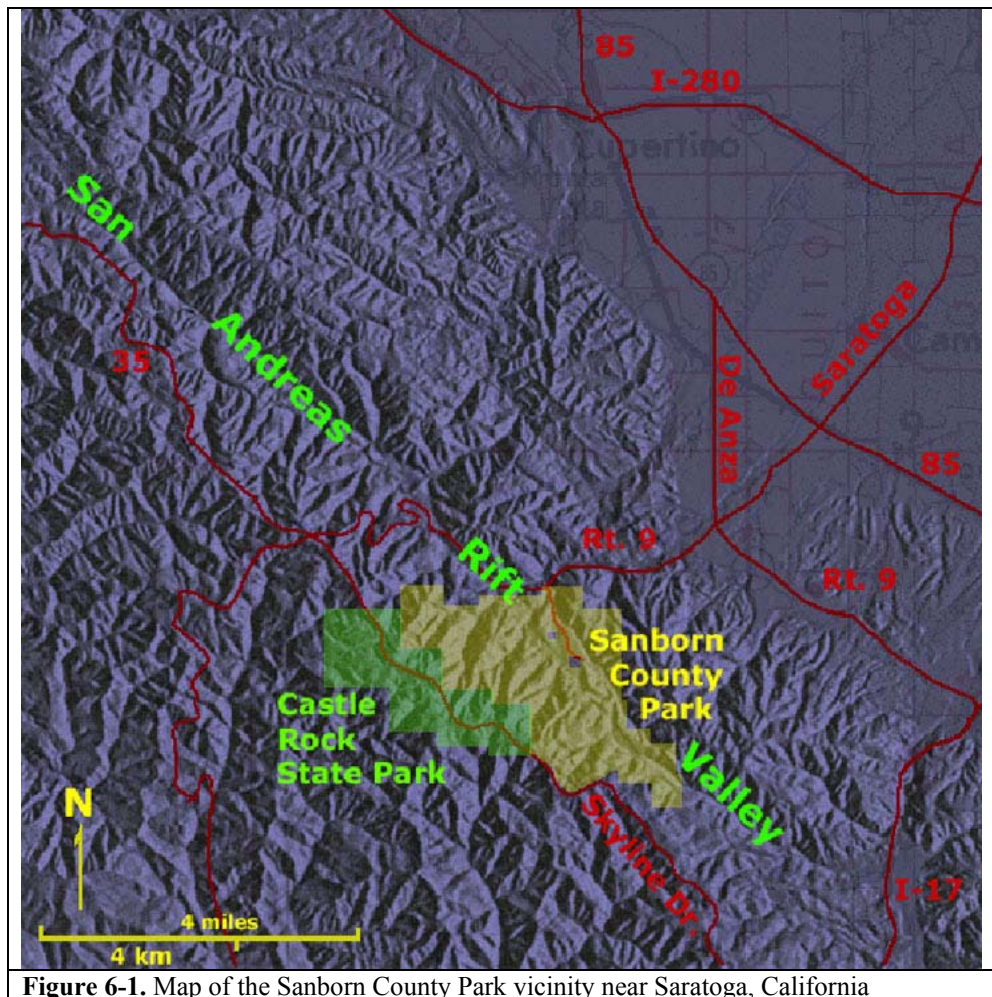


# Earthquake Trail, Sanborn County Park

## A Geology Hike Along the San Andreas Fault in Sanborn County Park, Santa Clara County, California

**Trip Highlights:** fault scarps, shutter ridges, sag ponds, landslides, fractured walls, offset streams, offset alluvial fan

Sanborn County Park straddles a section of the San Andreas Fault Zone where it passes through the Santa Cruz Mountains in Santa Clara County, California. This report is a guide to the Sanborn Earthquake Trail, a moderately strenuous hiking route that is 2.5 miles (4 km) long and leads through hilly terrain covered with a mixed redwood, Douglas fir, and oak woodlands and grasslands within the park and on other public land. The park area experienced strong earthquake shaking during the 1906 San Francisco Earthquake ( $M = 7.8$ ) and the 1989 Loma Prieta Earthquake ( $M = 7.0$ ). The trail provides access to a variety of geomorphic features associated with the fault zone (including offset streams, shutter ridges, sag ponds, fault scarps, and other fault-related landforms). Most of these landscape features are developed on an old alluvial fan system along streams draining from a high ridgeline eastward into the rift valley along the San Andreas Fault Zone. Other ongoing surface processes affecting the forested landscape including landslides, debris flows, floods, giant tree falls, and other forms of mass wasting and erosion, as well as both pre-historic and modern human activity that have left an imprint on the park landscape. The route follows established park trails including the route of the biology-oriented Sanborn Nature Trail.



**Figure 6-1.** Map of the Sanborn County Park vicinity near Saratoga, California

**How to get to Sanborn County Park:** From the north, take I-280 south to CA Highway 85 south. Exit right on De Anza Boulevard and proceed west a few miles to the intersection of Route 9 in downtown Saratoga. From the South, take CA Highway 85 and then take Route 9 west through the town of Saratoga. Proceed west on Route 9 from the town of Saratoga up Saratoga Canyon (Big Basin Way) about three miles. Turn left on Sanborn Road. Proceed one mile to the park entrance on the right. The best place to park is in the lot closest to the Park Office (midway up the hill, but below the

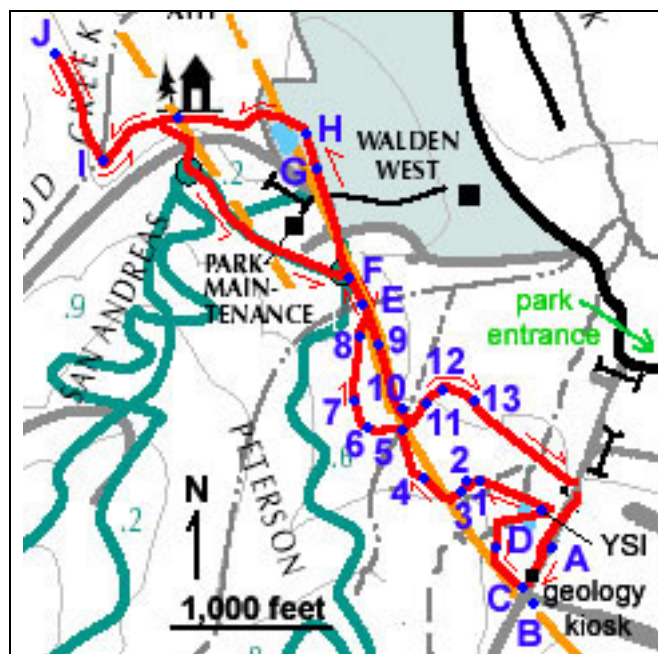
campground area). The park is accessible to buses (bus drivers should call the park in advance). Extreme care should be taken when turning onto Sanborn Road and when entering the park. A small day-use fee is required for each vehicle entering the park.

