NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

FIELD TRIP ROUTE
MAY 10, 2003
ALTAMONT INTERSECTION FIELD TRIP LOG

The field trip will start at the Park-and-Drive lot in Danville just east of the Sycamore Road exit.

The geology of Central California is a direct result of the interaction of the westward moving North American Plate and the east moving and subducting Pacific Plate. Movement has been continuous since the Upper Jurassic. Orogenies or mountain building episodes occur when large fragments of continental crust, sea mounts, etc., on the downgoing plate encounter the North American Plate. The major tectonics today are due to the Salinia block of the Pacific Plate moving eastward and crushing basins developed on the North American Plate.

Movement has occurred contemporaneously over the whole region, and pre-existing structures and sedimentary packages have been further deformed by later movement. Complexity and interaction are the rule.

The area can be subdivided into STRUCTURAL DOMAINS with consistent internal structure and stratigraphy.

We will start in the Mount Diablo Domain under the parking lot. The San Ramon Valley lies between the Mount Diablo Domain and the East Bay Hills Domain. The San Ramon Valley represents the remnants of a once extensive plain which has been crushed by the west moving Mount Diablo Domain and the east moving East Bay Hills Domain. Little subsurface information is available. Structural analysis indicates that the Valley should be underlain by a complex anticlinorium of intersecting east and west moving thrust faults.

The East Bay Hills Domain consists of thrusted and folded rocks which have generally moved eastward as a unit. The sediments consist of units of the Great Valley sequence. The deforming source is the allochthonous oceanic plate underlying the San Francisco Bay Block and the Hayward Fault Zone. All of the hills to the west as we proceed down I-680 towards Dublin are part of the East Bay Hills Domain. Most of the lower hills we see are large slumps derived from the rising hills.

As we pass the Bollinger Canyon overpass, we will pass over the site of the recent earthquake swarm (2003) between this area and Dublin. Epicenters and focal depth of the swarm indicates an east-west orientation of earthquakes, with a deepening of focus southward. The only major force with this orientation is the northward movement of the Diablo Range. It is believed that the earthquakes originate on a deep thrust fault originating under the Diablo Range and shallowing northward. A pass exists in the area from here to Crow Canyon indicating a topographic rise, separating
the Dublin area from the Alamo-Walnut Creek area along the San Ramon Valley. This subtle topographic rise is probably due to uplift at the front of the underlying blind thrust fault.

As we approach Dublin, the East Bay Hills Domain will remain on the right, or west. Near the I-580 / I-680 intersection we will get our first view of the Diablo Range Domain and the intersection with the East Bay Hills Domain. This intersection is marked by the sharp cliffs of the Maquire Peaks, a syncline composed of Miocene Briones sands and Pliocene sediments overlying an oceanic thrust plate. These rocks have been thrusted to the east out of a now destroyed basin.

The hills to the east of the Maquire Peaks form a large, smooth, anticlinal shape from this distance. This reflects the underlying structure. The Diablo Range is plunging towards us. In the Range, successively younger units are exposed northwards, until north dipping Livermore Gravels plunge under Holocene sediments in the valley.

As we proceed eastward on I-580, the Tassajara Hills, a part of the Mount Diablo Domain, will be on the north or left, and the east-west trending Livermore Valley on the south, or right. The east-west orientation is due to impinging thrusts from both the north and south, destroying the once extensive plain which included the San Ramon Valley.

Recent construction along the boundary of the Tassajara Hills has exposed caliche layers dipping 10 to 30 degrees to the south. Beds along the front dip 70-85 degree south, vertical, or overturned 85 degrees in Pleistocene units. The frontal thrust of the Mount Diablo Domain is a blind thrust.

As we look at the Diablo Range another topographic high which lacks an anticlinal shape comes into view east of Lake Del Valle and Arroyo Valle. This part of the Diablo Range is composed of a series of steeply dipping and overturned imbricate thrust sheets in the older rocks (Early Cretaceous—“Franciscan”). These units originated as thrust sheets which originally were on top of the Diablo Range and slid down into the syncline lying to the east of the anticlinal high. These units have been overturned, forming a now massive, overturned fold. Extensive chert beds and underlying greenstone and serpentinite form the base of many imbricate thrust sheets. These chert units are exposed at the northern plunge of the Diablo Range antiform, at the saddle to the south in the Pacheco Pass area and at the south plunge of the antiform in the Panoche Pass area. Overlying the cherts are thick greywacke and olistostrome beds.

