Western San Joaquin Basin Field Trip

Time		Miles	Stop	Stop Description / Activity	Special Note / Hazard
Arrival	Departure	To:	No.		
7:45 AM	8:00 AM	0.0	0	Meet outside main entrance of Harris Ranch Inn	Leave on time
8:25 AM	9:15 AM	25.0	1	Viewpoint from Kettleman North Dome sign	Regional geology/Traffic
9:45 AM	10:00 AM	9.6	2	Big Tar Canyon; McLure Member of Monterey Fm.	Lacks source rock qualities/walk
10:00 AM	10:15 AM	0.1	3	Big Tar Canyon; Temblor Formation	Shallow water deposit/walk
10:15 AM	11:05 AM	0.1	4	Big Tar Canyon; Kreyenhagen Formation; oil seep	Eocene source rock/walk
12:00 PM	12:45 PM	30.6	5	Lunch in City Park, Coalinga	Restrooms
1:00 PM	1:15 PM	6.1	6	Meet Jay Haas, Aera Safety Officer at intersection	Oil City Road with Shell Road
1:45 PM	2:30 PM	10.0	7	Cartwheel Ridge; Cut in Kreyenhagen Formation	Regional geology; cut bank
2:30 PM	2:45 PM	0.2	8	Walk; Temblor Formation in cliff along road	Oyster beds; view Coalinga field
3:00 PM	3:45 PM	1.0	9	See brea or tar sand in Quaternary on Temblor Fm.	Updip seal of Coalinga field
4:30 PM	ASAP	12.0	0	Return to Harris Ranch Inn & Restaurant	End BPSM meeting

*Sunrise 6:37 AM; Sunset 4:54 PM

Driving directions for the western San Joaquin basin field trip

Stop 0 to Stop 1. Drive from Harris Ranch Inn & Restaurant main entrance onto Hwy 198. Turn left or west onto Hwy 198 (W. Dorris Ave) to intersection with Hwy 5 and turn south for 21.5 miles (20 minutes) to Hwy 269. Drive south toward Avenal for 2.5 miles (3 minutes) to Stop 1 on the left at Kettleman North Dome Field (110 Skyline Blvd; 25 miles; 25 minutes).

Stop 1 to Stop 2. Drive 3.0 miles (5 minutes) south on Hwy 269 to Hwy 33. Turn left or south onto Hwy 33 for 0.8 mile (1 minute) then right or southwest onto Tar Canyon road. Drive about 5.8 miles (22 minutes) to the McLure Member of Monterey Formation outcrop on the right side of road. Need to go through a gate or two (9.6 miles; 28 minutes). Car will continue to drive up hill to Car Park then driver walks back.

Stop 2 to Stop 3. Walk up road approximately 0.1 mile to an outcrop of the Temblor Formation.

Stop 3 to Stop 4. Walk up road approximately 0.1 mile to an outcrop of the Kreyenhagen Formation and an oil seep on the right side of the Tar Canyon Road. Continue up hill to parked cars.

Stop 4 to Stop 5. Drive back on Tar Canyon Road to Hwy 33 (13 miles (35 minutes). Then turn north or left onto Hwy 33 toward Coalinga for 17.6 miles (18 minutes) to have lunch in George E. Olsen Memorial Park. Total distance to our lunch stop is 30.6 miles in 53 minutes.

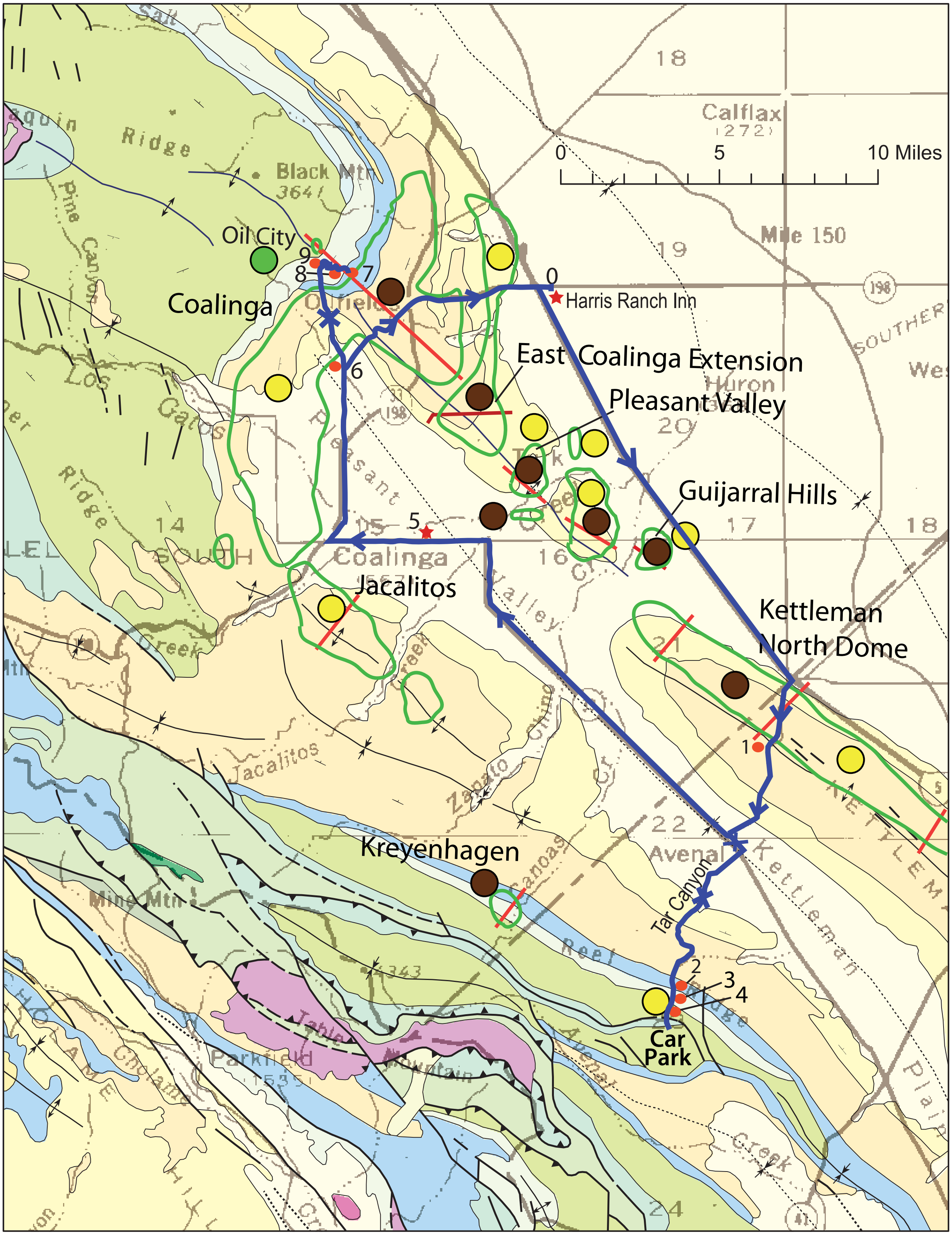
Stop 5 to Stop 6. Drive west on Hwy 33 a very short distance then north on Hwy 33 to the intersection of Shell Road and Oil Canyon Road to meet our Aera Energy representative Jay Haas. Total distance is 6.1 miles in 10 minutes.

Stop 6 to Stop 7. Following our Aera Energy representative to Cartwheel Ridge for about 10 miles within the Coalinga oil field property. Here we get an overview of the regional geology and what we will see on the cut bank created by a bulldozer for depositional study of the Temblor Formation. Porta-potty will be available.

Stop 7 to Stop 8. Walk down the road from Cartwheel Ridge for 0.2 mile to observe the cliff forming fossiliferous Temblor Formation on your left to the bottom of the outcrop.

Stop 8 to Stop 9. Drive about a mile to the brea or tar sand in a Quaternary deposit sitting on top of the Temblor Formation. Time will be spent hunting for fossils and observing the updip seal of the Coalinga oil field. Porta-potty will be available.

Stop 9 to Stop 0. Drive back to the Harris Ranch Inn & Restaurant and to the end of the BPSM Affiliates Meeting for 2018 ends. Thanks for attending our 11th annual meeting.



Field Trip Map & Route

Geologic Map Explanation

Petroleum System		Oil from source rock
Tumey-Temblor(.)	● (brown)	Tumey Formation
Kreyenhagen-Temblor(!)	● (yellow)	Kreyenhagen Fm
Moreno-Nortonville(.)	● (green)	Moreno Formation

Trip route

6 Geologic stop

7 Start/end or lunch stop

Field outline

Field cross section

Qls	Selected large landslides, such as Blackhawk Slide on north side of San Gabriel Mountains; early to late Quaternary.
Q	Alluvium, lake, playa, and terrace deposits; unconsolidated and semi–consolidated. Mostly nonmarine, but includes marine deposits near the coast. Quaternary
QPc	Pliocene and/or Pleistocene sandstone, shale, and gravel deposits; mostly loosely consolidated.
P	Sandstone, siltstone, shale, and conglomerate; mostly moderately consolidated. Pliocene.
M	Sandstone, shale, siltstone, conglomerate, and breccia; moderately to well consolidated. Miocene.
Mc	Sandstone, shale, conglomerate, and fanglomerate; moderately to well consolidated. Miocene.
E	Shale, sandstone, conglomerate, minor limestone; mostly well consolidated. Eocene.
Ep	Sandstone, shale, and conglomerate; mostly well consolidated. Paleocene.
Ku	Upper Cretaceous sandstone, shale, and conglomerate.
Kl	Lower Cretaceous sandstone, shale, and conglomerate.
KJf	Franciscan Complex: Cretaceous and Jurassic sandstone with smaller amounts of shale, chert, limestone, and conglomerate.
um	Ultramafic rocks, mostly serpentine. Minor peridotite, gabbro, and diabase. Chiefly Mesozoic.
gb	Gabbro and dark dioritic rocks; chiefly Mesozoic.

Stop 1:

Kettleman North Dome Field

Regional Geology

This Kettleman North Dome sign will be on your left as you drive south on highway 269. Turn left into the parking area adjacent to the Kettleman North Dome field sign where we will give you a regional view of the northern San Joaquin Basin and the petroleum geology.

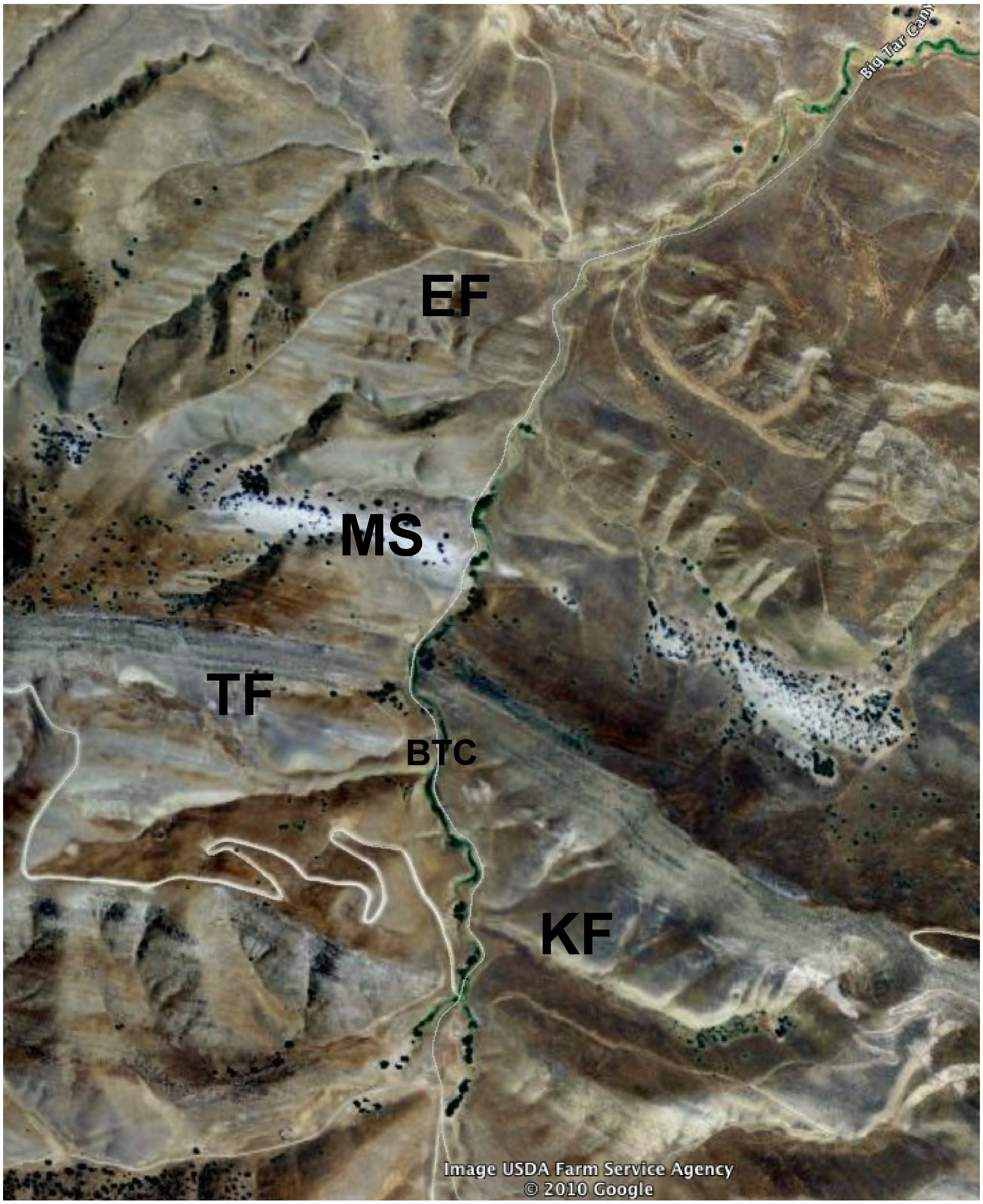
Looking west across the cultivated field one can see Big Tar Canyon or the valley that is located between Reef Ridge on the skyline. This ridge is held up by the Temblor Formation of Miocene age. The Kreyenhagen source rock is presently buried in excess of 3 kilometers beneath the cultivated field in the valley floor.

