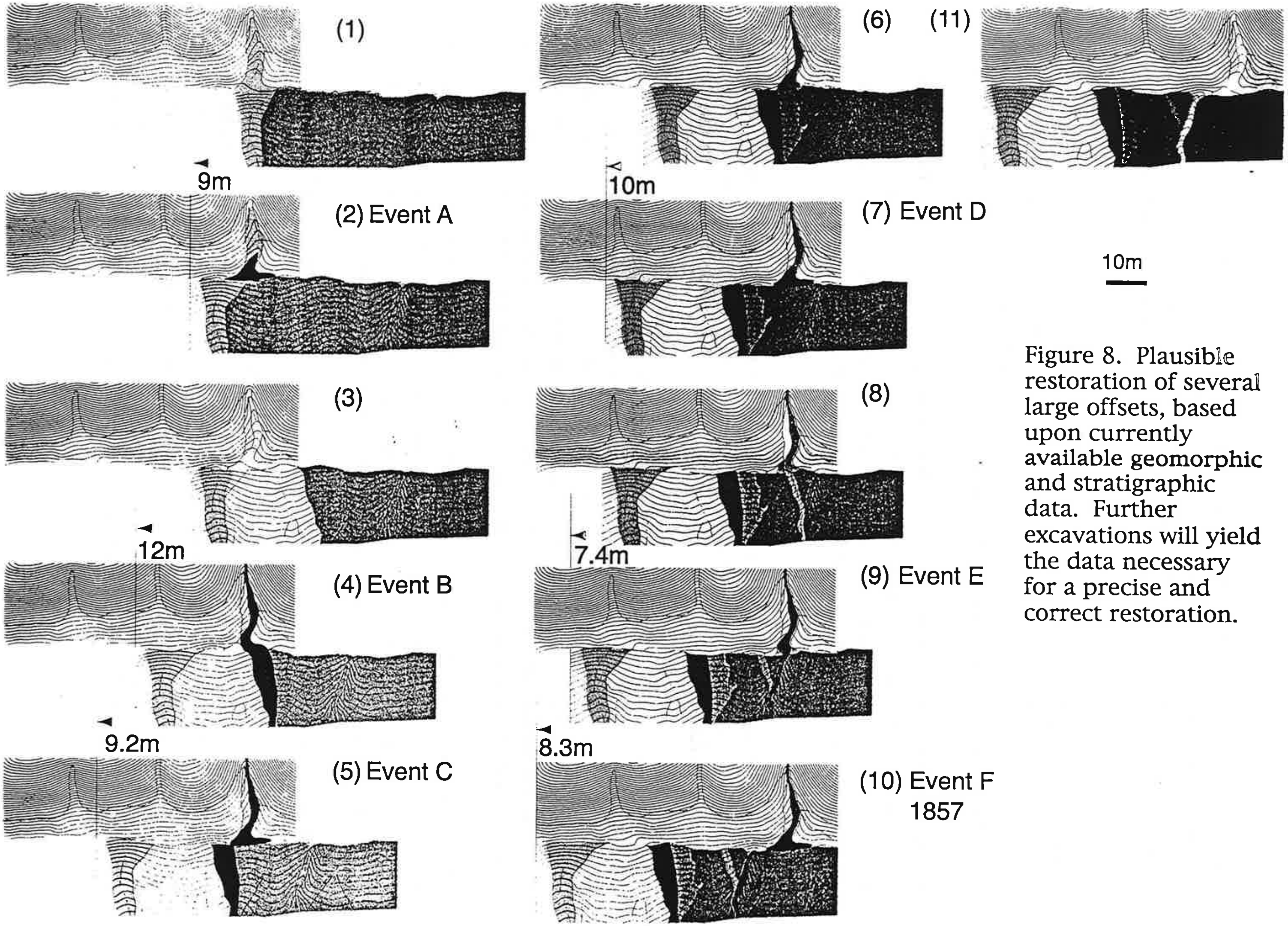


Figure 8. Plausible restoration of several large offsets, based upon currently available geomorphic and stratigraphic data. Further excavations will yield the data necessary for a precise and correct restoration.

Directions to Stop 14 - Return to the corner of 24th and Vine Streets and note the mileage on your odometer or **set your trip odometer to 0.0 mi**. Turn right (west) on 24th Street which in a short distance becomes Nacimiento Lake Road. At **1.7 mi** pass Adelaida Road and bear right, continuing on Nacimiento Lake Road. At **2.5 mi** pull off to the right side of the road and park by a granite quarry. This is Stop 14.

Directions to Stop 15 - Continue northward on Nacimiento Lake Road. At **5.9 mi** pass the junction with San Marcos Road, remaining on Nacimiento Lake Road. At **6.8 mi** park on the right side of the road opposite the intersection with Old Nacimiento Road. Here at Stop 15 we will look at the Miocene, deep-marine Monterey Formation.

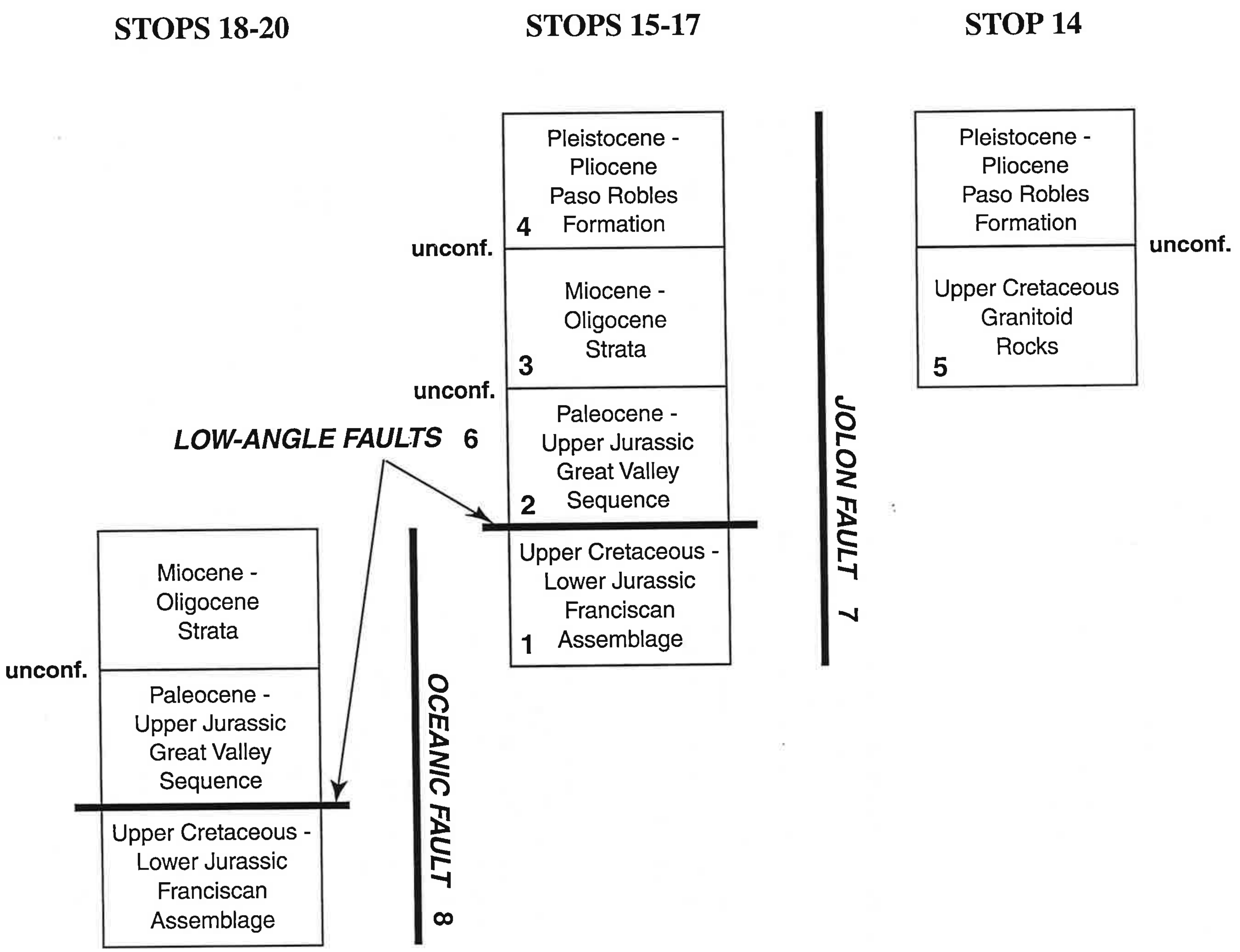
Directions to Stop 16 - Continue westward on Nacimiento Lake Road to **7.7 mi**. Park in the wide spot on the left side of the road. Here at Stop 16 we will observe at a distance the poorly exposed lower Miocene, shallow-marine Tierra Redonda (Vaqueros) Formation and its unconformable contact with even more poorly exposed Paleocene rocks. These rocks are part of what is called the Great Valley sequence.

