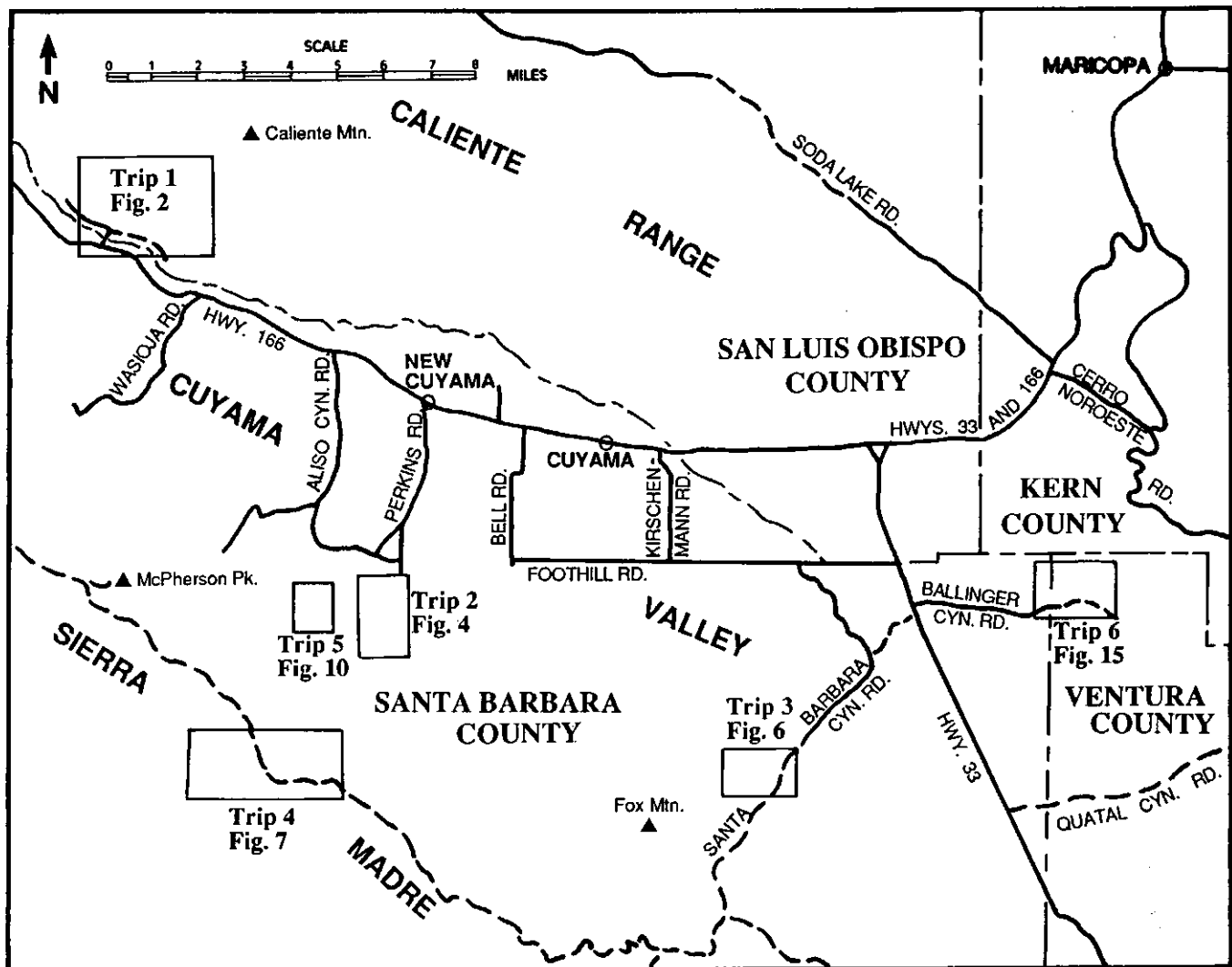


TERTIARY TECTONICS AND SEDIMENTATION IN THE CUYAMA BASIN, SAN LUIS OBISPO, SANTA BARBARA, AND VENTURA COUNTIES, CALIFORNIA



**TERTIARY TECTONICS AND SEDIMENTATION IN THE
CUYAMA BASIN, SAN LUIS OBISPO, SANTA BARBARA,
AND VENTURA COUNTIES, CALIFORNIA**

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April 18, 1988



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FIELD GUIDE TO MIOCENE DEPOSITIONAL ENVIRONMENTS IN THE CUYAMA VALLEY AND SIERRA MADRE, SAN LUIS OBISPO AND SANTA BARBARA COUNTIES, CALIFORNIA

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INTRODUCTION AND ACKNOWLEDGMENTS

The Cuyama Valley and Sierra Madre are just west of the place where Santa Barbara, San Luis Obispo, Kern, and Ventura Counties, California all meet (Fig. 1). This field guide is divided into several short parts or trips (Fig. 1), each trip includes a short drive from the town of New Cuyama and a two- to three-hour hike

to see rocks that show various aspects of the Miocene depositional environments represented in the area. All of the hikes require some cross-country walking, so ability to read a topographic map is essential for those making the trip. Also, good walking shoes or boots and a bottle or canteen of water are a necessity. The roads to the trailheads are easily negotiable in a two-wheel drive vehicle if they are dry, but carrying a shovel along is recommended. The description of each of the trips, or hikes, includes a road log from the park in the town of New Cuyama to the trailhead, a topographic map of the area to be visited, information on accessibility to the area, and comments on the difficulty of the hike.

General stratigraphic relationships in the area are discussed in Freitag and Fritsche (this volume), Thomas and others (this volume), and Perri and Fritsche (this volume). Additional supplemental references which may be useful to have along on some of the trips include Blake (1982), Lagoe (1985), and Davis and others (1986, 1987).