Big Tar Canyon

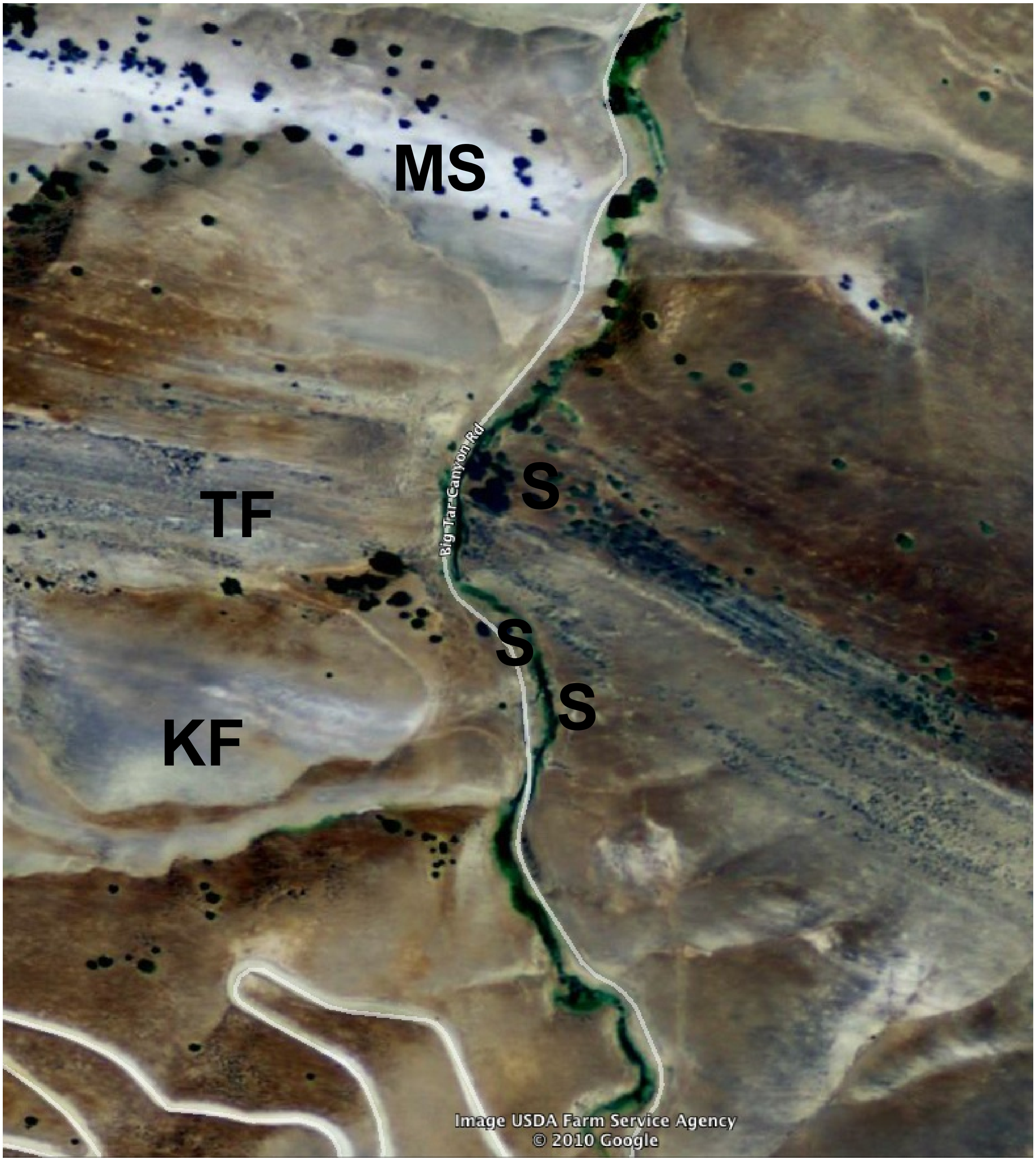
Stop 2: McLure Shale Member of the Monterey Formation

Stop 3: Temblor Formation

Stop 4: Kreyenhagen Formation with active oil seep



BTC = Big Tar Canyon (road)   EF = Etchegoin Formation
MS = McLure Shale Member of Monterey Fm.   TF = Temblor Formation
KF = Kreyenhagen Formation



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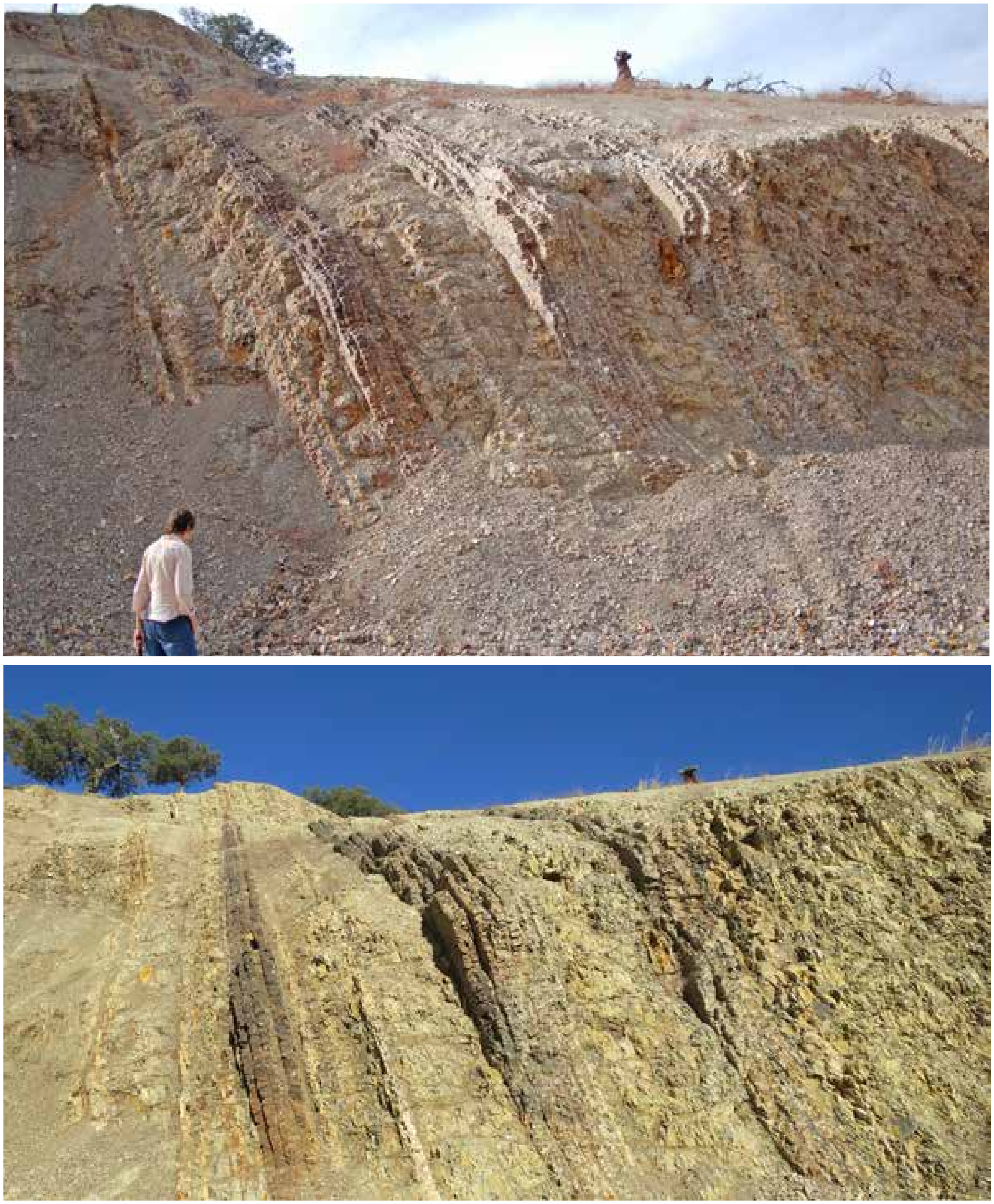
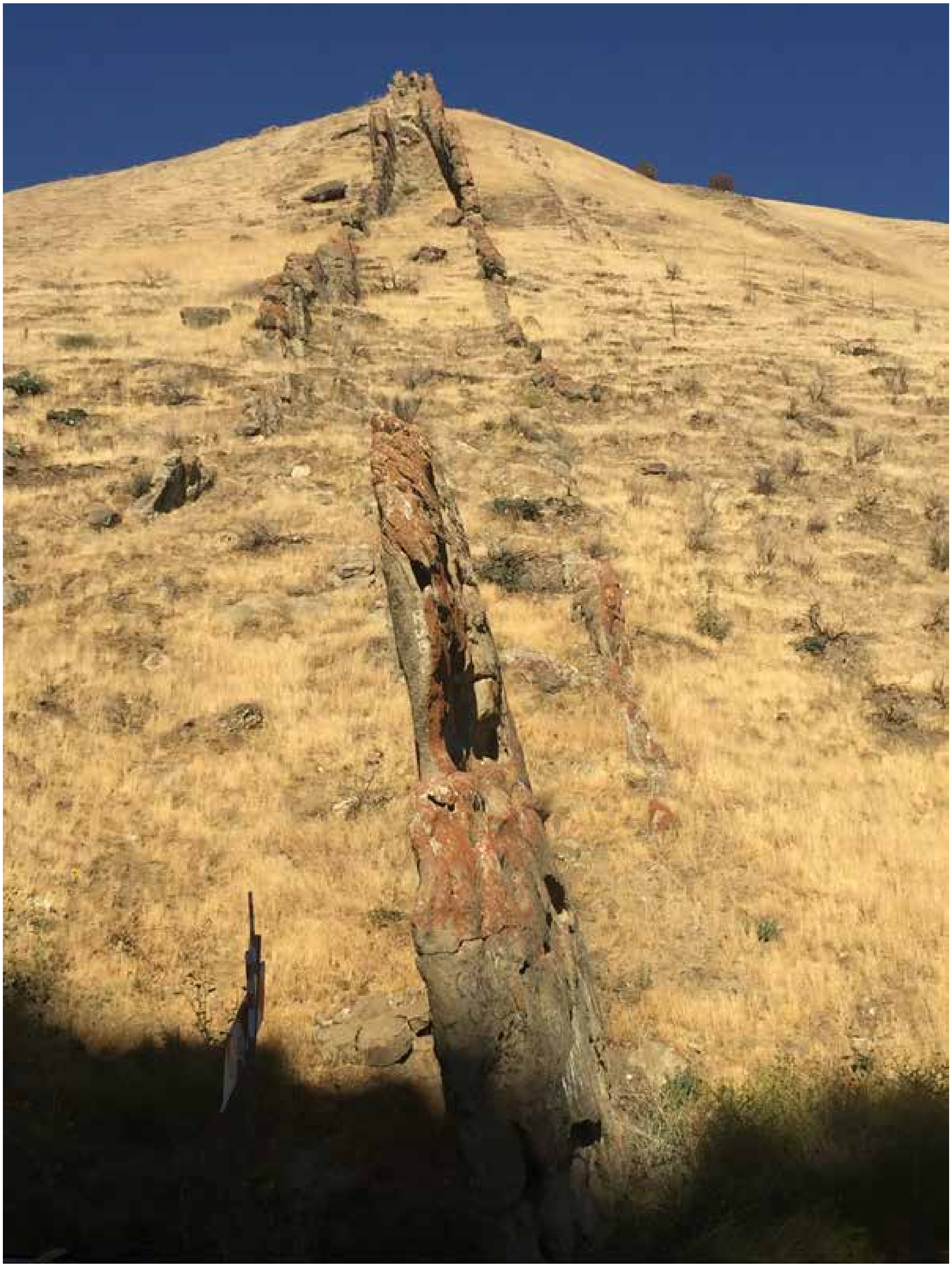


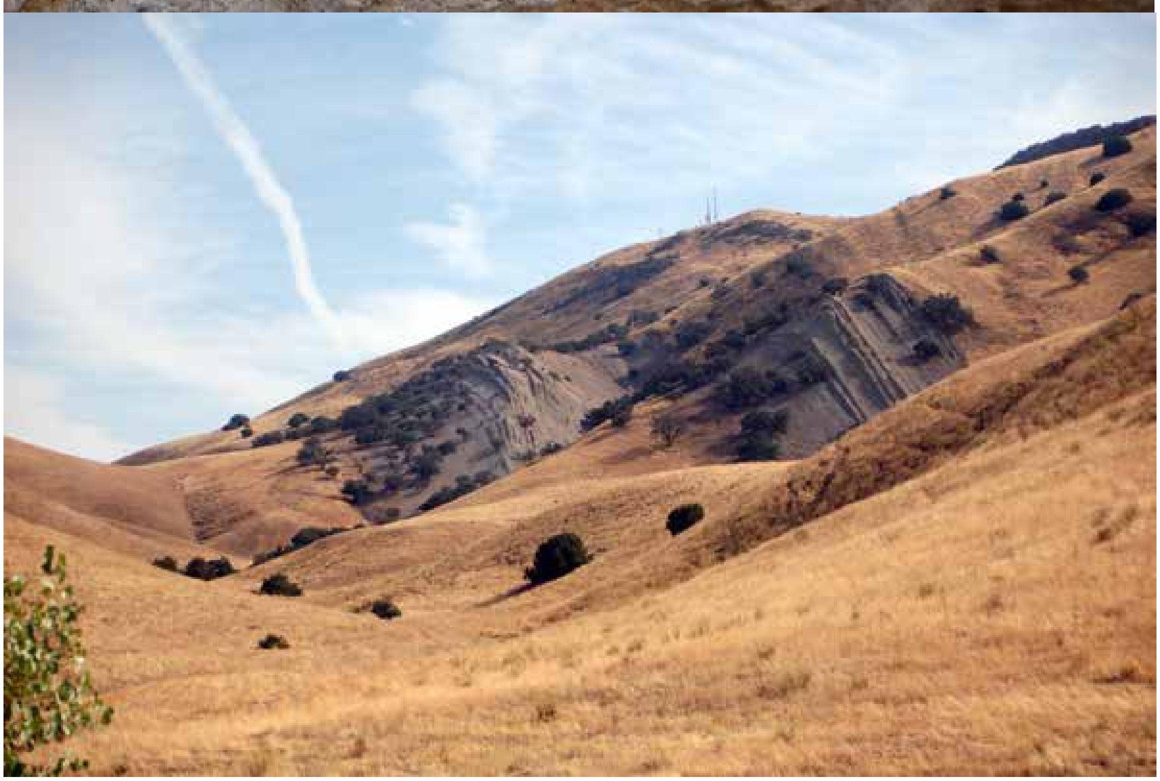
Stop 2 is the McLure Shale Member of Monterey Formation exposed along Big Tar Canyon road. This section includes mudstone and porcelanite, the latter occurring as the prominently outcropping bundles of beds.


