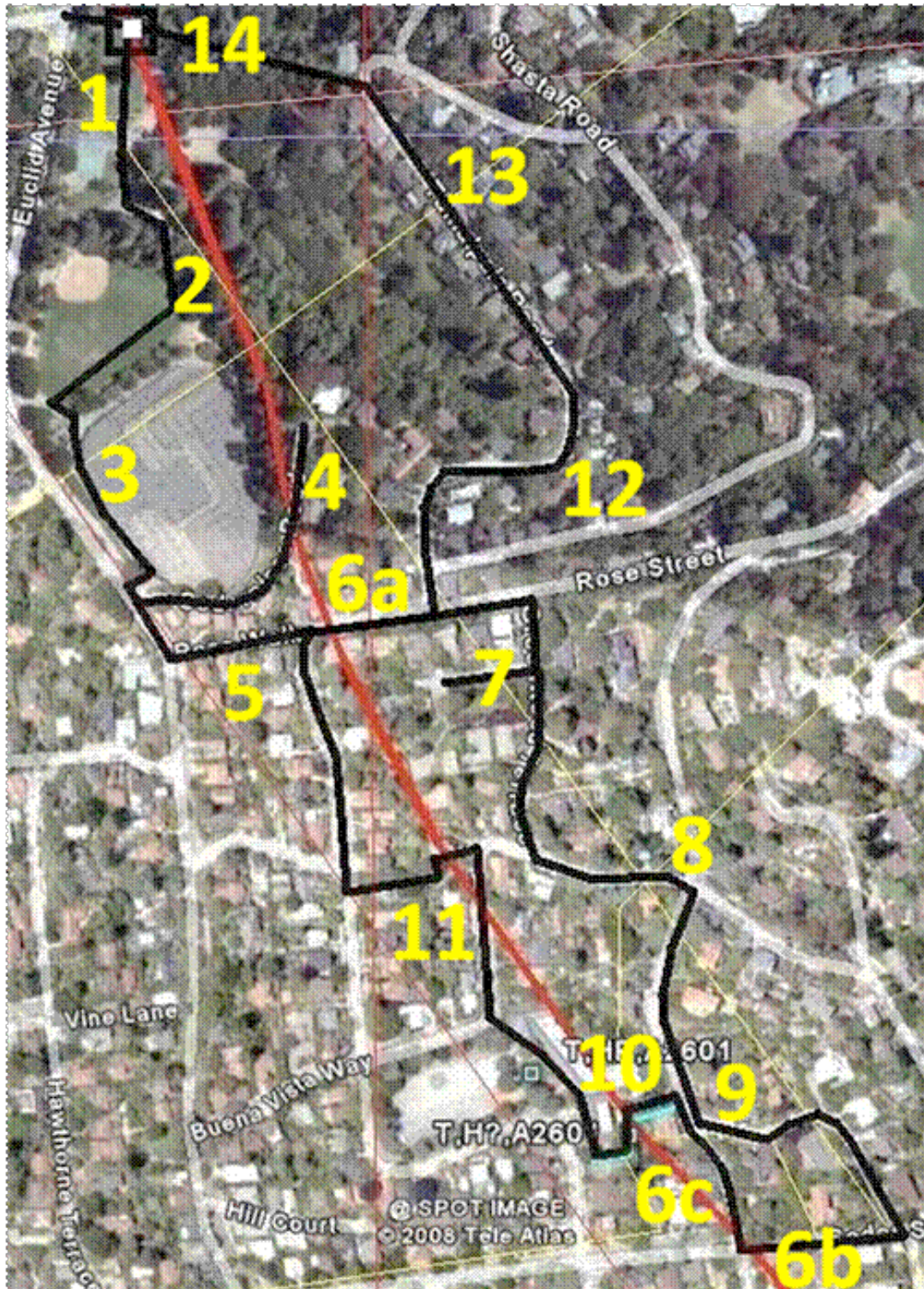


Berkeley Path Wanderers Association

# Hayward Fault Walk

Lead by Andy Datlen and Barbara West, September 6, 2008

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## Hayward Fault (1 on the map)

The Hayward Fault has two main parts, characterized by its behavior. The southern half, stretching roughly from Memorial Stadium south to where the fault starts just north of San José, is the moving half. It last moved in a huge jolt **140 years ago**, with the Bay Block sliding northwest about six feet in less than a minute on October 21, 1868. It has been sliding slowly since then, and you can see the evidence in the walls of **Memorial Stadium**, and many other places south through Oakland, San Leandro, Hayward, and Newark.