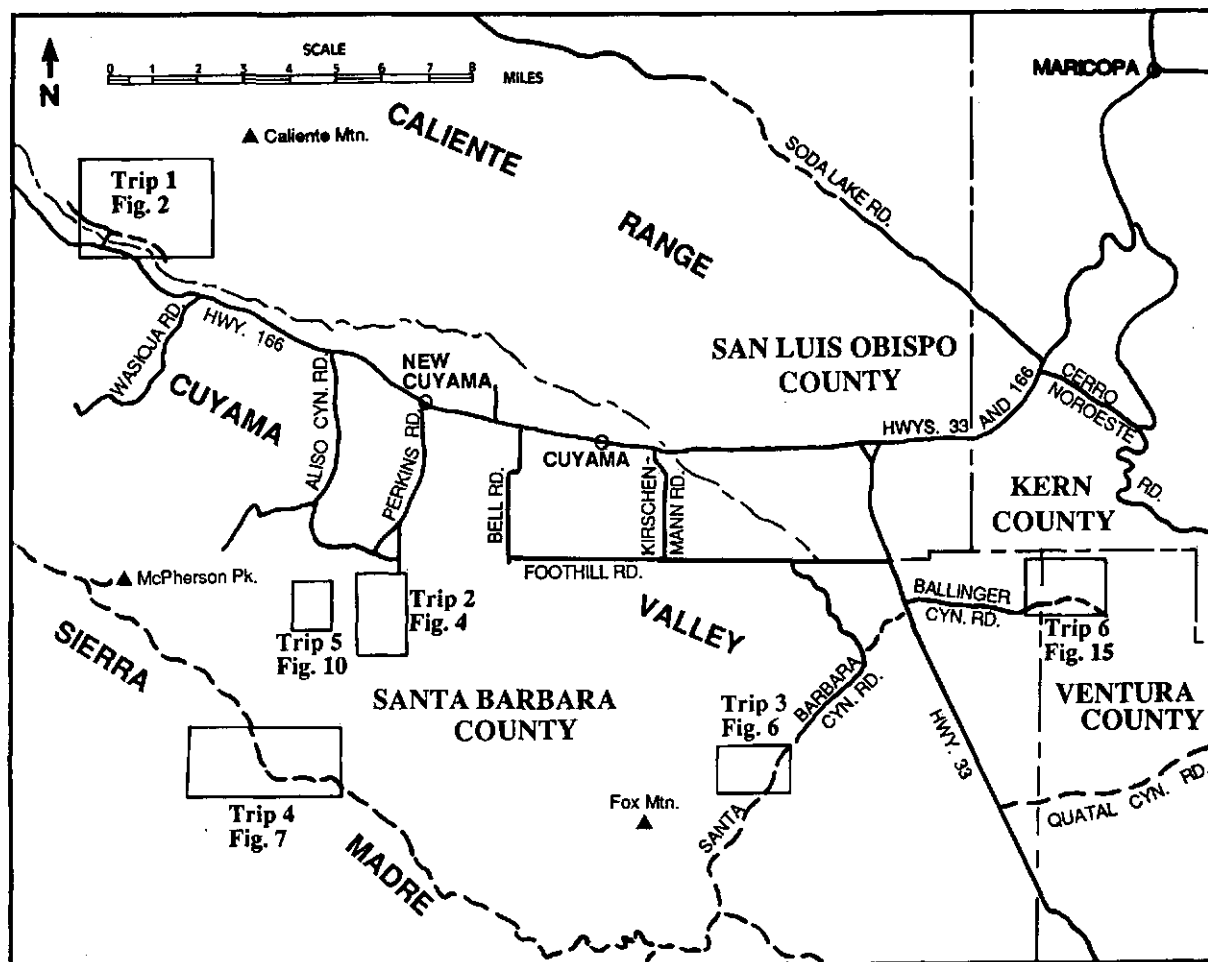


Figure 1. Road map of the Cuyama Valley area, southern California, showing location of the six field trip areas described in this field guide. Solid lines are paved roads; dashed lines are dirt roads.

Ever since the late 1940's when oil was discovered in the Cuyama Valley, the landowners and the Forest Service have had to put up with geologists who either had long-term research projects to complete or who had just a passing interest in learning more about the area. Many of the landowners have been very cooperative and accommodating over the years, and I wish to express my thanks to them for their indulgence and help. Three of them, **Mr. Hubbard Russell, Mr. Lamar Johnston, and Mrs. Gertrude Reyes**, require special acknowledgment in this field guide because the field trip access roads are on their property. If you use this field guide, be sure to request their permission for access and thank them for their understanding. The Mount Pinos District of the Los Padres National Forest administers the outcrop areas for Trips 2, 3, 4, and 5. **Mr. Trinidad Juarez**, the present District Ranger, receives special thanks for allowing access to the exposures along Sierra Madre Road. **Mr. Hollis Record**, Los Padres National Forest Geologist, also is acknowledged for his help over the years. Trips 1 and 6 are on land administered by the Bureau of Land Management. Finally, my sincere thanks to Jon Sloan for taking and printing the pictures that appear in this field guide and for his helpful comments on the text and to George Freitag for his help in preparing the manuscript.

Please remember that these field trips are on both private and public land. Your proper conduct while on any of these trips will ensure that others will be able to follow after you. As the Forest Service says, if you **pack it in**, be sure that you **pack it out**. Leave only footprints behind.

For those needing overnight accommodations, the Buckhorn Motel is in New Cuyama and the Comfort Inn is 24 mi east on Highway 166 in Maricopa. Campgrounds include Aliso Campground, a nice oak-forested area, and Ballinger Campground, an off-road vehicle recreation area. The only facilities at these two campgrounds are stoves, tables, and pit toilets. **Drinking water is not available** in the campgrounds and must be carried in. Aliso Campground is 2.8 mi west of the park in New Cuyama on Highway 166 to Aliso Canyon Road, then 6 mi south on Aliso Canyon Road. Ballinger Campground is reached via the route shown for Trip 6.

FIELD TRIP 1

Introduction

This trip is into the foothills of the Caliente Range on the north side of the Cuyama Valley in southeastern San Luis Obispo County (Figs. 1, 2). The major concern of the first part of the trip (Trip 1A) is to study a cyclical sequence of prograding delta front and prodelta deposits in the type area of the lower Miocene Painted Rock Sandstone Member of the Vaqueros Formation. Permission to make this trip must be obtained from Mr. Hubbard Russell of the Russell Ranch. The hike is between 1.5 and 2 mi round trip and is of moderate difficulty. The route, for the most part, follows stream canyons, and is a gradual climb. The elevation difference from the parking area to the outcrops is 600 ft. The access road crosses over the Cuyama River via a temporary bridge that, on rare

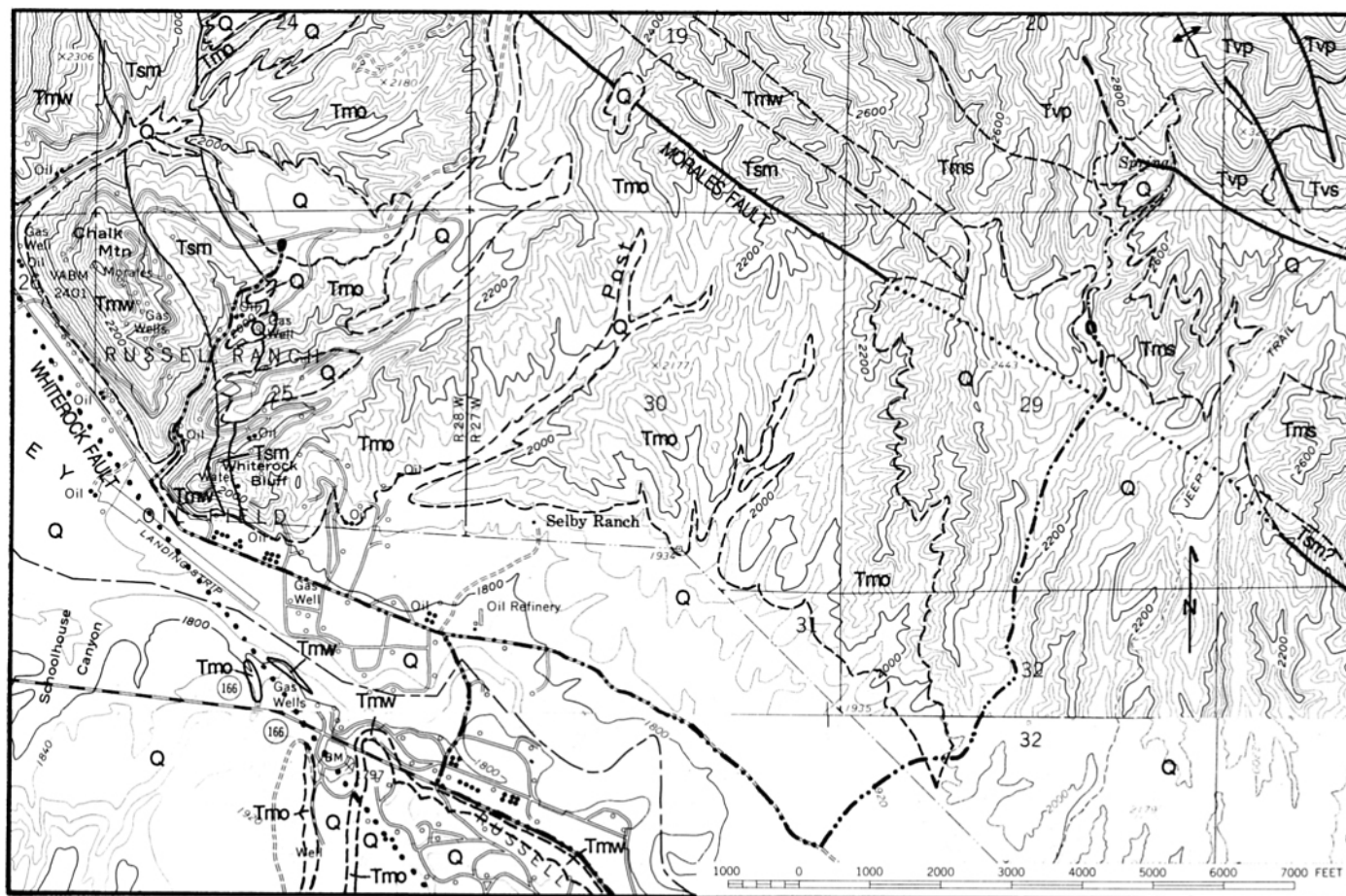


Figure 2. Geologic map of the Caliente Mountain and Whiterock Bluff areas (from unpublished maps of the Caliente Mountain and Peak Mountain quadrangles by T. W. Dibblee, Jr.) to be used with Field Trip 1. Hike route shown in dash-dot line; end of driving route shown in wide dash-double-dot line. See text for description of features along hike route. Formation symbols: Q = all Quaternary deposits, Tmo = Morales Formation, Tsm = Santa Margarita Formation, Tmw = Whiterock Bluff Member of the Monterey Shale, Tms = Salton Shale Member of the Monterey Shale, Tvp = Painted Rock Sandstone Member of the Vaqueros Formation, Tvs = Soda Lake Shale Member of the Vaqueros Formation.

occasions, can get washed away. The last 1.9 mi of the road is dirt, so this trip should not be attempted after a rain until the road is thoroughly dry. Halfway along the dirt road is a single dry stream crossing which could be trouble.