Directions to Stop 17 - Leaving the parking area, bear left (southwest) on Chimney Rock Road. At **10.1 mi** park on the left side of the road. The roadcut here at Stop 17 exposes Cretaceous, marine rocks of the Great Valley sequence.

Directions to Stop 18 - Continue westward on Chimney Rock Road. At **13.6 mi** turn left (south) on Adelaida Road; at **14.8 mi** turn right (southwest) onto Klau Mine Road; and at **17.0 mi** turn right (southwest) onto Cypress Mountain Road. Stop 18 consists of three roadcuts on the left (south) side of the road in the Franciscan Assemblage: the first at **17.6 mi**, next at **17.8 mi**, and last at **18.3 mi**. For each of them park off the road as best possible. We will look at each of them, then have a general discussion on the nature of the Franciscan Assemblage (a melange) at the last roadcut.

Directions to Stop 19 - Continue westward on Chimney Rock Road. At **20.0 mi** park off the raod for Stop 19. Located here is the contact between the Franciscan Assemblage to the north and the Upper Cretaceous, deep-marine Atascadero Formation (part of the Great Valley sequence) to the south. We will observe the nature of the contact and discuss its origin here.

Directions to Stop 20 - Continue southward on Chimney Rock Road. At **21.7 mi**, just before Whispering Ridge Ranch, where the forest gives way to grass-covered hills, is the same contact as was seen at Stop 19, but with the Atascadero Formation on the north and the Franciscan Assemblage on the south. At **23.8 mi** turn right (west) on Santa Rosa Creek Road. At **24.0 mi** is a contact between Franciscan melange on the south and the Upper Jurassic -Lower Cretaceous, deep-marine Toro Formation on the north. The same contact is crossed again at **24.6 mi**. Park off the road near roadcuts at **25.5 mi** for Stop 20. Exposed here are Miocene volcanic rocks. We will discuss the nature of the contact between these rocks and the Franciscan Assemblage at this stop.


STOPS 18-20
STOPS 15-17
STOP 14
Pleistocene - Pliocene Paso Robles Formation
4
unconf.
Miocene - Oligocene Strata
3
unconf.
Paleocene - Upper Jurassic Great Valley Sequence
2
Upper Cretaceous - Lower Jurassic Franciscan Assemblage
1
JOLON FAULT 7
Pleistocene - Pliocene Paso Robles Formation
unconf.
Upper Cretaceous Granitoid Rocks
5
LOW-ANGLE FAULTS 6
Miocene - Oligocene Strata
unconf.
Paleocene - Upper Jurassic Great Valley Sequence
Upper Cretaceous - Lower Jurassic Franciscan Assemblage
OCEANIC FAULT 8

Directions to camp - Continue westward on Santa Rosa Creek Road. Between Stop 20 and the town of Cambria we will pass exposures of the Miocene, deep-marine Monterey Formation, the lower Miocene, shallow-marine Vaqueros Formation, more Miocene volcanic rocks, and more rocks of the Franciscan Assemblage. At **35.8 mi** turn right (northwest) onto Main Street and pass through the quaint town of Cambria. At **37.6 mi** is a stop sign. Turn left and then right onto Highway 1 going north. At **40.2 mi** turn right (east) and at **40.3** mi right (south) again into San Simeon State Beach Camp.

References to geologic maps used on Day 2 -

Durham, D. L., 1968, Geologic map of the Adelaida quadrangle, San Luis Obispo County, California: U.S. Geological Survey, Geologic Quadrangle Map GQ-768, scale 1:24,000.

Hall, C. A., 1974, Geologic map of the Cambria region, San Luis Obispo County, California: U.S. Geological Survey, Miscellaneous Field Studies Map MF-599, 2 sheets, scale 1:24,000.

Seiders, V. M., 1982, Geologic map of an area near York Mountain, San Luis Obispo County, California: U.S. Geological Survey, Miscellaneous Investigations Map I-1369, scale 1:24,000.

References to field guides and geologic maps used on Day 3 -

Dickinson, W. R., and Page, B. M., 1970, Central California Coast Ranges: Geological Society of America, Cordilleran Section, fieldtrip guidebook, 26 p.

Hall, C. A., Jr., 1973, Geologic map of the Morro Bay South and Port San Luis quadrangles, San Luis Obispo County, California: U.S. Geological Survey, Miscellaneous Field Studies Map MF-511, scale 1:24,000.

Hall, C. A., Jr., 1973, Geology of the Arroyo Grande quandrangle, California: California Division of Mines and Geology, map sheet 24, scale 1:24,000.

Hall, C. A., Jr., and Corbató, C. E., 1967, Stratigraphy and structure of Mesozoic and Cenozoic rocks, Nipomo quadrangle, southern Coast Ranges, California: Geological Society of America Bulletin, v. 78, p. 559-582, 4 figs., 2 pls.

Hall, C. A., Jr., and Prior, S. W., 1975, Geologic map of the Cayucos-San Luis Obispo region, San Luis Obispo County, California: U.S. Geological Survey, Miscellaneous Field Studies Map MF-686, scale 1:24,000.

Hall, C. A., Jr., and Surdam, R. C., 1967, Geology of the San Luis Obispo-Nipomo area, San Luis Obispo County, California: Geological Society of America, Cordilleran Section, fieldtrip guidebook, 25 p., 1 map, and 2 stratigraphic columns.

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DAY 3, Friday, August 23

Directions to Stop 21 - Return to Highway 1 and turn left (south). Proceed **7.2 mi** to the intersection of Highway 1 with Highway 46. Note the mileage on your odometer or **set your trip odometer to 0.0 mi**. Turn left (east) onto Highway 46 and go **9.4 mi** to Stop 21 where we will examine one of the Tertiary volcanic rocks of the Coast Ranges.

Directions to Stop 22 - Continue eastward on Highway 46 for **7.9 mi** and turn right (southeast) on Vineyard Drive. Follow Vineyard Drive for **3.0 mi** into the town of Templeton and turn right (south) onto Highway 101. Proceed on Highway 101 into the town of Atascadero and turn right (southwest) onto Highway 41. Note the mileage on your odometer or **set your trip odometer to 0.0 mi** at the Highway 41/101 intersection. At **3.5 mi** park on the right side of the road for Stop 22. Exposed here is a fault contact between Great Valley sequence rocks on the east and Franciscan Assemblage rocks on the west.

Directions to Stop 23 - Continue westward on Highway 41 to **5.7 mi**. Park where possible before entering Devil's Gap. Here at Stop 23 are two contacts: the eastern one is between Great Valley sequence rocks on the east and serpentinized mafic volcanic rocks on the west, the western one is between serpentinized mafic volcanic rocks on the east and Great Valley sequence rocks on the west. We will discuss what type of contacts these two contacts represent.

Directions to Stop 24 - Continue westward on Highway 41 to **8.4 mi**. Park where possible near the entrance to Cerro Alto campground. Between here and Stop 23 the highway has traversed a syncline and at this stop we will examine the mirror image of the contact seen at Stop 23; here it is between Great Valley sequence rocks on the east and serpentinized mafic volcanic rocks on the west.

Directions to Stop 25 - Continue westward on Highway 41 to **9.6 mi** and park in a large turnout on the left (south) side of the road. Exposed here are serpentinized ultramafic plutonic rocks that occur underneath the mafic volcanic rocks seen at Stop 23. The discussion here will be on the origin of the rocks at Stops 23-25.