The southern half of the Hayward Fault has ruptured on average every 140 years for the past five earthquakes, according to trenching studies in which a big trench is dug about 12 feet deep across the fault, and samples of soil, rock, carbon, pollen, vegetation, and other evidence are taken and scientifically analyzed. This science is known as *paleoseismology*.

The northern half of the Hayward Fault, however, which is where we are standing, north to San Pablo Bay, **has not ruptured for more than 250 to 400 years**. It is jammed up solid. Meanwhile, the Pacific Plate has been moving northwest, deep underground, at a rate of a few millimeters a year.

I believe that, any day now, we are due for a massive **surface rupture earthquake** on the northern part of the Hayward Fault. That is why, on this walk, we will take every possible opportunity to stand and talk right on top of the fault, where it will probably rupture. We've got to do something to try to make it exciting.

From where we are standing, the fault runs somewhere along that bank behind the playground, and runs north under those houses by Codornices Creek, crosses Euclid, and continues north through Berkeley.

This walk is as much about the hazards of urban wildfires as much as it is of earthquakes because of what has happened so far this year in California, and the fact that wildfires will certainly be a consequence of the next earthquake on this fault.

## Plate Tectonics (2 on the map)

The surface of the earth, the *lithosphere*, is composed of a number of plates sliding around on the *asthenosphere*, which is the top layer of the molten *mantle*. Convection currents in the mantle cause the plates to slide around and slowly bash into each other, like the scum on a slowly simmering pot of soup.

Between any two tectonic plates, three main types of movement occur:

- **diverging or spreading**, which is occurring in the middle of the Atlantic Ocean
- **converging or colliding**, occurring in north India and forming the Himalayas
- **transform or strike-slip movement**, occurring right here now, under our feet as we speak

Two main plates lie here in California:

- **The Pacific Plate** is slowly twisting in a northwest direction.
- **The North American Plate** is moving in a southeast direction.

The boundary between the Pacific Plate and the North American Plate is considered to be the San Andreas fault, although it is much more complicated than that. The movement of the Pacific Plate is so powerful that it is **dragging chunks of the North American plate along with it as it goes**, and as we stand here, like it or not, we are going along for the ride.

The Hayward Fault is the first big crack in the Earth east of the San Andreas Fault. The Calaveras/West Napa Fault lies east of it, and farther east lies the Concord Greenville fault. The moving piece of crust west of the San Andreas Fault is known as the Salinian Block, **the piece between the San Andreas and where we are standing now is known as the Bay Block, and the area to the east is known as the East Bay Block.** [*Ask a couple of people to stand on either side.*]

When the Hayward Fault next ruptures, which it will very soon (more about that later), it will be a case of **the Bay Block suddenly slipping a few feet northwest against the East Bay Block**, and if it results in a surface rupture, which is highly likely, it will be right under our feet, which is why I chose this location as the start of our walk. I am sure the City of Berkeley did not knowingly choose to build the Tots Playground, and these picnic areas, right on top of the Hayward Fault.

The movement on the Bay area faults is known as *right lateral strike slip*, which means that no matter which side of the fault you stand on, the land on the other side of the fault is moving to the right. Thus, when you stand on the Salinian Block west of the San Andreas fault, Berkeley is moving to the right; whereas when you stand on the East Bay Block east of the Hayward Fault, **Berkeley is still moving to the right.**

This must be very disconcerting to the people who live in Berkeley, but you can be consoled by the fact that, if you think about the direction of movement of the block you are standing on, **you are moving to the left**, whether you are on the Bay Block looking east or on the East Bay Block looking west!

In fact, I am so sure of this that I will give this crisp, new twenty-dollar bill to the first person who spots a “John McCain for President” sign in somebody’s yard or window. Bumper stickers don’t count; it could be a tourist from Idaho.

If you really want to enjoy the rocking and rolling that will occur when the next earthquake strikes this part of the Hayward Fault, that picnic table right there will be a good place to sit. Make sure to bring a bottle or two of wine, and make sure it is well corked when you are not pouring it.