A short side trip (Trip 1B) after the above hike provides the opportunity to study upper bathyal basin plain deposits in the type area of the middle Miocene Whiterock Bluff Shale Member of the Monterey Shale and wave-dominated shoreface deposits of the overlying Santa Margarita Formation. As above, permission must be obtained from Mr. Hubbard Russell of the Russell Ranch. The area is within the Russell Ranch oil field and all the roads are paved. Access can be prevented, however, by washout of the Cuyama River bridge.

Road log for Trip 1A

Total mileage (interval mileage)

- 0.0 Leave the park in New Cuyama and head west on Highway 166.
- 0.4 (0.4) Perkins Road on left (south). Continue straight.
- 2.9 (2.5) Aliso Canyon Road on left (south). Continue straight.
- 6.4 (3.5) Wasioja Road on left (south). Continue straight.
- 8.3 (1.9) Arrive at Russell Ranch oil field. Turn right (north) into the oil field.
- 8.4 (0.1) Take the left fork in the road and head down a short hill.
- 8.6 (0.2) Cross the one-lane, temporary bridge over the Cuyama River.
- 8.8 (0.2) Turn right (east) at a "T" in the road.
- 9.2 (0.4) Dirt road on the left (north). Continue straight.
- 10.0 (0.8) Another dirt road on the left (north). Turn left (north) onto this road. As you travel on this road, be sure to close behind you all gates that you have opened. A normally dry stream crossing halfway along this road could be a problem.
- 11.9 (1.9) Park in a wide, flat area near a round watering trough. Exit the vehicle and begin the hike shown in Figure 3.

Description of the hike

The parking area is just north of the Morales fault and is in overturned beds of the Salton Shale Member of the Monterey Shale on the south limb of a large, overturned anticline. Relizian microfossils that were deposited in middle bathyal depths are common in this unit (Lagoe, 1985).

Proceed up the canyon north of the parking area to the second major tributary. Take the right fork and continue up the tributary. The cliffs on the high canyon walls are in Quaternary colluvial deposits.

The spring in this canyon marks a local, north-dipping thrust fault that pushes the Painted Rock Sandstone Member of the Vaqueros Formation on the north side of the fault over the Salton Shale Member of the Monterey Shale on the south side of the fault. The fault is near the hinge area of the overturned anticline.

North of the spring and fault are overturned beds of the Painted Rock Sandstone Member of the Vaqueros Formation. The first few exposures contain fossils, burrows, cross bedding, and heavy mineral laminations. The details of the environment of deposition for these rocks have yet to be worked out, but they probably are interdistributary bay deposits of some type.

Farther up the canyon, near the turn-around point (Fig. 2), are numerous, cross-bedded, coarsening-upward sequences (Fig. 3) that are stacked one on top of another. These represent interdistributary bay to prodelta to delta-front sequences that accumulated in the following way. A shallow, interdistributary bay, that had been accumulating muddy sediment on a delta platform, was invaded by a newly formed distributary that gradually prograded across the bay. As the river flowed into the bay, fine-grained, suspended-load mud was carried farthest from



Figure 3. View looking west near the turn-around point on Field Trip 1 of large-scale cross bedding in a coarsening-upward, prodelta to delta-front sequence in the Painted Rock Sandstone Member of the Vaqueros Formation. George Freitag near center of picture for scale. Note the sandstone bed at the base of the sandstone behind Freitag that continues from the delta-front cross beds on down into the vegetation-covered prodelta mudstone.

the river mouth and deposited on the existing bay mud as gently sloping prodelta deposits. The coarser grained, traction-load sand moved over the distributary-mouth bar and spilled down the delta front to accumulate as a large set of cross beds on the prodelta deposits. Progradation of the distributary channel eroded the distributary-mouth bar and created a truncated erosion surface on the delta-front deposits, which was covered in some places by the advancing channel deposits. As time passed, the distributary was abandoned and subsidence due to both compaction and tectonics ensued. The abandoned distributary delta-front lobe subsided to shallow bay depths and the area became once more an interdistributary bay into which bay mud was deposited. This cycle was repeated several times in this area. The thickness of each delta-front cross-bed set is proportional to the size of the distributary that made it, and the thickness of each coarsening-upward sequence is an indication of and is related to the depth of water in the bay at the beginning of each cycle.

To return to the parking area, climb to the ridge west of the exposures and walk south, down the slope into the canyon, then east back to the parking area. The canyon contains some moderately entrenched meanders. Note evidence that during a recent flood period, the deep channel was completely filled and water spilled out of the channel and across the necks of the meanders.

Roadlog for Trip 1B

Mileage starts at parking area for Trip 1A.

Total mileage (interval mileage).

- 0.0 Retrace route back to Russell Ranch oil field.
- 1.9 (1.9) Turn right (west) at a "T" in the road.
- 3.1 (1.2) Road back to Highway 166 on left (south). Continue straight passed Whiterock Bluff on the right (north).
- 4.0 (0.9) Turn right (north) onto road in canyon. Whiterock Bluff Shale Member of the Monterey Shale is exposed on both sides of the road.
- 4.4 (0.4) Note white, friable tuff bed in roadcut on the left (west).
- 4.5 (0.1) Contact between Whiterock Bluff Shale Member of the Monterey Shale and the Santa Margarita Formation.
- 4.6 (0.1) Take the right fork in the road and head up a short hill.
- 4.7 (0.1) Unconformable contact between the Santa Margarita Formation and the upper Pliocene Morales Formation.

- 4.8 (0.1) Arrive at "T" in road and turn around. Retrace route and park in a convenient place. Leave the vehicle to look at and/or collect those rocks of interest. See the description of the area below. Return to vehicle and continue south.
- 5.6 (0.8) Turn left (east) at a "T" in the road.
- 6.5 (0.9) Turn right (south) toward the Cuyama River bridge.
- 6.9 (0.4) Turn left (east) onto Highway 166 and return to New Cuyama.

Description of the Whiterock Bluff area

Rocks and microfossils from this type area for the Whiterock Bluff Member of the Monterey Shale have been studied and described by Hill and others (1958), Phillips (1976), and Lago (1985). The following comments are extracted from Lago (1985).

The shale in the Whiterock Bluff Member type section is calcareous in the lower two-thirds and becomes gradually siliceous in the upper one-third. This change in composition is directly related to the biogenous component, which is foraminiferal at the base and diatomaceous at the top. The base of the section is Relizian and the remainder is Luisian. Foraminifers in the lower part are extremely abundant and commonly occur in winnowed microcoquina layers. Tuff beds are common in the upper, diatomaceous part of the formation. Rare, thin sandstone beds in the section contain Bouma Tbc intervals (parallel laminated, convoluted, and ripple cross laminated). All these rocks were deposited in upper bathyal depths (Lago, 1985).