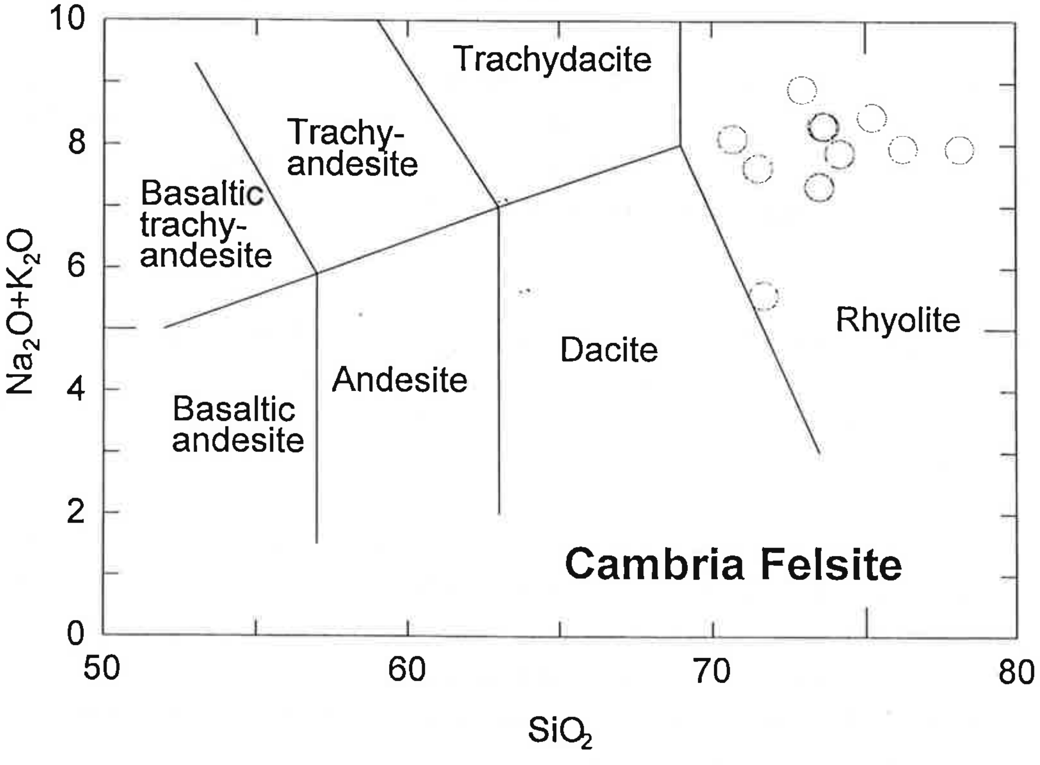
Directions to Stop 26 - Continue westward on Highway 41 to its intersection with Highway 1. Turn left (south) onto Highway 1 and exit immediately at the first offramp to the town of Morro Bay. In the absence of directional signs to Morro Rock, take Main Street south to 8th Street, 8th Street west to the ocean front, and then go northwest along the ocean to a parking lot on the north side of Morro Rock. From the parking lot we will walk to the base of Morro Rock and look at the lower Miocene intrusive rocks found there.

STOP 21

Cambria Felsite

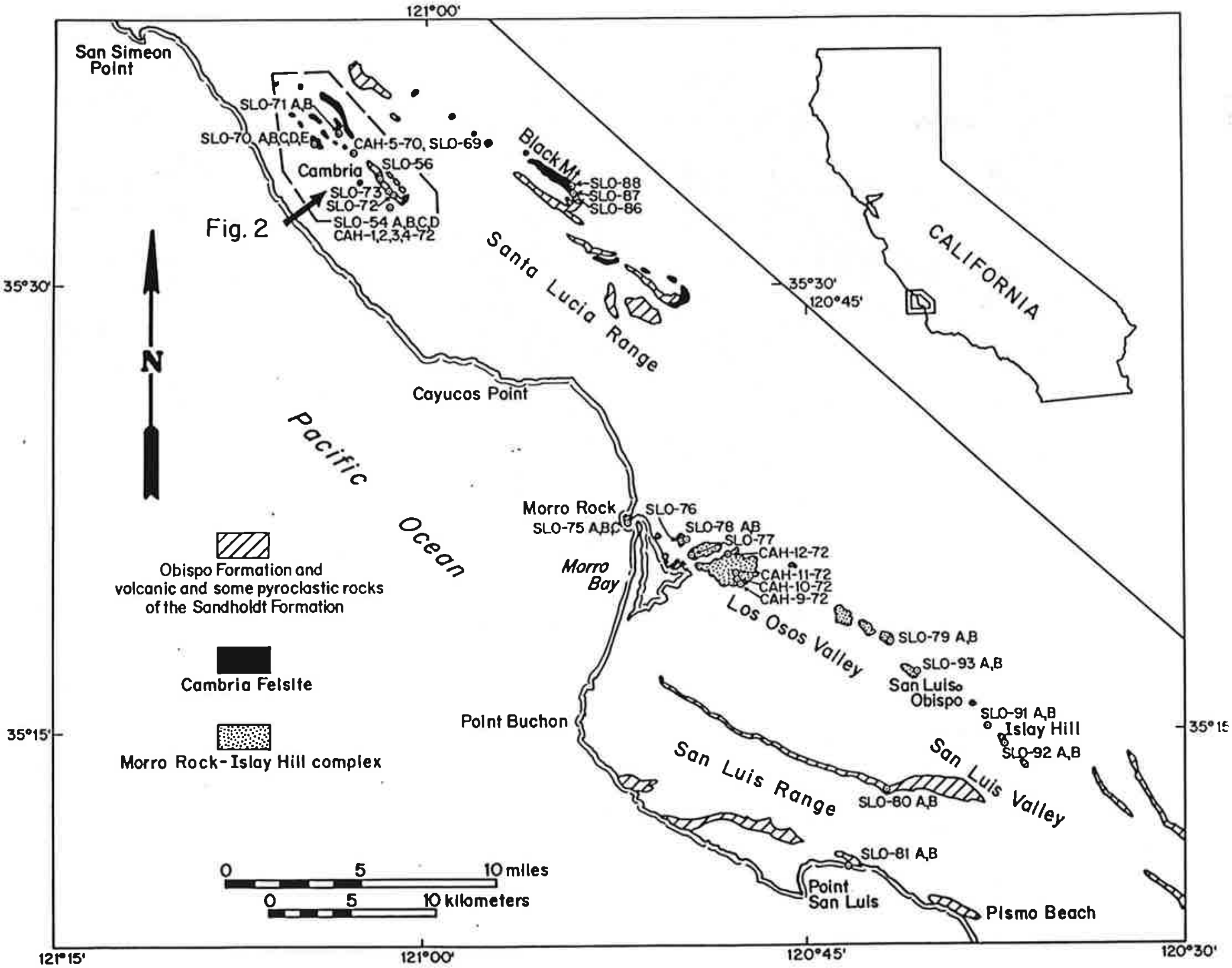
The Cambria Felsite consists of ~115 m of hard, rhyolite-dacite crystalline felsite; soft, white, poorly exposed tuff; and locally, a reworked soft tuff unit. Most of the felsite does not show bedding features or strongly preferred orientation of phenocrysts. Biotite flakes are partially aligned to form a weak foliation parallel to bedding. From 3 to 30% of the rock is composed of phenocrysts, typically subequal amounts of quartz and oligoclase, and minor biotite. The Cambria Felsite unconformably overlies Franciscan rocks and is unconformably overlain by the Lospe, Vaqueros, Sandholdt, or Pismo Formations. Ernst and Hall (1974) suggest that the Cambria Felsite is the extrusive equivalent of the Morro Rock/Islay Hill Complex, making it late Oligocene in age (~25 Ma).

Ernst, W. G., and Hall, C. A., Jr., 1974, Geology and petrology of the Cambria Felsite, a new Oligocene Formation, west-central California Coast Ranges: Geological Society of America Bulletin, v. 85, p. 523-532.