## **Berryman Reservoir** (3 on the map)

Berryman Reservoir was built as an earthen dam in the 1880s by Berkeley’s then-postmaster Napoleon Byrne, and it **first came into service in 1886**. This, of course, was long before East Bay Municipal Utilities District (EBMUD) came to exist. Like most *finished-water* reservoirs at the time, and well into the 1960s, it was open to the air. When it was built, **nobody had any idea that a very dangerous fault lay beneath it.** As I said before, the 1868 earthquake left no evidence on this northern half of the fault. Indeed, the natural topography made it seem like a good place to make a lake.

By *finished water*, I mean *absolutely ready to drink*, unlike the *raw water* in reservoirs like San Pablo, which is not fit to drink without treatment because of contamination from natural sources. After processing at the Water Treatment, or Filter, plants (like the one in Orinda), water is now stored in enclosed tanks—unlike back then, when it was stored in open lakes. All the former open reservoirs, like this one, Summit, Piedmont, and Central, were enclosed with wooden roofs covered with tar and gravel in the 1960s and 1970s.

This reservoir used to hold **15 million gallons** up until 2006, but studies during the 1990s showed that an earthquake on the Hayward Fault could rupture the earthen dam at the front and allow the water to flood everything below us, down as far as the waterfront. The approximate center of the fault zone is located just behind the reservoir, along the bank to the east, and it runs right underneath the house on the west side of Codornices Road.

This was a serious problem because most of downtown Berkeley was dependent on the water in this reservoir. Accordingly, a new pumping plant was built, and pipes were rerouted to Summit Reservoir (higher in the Berkeley Hills on the Kensington border), now the source of drinking water for the customers that Berryman used to serve, and **Berryman was drained in 2006**, after 120 years of service.

Note that **it took more than fifteen years, once the danger of the Hayward Fault to this reservoir was realized, to remove this threat to the City of Berkeley.** Nevertheless, depending on how strong the earthquake is, Summit Reservoir itself remains a danger in the same way because it is also a basin of water held behind an earthen dam, and it is even bigger at about 45 million gallons.

Plans are now underway to build a **new enclosed tank** at the Berryman Reservoir to serve downtown Berkeley and reduce the current dependence on Summit. This work is likely to start next year (2009), and will take at least until 2012.

## **Fault Location and Width** (4 on the map)

Maps of the Hayward Fault, including the Google Earth Helicopter Tour of the Hayward Fault, show the fault as a precise line on the surface of the earth. Nevertheless, that line should be interpreted as **a fault zone of about 100 to 200 feet in width.**

There are several reasons for this leeway. One is that the **evidence** of the surface ruptures over the past few thousand years, where they can be seen clearly, **is 50 to 100 feet wide.**

Because of **extensive urbanization**—that is, the construction of buildings and roads—as well as **landscaping**, most evidence of past surface ruptures has been wiped out; and, surprisingly, one of the best sources of geomorphological evidence of the fault is a set of aerial photographs taken in 1939, when buildings were fewer and vegetation less dense.

Another reason is the inaccuracies in the maps used to compile the fault location. Depending on the scale of the map, **any point could be up to 100 feet off from its true location.**

So, if you take both of these sources of error into account, you are looking at 100 to 200 feet of possible error. So, for example, if I tell you that right now you are standing on the fault, and this is where the surface rupture will occur in the next earthquake, don't be disappointed if it actually happens under those houses to our east.

However, each time we stop to look at the evidence of the fault, or the lack of it, I try to place you all as accurately as possible right on top of where the fault is most likely to rip open. I don't want you to be disappointed.

The location of the fault was **kept in the dark for many years** because of pressure from special interests like the local real estate companies. When I moved here in 1986 and sought to buy a house, I happened to see a map on the back-room wall of a local realty office. The fault had been clearly marked with a felt pen—and I was told to leave the room.

The State Law known as the **Alquist-Priolo Act of 1972** mandated that the California Geological Survey map all earthquake faults in California, and that property owners and real estate agents disclose whether buildings are within a fault zone. New construction within these zones is prohibited, unless a geologic investigation shows that the fault is not a hazard at a particular location.

However, **it took another twenty years before all of the faults in California** were fully mapped, and it wasn't until the late 1980s and 1990s that prospective buyers could obtain full knowledge as to whether a property lay in an active fault zone.

## **Rose Walk** (5 on the map)

Rose Walk (or the Rose Street Steps), running between Euclid and Le Roy Avenues, was **designed by Bernard Maybeck and built in 1913** to link the streetcar line that ended at the Berryman Reservoir (at the time, an open lake) with the houses on Le Roy Avenue and above in the hills.