Stop 2 is the Temblor Formation on the north side of the Big Tar Canyon road a short uphill walk from the McLure Shale Member of the Monterey Formation.

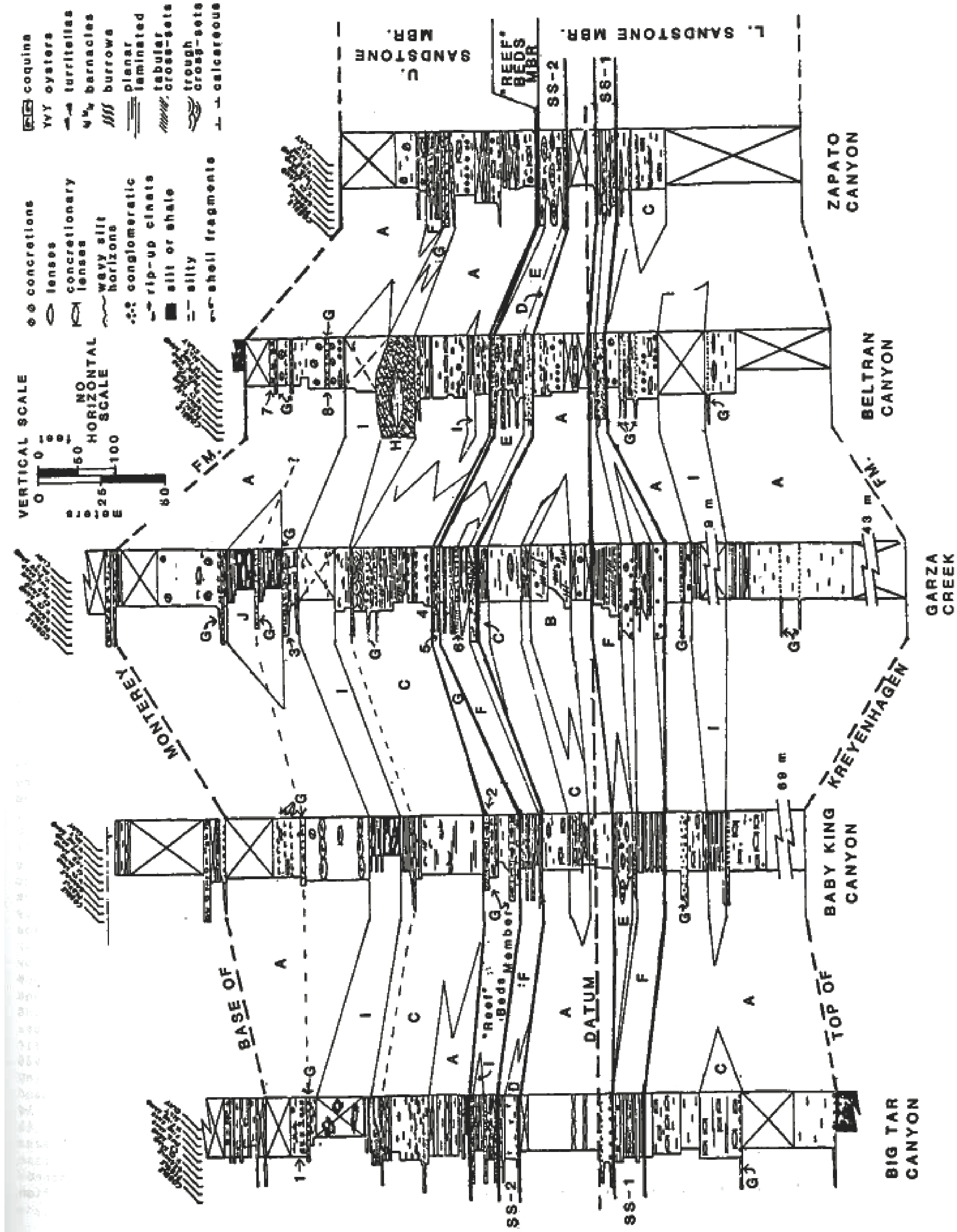

Stop 4 is the active seep of Kreyenhagen-sourced oil near the top of the Kreyenhagen Formation that is a short uphill walk from the Temblor Formation on the north side of the Big Tar Canyon road.

Active seep of Kreyenhagen-sourced oil near the top of the Kreyenhagen Fm. along Big Tar Canyon Road. Kreyenhagen is thermally immature at this location.

Top: Ridge-forming Temblor Fm. (left), overlain by gray McLure Shale Member of Monterey Fm. (center) and low hills of Etchegoin Fm. Shot from Reef Ridge. Avenal in distance.
Bottom: Ridge of Temblor Fm. (right), grassy Kreyenhagen Fm. (center), Domengine Fm. (left).



Top: Turritella coquina of a ‘reef’ bed exposed on Reef Ridge north of Big Tar Canyon.
Bottom: View south from Big Tar Canyon to McLure McLure Shale Member of Monterey Fm.



VERTICAL SCALE
NO HORIZONTAL SCALE
BIG TAR CANYON
BABY KING CANYON
GARZA CREEK
BELTRAN CANYON
ZAPATO CANYON
BASE OF MONTEREY FM.
TOP OF KREYENHAGEN FM.
DATUM
U. SANDSTONE MBR.
"REEF" BEDS MBR
L. SANDSTONE MBR.
SS-1
SS-2

Cooley, 1985

Oil tanks 1.2 mi. down Big Tar Canyon Road.

The oil tanks on the left are part of the Union Oil Tar Canyon Pump Station which services a pipeline running roughly northwest-southeast across Kettleman Plain.

Cattleguard and manmade concrete dip in road 1 mi. further at foot of Kreyenhagen Hills.

This is the approximate location of the unconformable contact between the Quaternary valley fill and the underlying 3000 feet of nonmarine sandstones, siltstones and conglomerates known as the Plio-Pleistocene Tulare Formation. Tulare Formation conglomerates hold up the first low hills.

Old water tank on right side of road 0.7 mi. past cattleguard and concrete dip.

Just beyond this is the approximate position of the conformable contact between the Tulare Formation and the underlying upper Pliocene San Joaquin Formation. The San Joaquin Formation consists of about 2200 feet of soft, sparsely fossiliferous siltstones and clay shales deposited under marine, brackish and lacustrine conditions. Mya and Ostrea bearing beds in the upper part of the formation mark some of the brackish water phases (Adegoke, 1969). A 50 foot thick pebble conglomerate/pebbly sandstone interval (the Cascajo Conglomerate Member of Adegoke, 1969) marks the base of the San Joaquin Formation.

Sign on right 0.4 mi. further: "Jerry Sagasser ranch headquarters, 4 miles".

The dirt road branching off to the right from here leads to the Jerry Sagasser Ranch. Two excellent exposures of the Temblor Formation occur on this property, in Baby King Creek and Garza Creek canyons.

0.3 miles past J. Sagasser ranch road - Big Tar Canyon Road makes a sharp jog to the right and then to the left. Road enters small alluviated flat.

This is the approximate location of the conformable contact between the San Joaquin Formation and the underlying Blue Sandstone Member of the lower to middle Pliocene Etchegoin Formation. The 1700 foot thick Blue Sandstone Member takes its name from the lenticular masses of coarse-grained, cross-bedded, blue sandstone, up to 500 foot thick, which are interbedded with the semifriable sandstones, siltstones, claystones, and minor conglomerates characteristic of the marine Etchegoin Formation.

Near end of flat 0.9 mi. further on, road makes a gradual turn to the right, passes an intersection with another paved road and then crosses Big Tar Creek for the first time.

This marks the approximate location of the contact between the Blue Sandstone Member and Basal Brown Member of the Etchegoin Formation. The 3500 foot thick Basal Brown Member contains less sandstone and more claystone and siltstone than the Blue Sandstone Member.

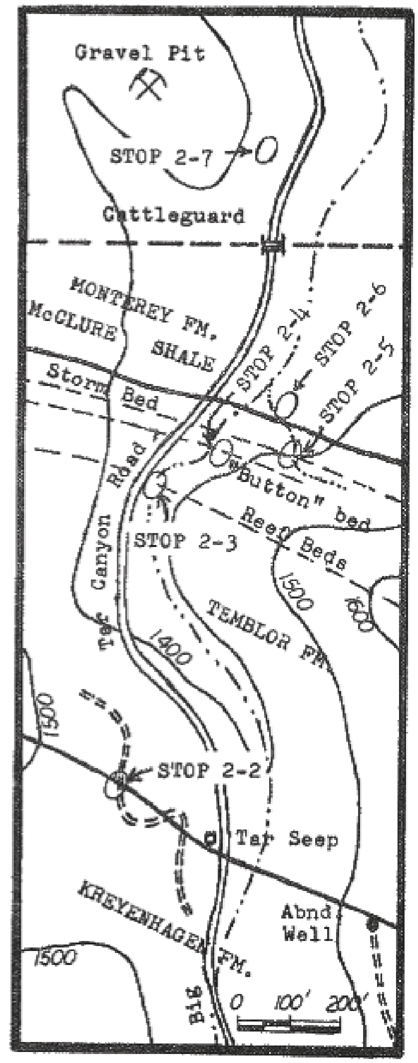


Figure 2-5. Map showing Reef Ridge stops 2-2 through 2-7 of the field trip.

Continue 0.5 mi., just past the remains of an abandoned ranch road (right side of road).

This is the approximate position of the conformable contact between the Basal Brown Member of the Etchegoin Formation and the underlying Reef Ridge Shale of the Monterey Formation.

We will now drive 0.7 mi. through the section to the base of the Temblor Formation. We will be examining the Temblor Formation and Monterey Formation exposed here for the duration of the trip (Fig. 2-5).

figure 2-6. Kreyenhagen Formation (Eocene)/Temblor Formation (Miocene) unconformable contact in Big Tar Canyon.

STOP 2-2. KREYENHAGEN FM./TEMBLOR FM. CONTACT

In the ditch on the north side of the road is an active oil seep, one of many in Big Tar Canyon (there is another in the creek bottom across the road). This seep produces 10 gallons of fluid (25% oil) per day (Hodgson, 1980). It is also home to the sorely mistreated Petroleum Fly (Psilopa petrolei), whose larvae inhabit the petroliferous nether reaches of a dark and dangerous seep micro-world where sticks and sampling apparatuses of the maliciously curious strike with little warning.

The oil fly's much-maligned home lies near the base of the Temblor Formation. Follow the abandoned road just above the seep for about 50 yards to the roadcut exposure of the Miocene/Eocene unconformity.

The brittle brown-to-purplish-grey siliceous mudstones in the left half of the outcrop (Fig. 2-6) represent the Eocene Kreyenhagen Formation. The lower Tertiary sequence in Big Tar Canyon is made up of the upper Eocene Kreyenhagen Formation and the underlying middle Eocene Avenal Sandstone. The Kreyenhagen Formation consists of 950-1250 feet of siliceous shales which were deposited in marine waters of bathyal depths (Dibblee, 1973). The Avenal Sandstone, which we will not see here, consists of 300-500 feet of fossiliferous shallow-marine sandstone. It conformably underlies the Kreyenhagen Shale and unconformably overlies the Upper Cretaceous Panoche Formation.

The friable, fine-grained, silty, unfossiliferous, massive light-colored sandstones of the right half of the outcrop (Fig. 2-6) represent the basal Temblor Formation. A thin pebble layer at the base of the sandstone marks the unconformity. As innocuous as it may appear, this unconformity represents all of the Oligocene and most, if not all, of the early Miocene. There is no early Miocene "Vaqueros" molluscan fauna in the basal Temblor Formation on Reef Ridge. However, some workers have correlated portions of this unfossiliferous and poorly exposed interval with the Vaqueros Formation (e.g., Bramlette, 1934; Goudkoff, 1934; Woodring, and others, 1940).

In Big Tar Canyon the Temblor Formation is just over 700 feet thick (fig. 2-7). It thickens by several hundred feet northwestward towards Baby King and Garza Creeks, and also downdip into the subsurface. The formation consists mostly of heavily bioturbated, massively bedded, fine-to-medium-grained "dirty" sandstones with interbedded intervals of sandy siltstone; thin-bedded siltstone, shale and fine sandstone; and coarse-grained sandstone which may be cross-bedded to planar laminated and conglomeratic. Sandy coquina beds, such as the "reefs", are common and pebbly horizons are not infrequent.

Megafossils are abundant in the Temblor Formation. The most common are Turritella ocoyana (gastropod), Aequipecten andersoni (pelecypod), Vaquerosella (Scutella) merriami (echinoid), and fragmented Balanus gregarius (barnacle). Several species, including Crepidula rostralis and Cancellaria dalliana (gastropods), and Patinopecten propatulus (pelecypod) are restricted to the "Temblor Stage" and indicate a middle Miocene age for the Temblor Formation (Adegoke, 1969; Addicott, 1970; Addicott, 1972).

Faunal and sedimentary characteristics indicate deposition of the Temblor Formation sands primarily on a shallow marine shelf well above storm wave base. Brief periods when tidal processes were dominant, however, are indicated by several thin intervals within the Temblor Formation (Cooley, this volume).

The following descriptions highlight interesting features in the Big Tar Canyon section of the Temblor Formation.

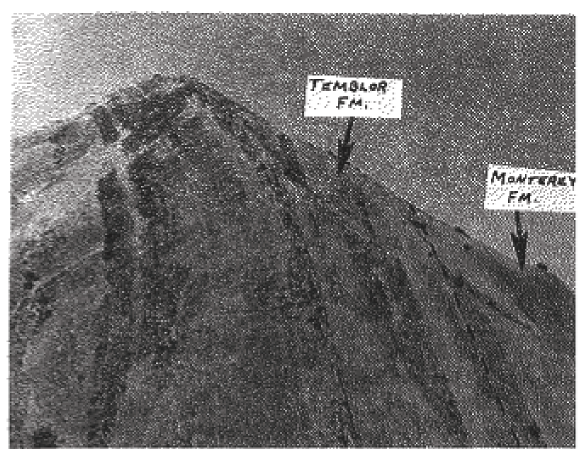


Figure 2-7. Temblor Formation exposed on northwest side of Big Tar Canyon.

Return to Big Tar Canyon Road and walk upsection to the point at which several prominent sandstone ledges are exposed all the way down to road level.