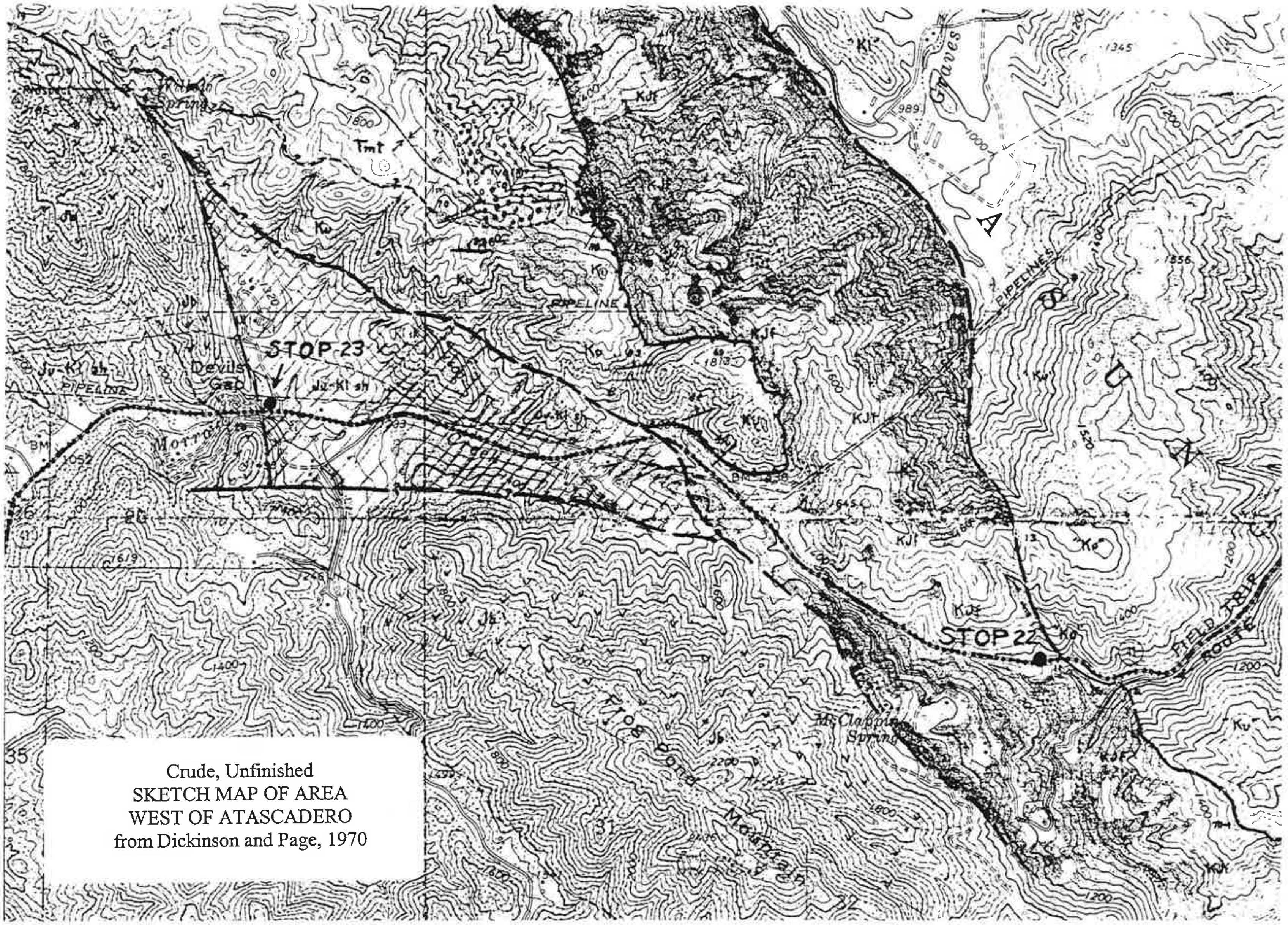


RADIOMETRIC DATES DETERMINED FOR SELECTED IGNEOUS ROCKS IN THE SANTA MARIA BASIN

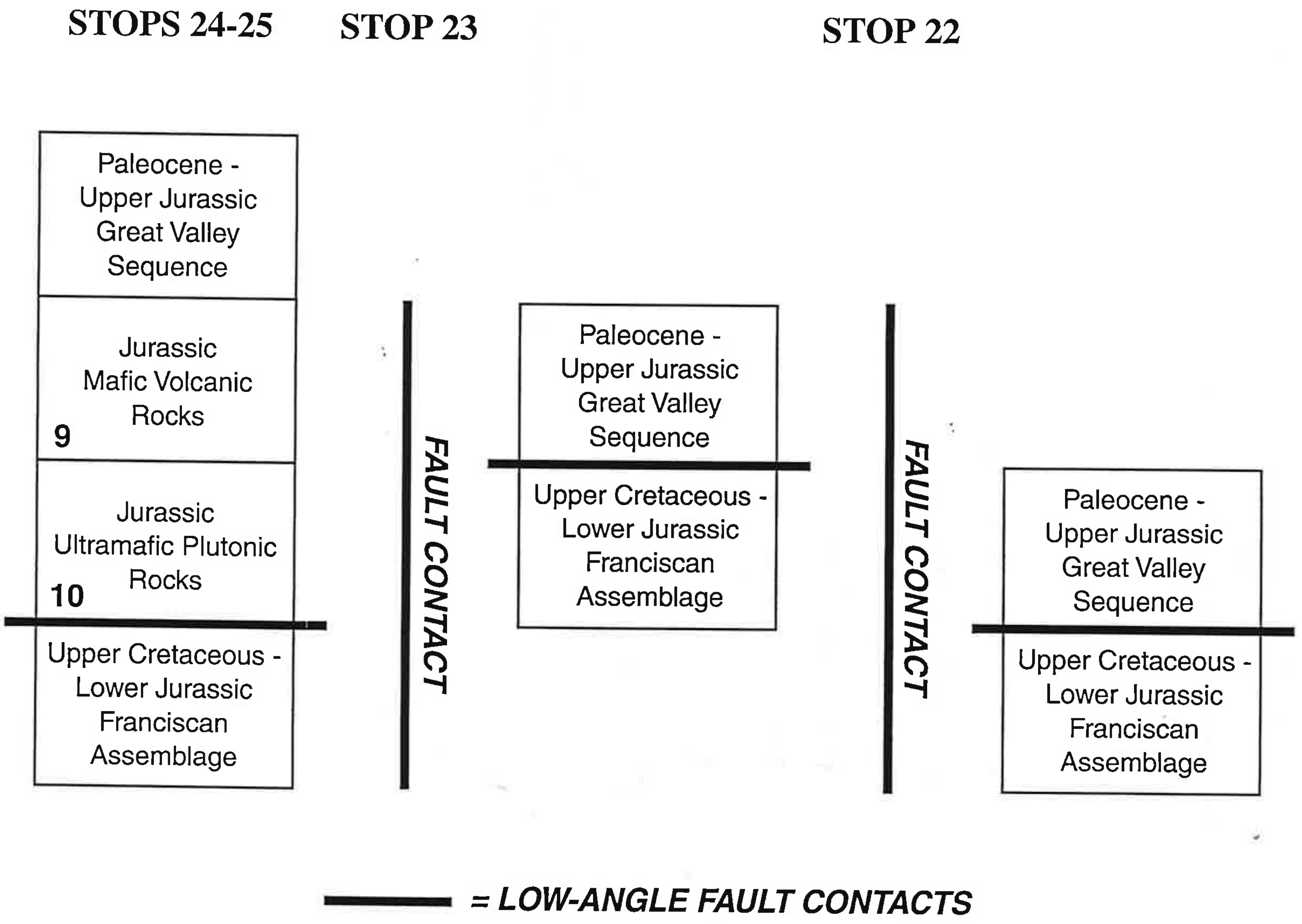
AREA	AVERAGE (MA)	DATES (MA)
Cambria Felsite	not determined	
Morro Rock/Islay Hill Complex	25.3	22.7±0.9 24.1±1.8 25.6±1.2 27.1±0.8 27.2±0.8
Obispo Tuff	16.2	15.7±0.5 15.7±0.9 15.8±0.5 16.7±0.5 16.9±0.8 (21.5±1.5)
Tranquillon Volcanics	17.0	16.5±0.6 17.2±0.5 17.4±1.2



STOPS 22-23



Crude, Unfinished
SKETCH MAP OF AREA
WEST OF ATASCADERO
from Dickinson and Page, 1970


STOPS 24-25
STOP 23
STOP 22
Paleocene - Upper Jurassic Great Valley Sequence
Jurassic Mafic Volcanic Rocks
9
Jurassic Ultramafic Plutonic Rocks
10
Upper Cretaceous - Lower Jurassic Franciscan Assemblage
FAULT CONTACT
Paleocene - Upper Jurassic Great Valley Sequence
Upper Cretaceous - Lower Jurassic Franciscan Assemblage
FAULT CONTACT
Paleocene - Upper Jurassic Great Valley Sequence
Upper Cretaceous - Lower Jurassic Franciscan Assemblage
= LOW-ANGLE FAULT CONTACTS