Almost all of the surrounding houses were **burned in the 1923 Berkeley Hills Fire**, and the houses you see here were designed by Henry Guttensen and built between 1924 and 1936. Notice that, with their tile roofs, they are a little more protected against fire than were the wood-shingle houses lost in the 1923 firestorm.

However, **they were not built to be earthquake-proof**, because no earthquake building standards existed at the time—indeed, it was not even generally known that an earthquake fault lay right here, at the top of the steps.

As we walk to the top of the steps, notice that a section is **twisting in a northwest direction**, which is the same direction as the movement of the Pacific Plate. Whether that is a direct result of fault movement, I do not know. You can see that the house on the left has just undergone extensive earthquake retrofitting.

According to the Alquist-Priolo Act, any significant renovations or remodeling to houses in the fault zone **must be done to standards that make them earthquake-survivable**. That, of course, was at the root of the furor over the new sports complex at Memorial Stadium.

## **Underground Utilities** (6 on the map)

You can see in a number of places on this walk along the Hayward Fault that a concerted effort has been made by PG&E, Comcast, and AT&T (or whatever they were named at the time) to put the **electrical, telephone, and cable lines underground**, with the junction boxes in concrete chambers and the wires running through metal or plastic conduit.

Typically, in older urban areas like Berkeley, lines carrying electricity, telephone, and cable (which includes television and the Internet) run along poles; and natural gas, water, and sewer run underground in pipes.

For example, at the top of Rose Walk (at 6a on the map), you can see that the **lines for electricity, telephone, and cable descend underground** at the pole near the corner of Tamalpais Road and Rose Street, and they remain underground along the entire Rose Walk complex and then along Le Roy Avenue. It is questionable whether this undergrounding will be of much value in an earthquake; if an earthquake were to cause a surface rupture here, the utilities underground are far too shallow to be protected.

In the 1989 Loma Prieta Earthquake, when I was working at EBMUD, we had more than **400 burst water mains within the first few hours**; and there is no reason to believe that anything else placed in pipes would fare much better. In a firestorm, underground utilities would be protected, of course, but would prove useless because the overhead wires that supply them would be burned to the ground. Exactly that happened during the 1991 Oakland Hills Fire. **We lost electricity to the pumping plants**, and the firefighters ran out of water because we could not fill the tanks.

The same thing will happen after the earthquake because the fires started by broken gas lines and other causes will burn the poles and overhead electrical wires.

Today, almost every home in Berkeley, and especially in these more affluent areas, is dependent on high-speed Internet, supplied by either Comcast (cable) or AT&T (DSL). In an earthquake or a firestorm, **everybody will likely lose that service for days or maybe even weeks**. In the 1991 Oakland Hills Fire and the 1989 Loma Prieta Earthquake, that couldn't have been a problem because e-mail and the Internet had not yet been invented.

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On Cedar Path (at 6b on the map), you can see that the overhead wires are entwined in a tangle of leaning trees and branches, with this thick telephone cable above us being stretched to its limit by a leaning tree. **This is a main line carrying high-voltage electricity wires on the top of the poles, then lower-voltage wires for the local houses, then the television and Internet cables, and finally the telephone wires in the fourth tier.** The vegetation all around us is as dry as tinder, and a firestorm would destroy all of these overhead utilities, and all the customers in the Berkeley Hills above us would lose their electricity, telephone, television, and Internet, probably for many weeks.

One reason all of these trees are leaning is that this is a landslide area, as well as being where the Hayward Fault would rupture in the earthquake. Couple that fact with all this dry, fire-prone vegetation, and you can see that this is an extremely vulnerable area. The bumpy ground from here down to La Loma Avenue is **evidence of fault ruptures** which have occurred time and again over the past ten- to twenty-thousand years.

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On La Loma Avenue (at 6c on the map), you can see covered concrete chambers which provide access to the cable, television, and electrical switches and circuitry. Notice that, in just the few years since they were installed, already they are cracked and broken. This is because we are standing on top of the fault right here, and it is nearly **impossible to build anything strong enough to withstand the slow movement of an earthquake fault.**

## Greenwood Common (7 on the map)

The Berkeley Landmarks Preservation Committee has designated Greenwood Common a landmark. Greenwood Common was conceived by William Wurster, former Dean of the College of Environmental Design at the University; the homes were designed by a group of prominent California architects; and the landscape plan was created by the internationally renowned landscape architect **Lawrence Halprin**.