**Potential Hazards:** Please be aware that poison oak, ticks, rattlesnakes, mountain lions, or other natural hazards can be encountered in the park (as anywhere in the Santa Cruz Mountains). Rattlesnakes are generally harmless unless provoked. Simply take another route if you encounter one, but warn others in the area to be aware. Rattlesnakes are most likely to be seen near water sources on hot summer days. All wildlife in the park is protected. Forest areas and streams may be hazardous during storms. Pets and smoking are not allowed on park trails. Bring some water on the hike.



**Figure 6.2.** A western diamondback rattlesnake warms itself in the morning sun on a park trail.

### Sanborn Earthquake Hike - Geology Field Trip Route



**Figure 6-3.** The route of the Sanborn Earthquake hike is shown in red. The San Andreas Fault is shown in orange.

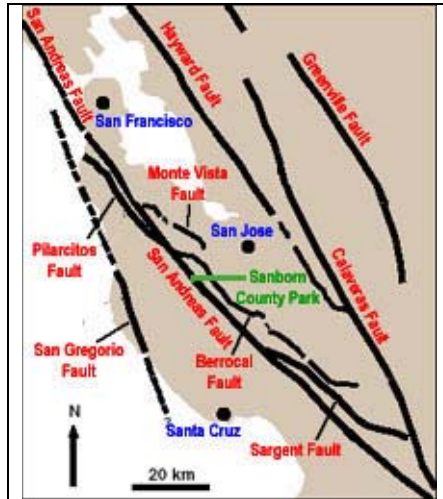
Please note that direction information in this text is started with bold text. Stops are organized as both letters (A-J) and numbers (1-13). The letter stops (in red) of the Sanborn Earthquake Trail were added to incorporate the preexisting numbered stops of the already established Sanborn Nature Trail. Each of the stops is marked by a lettered- or numbered-trail stop post.

From any parking location in Sanborn Park, proceed to the north end of the paved RV campground area to a kiosk displaying information about the geology of Sanborn Park. The kiosk is located at the intersection of the several trails about 80 meters (260 feet) north of the campground restrooms and water fountain. Maps and geologic information, as well as park rules and other related park information are posted here.

**Stop A** is located about 30 meters (100 feet) downhill of the Geology Kiosk near several large sandstone boulders. This first stop is located at the edge of the large field that provides one of the best views of the park vicinity: Landscape features include:

**The San Andreas Fault:** It may not be evident to most people who visit Sanborn County Park that they are basically right in the San Andreas Fault Zone. The fault passes through this portion of the Santa Cruz Mountains in and around Sanborn Park. The San Andreas Fault extends from great depths, measured in 10s of kilometers, to the surface, where it splays into a complex system of both parallel and interconnecting faults. The San Andreas, Hayward, Calaveras, and other earthquake faults are all part of the greater San Andreas Fault System (fig. 6-4). In the San Francisco Bay region, the San Andreas Fault System displays a total offset of about 286 miles (460 km), but only about 87 miles (140 km) of this offset occurred along the San Andreas Fault in the central Santa Cruz Mountains, the rest of the offset occurred on the Hayward and Calaveras faults in the East Bay region and other regional faults (Dickinson, 1997; Graymer, 2002).





**Figure 6-4.** The San Andreas Fault System in the San Francisco Bay region.

The San Andreas Fault is a relatively new geologic feature in the San Francisco Bay region. It began forming in the south central California region about 28 million years ago, but propagated through the Bay Area region only about 10 to 6 million years ago (Elder, 2001). Prior to the San Andreas Fault, a completely different continental margin configuration existed in California. Traditionally, the San Andreas Fault has been used to separate the North American Plate on the east and the Pacific Plate on the west in California. The offset along the San Andreas Fault is a strike-slip fault with right-lateral offset, such that the west side (the Pacific Plate) is moving northward relative to the east side (the North American Plate). (A USGS publication entitled This Dynamic Earth provides an introduction to plate tectonics theory; it is on-line at: <http://pubs.usgs.gov/publications/text/dynamic.html>.)

The San Andreas Fault is not perfectly straight. In places, such as in the Santa Cruz Mountains, the fault trace bends slightly to the left. This bend causes uneven forces throughout the crust (extending downward tens of kilometers) and results in the ongoing uplift of the Santa Cruz Mountain. Gradual changes in elevation are occurring continuously throughout the Coastal Ranges, both upward and downward with the build up of pressure, and its release from episodic earthquakes. Fission track studies and other data demonstrate that rock in the Santa Cruz Mountains has risen approximately 2 miles (3.2 kilometers) over the past 4.7 million years (a rate of about 0.6 mm per year) [Burgmann and others, 1994]. Since the highest elevations in the Santa Cruz Mountains are only slightly higher than 0.63 mile (1 kilometer), the rate of erosion of the mountain uplands is therefore about 0.4 mm per year. However, uplift and erosion factors are complex, and they are neither uniform nor synchronous throughout the Santa Cruz Mountains.

**The San Andreas Rift Valley:** Sanborn Creek is a headwaters tributary of the greater Saratoga Creek watershed that drains along Route 9 into Saratoga. The stream continues northward along a highly modified channel until it drains into the southern San Francisco Bay near Alviso. Over time, streams have carved a canyon following the zone of crustal weakness associated with the San Andreas Fault Zone. The combination of stream erosion and movement along different faults near the surface has resulted in the formation of the San Andreas Rift Valley; it is both a “geologic-structural” valley, and “surface-erosional” valley. The landscape is a reflection of two totally different geologic processes: tectonic forces affecting the earth below the ground and raising the land surface, and the combination of erosional and depositional processes occurring at the land surface. However, as we will see, the structural forces are, in part, controlling how and where erosion and deposition is occurring. The combined headwater valleys of Sanborn Creek, Lyndon Creek (to the south), and Saratoga and Stevens Creek define the trace of the San Andreas Rift Valley in the central Santa Cruz Mountains.