STOPS 13-20 and 22-25

Kinematic Analysis
Order of Events (Oldest First)

deposition of oldest knockers in JKf

oldest ↑

unit 10

unit 9

unit 2

Francisca / Great Valley

low-angle faults

upper K granitoids

high-angle faults

Miocene strata/Oligocene

↓ youngest

Paso Robles Fm

Preliminary Genetic Analysis
Pre-Plate-Tectonics Thinking

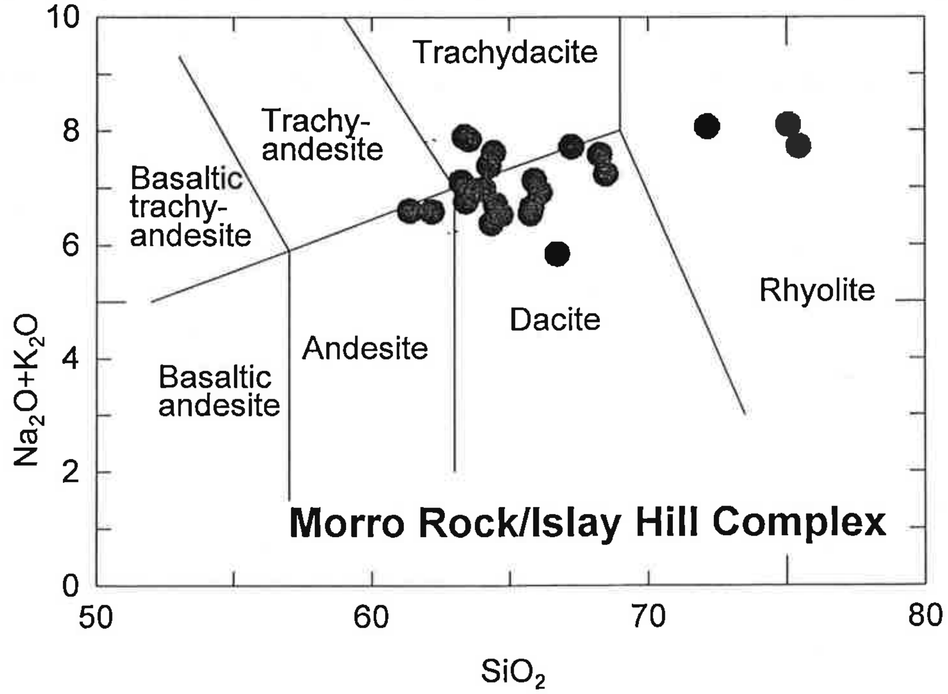
Final Genetic Analysis
Plate-Tectonics Thinking

STOP 26

Morro Rock/Islay Hill Complex

This complex is composed hypabyssal volcanic necks, plugs, and domes in a linear arrangement in Los Osos Valley. There are 13 prominent exposures and numerous minor ones; Morro Rock represents the northwestern-most prominence. Samples contain phenocrysts of plagioclase, quartz, K-spar, biotite, and minor pyroxene and hornblende. Small miarolitic cavities observed in Morro Rock give evidence for a shallow level of intrusion.

Ernst, W. G., and Hall, C. A., Jr., 1974, Geology and petrology of the Cambria Felsite, a new Oligocene Formation, west-central California Coast Ranges: Geological Society of America Bulletin, v. 85, p. 523-532.



Directions to Stop 27 - Return to Highway 1 and turn right (southeast) onto the highway. Exit Highway 1 at South Bay Blvd. Turn right (south) and at a Y-intersection bear left, remaining on South Bay Blvd. Cross Chorro Creek and Los Osos Creek and turn right (west) at Santa Ysabel Avenue and go into the town of Baywood Park. Turn left (south) on 7th Street, turn right (west) on Ramona Avenue, turn left (south) on Pine Avenue, and right (west) on Los Osos Valley Road. Los Osos Valley Road becomes Pecho Valley Road, which takes you into Montana de Oro State Park. The marine terraces and the roadcuts in the upper Miocene to Pliocene Pismo Formation are the subjects to be studied at Stop 27.

Directions to Stop 28 - Return eastward on Pecho Valley Road and Los Osos Valley Road. Continue southeastward on Los Osos Valley Road until it intersects Highway 101 south of San Luis Obispo. Turn right (south) on Highway 101 and go to the second exit, marked Avila Beach. Turn right (west) at the end of the offramp and go **1.5 mi** to a T-intersection. Turn right (west) and follow the main road all the way through the town of Avila Beach to Port San Luis. Park in the last parking lot at the end of the road south of the Port San Luis pier. This stop is to look at some spectacular exposures of pillow basalt in the Jurassic Franciscan Assemblage volcanics on the point south of the parking lot.

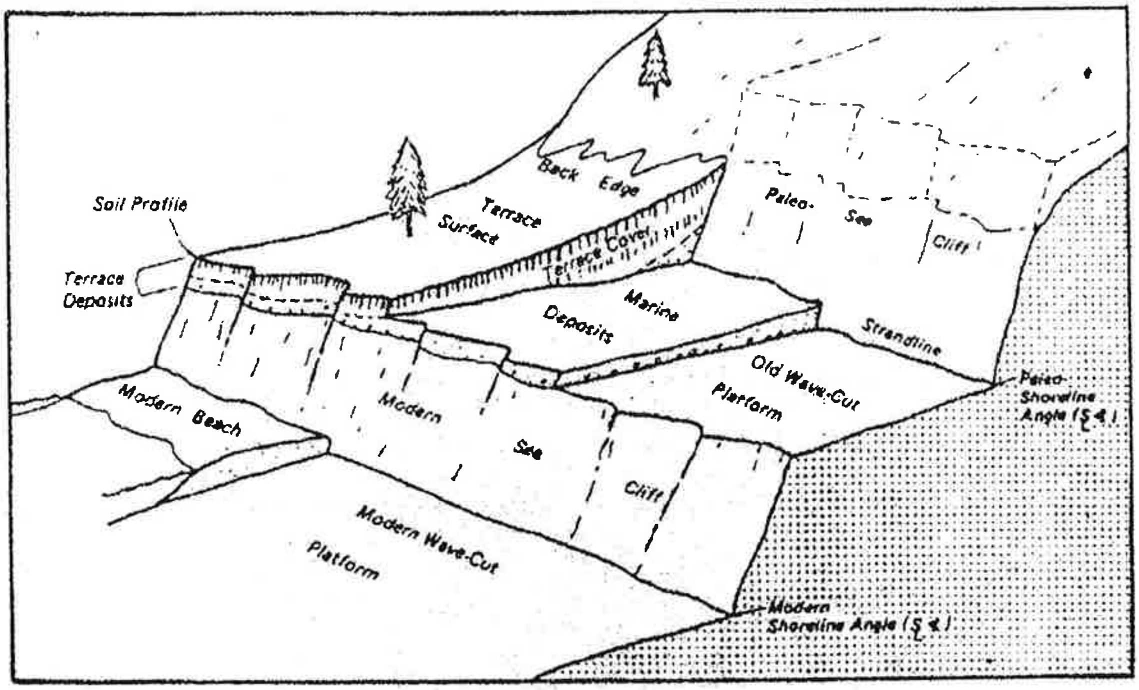
Directions to Stop 29 - Return northward along the beach road and park as close as possible to the next pier to the north of the Port San Luis pier. At this stop at sea level the pillow basalt is covered by the upper Pliocene Squire Member of the Pismo Formation.