FIELD TRIP 2

Introduction

This trip is into the foothills of the Sierra Madre on the south side of the Cuyama Valley in northeastern Santa Barbara County (Figs. 1, 4). The purpose of the trip is to study the regressive, wave-dominated, nearshore deposits of the middle Miocene Branch Canyon Formation and the transgressive and regressive, shallow-water, phosphatic deposits of the upper Miocene Santa Margarita Formation. The trailhead parking is a public access parking area on private land. The outcrops to be investigated are within the Los Padres National Forest. Permission to make the trip is not required, but please stay on the trail for the first one-third mile until the National Forest boundary is crossed. The hike is about 3 mi round trip and is a relatively easy walk. The route follows stream canyons and climbs only about 300 ft between the parking area and the outcrops. The access road is paved all the way to the parking area, so this trip can be made even after a rain.

Road log for Trip 2

Total mileage (interval mileage)

- 0.0 Leave the park in New Cuyama and head west on Highway 166.
- 0.4 (0.4) Turn left (south) onto Perkins Road.
- 3.3 (2.9) Take the left (east) fork at a "Y" in the road.
- 4.1 (0.8) Foothill Road. Continue straight.
- 4.5 (0.4) South Cuyama fault zone exposed in the steep stream cut on the left (east) (Fig. 5). If time allows on return, a short stop could be made here.
- 4.7 (0.2) Take the left (east) fork at a "Y" in the road.
- 4.9 (0.2) Take the left (east) fork at a "Y" in the road.
- 5.0 (0.1) Park in the area provided. Leave the vehicle and begin the hike shown in Figure 4.

Description of the hike

From the parking area walk south up the dirt road in Newsome Canyon. For the first mile, the road traverses the upper Miocene Santa Margarita Formation. Three folds and three faults are crossed along the way, but most of them will not be easily discernible. On reaching the junction of Newsome and Lion Canyons, bear to the right (west) up Lion Canyon; then after 0.2

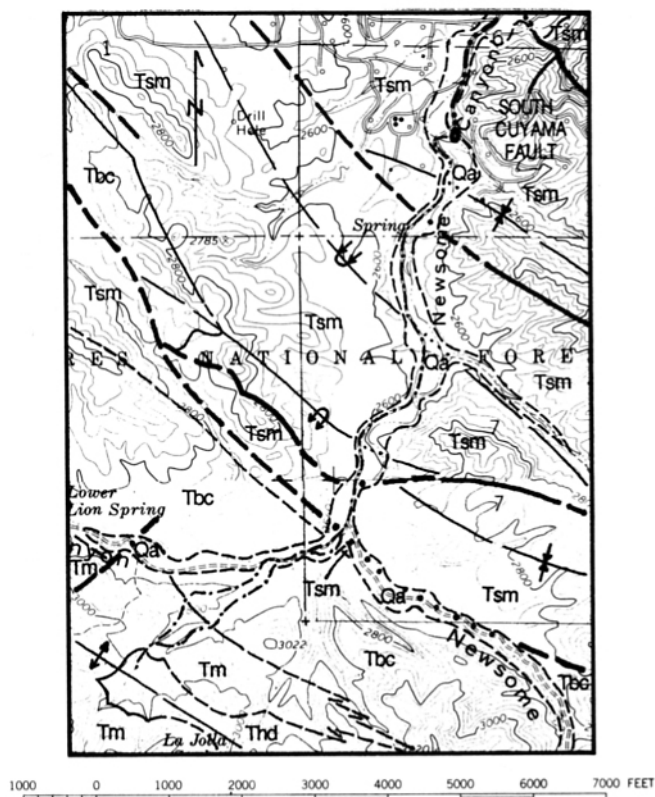


Figure 4. Geologic map of part of the Newsome Canyon area (from Fritsche, 1969) to be used with Field Trip 2. Hike route shown in dash-dot line; end of driving route shown in wide dash-double-dot line. See text for description of features along hike route. Formation symbols: Qa = alluvium, Tsm = Santa Margarita Formation, Tbc = Branch Canyon Formation, Tm = undifferentiated Monterey Shale, Thd = Hurricane Deck Formation. Quaternary terrace deposits have been omitted for simplification.



Figure 5. View looking southeast near the mouth of Newsome Canyon at the South Cuyama fault. Fault dips southwest and has reverse separation, with Santa Margarita Formation mudstone pushed up over younger Santa Margarita Formation sandstone.

mi turn left (south) and proceed up a small tributary as shown on Figure 4.

Beginning at the Newsome-Lion Canyon junction, the route traverses the middle Miocene Branch Canyon Formation from top to bottom for 0.4 mi. Several different lithosomes can be

distinguished in this formation (Perri and Fritsche, this volume), each of them portraying a different aspect of a prograding, wave-dominated, linear shoreline. The most obvious lithosome is the resistant, fossiliferous, storm-lag deposits (lithosome B of Perri and Fritsche, this volume) that are a typical, distinguishing characteristic of the Branch Canyon Formation.

Continue up the tributary to the contact with the undifferentiated Monterey Shale (lithosome H of Perri and Fritsche, this volume). The Monterey Shale is much coarser than usual here and, as can be seen on the map (Fig. 4), it interfingers a short distance to the east with the base of the Branch Canyon Formation. The environment of deposition here is interpreted as part of the transition zone or just slightly offshore, below wave base most of the time.

Climb to the top of the low ridge to the west and note the tight folding in the Monterey Shale along the crest of the ridge. These small folds are entirely contained within the Monterey Shale as disharmonic folds and are not reflected in the underlying or overlying sandstone units. Continue over the ridge into the next canyon to the west. A short walk up the canyon to the south will reveal the top of the Hurricane Deck Formation (Thomas and others, this volume; lithosome D is exposed here), which is more thoroughly studied on Field Trips 4 and 5.

Return back down the canyon and climb to the top of the ridge to the northwest (Fig. 4) in order to study deposition of the Branch Canyon Formation. The Branch Canyon Formation represents a prograding, wave-dominated, linear shoreline on a delta. The lower portions of the formation are fine-grained sandstone deposited during fair weather (lithosome E of Perri and Fritsche, this volume, Fig. 8) and storm periods (lithosome B) on the lower shoreface, and the upper portions are coarser grained sandstone, also deposited during fair weather (lithosome C) and storm periods (lithosome B), but on the upper shoreface. The fossil occurrences are also related to the depth of deposition. Vermetids occur at the base of the formation, turrillids a little higher up, bivalves of various types next highest, and finally sand dollars, oysters, and pectinids at the top of the formation. This sequence should be noted along the traverse through the formation.

Continue north off of the ridge and into Lion Canyon. On the north side of Lion Canyon near the upper contact of the Branch Canyon Formation is a resistant, storm-lag, sandstone bed (lithosome B of Perri and Fritsche, this volume) that has a set of generally east-directed cross beds at the top. An interpretation of this bed is that as the storm that deposited the bed waned, the current velocity dropped from high-flow regime, which had been depositing flat beds, to low-flow regime, which deposited landward-driven megaripples.

Return to the east bank of Lion Canyon at its junction with Newsome Canyon where the base of the Santa Margarita Formation is exposed in a stream-cut bank. Fine-grained phosphatic sandstone and mudstone are exposed here. Within the outcrop are a few phosphate nodule beds, some bentonite beds, and an almost unaltered, gray, vitric tuff. The lithology of this phosphatic interval and its included tuff and its occurrence overlying an upper shoreface sandstone unit, is almost identical to a similar set of beds exposed in the upper Sespe Creek area (Thor, 1978), which leads to the conclusion that the Cuyama depositional basin extended as far south as Sespe Creek at that time. Ingle (1969) indicated, based on study of foraminifers, that the phosphatic beds at Sespe Creek were deposited in marine water less than 150 ft in depth. A rapid, small transgression of this type could easily be accomplished by a eustatic sea level change (Perri and Fritsche, this volume). Continue north along the east bank of Newsome Canyon to see more phosphatic sandstone and mudstone beds exposed in a prospect excavation.

Continue northward down Newsome Canyon and back to the parking area.