The Gap in the hills to the south of the campground marks the fault line of the San Andreas Fault. The break in slope above the RV campground is probably a fault line scarp of the San Andreas Fault. However, in many places the fault is covered by alluvium or does not show an obvious surface expression. Please note that the fault location is not always easy to see (except in some cases as we shall see). In most places, the surface expression of the San Andreas Fault is complex. There are probably other faults in the area that may or may not display evidence of recent movement.

**Alluvial Fans:** The sloping fields in the main park area are part of a system of alluvial fans associated with streams draining from Castle Rock Ridge to the west. Over thousands of years, sediments eroded from the steep slopes above are deposited on the more level slope below. Alluvium is unconsolidated material on the land surface, including soil, boulders, and sediments deposited by wind and water. An alluvial fan is a fan-shaped accumulation of stream-deposited sediments that spreads out into a valley from a canyon source area, such as in the valley along a fault-bounded highland area. Where many alluvial fans join together along a mountain front, this broad sloping surface is called a *bajada* (an alluvial apron along a mountain front). Much of Sanborn Park is located on an old alluvial fan system that is currently being incised by streams. Bedrock on the uphill side of the break in slope is the source of sediments deposited on the alluvial fan on the downhill side.

Figure 6-5 is a portion of a geologic map showing of the Sanborn County Park area (Brabb and others, 2000). The west side is formed of Tertiary-age sedimentary rocks (roughly 40 to 30 million years) that probably overlie Salinian granitic basement (at depth). On the hillsides to the east of the San Andreas Rift Valley (toward Saratoga) the bedrock consists of

oceanic basement rocks and associated younger sedimentary rocks (Coast Range Ophiolite and Franciscan Complex, roughly 165 to 120 million years old). The sediments exposed on the alluvial fan were probably deposited within the last hundred thousand years.

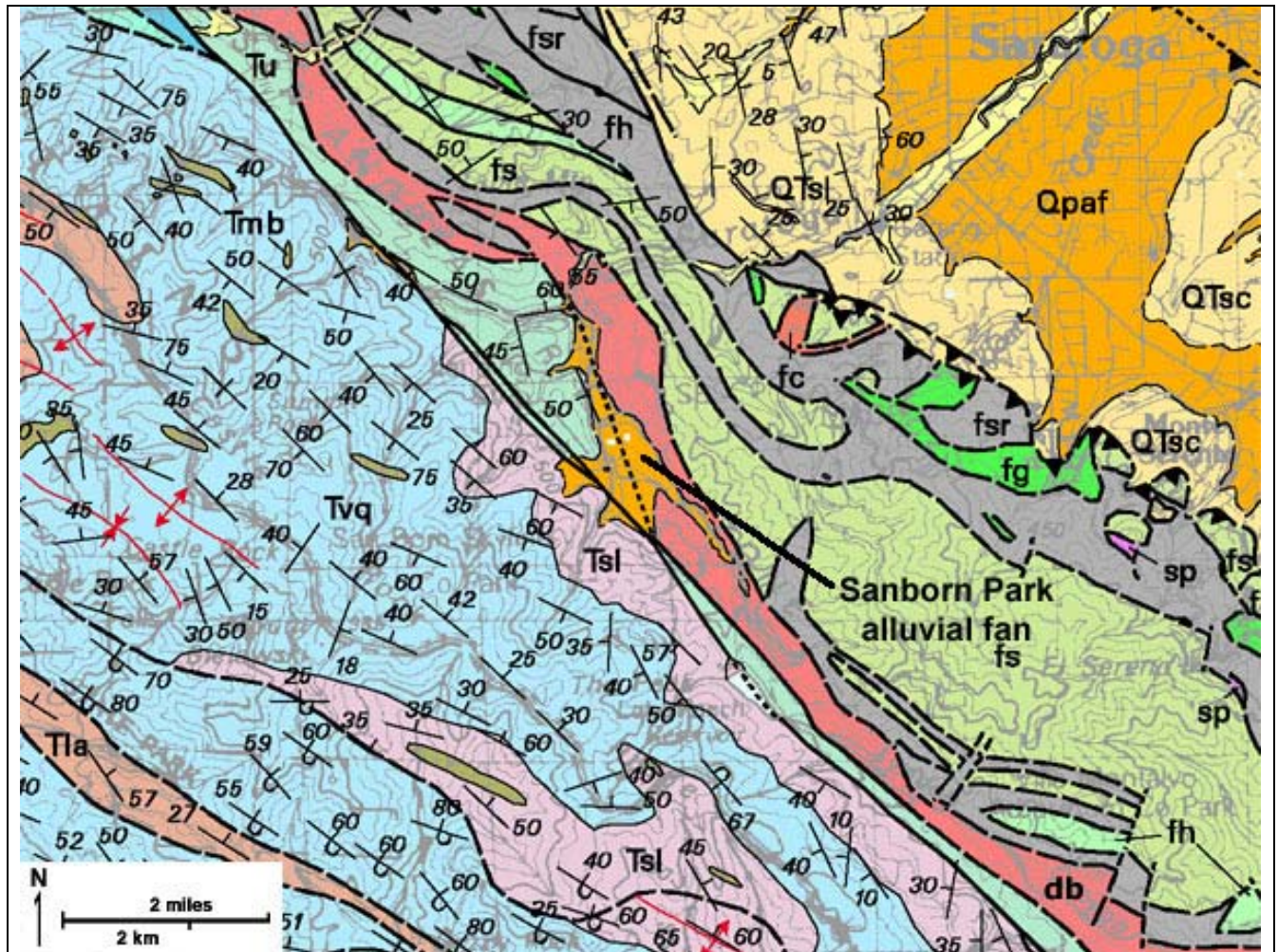


Figure 6-5. Geologic map of the area encompassing Sanborn County Park (from Brabb and others, 2000).

**Map legend**

Qpaf - Quaternary (Pleistocene) alluvial fan deposits  
 QTsc - Santa Clara Formation (gravel, sand, and mud of Pliocene and early Quaternary age)  
 QTsl - lake beds

Franciscan Complex (undivided) and other rocks east of the San Andreas Fault

fsr - sheared rock (mélange)  
 fg - greenstone  
 fh - argillite and shale, some sandstone  
 fs - sandstone  
 fc - chert  
 sp - serpentinite  
 db - diabase and gabbro (Coast Range Ophiolite)  
 Tu - Unnamed Tertiary mudstone, shale, argillite and sandstone (Eocene?)