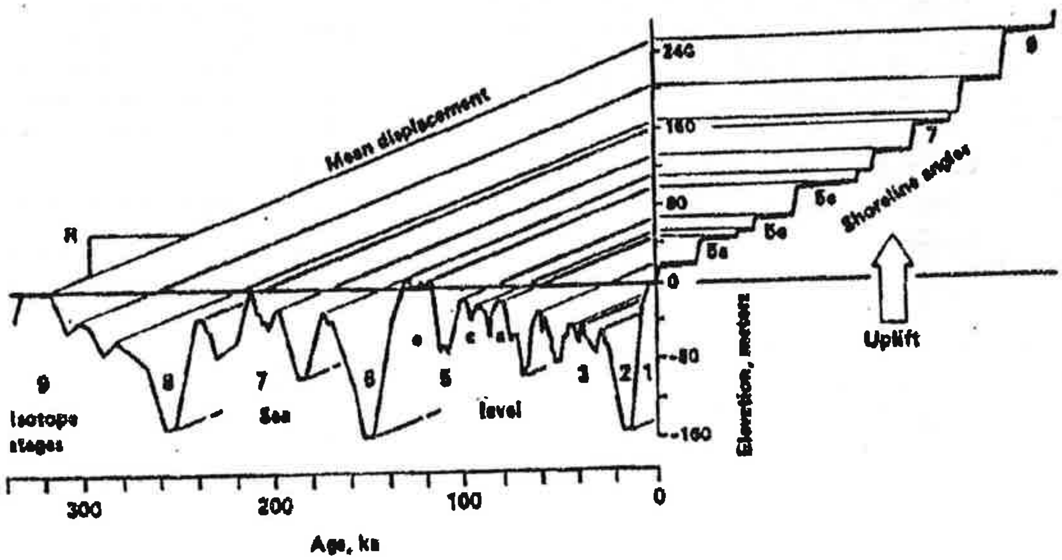
Directions to Stop 30 - Return to Highway 101 and follow it south to Pismo Beach. Exit the freeway to Pismo Beach at Hinds/Price Canyon Road. Turn right (south) at the end of the offramp and right again (west) at the signal light at Price Street. Go **0.7 mi** to the Sea Crest Motel on the left side of the road and park in the motel parking lot. Walk through the motel and down the beach access path to study the Obispo Formation in the sea cliffs.

Directions to Stop 31 - Note the mileage on your odometer or **set your trip odometer to 0.0 mi** at the motel parking lot. Turn right (south) out of the motel parking lot and go **0.7 mi** on Price Street. Turn left (northeast) on Hinds/Price Canyon Road, go under the freeway and proceed on Price Canyon Road to **4.2 mi**. Turn right (180°) into an oil field and go to an outcrop at **4.4 mi**. This outcrop exposes oil-saturated sandstone of the upper Miocene to lower Pliocene Edna Member of the Pismo Formation.

Directions to camp - Return to Price Canyon Road and continue northward. At 5.8 mi turn right (east) on Highway 227; at 6.2 mi turn left (north) on Corbett Canyon Road (listen for the echo); at 8.1 mi turn left (north) on Tifany Ranch Road; at 9.1 mi turn right (east) on Orcutt Road; and at 11.3 mi turn left (northeast) on Lopez Drive. Follow Lopez Drive into the Lopez Lake County Park Campground. Within the campground are exposures of the upper Miocene to lower Pliocene Santa Margarita Formation, which we will explore as time permits.

STOP 27

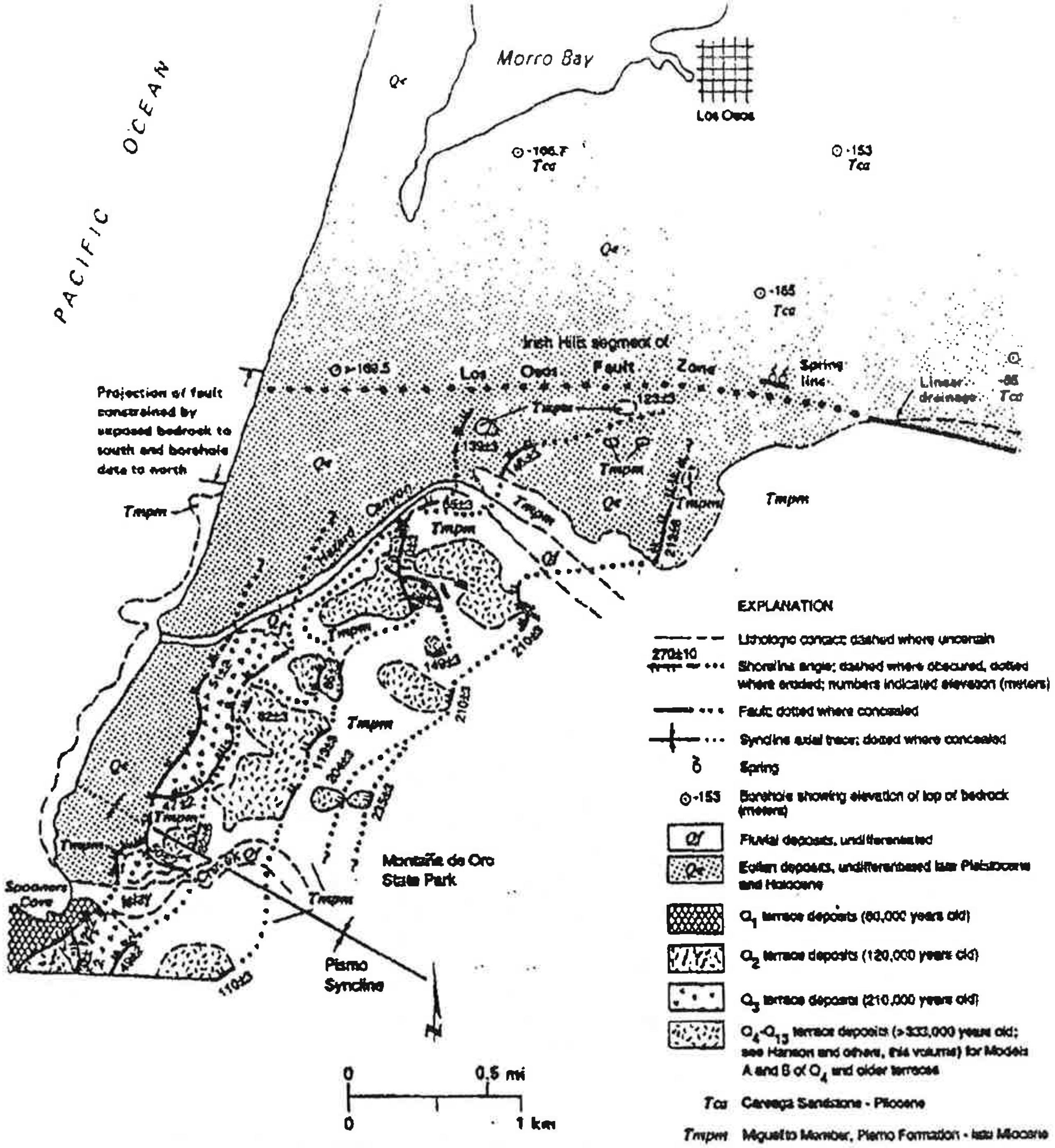




The slope (R) of the line drawn between the peak of sea level highstand and the abcissa is the uplift rate. If the uplift rate is constant, the uplift lines are parallel. The sea level curve is modified from Chappell (1983) and oxygen isotope stages and substages are from Shackleton and Opdyke (1973), (modified from Lajoie, 1986).