Proceeding eastward on I-580 towards Livermore we will pass through two anticlines and a syncline in the Livermore Gravels. Flank dips
are about 25 degrees. These hills mark the southern extent of the Mount Diablo Domain. Beyond the hills to the north is the wide expanse of the North Livermore Valley. This flat area is underlain by several subsurface anticlinal structures, which have been drilled (without success).

**STOP 1**

We will exit at the North Greenville Road exit, which will be our 0.0 mileage marker. Turn left, follow the road to the left, proceed under the freeway, turn right and follow Old Altamont Pass Road to a stop at 1.2 miles adjacent to a Cierbo sand outcrop. The low hills to the northwest as seen from the exit are expressions of an anticline with several tear faults partitioning the anticline. Data from wells indicates another thrust fault underlies the upper thrust responsible for the surface anticline. These thrusts are west vergent.

The Cierbo outcrop dips 27 to 30 degrees to the east and is on the west flank of a syncline. The east flank is exposed in the next valley to the north and dips 25 degrees to the west. The axis of the syncline is transverse to the hills. A tear fault occurs under the road. The hills to the south dip 18 degrees to the east at the top of the hill and dips swing around to the east-southeast and shallow to 10 degrees within a few hundred meters. An east vergent thrust occurs at the curve of the road with an underlying shallow syncline at the top of the curve. Another thrust – the Corral Hollow Thrust—occurs as the road straightens out to the east.

The Cierbo dips east and is composed of three massive sand beds. Interbedded clays separate the sand bodies, with the shale between the lower sand and the second sand thinning updip. On the west end of the sands is a disturbed zone dipping west. (Old fault or head of a landslide?) Beyond is a slump zone, a second zone with a channel-like appearance and a rounded tip as the slump moved down slope. Above is another thick slump zone with some included cobbles.

This area is within the Greenville Fault zone, an anastomosing series of thrusted outcrops. **What is the Greenville Fault?**

The **geometry** of the zone as well as its history is critical in any interpretation. **Geometry always** first – and then Genesis.

We know that Upper Cretaceous Lower Campanian rocks are present on the western flank of the Mount Diablo Antiform and that the antiform is plunging to the southeast. Contact between the Upper Cretaceous and the overlying Miocene Cierbo sands is exposed at the crest of the hills to the south of I-580 for several miles. An outlier of Cierbo also exists on the crest of the hill to the northeast.
Upper Campanian, Maastrichtian, and Lower Tertiary rocks are missing from the antiform but are present on the flanks to the east, south and west. This indicates uplift and erosion of the antiform prior to Upper Miocene time. Cierbo sands are shoreline sands and thus the area must have been eroded to sea level before burial. The Neroly does overlap the Cierbo to the northeast on the other flank of the antiform. When uplift occurred is not knowable in this area. We do know the antiform has been uplifted and this implies a corresponding syncline to the west. We see evidence of the continuous sinking of the syncline and receipt of sediments throughout the Upper Miocene, Pliocene, Pleistocene and Holocene. Only minor amounts of eroded Pliocene and Pleistocene sediments are present on the southeastern plunge of the antiform. The anticline did not rise correspondingly as the syncline sank. It stayed at a relatively stable level as the syncline accumulated 20,000' of sediments.

The antiform is asymmetric, overturned to the west. The implication here is that the syncline acted as the deforming force, actually underthrusting the anticline, probably riding on a deeper wedge. It is assumed the syncline started as a simple subsidence, thick in the center and thinning towards the edges as the sediments lapped the flanks of the anticline. No deformation occurred or is known to have occurred in the syncline as it moved passively to the east.

A serious space problem existed on the eastern flank of the syncline as the syncline moved to the east. This space problem does not exist at the inflection point (where the anticlinal form changes to a synclinal form), until this flank approaches the vertical. What happens to the synclinal flank?

The deeper portion of the syncline undoubtedly kept moving eastward under the overturned anticline. The upper portion kept getting squeezed and its volume could not fit in the diminishing space. Easiest relief is upwards and outwards. We now see thrusts both to the east and to the west arising above the inflection point.

Why is the trace fairly straight? The flank of the anticline has only a slight plunge to the southeast and thus is straight as is the inflection point. Highs and lows exist along the deforming flank as sediments of different strength encounter the squeezed zone. Lows would accumulate water. These are “sag ponds”, a term which should not include a genetic implication in its definition.