FIELD TRIP 3

Introduction

This trip goes to the Santa Barbara Canyon area of the eastern Sierra Madre in northeastern Santa Barbara County (Figs. 1, 6). 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.

Road log for Trip 3

Total mileage (interval mileage)

- 0.0 Leave the park in New Cuyama and head east on Highway 166.
- 2.0 (2.0) Bell Road on right (south). Continue straight.
- 4.0 (2.0) One-room Cuyama Post Office on right (south). Continue straight.
- 5.3 (1.3) Turn right (south) on Kirschenmann Road.
- 5.8 (0.5) Road on left (east). Continue straight.
- 7.9 (2.1) Turn left (east) on Foothill Road.
- 11.0 (3.1) Turn right (south) on Santa Barbara Canyon Road.
- 13.8 (2.8) Creek crossing in Santa Barbara Canyon; usually dry, but could be a problem after large storms. Road is now heading east.

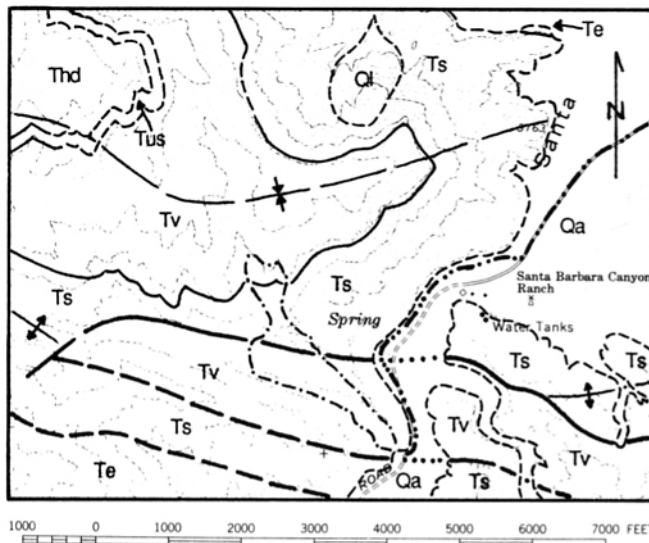


Figure 6. Geologic map of the Santa Barbara Canyon Ranch area (from Fritsche, 1969; and Vedder, 1968), to be used with Field Trip 3. Hike route shown in dash-dot line; end of driving route shown in wide dash-double-dot line; park near the word "ROAD" at the south edge of the map. See text for description 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.

- 14.1 (0.3) Turn right (south) at a "T" in the road.
- 16.0 (1.9) Across Santa Barbara Canyon on the right (west) are cliff exposures of steeply dipping Quaternary nonmarine Morales Formation lying in angular unconformity on steeply dipping Miocene marine Branch Canyon Formation (Perri and Fritsche, this volume).
- 16.8 (0.8) Across Santa Barbara Canyon on the right (west) are cliff exposures of the Miocene marine Hurricane Deck Formation (Thomas and others, this volume) with the Miocene marine Branch Canyon Formation lying conformably above on the higher slopes.
- 17.7 (0.9) Across Santa Barbara Canyon on the right (west) are cliff exposures of the Miocene marine Vaqueros Formation (Freitag and Fritsche, this volume).
- 18.0 (0.3) Rainbow Canyon is across Santa Barbara Canyon on the right (west). Exposed in the canyon is an anticline that has been faulted along an east-trending fault that is buried beneath the alluvium. On a spur in the center of the canyon is a small exposure of marine Eocene rocks (Fig. 6). Unconformably overlying the Eocene is the Oligocene nonmarine Simmler Formation, followed by the conformably overlying Miocene marine Vaqueros Formation.
- 18.6 (0.6) Turn right (west) onto Forest Service gravel road. Cross the creek in Santa Barbara Canyon and pass to the north of the Santa Barbara Canyon Ranch (Fig. 6). Exposures of red sandstone on the right (north) are of the Oligocene nonmarine Simmler Formation.
- 19.2 (0.6) Exposed on the canyon slope to the right (west), between the Simmler Formation and the Vaqueros Formation, is a fault that will be viewed up close on the upcoming hike.
- 19.5 (0.3) Park off the road at the mouth of a small canyon on the right (west). The hike shown on Figure 6 begins here.

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.

FIELD TRIP 4

Introduction

This trip travels along the central crest of the Sierra Madre on Sierra Madre Road in northeastern Santa Barbara County (Figs. 1, 7). The rocks to be studied, in ascending order, are the transgressive, nearshore-marine, valley-fill deposits of the Vaqueros Formation; the deep-marine deposits of an undifferentiated shale unit; and the submarine-fan deposits of the Hurricane Deck Formation (Thomas and others, this volume). All three units are lower Miocene and are conformable on one another. The access road travels along the northern edge of the San Rafael Wilderness and is behind a locked gate. Permits for each vehicle on the road and a key to the gate must be obtained from the District Ranger of the Mount Piños District of the U. S. Forest Service. The hike is 2.5 to 3.0 mi round trip and is not difficult. The route, which goes gently up and down along the Jackson Trail, has an elevation difference from beginning to end of 300 ft. Sierra Madre Road is dirt and it is impassable for a good deal of the winter and spring because of either snow or very muddy conditions. The Forest Service will not permit entry unless the road is passable.

Road log for Trip 4

Total mileage (interval mileage)

- 0.0 Leave the park in New Cuyama and head east on Highway 166. Follow the road log for Trip 3.
- 19.5 (19.5) Parking area for Trip 3.

Reset mileage and start again at this point. Because access was not permitted during preparation of this field guide, the mileages indicated are only estimates.

- 0.0 Parking area for Trip 3.
- 0.3 (0.3) Road crosses the Ozena fault. For the next 4 mi the road is in undifferentiated Eocene rocks.
- 2.5 (2.2) Access road on the left (east) to the Dry Canyon area.
- 3.5 (1.0) Road bears to the right (west) and leaves Santa Barbara Canyon.
- 4.3 (0.8) Locked gate across road. Vehicle permits and gate key required beyond this point.
- 4.4 (0.1) First exposures of Miocene rocks, Hurricane Deck Formation, are on the left (south) side of the road, dipping north and lying unconformably on the Eocene rocks. Monterey Shale, lying conformably on the Hurricane Deck Formation, crops out along the road for the next 11 mi.
- 5.5 (1.1) First of a series of several switchbacks on the road.
- 7.3 (1.8) Good exposure of Monterey Shale in road cut.
- 8.2 (0.9) View of Cuyama Valley to the right (north).
- 8.8 (0.6) Take the right (west) fork at a "Y" in the road.
- 9.1 (0.3) In the canyon to the left (east) of the road, the Monterey Shale lies in angular unconformity on the Eocene rocks. This is the highest stratigraphic level of onlap of the Miocene rocks on the pre-Miocene topographic surface.
- 9.2 (0.1) View of Santa Barbara Potrero. The geologic