Tertiary marine sedimentary rocks west of the San Andreas Fault

Tla - Lambert Shale (lower Miocene and Oligocene)  
 Tmb - Mindego Basalt and related volcanics (lower Miocene and Oligocene)  
 Tvq - Vaqueros Sandstone (lower Miocene and Oligocene)  
 Tsl - San Lorenzo Formation (Oligocene and upper and middle Eocene) - mostly shale and mudstone



**Stop B** is located at the intersections of trails near a park information kiosk just north of the campground restrooms. Note the abrupt change in slope near the kiosk and trail-intersection area. This break-in-slope at the top of the alluvial fan and what is probably the fault-line scarp of the San Andreas Fault (there is probably more than one strand of the fault in this valley). Three low pyramid-topped posts with red bands just south of the Stop B post show the plausible alignment of the San Andreas Fault. Whether there was surface rupture here from the 1906 earthquake is unknown. Without a recent major earthquake, or invasive trenching, the exact locations of faults in this area are not clearly visible. Surface erosional processes relatively quickly erase evidence of surface rupture along fault traces.

The amount of coseismic right-lateral surface rupture in the southern Santa Cruz Mountains caused by the Great San Francisco Earthquake of April 18th, 1906 is unclear, but probably varied between 1 and 3 meters (3 to 10 ft). The best reported observation was 1.5 meters (5 ft) of right-lateral offset in Wright's Tunnel (south of Lexington Reservoir); however, this amount of offset may not have been the total displacement within the broader fault zone of the San Andreas (Prentice and Schwartz, 1991); the main trace of the San Andreas Fault has been mapped east of the trail entrance (McLaughlin and others, 2002). Many of the ground ruptures in the southern Santa Cruz Mountains found after both the 1906 and 1989 earthquakes were a result of landslides induced by ground shaking. Nearly all the trails, roads, and man-made structures in the park area were constructed after the 1906 earthquake.

The greatest offset during the 1906 Earthquake occurred well north of the SF Bay region, with as much as 8.5 meters (28 ft) of right-lateral offset producing surface rupture in the region near Shelter Cove, and 6 meters (20 ft) near Point Reyes. Southward into the Santa Cruz Mountains, the amount of offset during that quake diminished to about 1 meter (3 ft) near Watsonville, to almost nothing observable on the surface south of San Juan Bautista, although tremendous seismic shaking was reported over a much greater region extending far to the south in the vicinity of Pinnacles National Park. Subsurface rupture along the fault probably extended well beyond the region of surface rupture (<http://quake.wr.usgs.gov/info/1906/offset.html> and Gilbert and others, 1907; Lawson, 1908).

The nearby water tank constructed by the Santa Clara County Water District is used mostly for irrigation purposes in the park (and for emergency purposes); it was constructed in 2003.

**Stop C** marks the trail head of a narrow path that leads downhill along the escarpment of the San Andreas Fault into the drainage of Sanborn Creek. This undeveloped section of the trail is inaccessible when wet. If the trail is closed, proceed down and pick up the route the Visitor Center/Youth Science Institute (YSI) and start the rest of the hike from there.

The volunteer trail leads several hundred meters downhill through a grove of small redwoods. The ecosystem around Sanborn Park includes redwood and Douglas fir forests in the cooler, wetter valleys and north- and east-facing slopes, whereas chaparral and shrub oak dominate the higher, dry west-facing slopes. The woodlands in and around the park have been heavily lumbered, particularly in the late 19th century.

Keep looking to the north through the gaps in the forest to where Sanborn Creek descends off of the escarpment of the San Andreas Fault. Just north of an “artificial” waterfall created by a pipe diversion of Sanborn Creek, the natural stream makes a hard right turn and flows along the fault for some distance before turning left resuming its initial downstream course in its incised valley. The bend in the stream formed along the escarpment as the western (uphill) side of the San Andreas Fault moved northward relative to the alluvial fan (downhill) side of the fault. Over time, the stream channel has continued to flow in its current path resulting in a dog-leg shaped path of the stream channel called an offset drainage. This zigzag-shaped bend shows that the gorge of Sanborn Creek has been offset by the right-lateral relative motion along the San Andreas Fault. Much of the landscape geomorphology in Sanborn Park is related to the formation of offset drainages and stream capture along the San Andreas Fault.

Continue downhill to a wet area near the intersection of several trails.

**Stop D** is located near some very large boulders where the narrow path intersects a larger park trail. Some springs are located nearby in a low area to the south of the stream (these springs do not flow in the late summer). Springs are common along fault zones because faults and fractures serve as fluid migration pathways. Whether these springs are related to a fault is unclear.

How did the large boulders get here? The boulders are derived from the Vaqueros Sandstone or the San Lorenzo Formation. Both of these sedimentary rock formations occur as bedrock in the hillsides to the west and above Sanborn

Park. The Vaqueros Sandstone is the dominant cliff-forming unit in Castle Rock State Park, located along the ridge west of Sanborn Park. These large blocks of sandstone migrated downslope onto the alluvial fan in landslides or debris flows from the upland areas to the west. The presence of the forest suggests that these events occurred long before the modern forest existed here (the forest would not likely survive an event intense enough to move such large boulders!). In addition, smaller rock fragments and debris probably surrounded these boulders, but have long since eroded away. Large boulders are a typical occurrence on the upper portion of alluvial fans.

The **Vaqueros Sandstone** (lower Miocene and Oligocene, roughly 20-to-30 million years old) consists of light-gray to buff, fine- to medium-grained, locally coarse-grained arkosic (feldspar mineral-bearing) sandstone interbedded with olive- and dark-gray to red and brown mudstone and shale. Sandstone beds are commonly from 0.3 to 3 meters (1 to 10 ft) thick and mudstone and shale beds are as much as 3 meters (10 ft) thick. In the region, the Vaqueros Sandstone varies from a few meters to as much as 700 meters (2,300 ft) in thickness (Brabb and others, 2000). The formation consists of sediments that were probably deposited in a shallow marine shelf environment, offshore of a river mouth that was probably far to the south (possibly in southern California). These sediments, now rock, were transported northward to their present location by movement along the San Andreas Fault System.

The **San Lorenzo Formation** (Oligocene and upper and middle Eocene, roughly 30-to-50 million years old) consists of dark-gray to red and brown shale, mudstone, siltstone, with local interbeds of sandstone, and is about 550 meters (1,800 ft) thick. Within the upper part of this formation are large, elongate carbonate concretions. The presence of shale suggests that the formation represents materials deposited in somewhat deeper water, farther offshore setting than the younger Vaqueros sediments.