Leave the Cierbo and proceed over Old Altamont Pass Road to the east.

At 2.5 miles we will see some west dipping rocks of the main antiform.
At 3.6 miles we will pass Dyer road. Bear to the right. At 4.4 miles we will pass some Campanian shales.

STOP 2. 4.6 miles. Just beyond the road to the Altamont Landfill pull over to the right and park on shoulder. Look up to the rail cut on the hills to the south and observe flat lying Campanian shales and sands. Walk down to the outcrop of Campanian sands on the north side of the road. Watch for traffic. Notice the change in hardness and lithology of these sands as compared to the Miocene Cierbo sands, which were near shore sands. These are deep water sands, probably mid fan.

For the next few miles we will drive through several windmill sites. Note how the topography is subdued due to flattening of dip, predominant shale lithology, and abundant slumping.

We have been on the west flank of the antiform until Summit School (old), now Summit Garage area. After passing the summit we will be in the east flank for about 4 ½ miles. Note that all dips, except at the crest, are in the 15 to 20 degree range. Several minor bedding plane thrusts have been mapped in the area. Just before we reach Grant Line Road, we will encounter the trace of the Midway fault striking through the valleys to the northwest and southeast. The higher portions of the hills are capped by Neroly sediments. About 1 mile to the south of I-580, the Cierbo appears under the Neroly and above the Campanian.

8.7 miles. Grant Line road, turn right. Pass under freeway to turnaround and park.

STOP 3. 9.3 miles. A good opportunity to view Neroly lithologies, pebbles, shales, and characteristic blue coloration. The blue color is a little more pronounced here than at most localities. Color is due to a montmorillonite-like clay mineral (derived from volcanic ash) which acts as a cement and surrounds sand grains.

Return to I-580 and head south on I-580. We will exit at the Patterson Pass exit for a brief rest stop. We will then proceed southward to the Corral Hollow exit.

**ALTERNATE ROUTE OVER I-580 from first stop**

For those of you who drive the Freeway into the Central Valley.

We will turn around and proceed back to I-580 and proceed to the east. For the next part of the field trip we will be in gentle dips of the anticlinorium. We will not be in the intersection zone until well up into Corral Hollow.
As we proceed up the hill, we are in the hanging wall of the Corral Hollow thrust and in Upper Campanian rocks, dipping west at about 10 degrees. The thrust is a bedding plane thrust along the contact between the Lower and Upper Campanian. Offset of the Cierbo contact is only about 1200’. The thrust occurs near the end of the long straight stretch up the hill just before the curve to the right.

Continue over the pass and head down the long straight stretch. At the curve leading to the underpass, we will cross the axis of the Mount Diablo antiform. A minor thrust – the Patterson Pass fault, crosses the road on the curve and heads up the valley to the south. Dips of 25 degrees to the west decrease to 5 degrees near the crest. As we go down the east flank of the structure, we will pass through minor tears and west vergent bedding plane thrusts.

At the offramp in the flat we will cross the Midway fault. Here, on both sides of the fault, Neroly rests on Campanian rocks. As we head south towards I-5 we will cross Midway Road and be in Pleistocene rocks.

CONTINUATION OF FIELD TRIP

Proceed south to the Corral Hollow exit. Tailings from brick production occur as humps and hummocks in the stream valley to the south. Dip slopes of Middle and Early Pleistocene sediments are tilted to the east, reflecting late tectonics. We will proceed through the Black Butte anticline to the next stop at its axis.

STOP 4 AT ENTRANCE TO CANYON. Stop just beyond bridge. Pull off road as far as possible. Sometimes fast and heavy traffic on this road.

From this location we will see the Cretaceous, probable Campanian, rocks dipping west at about 30 degrees across the creek. There is no apparent rollover into an anticline at this location but we will see the plunge at the next stop. The pediment surfaces to the north are in Pleistocene rocks. Lettis et al., have mapped this area and find uplift of lower, middle, upper Pleistocene and Holocene pediments. Uplift is several hundred meters.

STOP 5. BLACK BUTTE ANTICLINE. Park on hill and walk to amphitheater.