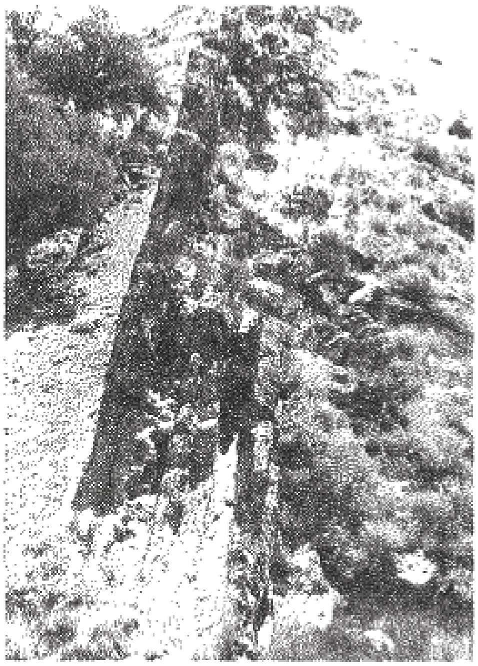


Figure 2-8. "Reef bed" exposure on southeast side of Big Tar Canyon Road.

STOP 2-3. "REEF" BEDS

The most striking features of the Temblor Formation on Reef Ridge are the "reef" beds. These form prominent weathering-resistant ledges (Fig. 2-8) which crest the ridge. The beds consist of sandy bioclastic limestone, the framework of which is a dense network of molluscan molds and shell fragments. Most of the beds are massive, but some are planar-laminated or show isolated cross-beds. The beds are conglomeratic and occasionally contain mammal bones and cobbles. The "reef" beds are 1-6 feet thick and alternate with finer-grained sparsely fossiliferous grey sandstones which are massive, planar laminated, or cross-bedded.

The beds are tabular to lenticular and can be laterally discontinuous. On the northwest side of the road, the two lowest beds overlap and pinch out beneath a large sandstone lens (Fig. 2-9). The uppermost bed is tabular and continuous, except for a slight downward swelling near the top of the slope.

"Reef" bed sedimentary structures suggest that these are high energy storm-lag deposits. The beds were probably sourced by tidal channels which lay not far to the west of Reef Ridge (Cooley, this volume).

Figure 2-9. Tabular and lensate sandstone bodies within the "Reef Beds". Northwest side of Big Tar Canyon Road.

A cowpath just above the creek on the south side of the road leads from the "reef" bed ledges to a gully. We will walk along this gully to the next prominent ledge which marks the beginning of our Stop 2-4.

STOP 2-4. "BUTTON-BEARING" SANDSTONES

The ledge-forming sandstone consists of moderately-sorted, medium-to-coarse-grained, planar laminated to cross-bedded, fossiliferous calcareous sandstone. The laminae and cross beds are armored with highly comminuted "button" sand dollars of the species Vaquerosella (Scutella) merriami. The cross-bedding in this ledge is tabular in sets up to 14 inches thick. Cross-bedding directions suggest dominantly westerly paleocurrents, with minor bidirectionality. Across the road this unit is not cross-bedded, but rather shows well-developed, discontinuous linear horizons of "button" armoring. A few tens of yards farther on the bed is replaced - except for a thin interval at the top - by a massive, unfossiliferous, well-sorted, yellowish-brown, medium-grained sandstone. The whole "button-bearing" bed, however, reappears about 150 yards beyond that.

The "button-bearing" unit's coarse-grained character, bioclastic content, current lamination, and cross-bedding suggest it was deposited by strong currents in shallow water. Since the unit is laterally correlative with open-shelf tidal deposits, it too was probably of tidal origin (Cooley, this volume). The lateral discontinuity of all but the uppermost beds may indicate filling of troughs or shallow depressions on the sea floor.

Continue upsection along the gully to the next fossiliferous ledge, which represents Stop 2-5.

STOP 2-5. BARNACLE BEDS

A barnacle-bearing bed of fine-to-medium-grained calcareous grey sandstone occurs stratigraphically below the fossiliferous ledge. The unabraded barnacles (Balanus gregarius) occur with shell debris in 7 or 8 discrete layers 4-14 inches apart. Clusters of 2 to 8 barnacles, cemented at their bases to large shell fragments, occur in some of the layers (Fig. 2-10). Some of these clusters are in life position. Thus, the sand was deposited in less than 12 meters (39.3 feet) of water, the maximum depth of occurrence of similar barnacles on the west coast today (L. Phillips, pers. comm., 1982).

The barnacles are large enough to indicate more than a year's in situ growth before death (L. Phillips, pers. comm., 1982). The thin shelly layers which the barnacles colonized probably represent multi-year intervals of nondeposition. The interbedded sparsely fossiliferous sandstones probably represent sudden influxes of sediment which smothered and buried the barnacles. This episodic sedimentation was probably storm-related. Normal fair-weather tidal or wave-induced currents kept the sea floor swept clean of sand, allowing the barnacles to grow. Severe turbulence associated with big storms periodically buried those colonies which grew between the storms.

The resistant ledge underlying the barnacle bed consists of a medium-grained sandy coquina which contains abraded shells of a large pecten, as well as gastropods (including Turritella ocoyana), oysters, and barnacles. The bed is tabular and can be traced northwestward several miles to Baby King and Garza Creeks with little change in character. Its geometry, lateral continuity, lack of internal sedimentary structures, and the diverse fauna of abraded fossils, suggest a storm origin for this bed.

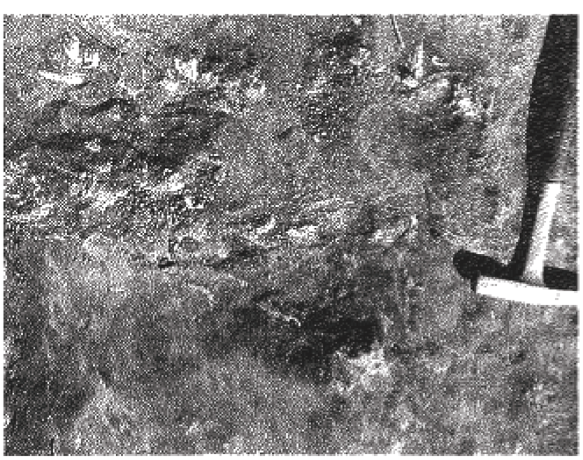


Figure 2-10. Barnacle clusters in growth position cemented to large shell fragments along discrete horizons within a massive sandstone.

We will continue walking along the gully almost to the creek, where several thin sandstone beds are visible.

STOP 6. TEMBLOR FM./MONTEREY FM. CONTACT

Thick tar-cemented conglomerates mark the basal Monterey formation in Garza Creek and Baby King Creek canyons to the northwest (Cooley, this volume). The lateral equivalents exposed in Big Tar Canyon vary along strike from thin pebble conglomerates to fine-to-medium-grained sandstones which contain only a few pebbles. Conglomerates include andesitic porphyry, greenstone, sandstone, and chert clasts. The lithic sandstone matrix also contains skeletal fragments of barnacles, oysters and pectens. Many small oil seeps are associated here with this basal unit and the beds are often tar-stained. The resistant sandstones are interbedded with brown nonresistant siltstones and fine-grained sandstones (Fig. 2-11).

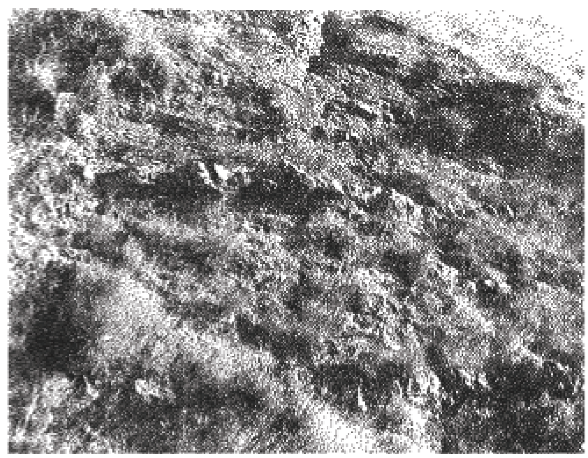


Figure 2-11. Basal sandstones of the Monterey Formation exposed on the southeast side of Big Tar Canyon.

What does this unconformity represent? Temblor Formation sedimentation began roughly at the same time as did the present episode of wrench fault tectonism (e.g., Harding, 1976, Fig. 2). Loomis and Glazner (1982) state that a major northward-progressing regional uplift in the San Joaquin Valley occurred at 15-13 mybp (see also Graham, and others, this volume) when the Mendocino Fracture Zone was subducted under the area. They calculated maximum total uplift during this time as 500 meters. Inception of uplift followed by subduction of an unstable triple junction (which, however it's done, must give the overlying crust one big bellyache) would explain the apparent general shallowing of Temblor Formation depositional environments upwards, at a time when global sea level was rising (Vail and Mitchum, 1980).

The time following this tectonically active period was marked by a complete change in sedimentation style - from shoaling clastics to deeper water, fine-grained, biogenic sediments. The transition is often gradational (Graham, and others, this volume), yet is marked in some places by basal sandstones and conglomerates.

Mapping the Temblor Formation/Monterey Formation contact, Cooley (this volume) noted that a thick basal conglomerate occurs in Baby King and Garza Creeks, but it thins laterally to sandstones and thin pebble conglomerates interbedded with shales as you see here. At the north and south ends of the Reef Ridge structure, the section is truncated and overlain with angular discordance by the Monterey Formation. It would appear that the Temblor Formation at Reef Ridge represents part of a mid-Miocene trough fill (Cooley, this volume).

At some point during Miocene uplift stages/early post-uplift time, subaerial exposure to the west of Reef Ridge caused a pulse of gravels to be funnelled into the Reef Ridge trough. The rims of the trough show only a minor disconformity, without thick conglomerates as in the center, yet no truncation of section as at the extreme ends. We are standing near the southern rim of the trough here in Big Tar Canyon.

These shoal water sandstones and conglomerates appear to have been the final phase of trough filling, for the overlying Monterey Formation siliceous rocks show no expression of the troughs. Instead clay shales and fine-grained sandstones of probably shelf depths grade rapidly into siliceous sedimentary rocks with bathyal benthic foraminiferal faunas (Dibblee, 1973; Bandy and Arnal, 1969).

The initial post-uplift subsidence seems to have been rapid. The Big Tar Canyon section, dated by paleontologic data provided by Gulf Oil Co. and summarized by Bandy and Arnal (1969) indicate a Luisian age for the upper Temblor Formation and a probable lower Mohnian age for the basal Monterey Formation (an age date that may come from higher in the section than the basal sandstones).

What caused this rapid subsidence? Who knows? Arm-waving possibilities:

Eustatic sea level rise. A drop in global sea level at 13 mybp was followed by a rise that lasted until 11 mybp (Vail and Mitchum, 1980). This period of rising sea level could explain the initiation of Monterey Formation deposition, thus eliminating the need for a tectonic subsidence mechanism. While the timing probably fits for the Reef Ridge section, a eustatic sea level rise at 13 mybp will not explain the generally older Temblor Formation/Monterey Formation further south in the Temblor Range. Instead, post-uplift subsidence appears to have progressed northward, just as did the uplift itself.

Thermal decay after a heating event (i.e., cooling and contraction). Subsidence caused by thermal decay is generally a "hotspot"-related phenomenon (e.g., Detrick and Crough, 1978). Therefore, this idea assumes that passage of the Mendocino Fracture Zone created a thermal instability, as suggested by sequentially younger volcanic centers developed from south to north along the San Andreas system (Dickinson and Snyder, 1979; Graham and Peabody, 1981).

Basin extension as the Mendocino Fracture Zone translated northward with propagation of the San Andreas fault (for explanation of the geometry of this situation, see Ingersoll, in press). Add to this the possible existence of a "slab window" (Dickinson and Snyder, 1979) which would perhaps increase crustal depression.

Isostatic compensation. Uplifts at triple junctions appear to be isostatically compensated by a directly underlying lithospheric mass (Crough, 1979). In this case, the compensating mass under the Mendocino Fracture Zone would have been moved northward by the San Andreas fault. The uplifted overlying plate, now uncompensated, would subside.

This event is only one of several such shoaling/deepening events recorded in San Joaquin Valley stratigraphy (another being the Kreyenhagen Formation/Temblor Formation contact we looked at earlier). Whatever the big-picture reason for the change in style of Miocene sedimentation, it was followed by a relatively quiescent period in which the basin filled in with little subsidence beyond that produced by load-imposed subsidence (Bandy and Arnal, 1969; Loomis, pers. comm., 1982). The period of Monterey Formation deposition corresponds to a period of increased strike-slip movement along the San Andreas fault (Harding, 1976). Wrench fault-related drag folds grew along the fault, and deformation propagated increasingly eastward with time (Harding, 1976). An interplay of wrench fault tectonism and eustatic sea level change seems to have been the primary control on sedimentation patterns from middle Miocene to the present. Indeed, the next shoaling event in the section, that of the clastic-rich Reef Ridge Member/Etchegoin Formation, is apparently the reflection in the San Joaquin basin of a global sea level fall which occurred at roughly 6.5 mybp (Vail and Mitchum, 1980; Keller and Barron, 1981).

Continue along the gully to the road; walk up the road to the McLure Member outcrop to your left (Fig. 2-12).

Figure 2-12. Exposure of Monterey Formation on northwest side of side of Big Tar Canyon. Resistant beds which are dotted with trees are dominantly porcelanites.

STOP 2-7. McLURE MEMBER

The section at Stop 2-7 grades from clay shales and siltstones above the sandstones of Stop 2-6 to increasingly more siliceous shales (Fig. 2-13). A porcelanitic zone 22 meters (72 feet) thick probably marks the lower to mid-Mohnian electric log high-resistivity zone of maximum transgression (Graham and others, this volume) - roughly equivalent to the tar-bleeding Antelope Shale we examined yesterday at Chico Martinez Creek.

The siliceous part of the McLure Member here is very much like that in the Polonio Pass area, although thinner. It consists of nonlaminated siliceous shales and porcelanites containing abundant quartz silt and recrystallized white peloids. There is probably much less clay here than in the Pyramid Hills Road section, since the weathering color here is brown rather than blue-green. Above this outcrop, the section is progressively less siliceous, grading from porcelanites to siliceous shales to clay shales. The Reef Ridge Member is a poorly defined unit here, simply representing the transition from biogenic siliceous sedimentation to the sandstone/shale sequence of the Etchegoin Formation. The Monterey Formation on Reef Ridge appears to represent a thin symmetrical transgression/regression event. The transgression was due to post-uplift subsidence of the basin, and regression was due to passive infilling of the basin, augmented by a eustatic drop in sea level, as already discussed. (See also Graham, and others, this volume.)