Volcanic rocks are present in the hillsides west of the fault with outcrops and boulders scattered throughout the Santa Cruz Mountains. The **Mindego Basalt** (Miocene and/or Oligocene) includes both extrusive and intrusive volcanic rocks that range in color from dark-gray to orange-brown to greenish gray breccia, tuff, pillow lavas, and flows. The intrusive rocks tend to be coarsely crystalline. Radiometric dates yield an age of about 20.2 (+/-1.2) million years (Brabb and others, 2000).

Along the San Andreas Fault, these rock units are highly fractured and mixed together. Pieces of the basalt can be found in streambeds in the area (but none has been yet observed in the park). Fossils are not common in either the Vaqueros or San Lorenzo formations locally. Collectively, the rocks on the west side of the fault in Sanborn Park are between 20 to 50 million years old, whereas the rocks on the east side of the fault are much older. The later belong to the Franciscan Complex, a mix of ancient marine sediments and oceanic crustal rocks that formed in the mid to late Mesozoic era, roughly between 200 to 100 million years ago (Elder, 2001). Franciscan rocks are not seen along this fieldtrip route.

**Continue downhill** and then bear to the right, avoiding the private residence (an arrow post marks the route). Proceed downhill; once you get to the paved road, take the small wooden bridge across the creek (with small ponds) and then proceed uphill to the left to the Visitor Center (Youth Science Institute building near the Park Office).

Local legend says that the shaking caused by the 1906 Earthquake caused much of the water to splash out of these ponds. Note that the dams and trail through the pond area have been modified since the earthquake. A significant portion of the water in Lake Ranch Reservoir (at the south end of the park) was also reported to have splashed out during the earthquake. The reservoir expanded a natural sag pond along the San Andreas Fault in the natural upland saddle between the drainages of Sanborn Creek (on the north) and Lyndon Creek (canyon to the south).

### **Nature Center /Youth Science Institute (YSI) - Optional Stop**

Park maps and brochures are available at the Nature Center/YSI. Several displays highlighting local Native American (Ohlone) culture and history are located on the outside patio area of the Nature Center. A number of artifacts are on display. Other exhibits include live animals that populate the Santa Cruz Range, earthquake and geology displays, an insect zoo, and a garden featuring native plants and plants used by Native Americans. The YSI is an educational institution that conducts a variety of Pre-K to teen school and group programs, after school science classes, and summer science camps (with similar programs at Vasona and Alum Rock county parks).

From the Nature Center/YSI, follow the route of the Sanborn Nature Trail. Near the Visitor Center, a sign points to the "Peterson Memorial Trail, San Andreas Trail, and Walden West." Follow the trail downhill past some big blocks of sandstone to a recently renovated stage area. The bridge across Sanborn Creek is at Stop 1 on the Nature Trail route.

## Geology along the Sanborn Nature Trail

**Stop 1** along the nature trail examines a coastal redwood, the California state tree. Coastal redwoods can grow to over 100 meters high and can live up to 2,000 years. The red bark contains a resin that helps protect it from fire. They also are able to reproduce through their root system when cut down or damaged by fire. Most of the redwoods in the park are younger than a century because the area was heavily lumbered in the late 1800s. The remnants of old logging trails are still visible in many places. However, these road scars can now serve as a measure of landscape change and forest recovery over time.

At the wooden bridge, note the incised character of the stream valley (Sanborn Creek, a tributary of Saratoga Creek along Route 9). Also note the abundance of large sandstone boulders in the creek bed. Signs describe the creek bed area as a “restoration area” to repair damage from past heavy foot traffic off the trails. The small stream has cut down into an older surface of the alluvial fan. Note that near Stop 1 a narrow flood plain forms the floor of this stream valley, and that the small stream is limited to an irregular channel incised into this flood plain. Floodwaters and possibly debris flows can completely fill the entire floodplain.

Proceed steeply uphill from the bridge along the Nature Trail to Stop 2.

**Stop 2** is located on a flat area, (possibly a old stream terrace) above the incised valley of Sanborn Creek. This stop in the Sanborn Nature Trail guide point out the differences between a redwood and a Douglas fir. Both trees are used for lumber, however, Douglas firs are currently farmed as Christmas trees throughout the Santa Cruz Mountains.

Continue taking the trail uphill.

**Stop 3** - Examine the character of the old alluvial fan surface preserved here between two incised valleys (to the north and south). Note the gentle slope to the east and the abundance of rock material on the surface between the trees. All the material beneath the surface is poorly consolidated alluvium deposited by stream processes, landslides, slumps, debris flows, floods, rockfalls, and creep from the hill slope above before the modern forest developed.

**Stop 4** is at a massive stump of a large redwood that was probably cut down in the late 1900's. The cutting of trees, and evidence of the road building to remove them, is still quite evident on the landscape after more than 100 years. Just past Stop 4 the trail approaches the steep escarpment of the San Andreas Fault. While walking along the trail, note how some of the drainages appear abandoned as the streams' headwater areas moved northward, over time, relative to the alluvial fan. It is likely that past great earthquakes in this region may have resulted in relative movement measured in meters. Such shifts in ground motion resulted in “stream capture” and the development of new drainages, and the abandonment of others.

Continue northward along the trail to the intersection of several trails. Go to the left and continue on the Nature Trail. In the vicinity of the trail intersection, note that the trail to the right follows an incised valley that does not have an active flowing stream. This valley is an example of an abandoned stream, cut off by migration of the headwater area by motion along the fault.

Beyond the trail intersection, the Nature Trail traverses part of the fault scarp of the San Andreas Fault. Although most of the relative displacement along the fault is horizontal, right lateral, strike-slip motion, part of the motion is also vertical in this area (resulting in the uplift of the Santa Cruz Mountains). In general, for every 10 meters the west side of the fault moves northward, the Santa Cruz Mountains also rise about one meter. It is also important to note that relative motion is not uniform everywhere along the fault (or faults), which adds to the complexity of the evolving landscape. In most places the trace of the fault is not easy to see except relatively soon after a major earthquake with surface ground rupture. Erosion and shifting surface sediments typically mask the traces of surface rupture within a few years.



**Figure 6-6.** A park trail near stop 4 follows a beheaded stream channel formed by right-lateral fault motion and stream capture. There is currently no stream channel to match the size of this valley. The escarpment of San Andreas Fault is to the right.