The Black Butte Anticline is thrusted to the east, placing Upper Cretaceous rocks over early Pleistocene sediments. The thrust dies out to the north in about 3 miles within Middle Pleistocene sediments. Here, the amphitheater has Neroly at the top of the hill, Cierbo sands ½ way down
and Cretaceous at the base of the hills. The unconformity can be traced by
color contrast completely around the area. The Elk Ravine tear fault strikes
to the west southwest. The axis of the anticline is not present to the south
of the road in this location. Only the west dipping flank is observed. About
a mile to the south, the rollover is mapped and continues to the south. On
the west flank of the anticline, landslides obscure the relationships along
the road. A few Cierbo outcrops are present along the road. Further to the
south, Cretaceous is overlain by Cierbo and Neroly sediments in a normal
relationship.

Proceed down the road past a turnoff to the south to Castle Rock.

STOP 6. CASTLE ROCK. Pull off on the shoulder for a view.

Castle Rock, a prominent feature, is composed of 15 degree west
dipping Neroly sediments. Dips in the area are in the range of 10 to 20
degrees. We are in the Mount Diablo Antiform Domain with gentle dips and
only minor bedding plane thrusting, usually recognizable only by dip
discrepancies. View toward the southeast shows panels of shallow dips.
These beds dip into the Callahan Syncline which is across the road in the
shallow, low lying topography. The area is underlain by Pliocene-Pleistocene
sediments, including gypsum of the Tulare formation. The southwest flank
of the syncline originally lapped on the flanks of the Diablo Range and are
now disturbed and overturned by the forward motion of the Diablo Range.

We will proceed westward. Note the shallow, south plunging dips of
the antiform in the hills to the north. Most of the hill is composed of Neroly
sediments with a thin, eroded cover of Plio-Pleistocene gravels.

For about 1 1/2 miles we will be in the shallow dips of the antiform.
The higher hills to the south are now part of the Diablo Range. Riders in
the Carnegie Motorcycle Park are responsible for the number of dirt trails
all up and down the hills in the Tesla formation.

Lying above the “Franciscan” along the Tesla fault are Upper
Cretaceous sediments, including Maastrichtian rocks, and the Eocene
Tesla formation, equivalent to the Domengine section to the north. These
rocks all dip toward the road at 60 to 90 degrees and are partially
overturned. A major boundary underlies the road for the next three miles
(Corrail Hollow fault). Another major fault – the Carnegie Fault - trends to
the west-northwest. The intersection zone lies between these two faults.

The Tesla occurs on the lower hills to the south and dips into the
valley. On the north side of the road, the Neroly occurs in vertical beds. On
the north side of the Carnegie fault, the antiform dips gently to the south
except at the immediate vicinity of the fault where it turns over to vertical.
We will take a lunch break at Carnegie Cycle Park.

STOP 7  VERTICAL OUTCROPS. Stop just past Alameda County line.

We will examine the outcrops, the vertical dips, and faulting within the section at this stop. We are in the intersection zone between the Carnegie fault and the Corral Hollow fault. As we proceed westward, the zone widens and the projection of the Callahan syncline trends east-west. The accompanying anticline to the north has Cierbo in the crest. The syncline has Plio-Pleistocene sediments in the center. Just past the main gate to Site 300, note the small quarry in Neroly to the right (north).

Walk westward from the stop making sure to watch for traffic. There's little room here. The sands are light colored, quartzose, soft, with thin pebble zones of black chert and "Franciscan" lithologies. No fossils were found but this outcrop is believed to be Cierbo underlyng Neroly in the higher hills. Note the folded bedding and contortions, organic material on bedding planes, cross bedding and shale beds. The sand beds are folded and overturned without apparent distortion of layers, suggesting shallow burial, and a fluid environment in which the beds were distorted.

Note the thick, dark colored cobble deposits lying above the light colored sands throughout this region. These probably represent a Pleistocene stream deposit. Many landslide deposits are also visible in the hills.

Proceed westward. Within a ¼ mile, note the vertical Neroly beds to the right.

STOP 8. View of steeply dipping Neroly in Canyon

Pull off the road to the right. We will observe the Neroly from a distance as access is limited. The dips are measured at 80 degrees to the north. The angle at which we are looking makes them appear to be about 60 degrees.

Proceed around the curve ahead and prepare to pull off the road to the left. Watch for traffic!!

STOP 9. NORTH TURN OF ROAD UP THE HILL.