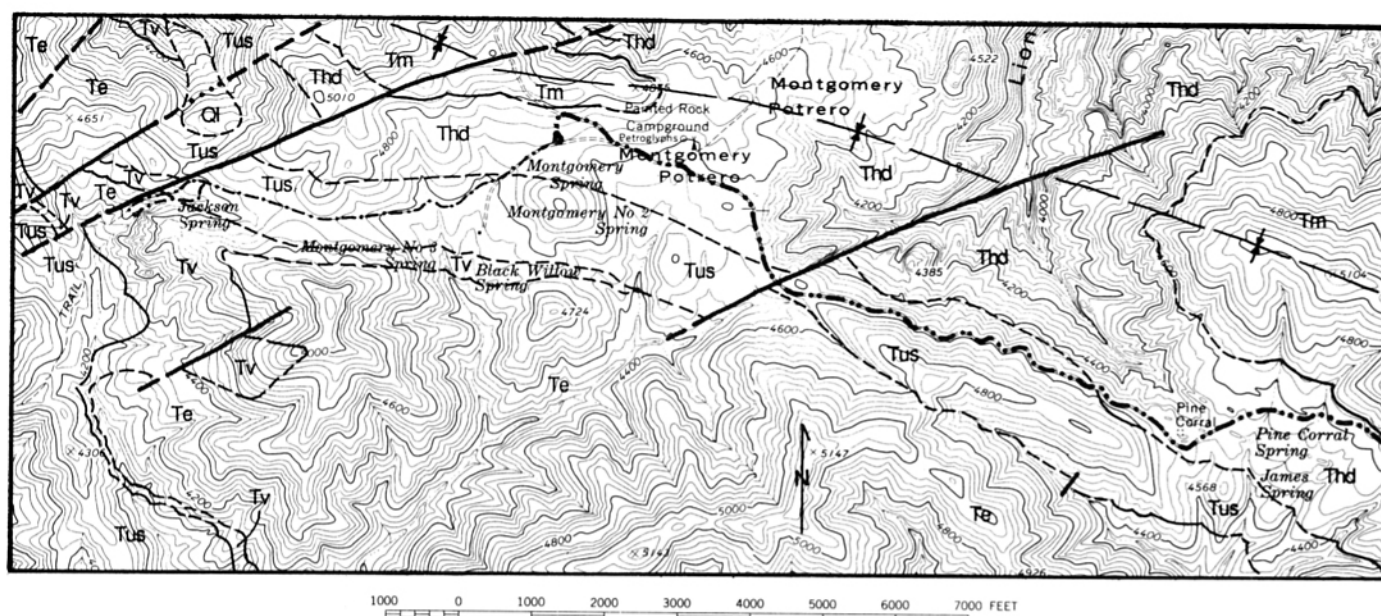


Figure 7. Geologic map of the Montgomery Potrero area (from Fritsche, 1969) to be used with Field Trip 4. Hike route shown in dash-dot line; end of driving route shown in wide dash-double-dot line. See text for description of features along hike route. Formation symbols: Ql = landslide, Tm = undifferentiated Monterey Shale, Thd = Hurricane Deck Formation, Tus = undifferentiated shale belonging to either the Vaqueros Formation or the Monterey Shale, Tv = Vaqueros Formation, Te = undifferentiated Eocene rocks.

explanation of the potreros (grassy areas used for grazing) is presented in the text.

- 9.7 (0.5) Trail into the San Rafael Wilderness on the left (south).
- 15.0 (5.3) Road on right (north) goes to Salisbury Potrero. Continue straight.
- 15.3 (0.3) Contact between the Hurricane Deck Formation and the conformably overlying Monterey Shale.
- 15.5 (0.2) Sweetwater Trail into the San Rafael Wilderness on the left (south).
- 16.9 (1.4) Pine Corral (Fig. 7). Exposures of the Hurricane Deck Formation here will be studied at the end of the hike described below.
- 18.5 (1.6) Painted Rock Campground on the right (north). A good spot for lunch. Exposures of the Hurricane Deck Formation here are described in the text below.
- 18.8 (0.3) Turn left (south) off of Sierra Madre Road toward the trailhead parking.
- 18.9 (0.1) Parking area for hike along the Jackson Trail.

Description of the hike

From the parking area walk west on the Jackson Trail toward Jackson Spring (Fig. 7). Just after leaving the parking area, the trail crosses the contact between a lower Miocene shale unit and the Hurricane Deck Formation (Thomas and others, this volume), but the contact is not visible because of the thick soil and grass cover on the potrero. The surrounding mountain tops and potrero surfaces have gentle, rounded topography and thick soil because these surfaces represent an old, deeply weathered erosion surface of probable Pleistocene age that has not yet been invaded by headward erosion of the younger, deeply dissected canyons. This old erosion surface probably corresponds in age to the well-developed terraces on the lower slopes of the Sierra Madre.

The sandstone cliffs west of Jackson Spring (Fig. 8) belong to the Vaqueros Formation of early Miocene age. Examination of the sandstone in this area will reveal cross bedding and common fossil fragments, mostly sea urchin spines. Note on the map (Fig. 7) how thick the formation is here and how rapidly it thins in all directions. The fossils and their preservation, and the grain size, cross bedding, and unit shape or geometry indicate that the Vaqueros Formation was deposited in a shallow-marine, high-energy, shoreface environment as a canyon fill in an irregular



Figure 8. View looking southeast near Jackson Spring of a relatively thick sequence of shoreface, valley-fill sandstone deposits of the Vaqueros Formation.

topographic surface that had been eroded on the pre-existing Eocene rocks. During the Oligocene, this area was an eroding highland, while to the east in the Santa Barbara Canyon area, the Simmler Formation (studied on Field Trip 3) was being deposited on a wide, delta plain. Note the differences in character between the Vaqueros Formation here and at the sites for Field Trips 1 and 3, where the depositional environment was deltaic.

Return to the conformably overlying lower Miocene mudstone that is east of Jackson Spring. Knowledge of the exact age and depth of deposition of this unit is meager, which is why there is confusion as to its correlation (Freitag and Fritsche, this volume). It represents continued transgression and deposition in deeper water than the Vaqueros Formation. A structureless sandstone bed within the shale to the east of Jackson Spring resembles the Hurricane Deck Formation in lithologic character, so may have been deposited in a similar environment. Based on this comparison, the shale was deposited at bathyal depths and the transgression was very rapid.

Hike back to the parking area and drive to Painted Rock Campground. The rocks exposed here belong to lithosome D of

the Hurricane Deck Formation (Thomas and others, this volume). All the rocks of the Hurricane Deck Formation in the Sierra Madre were deposited by gravity processes in the upper-fan portions of a submarine fan that was accumulating on a relatively steep delta slope. Lithosome D was deposited most likely by grain flow or creep or by mass sliding or slumping processes in either shallow channels or lobes.

Continue driving east toward Pine Corral. Where the road crosses a fault to the west of Lion Canyon, there is a good opportunity just to the right (south) of the road to see the undifferentiated lower Miocene shale unit in unconformable contact with the underlying Eocene rocks; the Vaqueros Formation is missing due to the onlapping nature of the unconformity.

A stop at Pine Corral offers further opportunity to study the Hurricane Deck Formation. In the outcrops to the left (west) of the road are examples of lithosome A of Thomas and others (this volume). Lithosome A is conglomeratic or pebbly sandstone and has a definitely scoured or channeled base. It was deposited probably by the same processes responsible for lithosome D (seen at Painted Rock Campground), but acting on coarser grained material. To the right (east) of the road, in the outcrop shown in Figure 9, are exposures of lithosomes B and C of Thomas and others (this volume). These two lithosomes were most likely deposited by turbidity current events (Thomas and others, this volume). Also in this outcrop can be seen flame structures and the gradual wedging out or truncation of beds laterally.

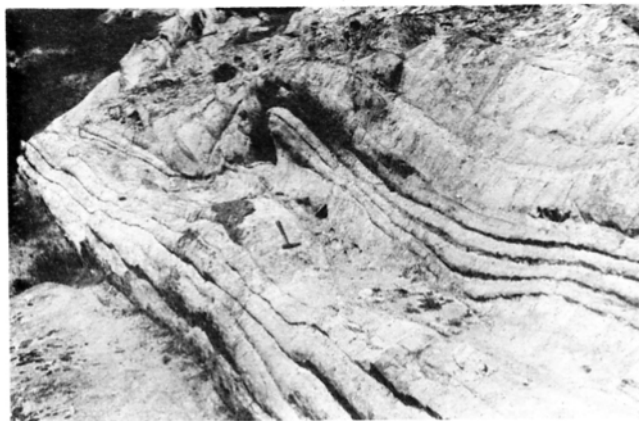


Figure 9. View looking northwest toward Pine Corral of graded and scoured or channeled sandstone beds (lithosomes B and C, respectively, of Thomas and others, this volume) in the Hurricane Deck Formation. Note how the upper sequence of beds has truncated the lower sequence.