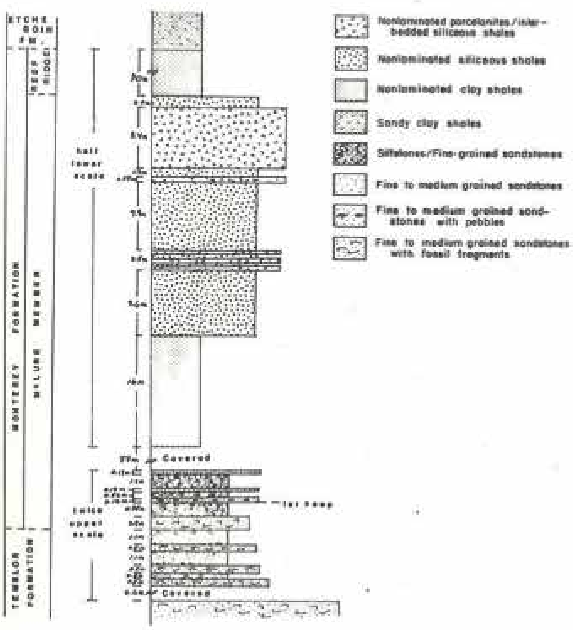


Figure 2-13. Measured section of the Monterey Formation in Big Tar Canyon.

Biogenic silica in the porcelanite zone is opal-CT. In the Garza Creek section, there is an opal-CT/quartz boundary in the lower siliceous shales; this has not been verified for the Big Tar Canyon section, but probably occurs in roughly the same part of the section. Therefore, this section may have seen sufficient burial (a maximum of 10,800', corresponding to 212°F) to just enter the hydrocarbon generative window. However, kerogen is not abundant in these rocks. Their total organic carbon values are generally much less than 1 wgt %. Furthermore the nonlaminated nature of the sediment suggests that its associated organic matter was probably subjected to oxidization and/or biodegradation post-depositionally. Therefore, the Monterey Formation here, although somewhat more organic-rich than at the Pyramid Hills Stop, is still not a likely source for high-grade oil. In general, the shelf facies of the Monterey Formation is probably a poor source rock, whereas several lithotypes within the basinal facies - especially the mat-laminated lithotype - are undoubtedly major hydrocarbon sources within the basin.

END OF DAY TWO

Troops disperse.

* * *

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Addicott, W.O., 1972, Provincial Middle and Late Tertiary Molluscan stages, Temblor Range, California: Pacific Coast Miocene Biostratigraphic Symposium, Pacific Sect. SEPM Proc., p. 1-26.

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Adegoke, O.S., 1969, Stratigraphy and paleontology of the marine Neogene formations of the Coalinga region, California: Calif. Univ. Pubs. Geol. Sci., v. 80, 241 p.

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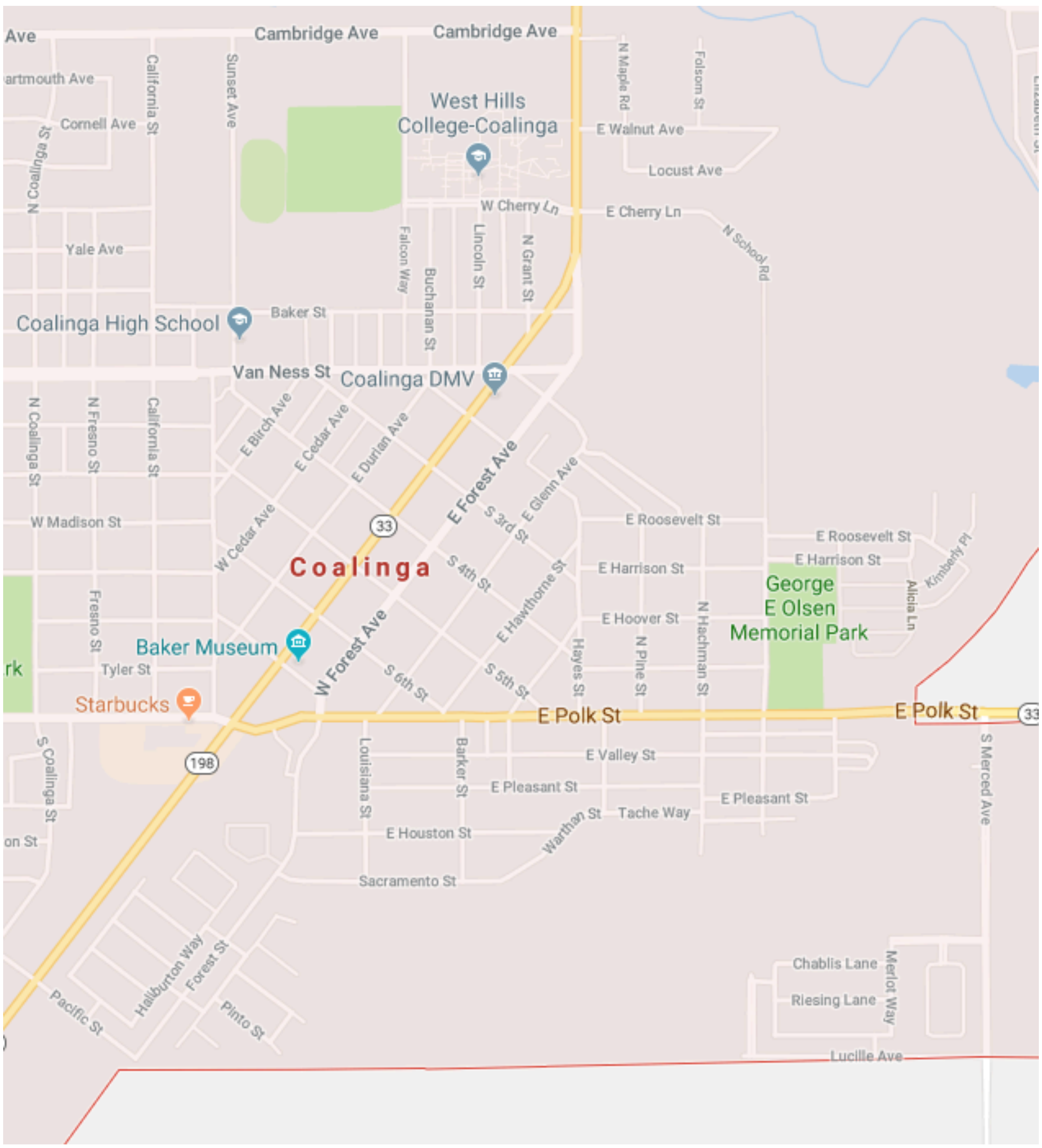
Barthel, K.W., von, 1976, Coccolithen, Flugstaub und Gehalt an organischen Substanzen in Oberjura--Plattenkalke Bayerns und SE Frankreichs: Eclogae Geol. Helv., v. 69, n. 3, s. 627-639.

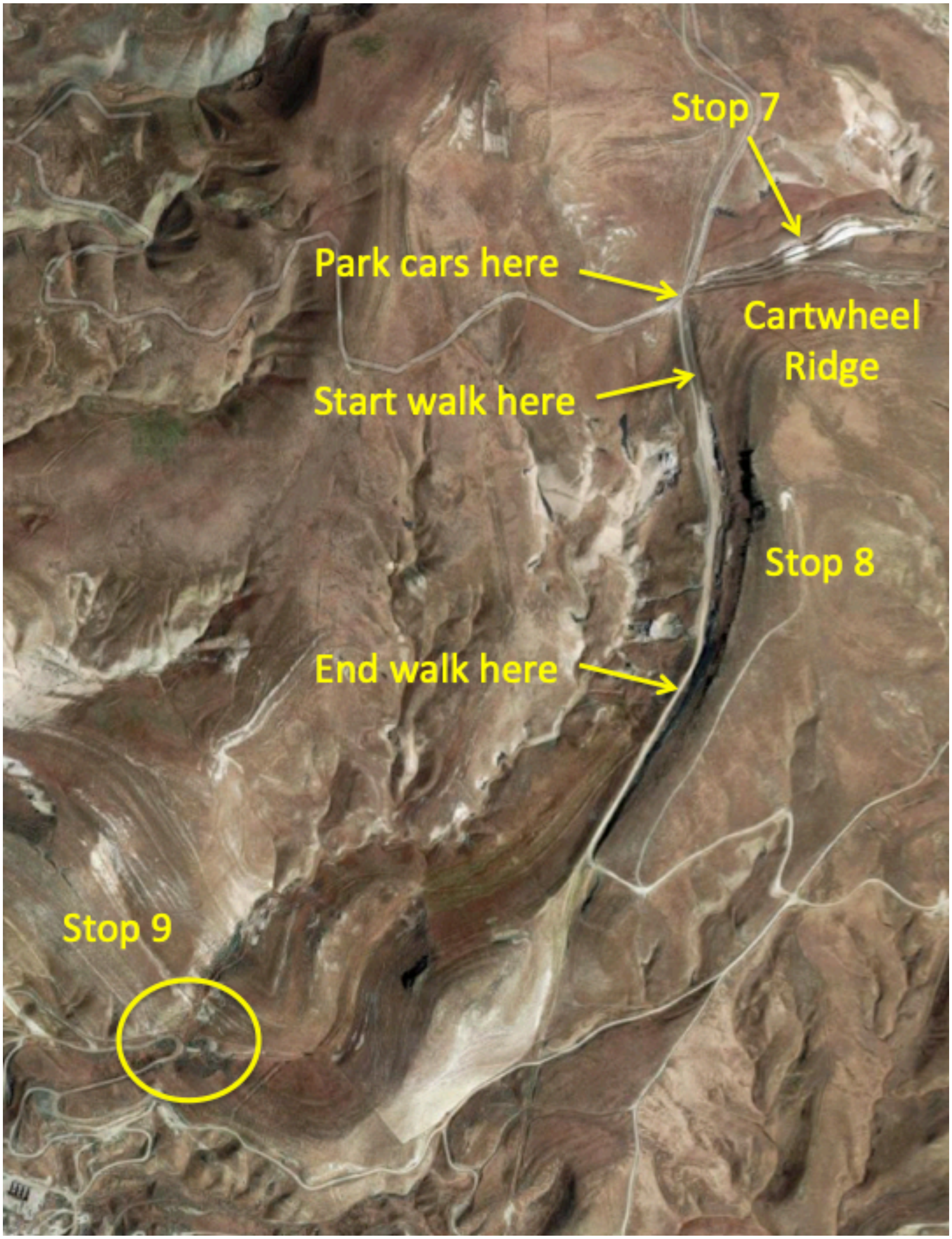
Stop 5: Lunch in the George E. Olsen Memorial Park in Coalinga

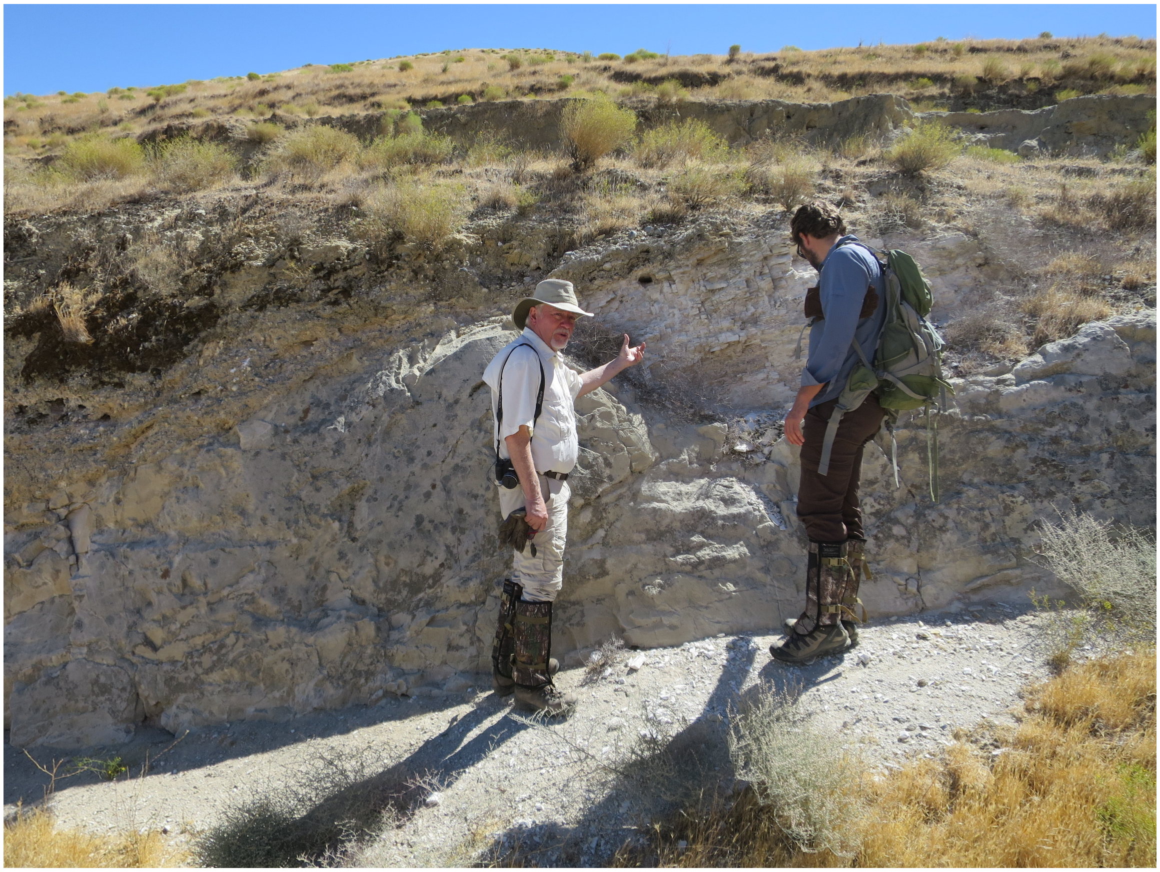


Stop 6: Meet at Junction of Oil City Road and Shell Road at 1:00 PM

Stops 7 and 8 on Coalinga anticline:

Kreyenhagen Formation and Temblor Formation on Cartwheel Ridge


Stop 7
Park cars here
Cartwheel
Ridge
Start walk here
Stop 8
End walk here
Stop 9



Steve Graham points out the injectite in the Kreyenhagen Formation at stop 7. Jared Gooley looks and listens.