Park on south side of road and walk up hill. We will look at the Tesla with coal beds, Cierbo, and Neroly lithologies. Tear faults exist in the valley to the east. Nomenclature of the faults in this area is not precise. The Corral Hollow fault follows the tears for a short distance. One branch
trends to the west-northwest at the Tesla-Cierbo boundary. Another trends
to the northwest and cuts the Carnegie fault, becoming the boundary
between the antiform and the intersection zone.

The small scale geologic map shows the relationships of the major
faults. Note the alignment of the synclines in an east-west direction across
the area. These syncline mark the position of the underlying trough. Note
how the trough area opens to the west and is completely closed to the east.

The trough existed between the Mount Diablo Antiform and the
encroaching Diablo Range. Its position is marked by Maastrichtian, Tesla,
Cierbo, Neroly, and Pliocene-Pleistocene gravels. As the trough or
syncline was squeezed between two massifs, space problems forced
sediments out and upwards from the area between. Anastomosing faults
define the area. It is believed that many more bedding plane faults exist in
the area than are mapped.

We will walk only a few hundred yards up the hill, examining the
lithologies. Note the thin, yellow colored beds within the Tesla. These are
coal beds. They aren’t much thicker in the Tesla area to the west where
they were mined!

Return to the cars and proceed slowly up the hill through the many
outcrops and curves. There really is no place to pull off the road for more
than a car or two. Most of the outcrop will be Tesla, with a major thrust
fault in one of the gullies about 1/2 way up the hill. Cross into footwall
Cierbo and then Plio-Pleistocene near the top. We will pass a landslide
area, freshly exposed 2 years ago and now vegetation covered.

STOP 10  PASS AT TOP OF HILL.

Look at the various lithologies in the Tesla formation

STOP 11. VIEW OF LAS POSITAS UPLIFT

Proceed down hill to intersection with Greenville road. Pull off road just
around the corner for a view of the Las Positas Fault uplift and intersection
with Altamont Hills.

STOP 12. PULL OFF ON SHOULDER TO RIGHT, TOP OF HILL

A good chance to examine Holocene gravels uplifted into an antiform
during Holocene time.

Return to I-580 and back to Danville. END OF TRIP.
GEOLGY
OF
CENTRAL
CALIFORNIA

MOUNT DIABLO - DIABLO RANGE
INTERSECTION
THE ALTAMONT HILLS
NORTHERN CALIFORNIA GEOLOGICAL SOCIETY
MAY 2003 FIELD TRIP
RON CRANE
ALTAMONT HILLS – DIABLO RANGE INTERSECTION

STRATIGRAPHY

Three intersecting stratigraphic regimes exist. One is the Mount Diablo Antiform – Altamont Hills area. The second is the Diablo Range itself. The third is the area between the two massifs.

1) In the Mount Diablo Antiform, the earliest exposed sediments are Cenomanian-Turonian deep sea sediments with turbidites on the west flank. Coniacian and Santonian sediments in a similar section occur to the north. These rocks are undoubtedly present in the subsurface and make up the bulk of the Antiform. Lower Campanian sediments are extensively exposed in the region from the Brushy Creek Fault to the south. Upper Campanian sediments appear on the plunge of the antiform.

   The Miocene Cierbo section unconformably overlies Upper Cretaceous rocks with no intervening Lower Tertiary section. Miocene Neroly sediments overlie the Cierbo conformably to the south but progressively overlap the Cierbo to the north. A thick Neroly section appears to the northeast and laps onto the antiform. This, in turn is covered by a Pliocene non-marine section. This section includes gypsum of the Tulare formation west of the Black Butte anticline adjacent to the Diablo Range. Pleistocene and Holocene gravels appear on both the east and west flanks of the Antiform.

2) In the Diablo Range, the bulk of the sediments are Early Cretaceous turbidites, olistostromes, and chert dominated imbricate thrust sheets. Most of these sediments are slightly metamorphosed. In the Lake Del Valle area, Upper Cretaceous turbidites and deep sea shales unconformably overlie a gravity slide of broken oceanic crust. This slide rests (on the Coast Range Thrust) on Early Cretaceous rocks. A Miocene section overlaps this section to the north and in turn is overlapped by thick Plio-Pleistocene gravels (Livermore Gravels), grading into Holocene sediments in the Livermore Valley.