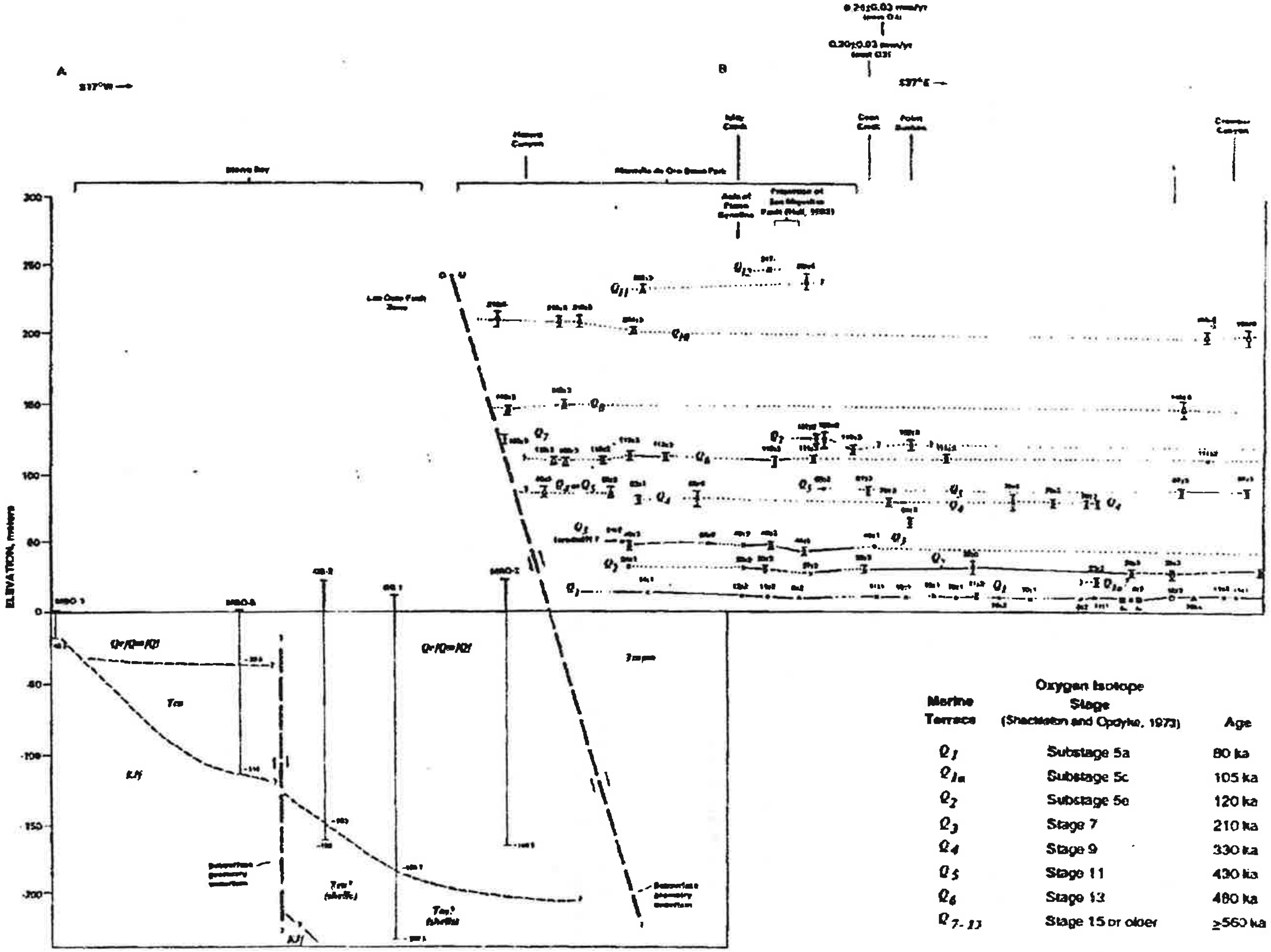
Diagram showing the relationship between sea level fluctuations and emergent marine terrace elevations on a rising coastline

STOP 27



Generalized geologic map of Quaternary deposits in the Montaña de Oro and Morro Bay areas illustrating distribution of marine terraces and interpreted location of the Los Osos fault zone. (After Hanson and others, this volume).

STOP 27



Marine Terrace	Oxygen Isotope Stage (Shackleton and Opdyke, 1973)	Age
Q_1	Substage 5a	80 ka
Q_{1a}	Substage 5c	105 ka
Q_2	Substage 5e	120 ka
Q_3	Stage 7	210 ka
Q_4	Stage 9	330 ka
Q_5	Stage 11	430 ka
Q_6	Stage 13	480 ka
Q_{7-13}	Stage 15 or older	≥560 ka

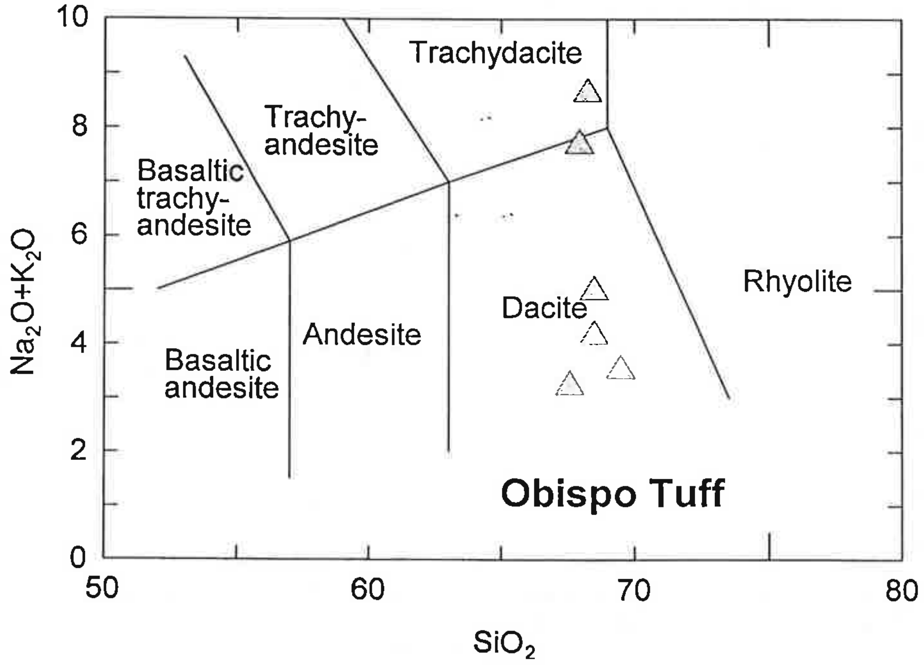
Longitudinal profiles of marine terraces between Morro Bay and Crowbar Canyon, across the Pismo Syncline and projection of the San Miguelito Fault. No vertical exaggeration. For location of profile, see Hanson and others (this volume)

STOP 30

Obispo Formation

The Obispo Formation is a crystal-bearing vitric tuff. Crystals consist principally of unzoned oligoclase and anhedral quartz with trace amounts of biotite and magnetite. The matrix consists of glass shards, collapsed pumice fragments, and microperlite, all altered and replaces to a small but variable extent by carbonate, zeolite(s), and clay minerals. The tuff is interbedded with basalt and andesite flows, calcareous siltstone, and mudstone. The formation is thickest between the towns of San Luis Obispo and Nipomo, where it reaches a thickness of 1, 000 m. Part of the formation was deposited in a marine environment, and part of the volcanic material was extruded into a submarine environment. The Obispo Formation locally lies concordantly above the Rincon Formation and locally below either the Monterey or Point Sal Formations.

Hall, C. A., Jr., 1967, Stratigraphy and structure of Mesozoic and Cenozoic rocks, Nipomo quadrangle, southern Coast Ranges, California: Geological Society of America Bulletin, v. 78, p. 559-582.



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DAY 4, Saturday, August 24

Directions to Stop 32 - Leave the Lopez Lake campground and return to Highway 101 via Lopez Drive. Turn left (south) onto Highway 101 and follow it for **12.4 mi** to its intersection with Highway 166. Turn left (east) onto Highway 166 and note the mileage on your odometer or **set your trip odometer to 0.0 mi**. Between Bull Canyon Road (3.2 mi) and Suey Creek Road (4.6 mi) the roadcuts expose the Obispo Formation. At **7.2 mi** pull to the right side of the road and park. Exposures in the roadcuts here show complexly folded, upper Miocene Monterey Formation.

Directions to Stop 33 - Continue eastward on Highway 166 to **15.2 mi** and turn right (south) onto Tepusquet Road. Park by the roadcut just south of the intersection to look at Franciscan Assemblage rocks.

Directions to Stop 34 - Continue southward on Tepusquet Road to **18.0 mi**. Park near a good roadcut and look at the exposures of the Upper Cretaceous Carrie Creek Formation (Great Valley sequence rocks).

Directions to Stop 35 - Continue southward on Tepusquet Road to **18.8 mi**. Park off the road as best possible and note the exposures of upper Oligocene, nonmarine Sespe Formation. Part of the discussion at this stop will concern the origin of this unit.

Directions to Stop 36 - Continue southward on Tepusquet Road to **19.2 mi** where the upper Oligocene to lower Miocene, shallow-marine Vaqueros Formation is exposed.

Directions to Stop 37 - Continue southward on Tepusquet Road to **19.8 mi**. At this stop is the contact between the Vaqueros Formation and the overlying lower Miocene, marine Rincon Shale.

Directions to Stop 38 - Continue southward on Tepusquet Road to **20.1 mi**. to see exposures of the Rincon Shale.

Directions to Stop 39 - Turn around, return to Highway 166, and note the mileage on your odometer or **set your trip odometer to 0.0 mi**. Turn right (east) onto Highway 166. At **8.5 mi** pull to the right side of the road and park by a roadcut. The unit exposed here is an upper Oligocene nonmarine conglomerate. Is it the Sespe Formation or the Simmler Formation?

Directions to Stop 40 - Continue eastward on Highway 166 to the town of New Cuyama. At **36.2 mi** is a park on the right side of the road where we will stop to use the facilities and discuss stratigraphic terminology problems.