FIELD TRIP 5

Introduction

This trip is similar to Trip 2 in that it goes into the foothills of the Sierra Madre on the south side of the Cuyama Valley in northeastern Santa Barbara County (Figs. 1, 10). Whereas Trip 2 concentrated on the middle and upper Miocene Branch Canyon and Santa Margarita Formations, the major concern of this trip will be the upper submarine-fan channel deposits of the lower Miocene Hurricane Deck Formation and the moderately deep-water slope or prodelta deposits of the middle Miocene Monterey Shale. Fossil beds in the Branch Canyon Formation will also be observed. Access to the parking area is over an oil field road on the Johnston Ranch, and permission to make this trip must be obtained from Mr. Lamar Johnston. The exposures to be studied are all within the Los Padres National Forest. The hike is about 2 mi round trip and is relatively easy. Elevation difference from the parking area to the

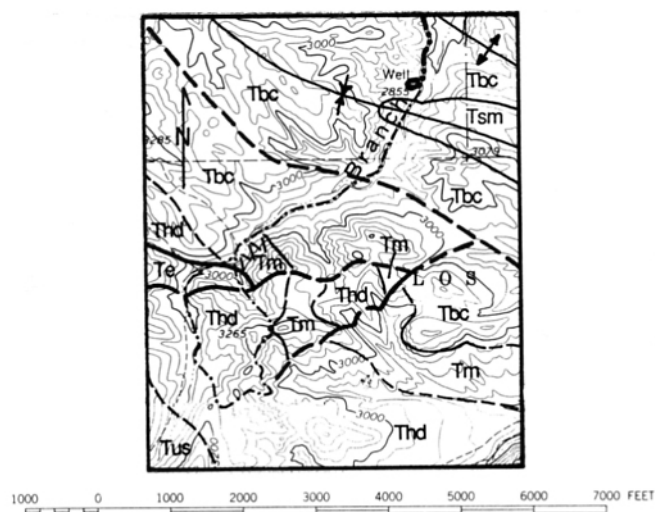


Figure 10. Geologic map of part of the Branch Canyon area (from Fritsche, 1969) to be used with Field Trip 5. Hike route shown in dash-dot line; end of driving route shown in wide dash-double-dot line. See text for description of features along hike route. Formation symbols: Tsm = Santa Margarita Formation, Tbc = Branch Canyon Formation, Tm = undifferentiated Monterey Shale, Thd = Hurricane Deck Formation, Tus = undifferentiated shale belonging to either the Vaqueros Formation or the Monterey Shale, Te = undifferentiated Eocene rocks. Quaternary terrace deposits have been omitted for simplification.

highest outcrops to be observed is 360 ft. The access road is paved all the way to the parking area, so as with Trip 2, this trip can be made at almost any time.

Road log for Trip 5

Total mileage (interval mileage)

- 0.0 Leave the park in New Cuyama and head west on Highway 166.
- 0.4 (0.4) Turn left (south) onto Perkins Road.
- 3.3 (2.9) Take the right (west) fork at a "Y" in the road.
- 4.0 (0.7) Cross a cattle guard.
- 4.3 (0.3) Boulevard stop at Foothill Road. Continue to the right (west) on Foothill Road.
- 4.5 (0.2) Take the left (south) fork at a "Y" in the road.
- 4.7 (0.2) Oil field road on right (west). Continue straight.
- 4.8 (0.1) Turn right (west) at oil field road and cross a cattle guard.
- 5.1 (0.3) Bear left (south) around some oil storage tanks at a "Y" in the road.
- 5.7 (0.6) Cross a cattle guard.
- 6.0 (0.3) Branch Canyon water well. Park in the flat area here, off the road and away from the well, so that oil field workers can have access and turn-around space. Begin the hike shown in Figure 10 from this point.

Description of the hike

In the canyon just west of the parking area at the Branch Canyon water well (Fig. 10, near the "2" in "2855") in the uppermost part of the Miocene Branch Canyon Formation, are abundant specimens of *Balanus gregarius*. Although most of the specimens are either fragmented or well cemented into the rock (Fig. 11), diligent searching will produce some good collectable examples. This is true of almost all of the fossils in the Branch Canyon Formation. Ostreids and *Astrodapsis whitneyi* are also found at this locality.

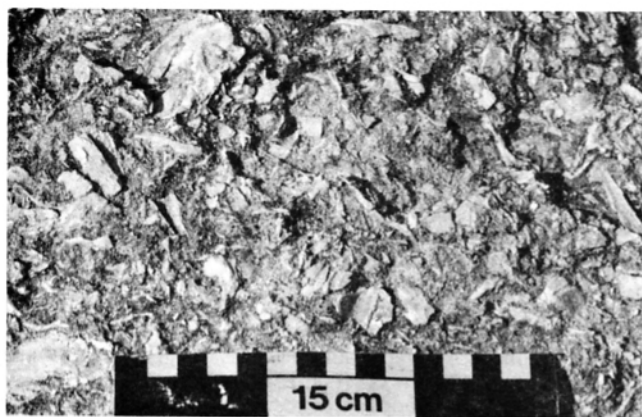


Figure 11. Fragments of *Balanus gregarius* exposed just west of the Branch Canyon water well in a storm-lag deposit (lithosome B of Perri and Fritsche, this volume) of the Branch Canyon Formation.

Return to the parking area and walk south through the Forest Service gate up the old Branch Canyon road. On the south side of the syncline (Fig. 10) at the point where the road first crosses the creek are several resistant beds in the stream cut on the right (west) side of the road. These beds contain, among other fossils, *Astrodapsis whitneyi* (Fig. 12), *Lyropecten crassicardo*, and *Mytilus expansus*. These beds probably are storm-lag concentrations in the upper shoreface of a wave-dominated, linear shoreline on a delta (lithosome B of Perri and Fritsche, this volume).

Continue up the canyon to near the 3,000-ft level, where a slice of undifferentiated Eocene rocks is exposed between two faults. These rocks have received little study in this area.

Follow the left (east) bank of the stream to a vertical stream-cut exposure of the lower Miocene Hurricane Deck Formation (Thomas and others, this volume). This exposure displays bedding and cross bedding, which are unusual for this formation. Rip-ups or intraclasts are common in these beds.

Proceed south and climb up to the low saddle on the southeast side of the canyon. In this area are numerous, knob-like

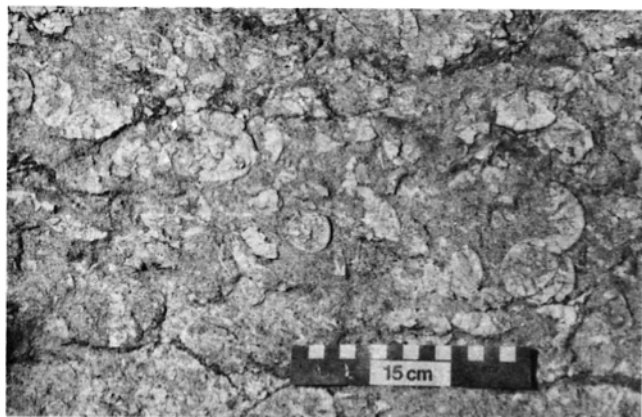


Figure 12. Fragments and a few whole specimens of *Astrodapsis whitneyi* exposed south of the Branch Canyon water well on the west side of Branch Canyon in a storm-lag deposit (lithosome B of Perri and Fritsche, this volume) of the Branch Canyon Formation.

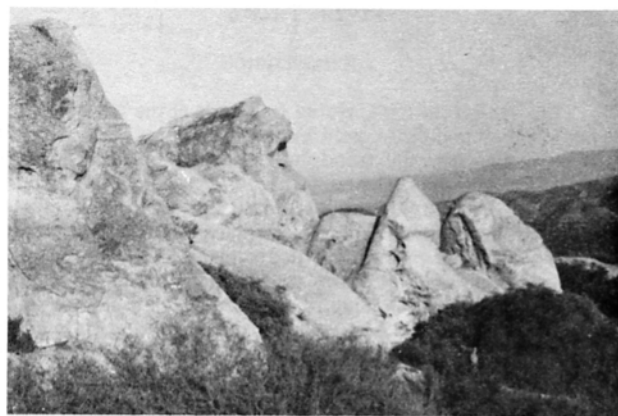


Figure 13. View looking north near the turn-around point on Field Trip 5 of typical knob-like exposures of the Hurricane Deck Formation. The picture in Figure 14 was taken near the pock-marked knob to the right-center of this picture. Note person for scale.

exposures that are typical of the Hurricane Deck Formation (Fig. 13). The rocks here belong mostly to lithosomes A and D of Thomas and others (this volume) and represent either grain flow or creep or mass sliding or slumping of sand and gravel down shallow channels on the upper-fan portion of a submarine fan. Follow the route through the knobs shown on Figure 10 to view the lithologic aspects of these rocks. Large rip-ups or intraclasts (Fig. 14) are common, as well as large channels filled with pebble conglomerate. A study to see if imbrication exists in the pebbles has not yet been done.