3) In the section between the Antiform and the Diablo Range, a section of Maastrichtian rocks and (Early Tertiary) Paleocene and Eocene rocks of the Tesla Formation are exposed. These sediments probably underlie the Livermore Valley and appear again along Lone Tree Creek and extend to the south. They are missing on the Antiform and in the Diablo Range. An original trough, now extensively compressed probably contains a thick section of these Lower Tertiary rocks and their high organic content is the most probable source for the Livermore Oil Field.
The following stratigraphic chart (true time scale) shows the distribution of the section in the 3 areas.

![Stratigraphic Chart](image)

Figure 27 Stratigraphic Chart

Individual detailed descriptions of the various units can be found in the literature of the area.

The Upper Cretaceous rocks are deep sea shales and turbidites. The southern part of the Mount Diablo antiform is dominated by shales. This is probably an area between major fans. Rocks of the same age, both to the north and south, have more abundant sands. The Maastrichtian section is more sand rich. The section at Lake Del Valle also is more sand rich. The Tesla formation is composed of white, quartzitic sands, buff sands, coals, and chocolate shales and marine clays. It is correlative with the Domengine Formation to the north.

The accompanying geologic map, which also shows the location of structural sections, shows the distribution of the major stratigraphic units.
Figure 28 Altamont Hills Geologic Map with Cross Section locations

The general structure can be discerned by a structural contour map on top of the Cretaceous. All areas above sea level are shown in green. Figure 29.
STRUCTURE

The general structure of the region can be seen on the following map showing the contours of the general structure of the Mount Diablo Antiform, the Diablo Range, and the narrow trough between the 2 massifs.

![Map of Mount Diablo and Diablo Range](image)

**Figure 30** General Structure, Mount Diablo-Diablo Range Intersection

Portions of the general structure of the Diablo Range are shown in black. The maps extends westward only to the Williams thrust. The general structure of the Mount Diablo Antiform is shown in red. The plunge of the antiform into the Altamont Hills is apparent, with a saddle between the Antiform and the Black Buttes Anticline. The trough between the two structures is uncolored but it may be seen that it extends into the Livermore Valley.

The Diablo Range has moved to the northeast while the Mount Diablo Domain has moved to the southwest. The Diablo Range is an Albian structure which has been reactivated in the late Tertiary. The major structure has moved about N45E, while the northern portion has been slightly detached and has moved about N10E.
The gross structure resembles a large slump into the old trough area. A subsidiary slump occurs at the boundary between Upper Cretaceous and "Franciscan" rocks along the Tesla fault.

Figure 31, perspective view, Mount Diablo-Diablo Range Intersection

The fault movement within the area shows complex movement. Part of the reason for this is that pre-existing structure has been modified by later movement which has taken advantage of existing lines of weakness, and in some cases, reversed the sense of movement. A careful examination of the structural cross sections reveals regions in which this has happened.

The Diablo Range, internally, has vertical to overturned dips and faults indicating several periods of movement. The latest movement has been the modification of the Mount Diablo Antiform by the east vergent Black Buttes thrust and anticline. The San Joachin border fault picks up to the south as the Black Buttes thrust dies out. The San Joachin thrust does not break the surface in its frontal portion. Its northern boundary is a complex tear fault buried by alluvial deposits and landslides.

The southwest flank of the Mount Diablo Antiform is overturned along its entire length. Squeezing of sediments and backthrusting of the cover sediments obscures this relationship over the southern part along the trend. This is expected because the motion of the anticline towards the southwest as it changes from a normal flank to vertical to overturned compresses the section on its flank. A complex fault zone develops on the surface as the rocks move upwards and outwards. This superficial complexity along a straight trend has led early
investigators to conclude that the feature was a strike-slip fault – the Greenville fault.

Figure 32. Late fault movement in the Altamont Hills

Outcrops of Upper Cretaceous rocks are shown in green. Teeth on the fault indicates the direction of thrust movement.

The geometry of the Mount Diablo Antiform, the Intersection and the Diablo Range are illustrated in a series of 25 cross-sections. The first section is parallel to Section MD10 shown in the Guidebook to the Mount Diablo Region, Northern California Geological Society, Spring Field Trip, May, 2002.