Concretion in the Temblor Formation at bulldozer cut at stop 7.

Stop 8 is the walk down road from Cartwheel Ridge to observe and discuss the Temblor Formation. Notice the lithology and the fossils. Jared Gooley is our scale. Off to the west down the canyon is the Coalinga oil field.

Coalinga oil field looking west from the road down from Cartwheel Ridge.

Top: Lower Variegated Mbr, Temblor Fm. disconformably overlying Kreyenhagen Fm.
Bottom: Oyster reef in estuarine facies of the middle Temblor Fm., Cartwheel Ridge.

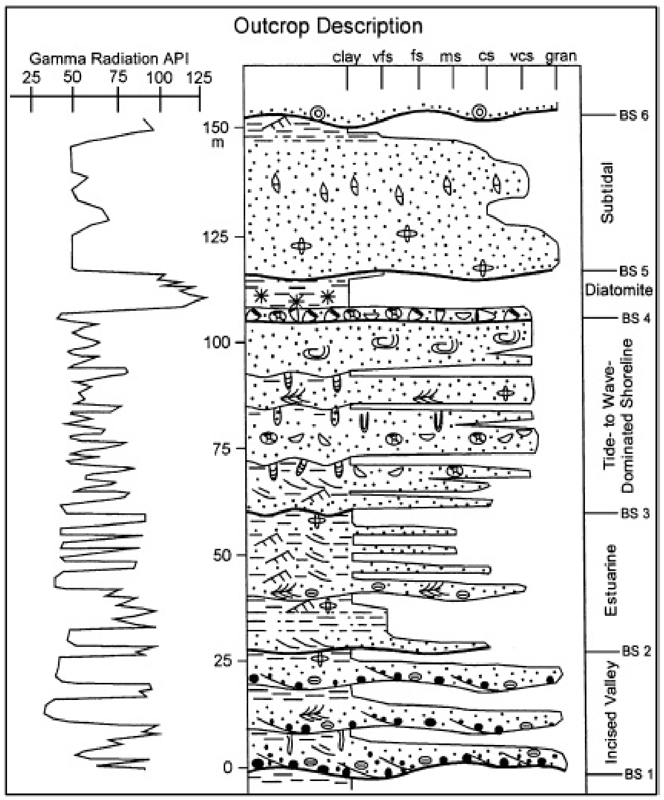
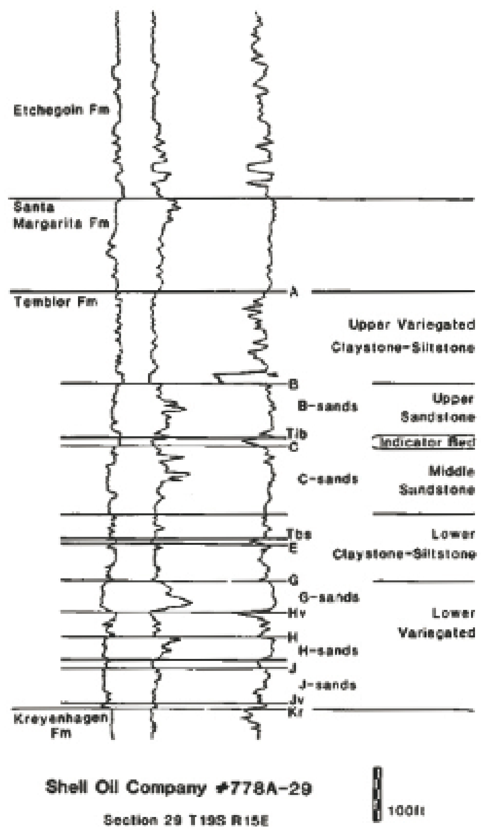


Fig. 5. Outcrop description for Cartwheel Ridge to Laval Grade (see Fig. 2 for location, Fig. 8 for legend). The Kreyenhagen Shale is present below 0 m and the Santa Margarita Formation occurs above 152 m. vfs = very fine sand; fs = fine sand; ms = medium sand; cs = coarse sand; vcs = very coarse sand; gran = granules; BS = bounding surface.



Shell Oil Company #778A-29

Section 29 T19S R15E

Bate, 1985

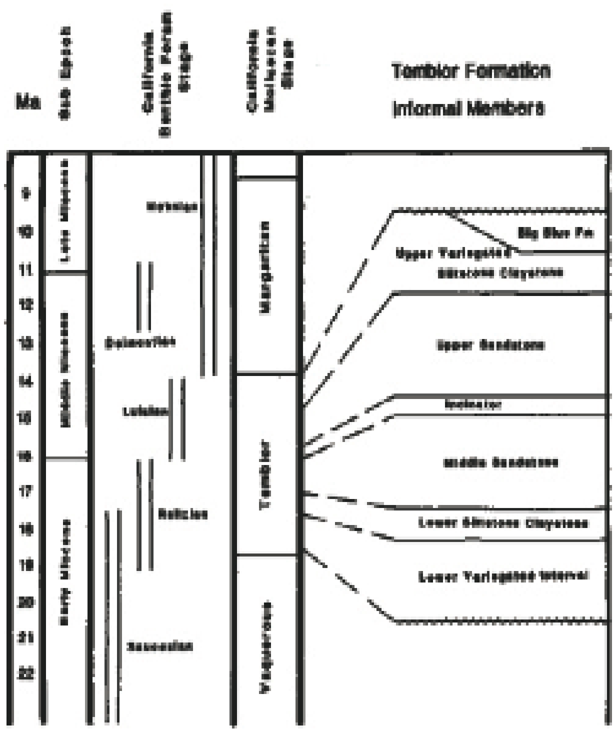


Figure 2. Informal members of the Temblor Formation on Coalinga anticline, and stratigraphic position of the Big Blue Formation, with biochronology of Poore and others (1981).

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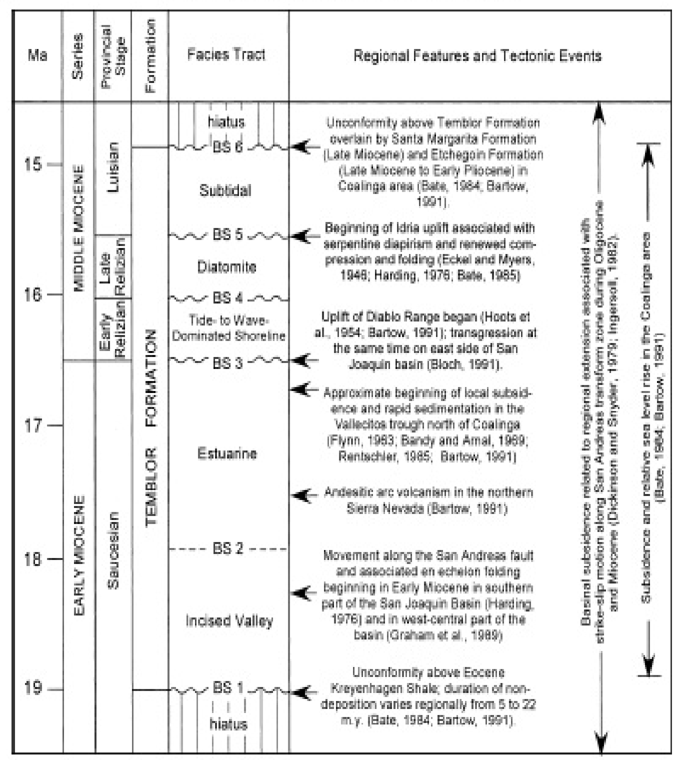
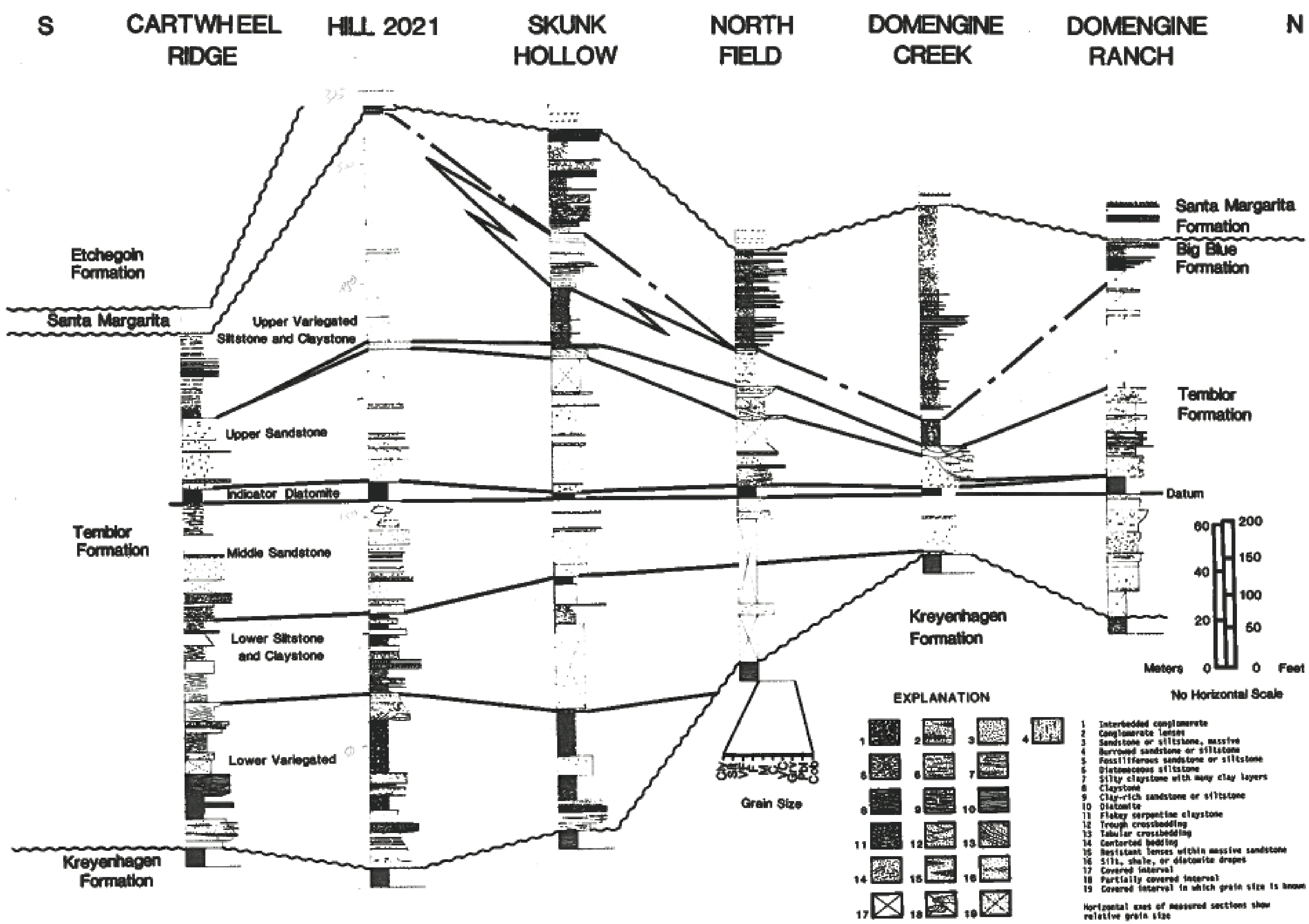


Fig. 10. Origin of Temblor Formation facies tracts and bounding surfaces related to regional features and tectonic events. Provincial stages are from Kleinpell (1938) and Bartow (1991). BS=bounding surface.

Bate, 1985



S
CARTWHEEL RIDGE
HILL 2021
SKUNK HOLLOW
NORTH FIELD
DOMENGINE CREEK
DOMENGINE RANCH
N
Etchegoin Formation
Santa Margarita
Upper Variegated Siltstone and Claystone
Upper Sandstone
Indicator Diatomite
Temblor Formation
Middle Sandstone
Lower Siltstone and Claystone
Lower Variegated
Kreyenhagen Formation
Santa Margarita Formation
Big Blue Formation
Temblor Formation
Datum
Kreyenhagen Formation
Grain Size
60
40
20
Meters 0
200
150
100
50
0 Feet
No Horizontal Scale
EXPLANATION
1 Interbedded conglomerate
2 Conglomerate lenses
3 Sandstone or siltstone, massive
4 Burrowed sandstone or siltstone
5 Fossiliferous sandstone or siltstone
6 Diatomaceous siltstone
7 Silty claystone with many clay layers
8 Claystone
9 Clay-rich sandstone or siltstone
10 Diatomite
11 Flakey serpentine claystone
12 Trough crossbedding
13 Tabular crossbedding
14 Contorted bedding
15 Resistant lenses within massive sandstone
16 Silt, shale, or diatomite drapes
17 Covered interval
18 Partially covered interval
19 Covered interval in which grain size is known
Horizontal axes of measured sections show relative grain size

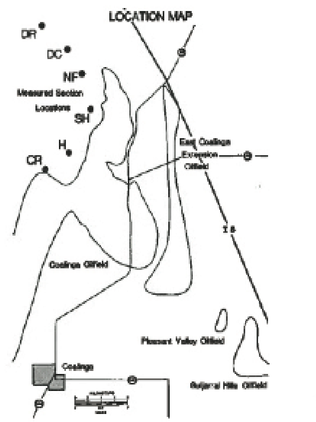


Figure 15. Location map of Coalinga area for paleogeographic maps. Measured Section locations are: Cartwheel Ridge (C R), Hill 2021 (H), Skunk Hollow (SH), North Field (NF), Domengine Creek (DC) and Domengine Ranch (DR). Paleogeographic interpretation based on outcrop and well log correlation (Bate, 1984). Field outlines after Munger (1981).

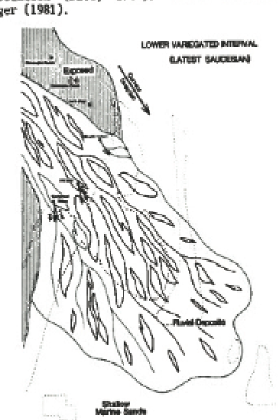


Figure 16. Three separate intervals of coarse fluvial deposits are found as far south as the Guijarral Hills area, separated by estuarine clays and silts representing marine-dominant periods. No deposition on northern three measured section locations during this time.

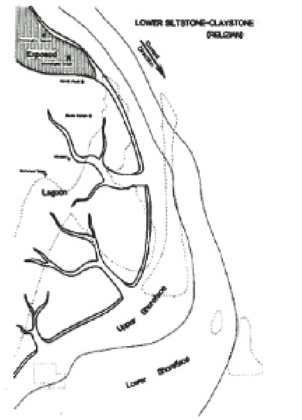


Figure 17. Marine transgression (coincident with cessation of local uplift) filled the fluvial valleys and allowed barriers to form, fronting a lagoon over much of the Coalinga area.