**Stop 5** in the Nature Trail guide shows how to differentiate poison oak from blackberry (both have characteristic 3 leaves). Poison oak is abundant everywhere in the Santa Cruz Mountain. Although the plant foliage is most toxic, the barren branches, fallen leaves in winter months, and soil around the plants still can cause serious reactions to some people. Smoke from burning brush can carry the toxic resins. Simply washing laundry may not be enough to remove toxic resins from clothing. The best solution to the poison oak problem is to learn to recognize and avoid the plant in all seasons.

**Stop 6** is at another massive stump of a redwood harvested in the 1800s. This tree was about 1,000 years old and probably about 80 meters (260 ft) high when it was cut. During its lifetime the tree probably experienced several major earthquakes, and in the course of its lifetime the land it occupied probably moved as much as 17 meters (56 ft) northward relative to the opposite side of the fault! (This estimate is based on right-lateral slip rates along the local section of the San Andreas Fault by McLaughlin and others, 1999.)

**Stop 7** is near the location of a large Douglas fir that fell during the storms of 1995. Note the abundance of rock material tangled in its decaying roots. This fallen tree is a testament to the erosional forces created by biological activity. The hummocky character of the forest landscape is partly a result of tree falls in the past. Other forces affecting the hillside are the constant seasonal wetting and drying causing clays in the soil to expand and contract, gradually causing materials to creep down slope. During colder periods in the past, freezing and thawing of the land surface probably also generated significant amounts of ground movement and supply of sediment to the alluvial fan. Combined with the force of gravity, weathered rock and soil migrates down slope over time, these processes are collectively called mass wasting.

**Stop 8** is by a small wooden bridge over another small stream that crosses a strand of the San Andreas Fault. The small streams in this area tend to dissipate as they approach and cross the fault. The flat area downslope is in part an ephemeral sag pond. A sag pond is a fault-related low area where water may accumulate because sedimentation cannot keep pace with the tectonic forces warping it downward, or erosion cannot keep pace with uplift blocking a drainage outlet.

## Northern Sanborn County Park Area

At the trail intersection beyond Stop 8, leave the Nature Trail temporarily. Turn left and proceed northward along the trail toward Walden West and the American Youth Hostel (Welch Hurst House). From this point the trail basically follows the trace of the San Andreas Fault. (**Note:** Do not follow the “San Andreas Trail” — this trail leads uphill to the Skyline Boulevard area near Castle Rock State Park; part of this trail is on the return route).

**Stop E** is located near two large “fairy rings” on the right side of the trail. These circular groves of redwoods formed when a large “parent” tree died (or was cut) and a ring of new trees sprouted around the base of the missing tree. Also note the low rocky linear ridge along the right side of the trail as you approach the park maintenance buildings (on the



left). This is a “shutter ridge” formed by diversion of streams along the San Andreas Fault. Whether this is also a “pressure ridge” created by local compressional uplift along the fault is unclear.



**Figure 6-7.** A "fairy ring" of redwoods at Stop E.



**Figure 6-8.** The trail follows a shutter ridge along the San Andreas Fault between stops E and F near the park maintenance facility. The shutter ridge is on the right side of the trail. The slope to the left is part of the old alluvial fan along the mountain from of Castle Rock Ridge.

**Stop F** is located at the intersection of the trail with the paved road. The road splits here to the park maintenance area, Walden West, and continues northward to the American Youth Hostel. The San Andreas Fault passes through this vicinity. Take time to look at the stone walls and stream culverts in this area. One of the pillars just downhill of the intersection displays a date of 1955 with a geology pick commemorating Vernon Pick, a successful Utah uranium prospector who temporarily owned this land.

Look for recent cracks, fractures and right-lateral offsets in the stone walls that may be a result of earthquake damage or fault creep. However, not all damage to the walls and culverts in this area may be from earthquakes, but could be from slumping, tree-root breakage, or other causes related to gravity-driven “mass-wasting creep” (as opposed to “fault creep” which is of tectonic origin). Earthquake shaking can cause ground ruptures that are not on the trace of the fault. However, right-lateral offset is a good indication of surface rupture along the San Andreas Fault. Despite the large amount of right-lateral offset associated with the fault, there is only minor evidence of movement along the fault at the time this report was written. This segment of the San Andreas Fault is considered “locked” since the 1906 Earthquake, unlike other faults in the region where faults show evidence of slow movement or “creep.” Different segments of the regional fault system are “locked” or “creeping” and although all fault segments are potential sites for large damaging earthquakes, the locked segments are locations where pressure will be released in potentially large, damaging earthquakes in the future (as they often have in the past). The Sanborn County Park area experienced heavy shaking during the 1989 Loma Prieta Earthquake, but no significant surface rupture was reported in the vicinity.

Mr. Pick named the land Walden West, and for a time developed an underground uranium ore testing facility and bomb shelter farther up the road (this underground structure was later sealed off and abandoned for public safety concerns). Local legend says that shortly after building his laboratory Mr. Pick chose to abandon his homestead to live in relative tax-exempt freedom outside of the United States. The County then purchased the land in 1977 for inclusion in Sanborn Park. Walden West is a K-12 summer day camp under the direction of the Santa Clara County Department of Education.

Downhill from the intersection, the road follows a stream valley that may have once been the path of Todd Creek—a stream that has been offset by the fault. Because of more recent stream capture, Todd Creek now drains north of the large field below Walden West (located on the hilltop on the right). The broad field area was once the floodplain of Todd Creek, and in the past was partially occupied by a natural sag pond. Since the 1906 earthquake, this field was drained and used as an orchard. The hill that Walden West occupies is another shutter ridge formed from the offset of Todd Creek by the fault. The straight hillside along the right side of the field suggests that fault offset may have contributed to the formation of a small rift valley within the larger rift system that formed the entire valley. The intersection at the south end of the field basically marks a stream divide between headwater areas of Sanborn Creek (to the south) and Todd Creek (to the North). As you will see as you continue the hike, Todd Creek is in the process of capturing stream drainage around this former sag pond area.

**Stop G** is in the field along the road leading to the American Youth Hostel. Follow the dirt trail from the stop G sign post out to a line of three red pyramid-topped posts. The three posts mark a known location of the San Andreas Fault.