The Mount Diablo Antiform can be traced continuously to the south. The overturned western flank becomes progressively less overturned until Section A17. The anticline becomes symmetrical to Section A19. Beyond this, the westward thickening of the deeper Cretaceous section, under compression forms an anticlinal structure. The structure disappears by Section A25. A new structural regime, the east flank of the Diablo Range uplift, continues to the south.
Sections A1 to A3 demonstrate the asymmetric anticline-syncline pair of Mt. Diablo-Tassajara Valley syncline. The thrust sheet underlying the valley, the series of thrusts and backthrusts at the western edge of the anticline (Greenville Fault zone), and the old normal fault, tensional system on the east flank of the anticline are typical structures in this area. Note the unconformities and thinning of units on the east.

To the west, Plio-Pleistocene sediments are folded and faulted. The Miocene Neroly and Cierbo are present, underlain by a discontinuous Eocene section which once lapped up the western flank of a shallow structure.
Figure 34. Cross Sections A4-A6

Sections A4 to A6 show the same general structure. The western syncline simplifies as the thrusts die out. An eastward vergent thrust from the Greenville Fault Zone becomes more prominent to the south. The graben faults die out and bedding thrusts move up the east flank.

As the sections are traced to the south, the influence of the Diablo Range thrusts become apparent. Note on sections A8 and A9 that the Las Positas Fault Zone is actually the leading edge of a thrust sheet, one with little actual displacement. This is due to movement just starting on this thrust.
Figure 35  Cross sections A7-A9

Section A8 indicates the Diablo Range High and the Antiform have not yet interfered with one another. Section A9 shows extensive interference. The trough between the two structures becomes more defined. Note the onlap of the sedimentary section onto the Diablo Range High.

The sections are somewhat misleading inasmuch as the section across the Diablo Range is not drawn perpendicular to the b-axis direction. It was considered more important to continue to document the extension of the Antiform to the south.
Sections A10 to A12 show the continued development of the trough in the intersection zone. On sections A11 and A12, the crest of the antiformal duplex of the Diablo Range lies on the western edge of the sections.

To the east of the crest, the structure within the region appears to be a series of imbricate thrusts which have gravitationally slid into a low area (the trough). Pliocene sediments unconformably overlie both Upper Cretaceous and Lower Cretaceous structures, indicating movement prior to Pliocene time.
The frontal zone of the Diablo Range starts to form a massive overturned anticline.

Figure 37. Cross Sections A13-A15

A tightly squeezed trough exists between the Diablo Range and the Mount Diablo Antiform. No data exists to determine the depth and extent of this trough. It may extend well back under the thrusted Diablo Range.
The Black Butte Anticline represents an eastward vergence of the basic structure. The westward vergence of the Mount Diablo Antiform ends.
The position of the Mount Diablo antiform changes to a shelf edge in the Upper Cretaceous. Figure 40. Cross Sections A22-A25
One of the most critical needs in understanding the deeper structure of the area is a depth to basement determination and map. This can only be done by geophysical means. This has not been done.

Figure 38. Cross Sections A16-A18
UNCONFORMITIES AND HISTORY

Several unconformities are present in the region. Each reflects movement or uplift of the region.

The earliest known and most significant unconformity is an Albian event. The Early Cretaceous sediments of the Diablo Range were thrust and folded, creating a subsea high. Portions of the oceanic crust were thrust over these sediments and also gravitationally slid into place. This section was then buried by Albian, Cenomanian and Turonian deep sea sediments, onlapping the high.

The Altamont Hills area, as part of the Mount Diablo Antiform, became a low lying structure during the Late Cretaceous and Early Tertiary. Part of this was due to the formation of tensional faults of grabens, with erosion on the high side and deposition in the downthrown side. Maastrichtian sediments thicken away from the Antiform and are not present on the up side of the Brushy Creek Fault southwards until the Corral Hollow area, and the buried trough.

Paleocene sediments are also unknown over much of the area. Sediments of this age are missing, probably through a combination of non-deposition and erosion.

Rocks of the Eocene age Domengine and Tesla Formations surround the Antiform on all sides, as well as onlapping the Diablo Range on the north and east. Sediments of this age are present in the Central Valley and underlie the Livermore and San Ramon Valleys as well as probably being present at depth under the Tassajara Hills.

The Oligocene was the time of sea level lowering and the area was probably subjected to erosion. Much of the lower Miocene section is also missing.