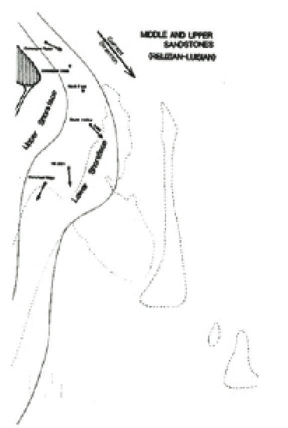


Figure 18. Steady transgression resulted in deposition of shallow marine sandstones over lagoonal sediments. Indicator diatomite was deposited during this time.

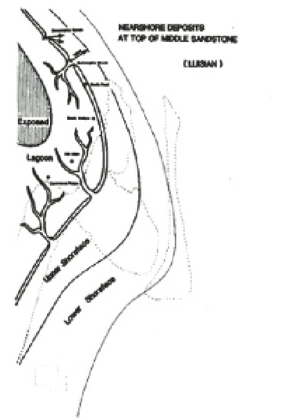


Figure 19. Uplift of Joaquin Ridge, associated with protrusion of the New Idria serpentine diapir, resulted in regression of all environments basinward and passage of barrier bars and surf zone over measured section locations.

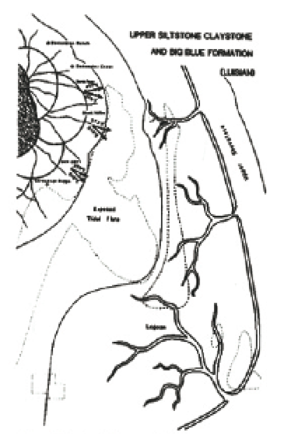
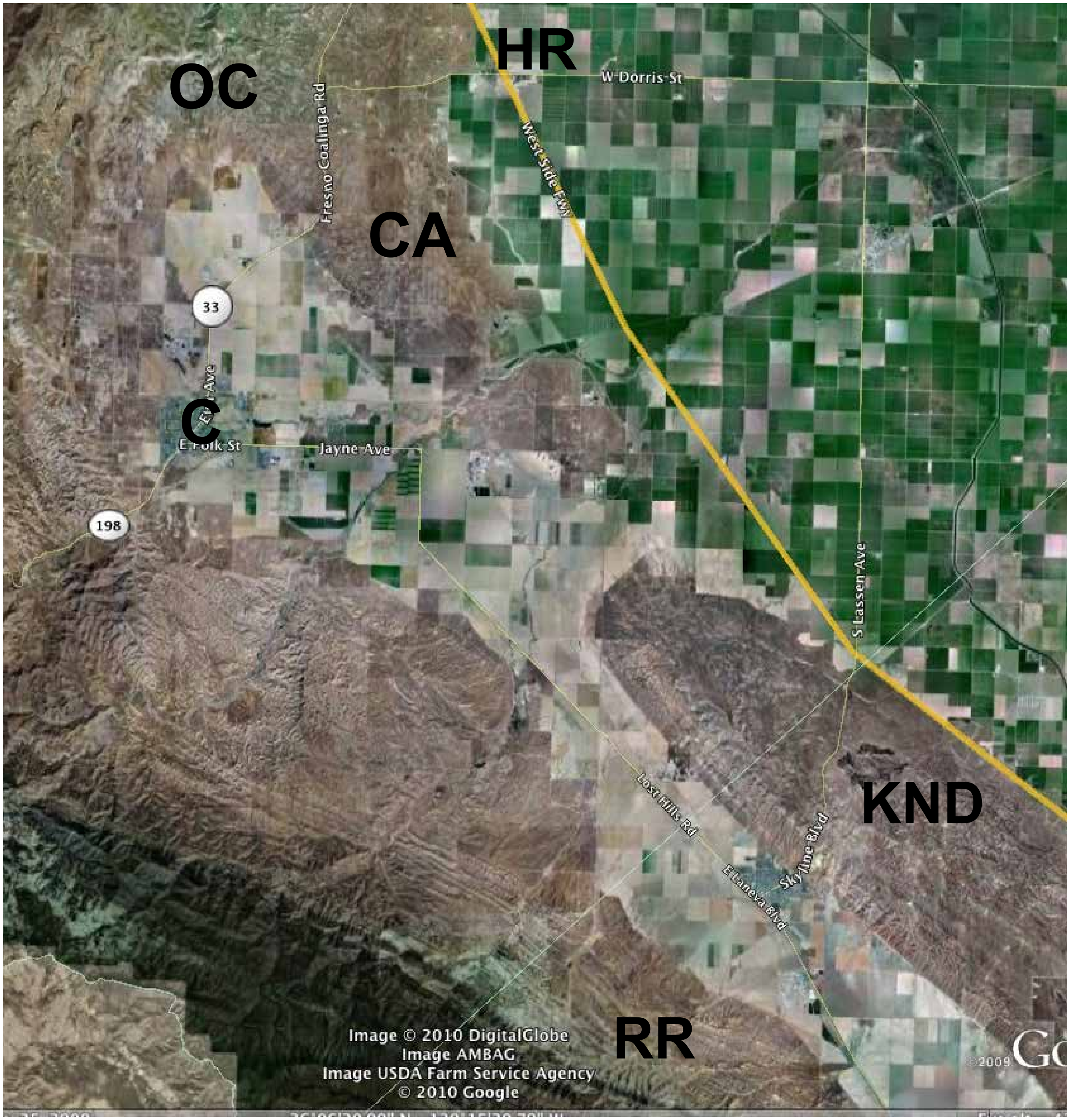
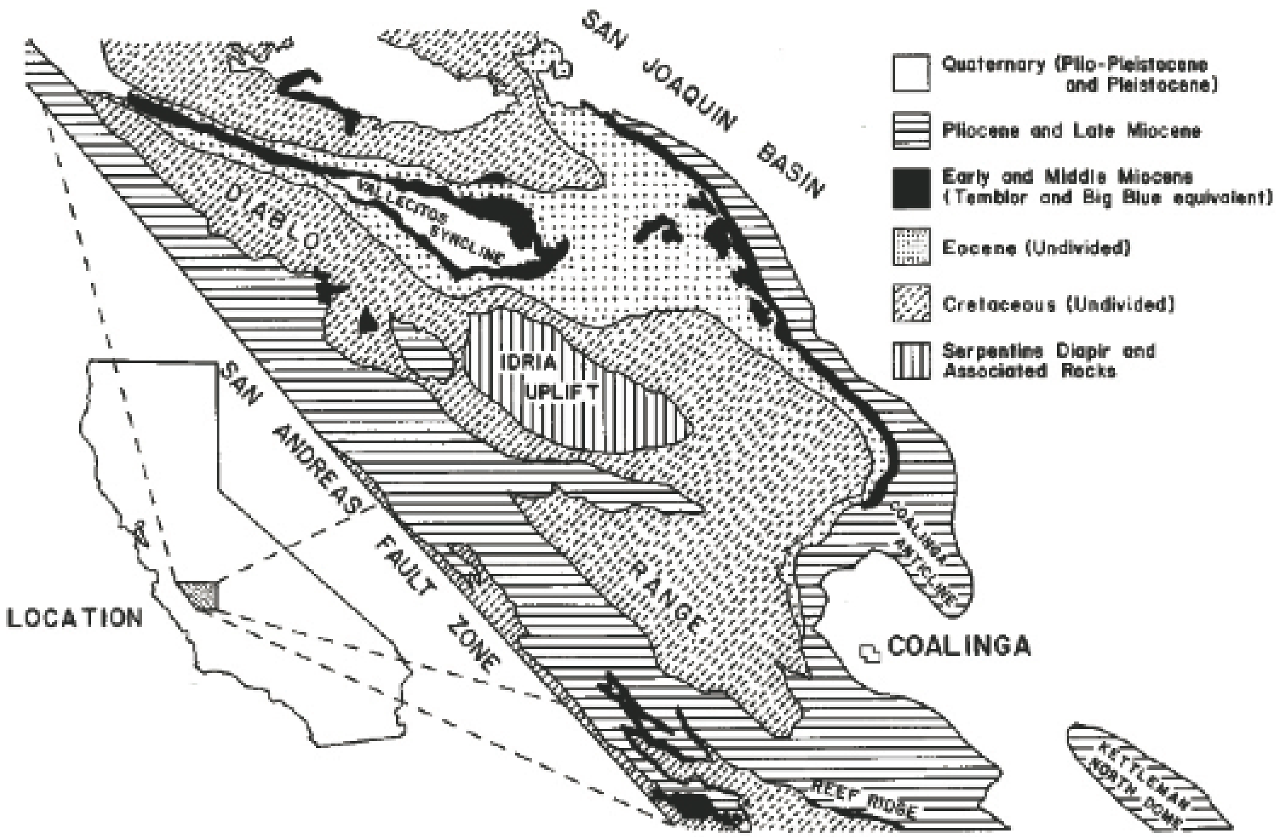


Figure 20. Alluvial fans of Temblor lithology were produced by unroofing associated with the uplift. Eventually, protrusive serpentine was eroded to cover the fans with serpentine alluvial sediments which interfingered with serpentine tidal flat deposits.

Bate, 1985

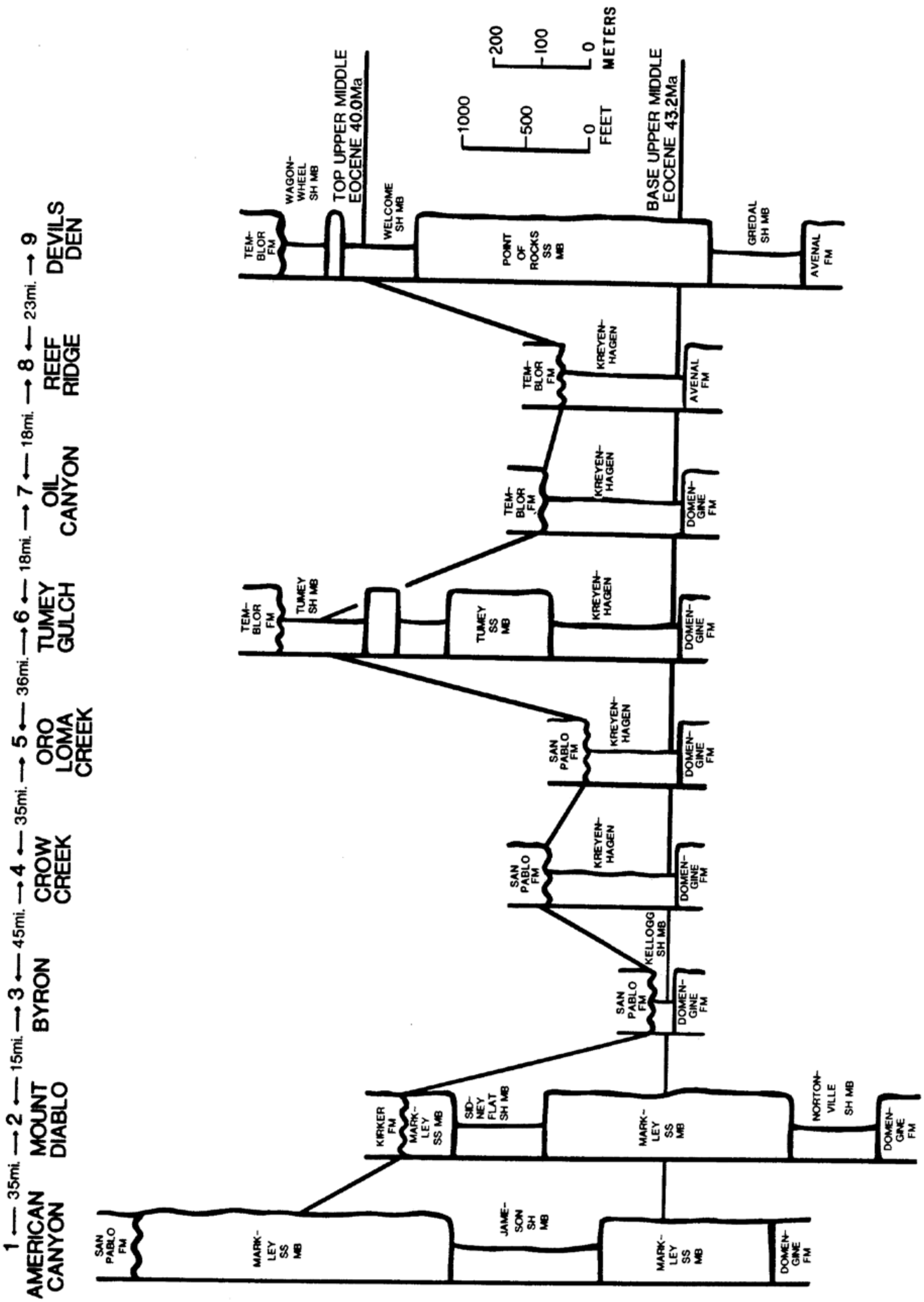


CA = Coalinga anticline
OC = Oil Canyon
KND = Kettleman North Dome
RR = Reef Ridge
C = Coalinga
HR = Harris Ranch