An exploratory trench was dug in this location by the U.S. Geological Survey to characterize the past earthquake activity of the San Andreas Fault. Sag pond areas along earthquake faults often preserve layered sediments containing organic materials that can be dated using radiocarbon dating methods. If these layers of offset by fault rupture, then the relative age of past earthquake events might be determined. The difference between a “fault” and an “earthquake fault” is that the latter shows evidence of fault movement during the Holocene (the current geologic epoch that began roughly 11,500 years ago following the last ice age of the Pleistocene Epoch). Not all faults are active, including some of the faults in and around the San Andreas Fault System.



**Figure 6-9.** The trace of the San Andreas Fault runs through an abandoned field near Walden West. In the past, the field was a sag pond that was drained and used as an orchard. In the more distant past, Todd Creek used to drain across this area before stream capture occurred and altered the stream's path to its modern drainage to the north of the field. The headwater valley of Todd Creek can be seen in the top of this image.

**Stop H** is located farther down the trail at an intersection with another trail connecting the playing fields at Walden West to a pond surrounded by a redwood forest. Note the drop from the field to the creek below. Although this area has been heavily modified over the years, it still reflects the character of the natural sag pond that existed here in the past. The trace of the San Andreas Fault runs through this pond area. The Stop H area provides a reasonable view to the north across the valley of Saratoga Creek and northwest along the trend of the San Andreas Rift Valley toward Table Mountain and the more distant grass-covered peak of Black Mountain located within the Monte Bello Open Space Preserve. Note the abundance of chaparral growing on the south facing slopes of Table Mountain.

Continue along the trail around the pond and turn right on the paved road toward the American Youth Hostel. Examine stone walls along the trail for evidence of fault damage (none was obvious at the time this report was written).

The American Youth Hostel is a log-style house with a large hexagonal central room that was originally named "Welch-Hurst House" and was built in 1908 as a summer home for the Honorable Judge James Welch and his family. In 1955 Welch Hurst and surrounding lands were sold to Mr. Vernon Pick. When the house and land was sold to the county, renovation costs were considered too high and the house was slated for demolition. However, the Santa Clara Valley hostelling club saved and renovated the building through a grassroots collective effort beginning in 1979. The Sanborn Park Hostel is now listed on the National Registry of Historic Places ([http:// www.sanbornparkhostel.org/about.html](http://www.sanbornparkhostel.org/about.html)).

A large fairy ring of redwood trees is the location for a picnic ground in front of Welch-Hurst House. The building is made of native sandstone from the Vaqueros and San Lorenzo formations. Note the large round concretions used as monument caps near the front door of the house. Concretions are abundant in the San Lorenzo Formation. Also note the

large Indian mortar hole carved in the large sandstone slab incorporated into the front right side of the path leading to the front of the house. Other mortar holes used for grinding acorns and other food products by Native Americans can be seen in several large boulders along a short trail behind the hostel building.

Continue around the left (west) side of the Hostel building. Follow the stairs or path down to the low flat area next to the building that is currently used as a volleyball court. Note that the Hostel building is built on a low straight ridge covered with blocky alluvium. The building is situated on an old terrace of Todd Creek just west of the trace of the fault. The low flat area occupied by the volleyball court probably represents a stream meander in Todd Creek after being captured in its current drainage configuration, but well before the incision of the modern gorge.

Continue west across the flat area and follow the old road downhill.

**Stop I** is located at a bridge over Todd Creek. Todd Creek has a steep drainage profile relative to Sanborn Creek. The creek is rapidly carving downward into the older alluvial fan deposits that once filled this portion of the San Andreas Rift Valley to a relatively higher level than exists today. Note the size of the large boulders in the creek and exposed in the steep hillsides along the creek and the road. These blocks are not bedrock, but rather, are materials that moved down the slope by mass movement in the past (landslides, rockfalls, debris flows, creep, etc.).

Continue west along the trail for a couple hundred meters to the next stop.

**Stop J** is located near a precipitous drop off where a landslide has taken away part of the old road. The poorly consolidated sediments of the alluvial fan are prone to landslides in areas of steep stream incision. Use caution when approaching the escarpment! To get a better (and safer) look, continue along the rerouted trail through the local grove of redwoods. From the trail above the slump escarpment it is possible to see the layered beds of alluvial sediments. Note the tree roots exposed in the surface soil profile. The lack of trees in the landslide area reflects that much of this hillside fell away in a massive landslide event that happened during the particularly wet winter of 1995. Also note that very little sediment remains in the toe area of the landslide. Much of the landslide material probably moved downstream in the form of a debris flow. Numerous other slumps and landslides occur throughout the hills in this vicinity.

Return along the old road (trail) to the intersection with the paved road. Bear to the right, and then bear to the left past the gate onto the route of the San Andreas Trail. Follow this trail back to the vicinity of the Park Maintenance Building near Stop 8 on the Sanborn Nature Trail.

Along the San Andreas Trail look for landscape features that might display evidence of faulting and stream offset. The San Andreas Fault Zone is complex, in many places it is represented by multiple parallel and interconnecting faults. The landscape features, including linear scarps and the sag ponds, suggest that there may be several active faults within the vicinity. Erosional processes are having a difficult time keeping pace with the offset along the faults in this area. Note that although the landscape has been heavily modified by recent human activity, it still basically reflects the geomorphic profile of an alluvial fan, similar to the area near the RV campground area. It is likely that these flat areas were once aligned, but have since been offset by movement along the fault.

### **Sanborn Nature Trail (continued)**

**Stop 9** in the Sanborn Nature Trail guide discusses how the leaves, flowers, and fruit of the California buckeye are poisonous to humans and animals. However, buckeye nuts were prepared as food by the Ohlone Indians when acorn supplies were low. Buckeye nuts are rich in starch, but are not suitable for food because they contain a poisonous glucoside, aesculin, which can cause severe gastroenteritis, depression, hyperexcitability, dilated pupils, and coma. The Native Americans roasted the nuts among hot stones, peeled and mashed them, and leached them with water for several days. This treatment apparently removed the toxic aesculin. Buckeyes can be particularly hazardous to pets (particularly dogs that chew sticks).

Stop 9 also is near what appears to be a man-made cut through the shutter ridge along the San Andreas Fault.



**Stop 10** provides an opportunity to examine the curved trunks of trees along the offset stream drainage. Whether these trees are readjusting back to a vertical direction because of fault motion is unclear. However, it is more likely that the trees are adjusting to the slow creep of surface materials down the slope into the creek bed.