The house on the north, second from the street, with three bedrooms and one and a half baths, just sold for slightly over a million dollars (in 2008). The eight homes around Greenwood Common were each designed by a different architect. Notice how, unlike the rest of the Berkeley Hills, the common garden was designed to be free of the dense, flammable vegetation that will cause a disaster in the coming firestorm.

However, surviving in the Berkeley Hills is **as much dependent on how your neighbors maintain their land as the way you do**, and unfortunately those neighbors to the west, where the fault is located, have let their properties become overgrown with flammable vegetation.

Greenwood Common, especially if it were re-landscaped with more drought-tolerant plants, is an example of how homes in the Berkeley Hills could be fireproofed and could even prevent a firestorm from taking hold. Recent California fires have shown that maintaining a defensible space around houses allows them to be saved.

During the fires last year in San Diego, I heard a fire chief openly say on broadcast news that, if you have cleared a defensible space around your house, they will defend it; but if you haven't, they will let it burn. Take a look to the east, for example, and note the difference.

## Berkeley Hills Fire of 1923 (8 on the map)

This house, at the southwest corner of Buena Vista Way and La Loma Avenue, is typical of many in the Berkeley Hills and is extremely vulnerable to being lost in a firestorm due to being **surrounded by and having its roof covered with dense flammable vegetation**.

The Hayward Fault runs about 200 feet south of here, right under the area at the corner of Buena Vista Way and La Loma Steps, which we will be visiting later on in this tour.

The last time this area burned was in 1923, when a **massive firestorm consumed about 600 homes within the space of a few hours**. Only about 50 of the wood-shingle homes built around the turn of the century or in the early 1900s survived. All the homes we are walking by today were built after that firestorm.

The Berkeley Fire Department was overwhelmed, and **some fire hydrants ran out of water**. Berkeley students and faculty saved the University from the flames, but about 25% of them were left without homes. The City of San Francisco sent fire equipment across the Bay by ferry, and it helped fight the fire for a few hours. Fortunately, the Santa Ana, or Diablo, winds that fanned the flames died down, and the firefighters were able to stop the fire.

One of the significant contributors to home fires in an earthquake is **gas pipes pulling apart underneath the house due to twisting of the supports and beams to which the pipes are attached**. Fortunately there is a very simple solution, and that is the installation of an emergency seismic gas shutoff valve. Such a valve is designed to stop the flow of gas at about magnitude 5.0 on the Richter scale.

However, most people have not heard that such a valve is available, much less have had one installed on their incoming gas supply. If you look through those bushes at the side of that house, you will see the incoming gas shut-off valve on the right. It is not an emergency shut-off valve. Although this house appears to be unoccupied, that valve has been left in an open position, meaning that pilot lights are probably still burning.

**It costs a mere \$450 to have an emergency gas shut-off valve installed—\$300 for the valve, and \$150 for the labor.** I had one put on my gas line about 18 months ago, and every time we have one of those small shakers at night, I go right back to sleep, knowing that at least a broken gas line will not be the cause of the loss of my house after an earthquake.

As we round the corner, look east up Buena Vista Way. All the trees you see, with their dense flammable crowns going up the hillside, form what the Fire Departments call a **fire ladder**. I watched the 1991 Oakland Hills firestorm from the roof of my house and saw it jump from tree to tree, about one a minute, all the way up to the top of the hill.

## **Hazardous Construction** (9 on the map)

When the 1989 Loma Prieta earthquake occurred, I was working at the EBMUD head office in West Oakland. Fortunately, I had already reached my home in El Sobrante, a modern, well earthquake-proofed structure: **a wood frame house well tied together, bolted to a reinforced concrete slab.**

I watched, mesmerized, as the house rocked back and forth and twisted with the earthquake waves as they rolled across the landscape like a wind blowing across a cornfield. Although my house suffered no damage, as I traveled to work the next morning, I passed several houses that had not been bolted to their foundations, or had unreinforced foundations, or had crawl spaces without shear-wall reinforcing. **Those houses had literally jumped off their foundations and landed on the ground alongside.** All had to be demolished.

As well, about one chimney in four had collapsed, with the bricks often falling through the roof and into the house. Fortunately nobody was hurt, as far as I know, by falling chimneys. A year later when I moved to South Berkeley, I saw that two chimneys on my block had collapsed in that earthquake and were being demolished and rebuilt.