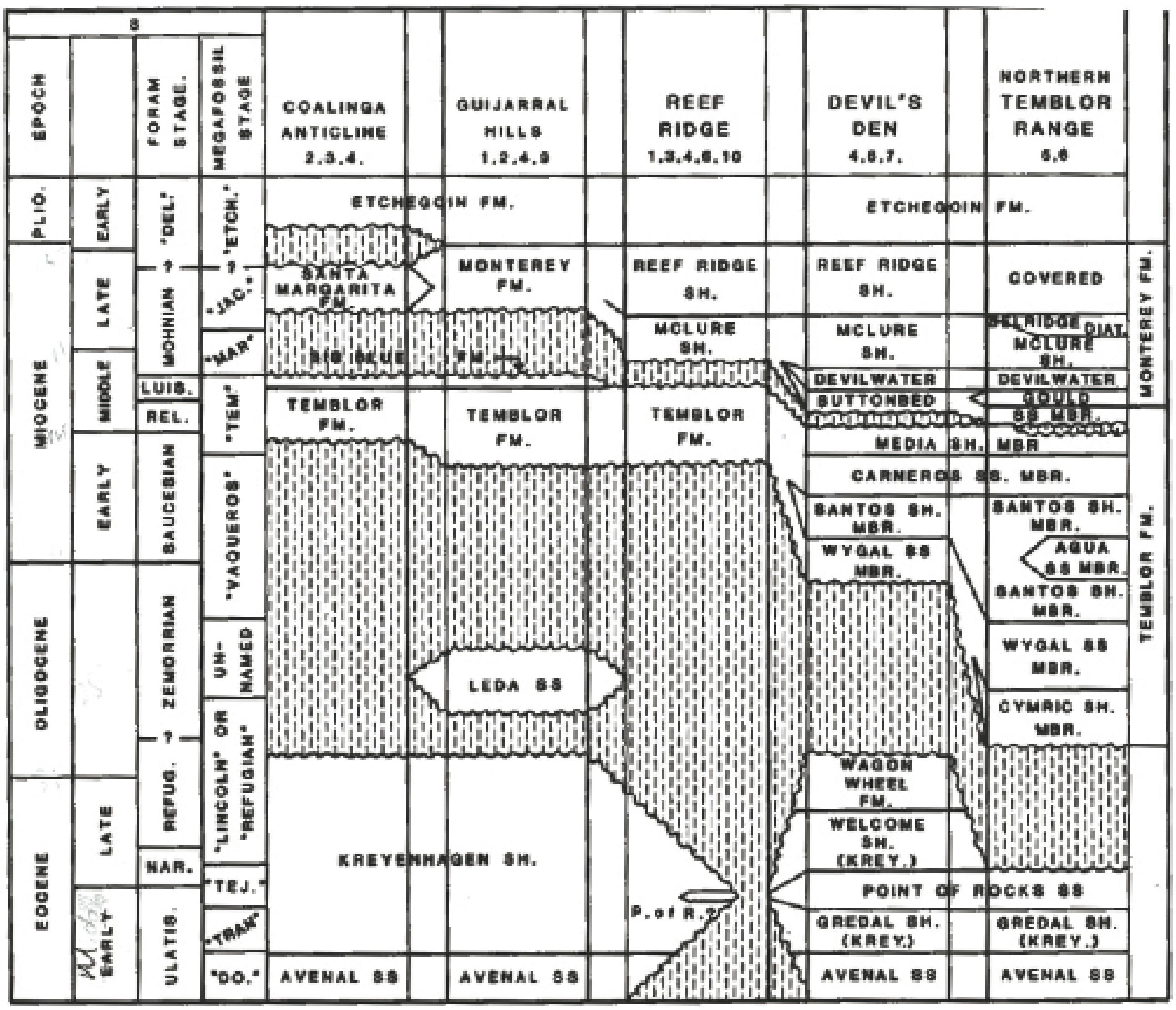


Quaternary (Plio-Pleistocene and Pleistocene)
Pliocene and Late Miocene
Early and Middle Miocene (Temblor and Big Blue equivalent)
Eocene (Undivided)
Cretaceous (Undivided)
Serpentine Diapir and Associated Rocks
SAN JOAQUIN BASIN
VALLECITOS SYNCLINE
DIABLO
IDRIA UPLIFT
RANGE
SAN ANDREAS FAULT ZONE
COALINGA ANTICLINE
COALINGA
KETTLEMAN NORTH DOME
REEF RIDGE
LOCATION

Bate, 1985

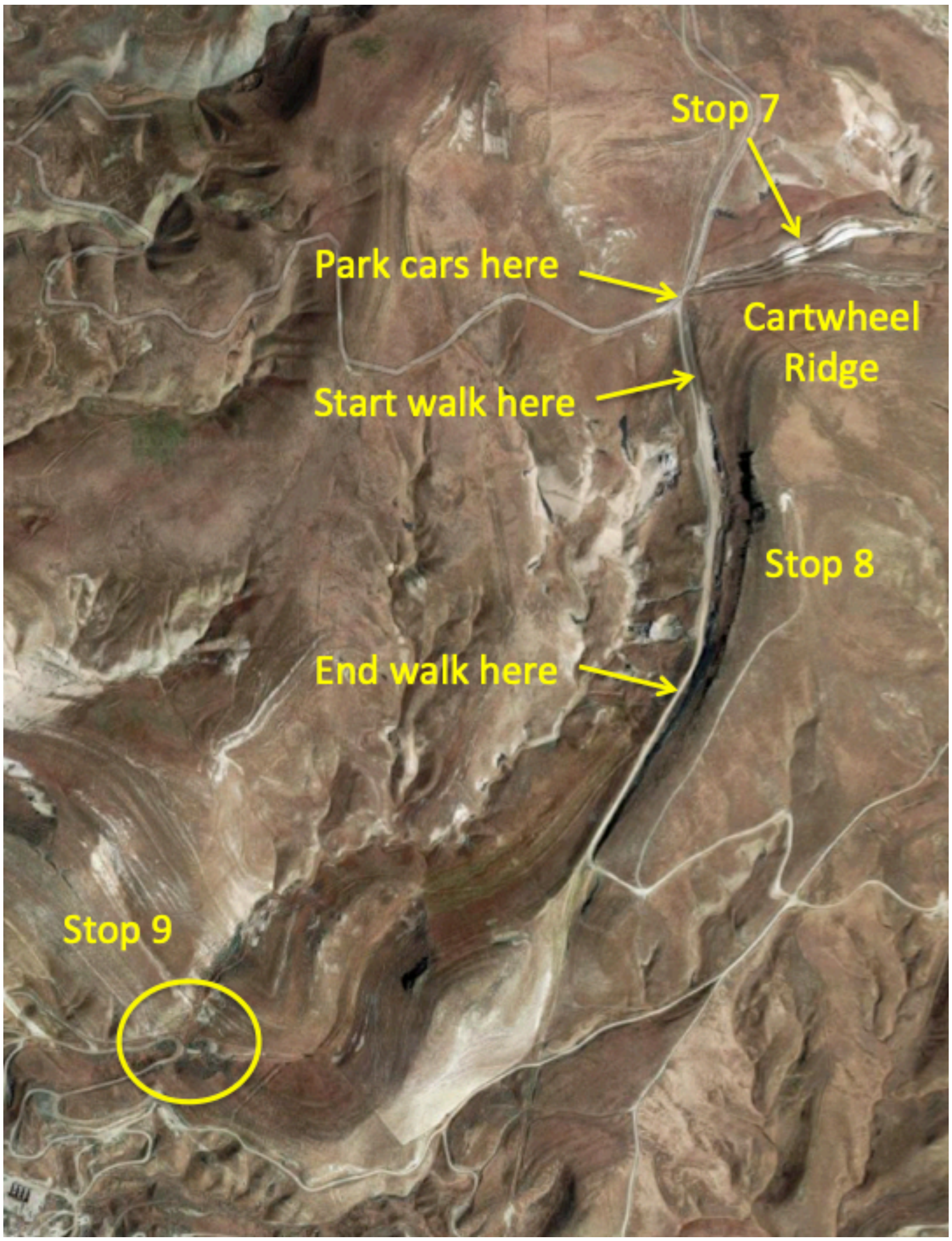


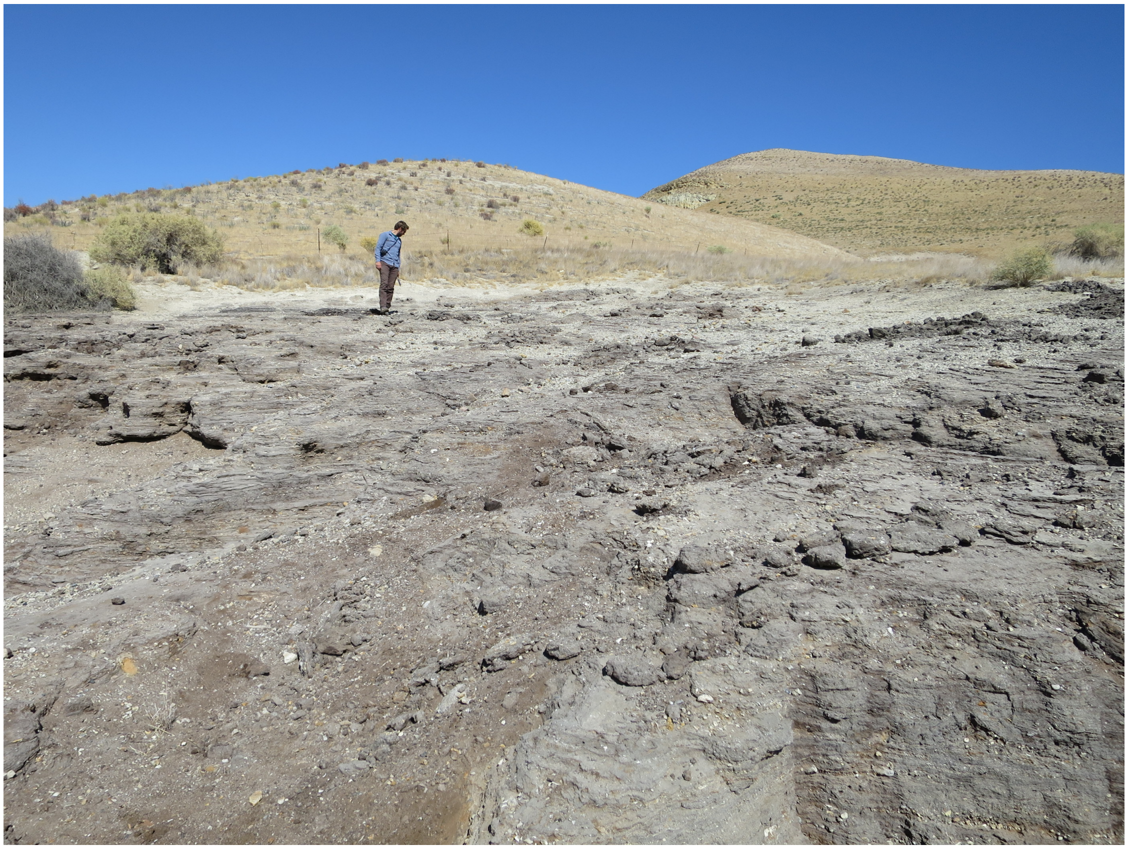
R. Milam, Stanford PhD


EPOCH
FORAM STAGE.
MEGAFOSSIL STAGE
COALINGA ANTICLINE 2,3,4.
GUIJARRAL HILLS 1,2,4,9
REEF RIDGE 1,3,4,6,10
DEVIL'S DEN 4,6,7.
NORTHERN TEMBLOR RANGE 5,6
PLIO.
EARLY
"DEL."
"ETCH."
ETCHEGOIN FM.
MIOCENE
LATE
MOHNIAN
"JAC."
"MAR"
SANTA MARGARITA FM.
MONTEREY FM.
REEF RIDGE SH.
COVERED
MCLURE SH.
BELRIDGE DIAT.
MONTEREY FM.
BIG BLUE FM.
MIDDLE
LUIS.
REL.
"TEM"
DEVILWATER
BUTTONBED
GOULD SS MBR.
TEMBLOR FM.
MEDIA SH. MBR
EARLY
SAUCESIAN
"VAQUEROS"
CARNEROS SS. MBR.
SANTOS SH. MBR.
WYGAL SS MBR.
AGUA SS MBR.
TEMBLOR FM.
OLIGOCENE
ZEMORRIAN
UN-NAMED
LEDA SS
CYMRIC SH. MBR.
EOCENE
REFUG.
"LINCOLN" OR "REFUGIAN"
WAGON WHEEL FM.
WELCOME SH. (KREY.)
KREYENHAGEN SH.
NAR.
"TEJ."
POINT OF ROCKS SS
P. of R.
ULATIS.
"TRAN"
GREDAL SH. (KREY.)
"DO."
AVENAL SS

Cooley, 1985

Stop 9: The brea or tar sands of Quaternary age

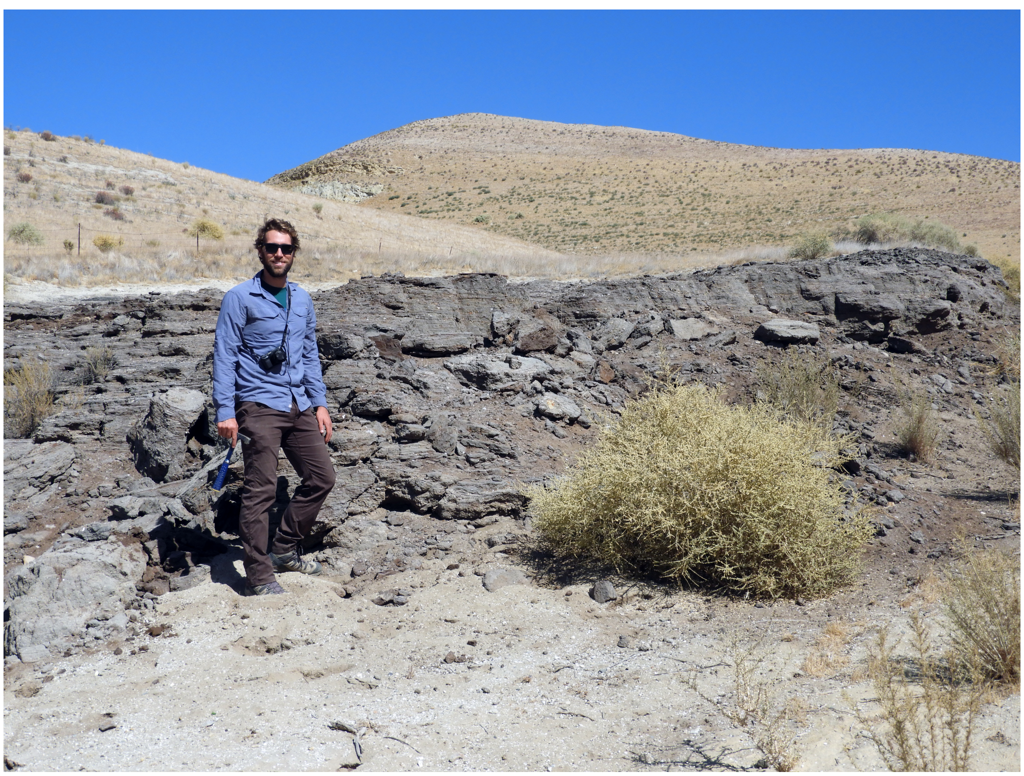




Stop 9 is the brea or tar sands of Quaternary age very near the Coalinga oil field production.

Look for the insects stuck in the brea.


The brea at stop 9.


Jared Gooley is the scale for the brea deposit of Quaternary age at stop 9.