**Stop 11** in the Sanborn Nature Trail guide examines a Pacific madrone tree. Madrone trees have a multitude of uses. The fruit (berries) are an important food source for many species of mammals and birds. The Ohlone Indians ate the berries both raw and cooked. Early European-descent settlers preferred to use charcoal derived from madrone wood in the manufacture of gunpowder. Both Indians and early settlers used madrone tea brewed from its bark, leaves, and roots as relief for stomachaches and treatment for colds, and was used topically as an astringent (useful against inflammation and to stop bleeding). Today, madrone is primarily used as an evergreen ornamental plant. Its hard wood resembles black cherry and is used as furniture paneling, flooring, tobacco pipes, and other novelties, in addition to fuel wood.

**Stop 12** is a pile of large boulders along the Sanborn Nature Trail that displays tafoni-style weathering. Tafoni forms on rocks exposed at the surface for long periods of time (as these boulders resting on an old surface of the alluvial fan). When precipitation soaks into porous sandstone, some of the mineral cement dissolves. As the rock dries out, capillary action brings moisture along with dissolved minerals to the surface. As the water evaporates, the minerals precipitate. In this manner, the rocks actually break down from the inside out as this weathering process removes the mineral cement below the surface. The wind and weather help to sculpt away the softer rock, leaving the more resistant, tightly cemented-surface rock behind. Tafoni-style weathering is responsible for the unusual character of the massive Vaqueros Sandstone outcrops in Castle Rock State Park on the ridge west and above Sanborn County Park and along Skyline Boulevard.

**Stop 13** in the Sanborn Nature Trail guide describes the dusky-footed woodrat, a common pack rat in woodland and chaparral habitats throughout California. Woodrats gather litter from the forest floor to build small lean-to style middens, typically under brush or in the pockets of tree stumps. Woodrats will gather whatever catches it eye, including garbage, and incorporate them into their middens.

This is the end of the hike route. Continue on the trail to return to the Park Office area.

Special thanks to **James S. Moore** (Eagle Scout, Boy Scouts of America, Skyline Council, Troop 5, Palo Alto, CA); to **Tom Borra** (Sanborn Park ranger, County of Santa Clara, Environmental Resources Agency, Los Gatos, CA), and to **Carol Prentice** (U.S. Geological Survey, Earthquake Hazards Team).

### **Selected References and Resources**

Alden, P. and Heath, F., 1998, *National Audubon Society Field Guide to California*: NY: Chanticleer Press., 477 p.

Brabb, E.E., Graymer, R.W., and Jones, D.L., 2000, Geologic Map and Map Database of the Palo Alto 30' x 60' Quadrangle, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-2332 (available on-line at: <http://pubs.usgs.gov/mf/2000/mf-2332/>).

Brown, R.D., Jr., 1990, Quaternary Deformation: In *The San Andreas Fault System, California*: Wallace, R.E., ed., U.S. Geological Survey Professional Paper 1515, p. 83-113.

Burgmann, R., Arrowsmith, R., Dumitru, T., and McLaughlin R., 1994, Rise and fall of the southern Santa Cruz Mountains, California, from fission tracts, geomorphology, and geodesy: *Journal of Geophysical Research*, v. 99, no. B10, p. 20,181-20,202.

Dickinson, W.R, Tectonic implications of Cenozoic volcanism in coastal California: *Geological Society of America Bulletin*, v. 109, no. 8, p. 936-954.

Elder, W., 2001, Geology of the Golden Gate Headlands: Field Trip 3: In *Geology and Natural History of the San Francisco Bay Area, A Field-Trip Guidebook*: Stoffer, P.W. and Gordon, L.C. eds., U.S. Geological Survey, Bulletin 2188, p. 61-86, (on-line at: <http://geopubs.wr.usgs.gov/bulletin/b2188/>).

- Gilbert, G.K., Humphrey, R.L., Sewell, J.S., and Soul J. F., 1907, The San Francisco Earthquake and Fire of April 18, 1906 and their effects on structures and structural materials: U.S. Geological Survey Bulletin 324, 170 p.
- Graymer, R.W., Warno-Wojcicki, A.M., Walker, J.P., McLaughlin, R.J., and Fleck, R.J., 2002, Controls on timing and amount of right-lateral offset on the East Bay fault system, San Francisco Bay region, California: *Geological Society of America Bulletin*, v. 114, no. 12, p. 1471-1479.
- Lawson, A.C., chairman, 1908, The California Earthquake of April 18, 1906: Report of the State Earthquake Investigation Commission: Carnegie Institution of Washington Publication 87, 2 vols.
- McLaughlin, R.J., Langenheim, V.E., Schmidt, K.M., Jachens, R.C., Stanley, R.G., Jayko, A.S., McDougall, K.A., Tinsley, J.C., and Valin, Z.C., 1999, Neogene contraction between the San Andreas Fault and the Santa Clara Valley, San Francisco Bay region, California: *International Geology Review*, v. 41, p. 1-30.
- McLaughlin, R.J., Clark, J.C., Brabb, E.E., Helley, E.J., and Colón, C.J., 2002, Geologic Maps and Structure Sections of the Southwestern Santa Clara Valley and Southern Santa Cruz Mountains, Santa Clara and Santa Cruz Counties, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-2373 (10 digital maps and cross sections plus report data are on-line at: <http://geopubs.wr.usgs.gov/map-mf/mf2373/>).
- Page, R.A., Stauffer, P.H., Hendley II, J.W., Donlin, C., Boore, S., Mayfield, S., and Diggles, M.F., 1989, Progress toward a safer future since the 1989 Loma Prieta Earthquake: U.S. Geological Survey Fact Sheet 151-99, on-line at: <http://geopubs.wr.usgs.gov/fact-sheet/fs151-99/>.
- Prentice, C.S. and Schwartz, D.P., 1991, Re-evaluation of 1906 surface faulting, geomorphic expression, and seismic hazard along the San Andreas Fault in the southern Santa Cruz Mountains: *Bulletin of the Seismological Society of America*, v. 81, no. 5, p. 1424-1479.
- Selby, M. J., 1993, *Hillslope Materials and Processes*: Oxford Univ. Press, 466 p.
- Stoffer, P.W., 2002, *Rocks and Geology of the San Francisco Bay Region*: U.S. Geological Survey Bulletin 2195, 58 p.; available on-line at <http://geopubs.wr.usgs.gov/bulletin/b2195/>.
- Wallace, Robert E., 1990, *The San Andreas Fault System, California*: U.S. Geological Survey Professional Paper 1515, 283 p.