The house you see on the opposite side of the street, at the southeast corner of Laverada Road and La Loma Avenue, is a classic example of a disaster waiting to happen in the next earthquake on the Hayward Fault. Located about 150 feet from the fault, the house has a huge unreinforced brick chimney which is already starting to lean, and it has an old, dried-out, wood-shingle roof. Judging by its vintage, probably 1930s or 1940s, I would bet that it is neither bolted to the foundation nor reinforced with shear walls.

This house is typical of so many in the Berkeley Hills, built on or close to the fault, **before modern seismic standards were put in place.** Often they are jammed close together, surrounded by dense dry vegetation, and located on a steep hillside. For an example, look up the hillside above you.

## Hillside Elementary School (10 on the map)

The first Hillside Elementary School was a **small wood-shingle building located on the southwest corner of Le Roy Avenue and Virginia Street**, and it burned down in the 1923 Berkeley Hills Fire. This building we see here was designed by Walter H. Ratcliff in 1925, and for 58 years children unwittingly sat inside in classrooms located smack on top of the most dangerous fault in North America.

The recent earthquake in Sichuan, China (May 12, 2008), where dozens of unreinforced masonry buildings collapsed, killing thousands of children as they sat in their classes, is a reminder of what could have happened here.

Where we are standing, at the rear of this school, is located right on top of the fault. As you descend into the backyard of the school, look back to see how the steps are being twisted in a northwest direction.

Don't dally too long here. If the earthquake happens, you are trapped! The steps you just came down will crumble, and the building in front of you will collapse. Also, because this is a **landslide area**, a massive landslide is likely, especially if the ground is wet during the winter.

In the school backyard is a cut (now filled with concrete) where a 12-foot trench was dug to study the fault, to comply with the **Alquist-Priolo Earthquake Fault Zoning Act of 1972**. Based on its findings, the school was quickly closed and abandoned in 1983.

As we walk south around the school and view its west front façade, we can see why its architecture made it a **designated National Historic Landmark**. On the north end, Hillside's auditorium boasts a wood-beam ceiling, wood floors, and a view of San Francisco Bay. It was listed as a Berkeley landmark in 1980 and placed on the National Register two years later.

What to do with it now is a real dilemma because seismically retrofitting such an old structure to the standards needed to withstand a surface rupture, when it is sitting partly on the fault itself, would cost many millions of dollars.

## Why Did They Build Right On The Fault? (11 on the map)

In the early 1900s, houses were built in a style featuring **wood-shingle siding and roofs**, to blend with the vegetation, and laid out in winding streets following the hills topography. Close to 650 houses were built like this in the Berkeley Hills between the late 1800s and 1923. As we have already learned, the 1923 Berkeley Hills Fire destroyed all but about 20 of these homes.

After 1923, rebuilding the burned houses was a booming business, just like after the 1991 Oakland Hills Fire, with many houses (but by no means all) rebuilt with tiled roofs and stucco walls to make them less vulnerable to fire.

But nobody thought about the possibility of an earthquake, and even if they did, **building codes designed to help buildings withstand an earthquake hadn't been developed back then**.

They just didn't know. Nobody did!

Although a scientist named Alfred Wegener first thought of the possibility of **moving plates of the Earth's crust in 1912**, nobody believed him. The idea was too outlandish. Eventually in the 1960s, a Canadian geologist named Tuzo Wilson and others finally proved beyond a shadow of a doubt that **the Earth's surface is composed of moving plates**, bashing into and sliding under and past each other.

It wasn't until the 1980s that this fault, right here—the Hayward Fault—was mapped with a high degree of accuracy. It wasn't until last year (2007) that a reasonably accurate fault line was published by the United States Geological Survey (USGS) as the Google Earth Helicopter Tour of the Hayward Fault.

Satellite imagery wasn't declassified by the military until the 1980s, and even basic aerial photography wasn't common until World War II.

The science of paleoseismology was not fully developed until the 1990s, and its necessary scientific adjunct, *geochronology*, was developed over the '40s and '50s.

**Realistically, there was no way to know the existence, least of all the location, of the Hayward Fault here through Berkeley with any degree of certainty until the advances in science and technology of the past twenty years.**

When all of these roads, houses, schools, and the University were built, even the 1906 San Francisco earthquake was beginning to fade in people's minds, and the 1868 Hayward Fault earthquake was a distant memory only a very few held.