STOPS 32-38

Hall, 1978	Dibblee, 1994a	Oltz and Suchsland, 1975	Dibblee, 1994b
Monterey	Upper Monterey	Monterey	Upper Monterey
Point Sal	Lower Monterey	Point Sal	Lower Monterey
Obispo	Obispo	Obispo	
Rincon	Rincon	Rincon	
Vaqueros	Vaqueros	Vaqueros	Sandstone of Hurricane Deck
Lospe?	Sespe	Sespe	Sespe?
Great Valley	Great Valley	Great Valley	Great Valley
Franciscan	Franciscan	Franciscan	Franciscan

← Twitchell Dam quadrangle →

← Tepusquet Canyon quadrangle →

Directions to Stop 41 - Note the mileage on your odometer or **set your trip odometer to 0.0 mi** and proceed eastward on Highway 166. At **5.3 mi** turn right (south) on Kirschenmann Road; at **7.9 mi** turn left (east) on Foothill Road; and at **11.0 mi** turn right (south) on Santa Barbara Canyon Road. At **14.1 mi** turn right (south) at a T-intersection in the road. At **18.6 mi** turn right (west) onto a Forest Service gravel road and cross the creek in Santa Barbara Canyon. At **19.5 mi** park off the road at the mouth of a small canyon on the right (west). Here at Stop 41 we will take the hike described on the following page and study the Oligocene, nonmarine Simmler and upper Oligocene to lower Miocene, marine Vaqueros Formations.

Directions to Stop 42 - Return to Highway 166 and follow it eastward **4.7 mi** to its intersection with Highway 33. Turn right (south) on Highway 33 and note the mileage on your odometer or **set your trip odometer to 0.0 mi**. At **11.3 mi** pull to the side of the road and park near a large roadcut. The purpose of this stop is to study the Miocene, nonmarine Caliente Formation.

Directions to Stop 43 - Continue southward on Highway 33. At **18.4** mi the highway crosses the Ozena fault. Pull off the road and stop for a discussion of the Ozena fault.

Directions to Stop 44 - Continue southward on Highway 33. At **21.9** mi the highway crosses the Big Pine fault. At **23.0 mi** the road crosses the contact between the middle Eocene, marine Matilija and Cozy Dell Formations. At **23.6 mi** pull off the road on the right into a large parking area. At this final stop on the trip we will discuss the Big Pine fault and summarize what has been learned on this trip.

Getting home - Continue southward on Highway 33 all the way to Ventura. At the intersection of Highway 33 with Highway 101 head eastward by following the signs directing you to Los Angeles. Follow Highway 101 into the San Fernando Valley. From here you are on your own. I hope that you had an interesting and educational trip!

References to field guides and geologic maps used on Day 4 -

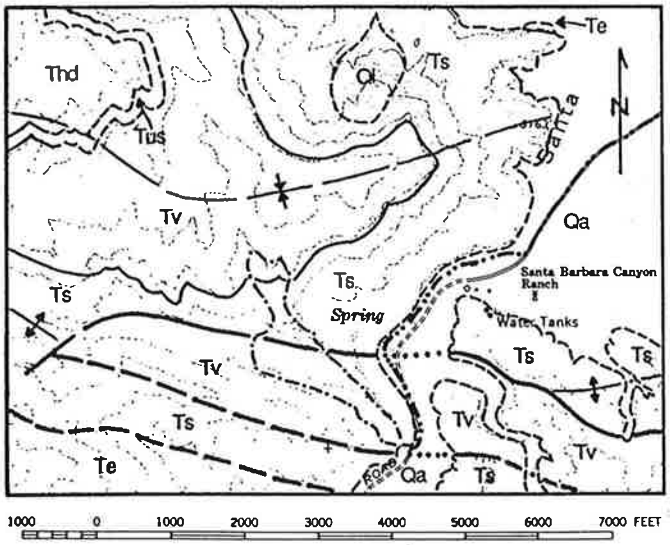
Davis, T. L., Namson, J. S., Dibblee, T. W., Jr., and Lagoe, M.B., 1987, Structural evolution of the western Transverse Ranges, in Davis, T. L., and Namson, J. S., eds., Structural evolution of the western Transverse Ranges: Society of Economic Paleontologists and Mineralogists, Pacific Section, book 48A, p. 99-156.

Dibblee, T. W., Jr., 1994a, Geologic map of the Santa Maria and Twitchell Dam quadrangles, Santa Barbara and San Luis Obispo Counties, California: Santa Barbara, California, Dibblee Geological Foundation Map #DF-51, scale 1:24,000.

STOP 41

Introduction

This trip goes to the Santa Barbara Canyon area of the eastern Sierra Madre in northeastern Santa Barbara County.
Rocks to be studied are the alluvial fan, floodplain, and upper delta plain deposits of the Oligocene Simmler Formation and the lower delta plain, delta front, and interdistributary bay deposits of the lower Miocene Vaqueros Formation. Although the road to be used is a public access road and the outcrops are within the Los Padres National Forest, courtesy dictates that you inform Mrs. Gertrude Reyes at the Santa Barbara Canyon Ranch of who you are and why you are roaming the hill near her house. The hike is about 1.5 mi round trip and is of moderate difficulty. The route climbs a ridge and returns down a canyon. The elevation change from vehicle to the highest point on the hike is 550 ft. The access road is paved to the Santa Barbara Canyon Ranch and is a good, hard-surface gravel road from there on. Although the road to the parking location dries quickly and should be passable within a day after a rain, it is subject to closure by flooding, and the Forest Service should be contacted for road condition before attempting the trip.



Geologic map of the Santa Barbara Canyon Ranch area (from Fritsche, 1969; and Vedder, 1968), to be used with Field Trip 3. Hike route shown in dash-dot line; end of driving route shown in wide dash-double-dot line; park near the word "ROAD" at the south edge of the map. See text for description of features along the hike route. Formation symbols: Qa = alluvium, Ql = landslide, Thd = Hurricane Deck Formation, Tus = undifferentiated shale belonging to either the Vaqueros Formation or the Monterey Shale, Tv = Vaqueros Formation, Ts = Simmler Formation, and Te = undifferentiated Eocene rocks.

Description of the hike

Begin climbing the ridge on the north side of the canyon. The rocks in the Vaqueros Formation that are exposed along the ridge include interdistributary bay deposits and storm deposits (lithosomes D and G, respectively, of Freitag and Fritsche, this volume). The lithosome G storm-deposit beds are easily recognizable because of the abundance of broken fossil fragments. Near the top of the ridge, just south of the fault (Fig. 6), is a thin exposure of prodelta deposits (lithosome H of Freitag and Fritsche, this volume). This lithosome H exposure probably should be mapped as the overlying Vaqueros or Monterey shale unit.

The fault on the ridge top brings Simmler Formation on the north into contact with Vaqueros Formation on the south. Davis and others (1986, 1987) offer two different explanations for the origin of this fault and other nearby faults. Vedder (1968) also shows a cross section through the fault.

North of the fault is the Simmler Formation. Rocks representing three nonmarine environments can be seen between the fault and the contact with the overlying Vaqueros Formation. Immediately north of the fault is an alluvial fan conglomerate (member D of Blake, 1982) consisting of rounded boulders and cobbles of Eocene sandstone in a red sandstone matrix. The highland of Eocene sandstone that was eroding at the time was to the south of the Ozena fault. The next rock to the north is a fluvial, red sandstone (member G of Blake, 1982). Most of the rock probably was deposited in channels and bars of a river system on an upper delta plain. Just beneath the Vaqueros Formation is a pink, red, and purple mudstone and pink sandstone deposit (member H of Blake, 1982; lithosome A of Freitag and Fritsche, this volume). This unit represents upper delta plain interdistributary levee and overbank deposits and some lower delta plain bay-margin deposits.

At the contact with the Vaqueros Formation, are exposed a chert-replaced limestone bed and a barnacle "reef" bed (lithosomes B and C, respectively, of Freitag and Fritsche, this volume). The origin of the limestone is open to suggestion; the barnacle "reef" was an intertidal, living community on the margin of an interdistributary bay.

Above the Vaqueros Formation contact and in the two canyons to the west are delta-front and distributary-channel sandstone deposits (lithosomes E and F, respectively, of Freitag and Fritsche, this volume). The cross-bedded delta-front and overlying channel deposits were left by smaller distributaries than the one seen on Field Trip 1 (Fig. 3).

Return to the parking area down the canyon. In the bottom of the main canyon, just below 3,200 ft, is a relatively thick, fossiliferous storm deposit (lithosome G of Freitag and Fritsche, this volume) that parallels the canyon for some distance.

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