The Briones-Cierbo sand section onlaps the Antiform on all sides and covers and onlaps Cretaceous sediments. The section is also present on the north and west sides of the Diablo Range but does not appear to exist on the east flank. This is probably due to non-deposition, as the sediments swept around a low lying land mass and passed through the saddle of the Altamont Hills. The Cierbo thins on the flanks of the east-west anticline lying between the plunging Antiform and the Diablo Range, indicating some early growth of the anticline. It has been subsequently broken by later deformation.

The Neroly section, comprised of volcanic sediments coming from the Sierras, passed across the area and overlapped the Cierbo on the eastern flank of the Antiform, resting directly on Upper Cretaceous rocks.
The Pliocene section is undifferentiated over most of the Altamont Hills where it has been substantially eroded. Very thick sediments occur in the Tassajara Hills. The Livermore Gravels overlap older units until they lie directly on the Early Cretaceous rocks of the Diablo Range, after onlapping Late Cretaceous rocks in the Lake Del Valle area. The Pliocene section is thick on the eastern and western flanks of the Antiform; may be present on the southern flank of the Antiform north of Corral Hollow and thickens into the Intersection area. The conformable gravels on top of the Neroly in scattered remnants on the south plunge of the Antiform have not been age identified and could be of Pleistocene age.

The Callahan Syncline occurs south of Corral Hollow, is immediately adjacent to the Diablo Range and strikes across the outcrop in the Lone Tree Creek area to the normal frontal zone of the uplifted Diablo Range. Pliocene sediments rest unconformably on oceanic plate serpentine near the Thomas shaft of the Hetch Hetchy Tunnel and dip conformably with the serpentine to the east at about 80 degrees. This conformable dip was also found in the tunnel. The Pliocene overlaps Neroly just to the north, a Miocene sandstone just to the south, and Eocene rocks a mile to the south. The Pliocene section contains gypsum, indicating some evaporation in a shallow sea, perhaps correlating to the Carbonea formation.

Major movement of the Antiform and the Diablo Range occurred in the Pleistocene and Holocene and is continuing today. Middle and Late Pleistocene terraces have been uplifted on the eastern flank of the Antiform. The San Joaquim Fault shows minor movement in the Holocene, but because it is a shear and thrust fault it does not break the surface. The Las Positas Thrust Fault involves Pliocene and Holocene sediments as do the folds and thrusts underlying the southeastern Livermore Valley. Sediments of a similar age are involved in the leading edge of the Mount Diablo Structural Domain as well as along the western edge of the San Ramon Valley.
BIBLIOGRAPHY


Bartow, J. Alan. 1992, “Cenozoic Stratigraphy of the Northern San Joaquin Valley, Central California”, in Field Guide to the Tectonics of the Boundary between the California Coast Ranges and the Great Valley of California, Pacific Section, AAPG, April, 1992

Bartow, J. Alan, 1985a, “Map and cross sections showing Tertiary stratigraphy and structure of the northern San Joaquin Valley, California”, USGS Miscellaneous Investigations Map MF-1761, scale 1:250,000


Crane, Ron, 1995. Geologic quadrangle maps: Tassajara, Livermore, Byron Hot Springs, Altamont, Clifton Court Forebay, Midway, Tracy, Lone Tree Creek, Cedar Mtn., Available from H& L Hendry, Concord, California

Dibblee, T.W., Jr. 1980, Preliminary geologic map of the Midway quadrangle, Alameda and San Joaquin Counties, California”: USGS Open-File Report 80-535, scale 1:24,000

Dibblee, T.W., Jr., 1980, Preliminary geologic map of the Altamont quadrangle, Alameda County, California”: USGS Open-File Report 80-538, scale 1:24,000

Dibblee, T.W., Jr. and Richard L. Darrow, 1981, “Guidebook to the regional geology of the East Bay Hills and the northern Diablo Range-Livermore Valley Area”, in Geology of the Central and Northern Diablo Range, California, Pacific Section AAPG


Hafenbrack, J.H. and H.S. Sonneman, 1976, “Livermore Valley Area” in A Tour of the Reservoir rocks of the Western Sacramento Delta, Pacific Section, AAPG-SEG-SEPM


Lettis, W.R., J.A. Barton, H.S. Sonneman, J.R. Switzer., “Geologic Map of the East Flank of the Diablo Range from Hospital Creek to Poverty Flat, San Joaquin, Stanislaus and Merced Counties, Calif”, Map I-1656
Page, B.M. "Geology of the Coast Ranges of California": in Geology of Northern California, California Division of Mines and Geology Bulletin 190, p 267