Continue along the route on Figure 10 to the saddle to the north where undifferentiated Monterey Shale lies conformably on the Hurricane Deck Formation. This thin sequence of Monterey Shale interfingers to the west with the base of the Branch Canyon Formation. Because of its grain size and stratigraphic position, it probably represents either offshore prodelta or deep-water delta slope deposits.

Proceed down the canyon to the north and rejoin the road in Branch Canyon to return to the parking area.



Figure 14. Large rip-ups or intraclasts in the Hurricane Deck Formation. Picture taken at outcrop shown in Figure 13.

FIELD TRIP 6

Introduction

This trip is into the Cuyama Badlands at the east end of the Cuyama Valley in northwestern Ventura County (Figs. 1, 15). The purpose is to view the floodplain deposits of the Oligocene Simmler Formation; the unconformably overlying, transgressive and regressive, shoreface to offshore, mildly wave-dominated deposits of the lower Miocene Vaqueros Formation; and the foreshore to upper delta plain deposits of the lower Miocene Caliente Formation. This trip is on land administered by the Bureau of Land Management and access permission is not required. The hike is 2 to 2.5 mi round trip and of moderate difficulty in the middle, although the difficult part can be avoided with a little extra walking. The rocks to be studied are in two adjacent canyons and the climb from the parking area to the highest point to be visited in the canyons is 250 ft. The shortest route requires going over the ridge between the two canyons, which is an additional climb of 200 ft. It is also possible to go back out the first canyon to the junction and then up the second canyon. The access road to Ballinger Campground is paved and can be traversed at any time. The last 0.7 mi from the campground to the parking area is a dirt off-road vehicle road. It can be driven easily in a two-wheel drive vehicle, but after a good rain will require several days to dry out. It is possible, of course, to park in the campground and make the trip by walking an extra 1.5 mi.

Road log for Trip 6

Total mileage (interval mileage)

- 0.0 Leave the park in New Cuyama and head east on Highway 166.
- 2.0 (2.0) Bell Road on right (south). Continue straight.
- 4.0 (2.0) One-room Cuyama Post Office on right (south). Continue straight.
- 5.3 (1.3) Kirschenmann Road on right (south). Continue straight.
- 5.5 (0.2) Highway bridge over the Cuyama River.
- 10.2 (4.7) Turn right (south) on Highway 33.
- 13.0 (2.8) Foothill Road on right (west). Continue straight.

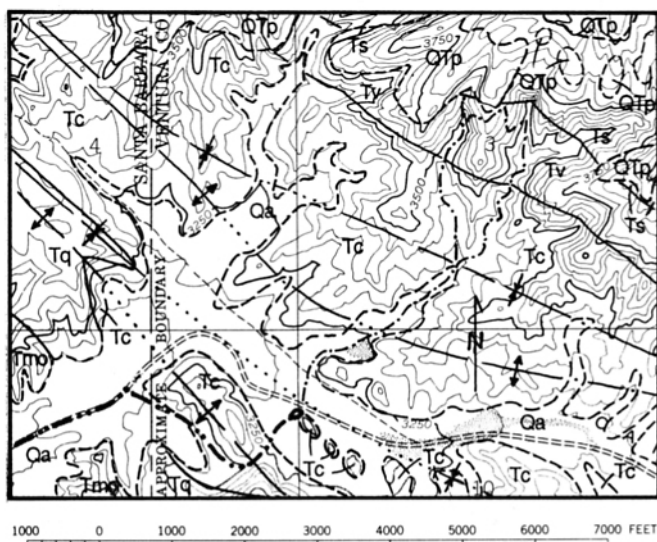


Figure 15. Geologic map of the Ballinger Campground area (from Dibblee, 1972) to be used with Field Trip 6. Hike route shown in dash-dot line; end of driving route shown in wide dash-double-dot line. See text for description of features along hike route. Formation symbols: Qa = alluvium, QTp = Paso Robles Formation, Tmo = Morales Formation, Tq = Quatal Formation, Tc = Caliente Formation, Tv = Vaqueros Formation, Ts = Simmler Formation.

- 13.8 (0.8) Turn left (east) on Ballinger Canyon Road.
- 17.3 (3.5) Ballinger Campground. This is a designated off-road vehicle (ORV) area and is very noisy on weekends. Continue through the campground and follow the ORV road that goes up to the saddle east of the campground (Fig. 15).
- 17.8 (0.5) Saddle in ORV road. Continue through the saddle and down the hill on the other side.
- 18.0 (0.2) Park at the bottom of the hill where the road turns to the right (east). Leave the vehicle and begin the hike shown in Figure 15.

Description of the hike

From the parking area, hike across Ballinger Canyon and up the large canyon to the north (Fig. 15). Exposures on both sides of the canyon are in floodplain deposits of the Miocene Caliente Formation. An anticline trace is crossed about 0.3 mile from the parking area. At the place where the canyon divides into two major tributaries, is a syncline in the Caliente Formation. Take the right (east) fork and proceed up the canyon. The return route will come down the left (west) fork.

The Vaqueros Formation exposed in these two tributaries lies in slight angular unconformity on the Oligocene nonmarine Simmler Formation and is conformably overlain by the Miocene nonmarine Caliente Formation. The Vaqueros Formation is transgressive in the lower half and regressive in the upper half. The unconformity at the base of the Vaqueros indicates that the transgression was across an erosional coastline. The rocks show that the environment was mildly wave dominated. The conformable passage at the top of the formation from marine to nonmarine rocks indicates that the environment was deltaic. Mild wave domination persisted on the delta coastline.

About 200 ft south of the contact with the Vaqueros Formation (Fig. 15), a resistant limestone bed is exposed. Although the contact between the Vaqueros and Caliente Formations is based on a change in color from yellow to red or pink (supposedly marine to nonmarine), both oysters and shark teeth are found in the lowermost Caliente Formation, which indicates that the change from marine to nonmarine conditions does not correspond to the color change. The limestone bed is further evidence that marine conditions persisted into what is the Caliente Formation because it contains marine foraminifers and very small bivalves (R. J. Menzie, personal communication). Analysis of the limestone is still in progress.

Just north of the Vaqueros-Caliente contact in the Vaqueros Formation, the fine-grained sandstone contains common secondary gypsum veins, so it may be gypsum cemented. Also plant fragments are common in the upper third of the formation. The plant material is a reflection of the deltaic setting. The lack of structures in the rock indicative of tidal or river currents, however, suggests that this was a low-energy shoreface environment with the dominant current being mild wave action. This upper portion of the formation is the regressive or progradational part.

About 700 ft up the canyon beyond the Vaqueros-Caliente contact, the rock is a very fine-grained mudstone that was deposited in an offshore environment. Microfaunal studies of this mudstone are not complete, so a determination of depositional depth is not available.

Below the mudstone in the lower portion of the formation is a transgressive sandstone. Climb the hill to the west, using the switchback method for safety, and look at the base of the Vaqueros Formation just below where it is covered unconformably by the Plio-Pleistocene, fluvial Paso Robles Formation. A bed of oysters and other fossils occurs here in an upper shoreface setting.

Finish the climb to the ridge and look west at the lower contact of the Paso Robles Formation on the east-facing slope of the next canyon. Note the deep canyon or channel that was cut into the Simmler Formation during the late Pliocene and then filled by