The house at 2577 Buena Vista Way, under reconstruction, is so close to the fault line, or possibly even right on it, that its new concrete piers extend 23 feet into the ground in an attempt to make it strong enough to remain standing when the earthquake happens.

## **Defensible Space** (12 on the map)

On May 10, 2008, Governor Arnold Schwarzenegger held a press conference to describe how a fire-hazard audit of his own property in Brentwood revealed serious hazards which made his residence vulnerable to wildfire.

He went on to describe how **state law requires a minimum 30-foot defensible space all around the house—up to a 100-foot defensible space, depending on the land's angle of slope and type of vegetation**. This law, enacted in the wake of the 1991 Oakland Hills Fire, has been well enforced in the City of Oakland. However, in Berkeley, as we can see as we look at that vegetation surrounding those houses on Shasta Road, **nobody at all is following that law, and clearly the Berkeley Fire Department does not appear to be enforcing it.**

In watching recent televised reports of the fires burning in California (in 2008), I have heard Fire Department spokespersons come right out and say that if you have cleared the required defensible space around your house, they will try to defend it, but if you have not, they will let it burn. Obviously, with limited resources, they are only going to save what can be saved.

It's not only vegetation. I have seen piles of dry logs, other flammable material, and even abandoned cars nestled in the brush on some properties here in the Berkeley Hills. Some cities, like in San Diego County where they had fires last year, will contract with private companies to clear your property for you—and then put the bill on your taxes.

On the west side of Tamalpais Road, all the vegetation within 30 feet of these wooden houses lies on city property—because that property *is* the eastern edge of Codornices Park. As we saw at the beginning of this walk, many barbecue pits are nestled within the trees there, and a wayward spark, combined with a dry Diablo wind blowing up this hillside, could create in a few minutes a huge wildfire similar to the 1991 Oakland Hills conflagration, easily overwhelming the Berkeley Fire Department.

Also, in the 1991 fire, **the Fire Department ran out of water at the hydrants after a few hours because the electrical wires running to the pumping plants to feed the reservoirs had been burned, and the tanks stood empty.** *The same thing can happen here in Berkeley.*

## What Made the Berkeley Hills? (13 on the map)

About 145 million years ago, **the predecessor to the Pacific Plate, called the Farallon Plate,** began to collide with the North American Plate, and instead of sliding past it, it dived under it, leaving behind bits and pieces of whatever it had brought on its movement across the Earth. That's why we have such a variety of rocks here in the Bay Area—souvenirs from all over the world, both volcanic and sedimentary.

This process continued until about 30 million years ago when the Farallon Plate was almost entirely consumed beneath the North American Plate. Then **the Pacific Plate arrived, and instead of being subducted, it began to slide past the North American plate, just like it is doing now.** This process of sliding gradually moved northwards and reached the Bay Area about 15 million years ago.

About 3.5 million years ago, the two plates were contacting each other at more of an angle than they are today. **This contact caused pressure from a process known as *transpression*, which slowly forced up the ranges of hills we see here today: the Oakland-Berkeley Hills, Mount Tamalpais, and Mount Diablo.** To illustrate this process, if you were to push on the edge of a carpet while, at the same time, dragging it sideways, you would get ripples in the rug very similar to the parallel ranges of hills we have here in the Bay Area. Cool!

**This all happened a mere two- to one-million years ago, and it is still going on today.** In fact, between the Hayward Fault and the Calaveras/Franklin Fault (next to us to the east) is a thrust fault known as the Pinole/Moraga/Miller Creek Fault, where the land is rising rather than sliding. And, of course, the Diablo Fault under Mount Diablo continues to push that mountain upwards.

However, **much of the pressure of the Pacific Plate against the North American Plate has changed into strike-slip movement,** and the rise of Mount Diablo and the East Bay Hills is much less than it used to be.

So, geologically speaking, the hills in the Bay Area are very young, which of course is why we don't find any dinosaur skeletons here. Although, as I said earlier, individual rocks are much older than that because they were brought here by previous plate tectonic movement and were deposited on the edge of the North American Plate.

## Wrap-up (14 on the map)

Near the bottom of Tamalpais Steps, if you look back up, you can see that the bottom part is twisting to the northwest. That's exactly the direction of the Pacific Plate movement, and it happens to be within about fifty feet of the fault location as shown on the Google Earth satellite imagery.

As we noted at the beginning of this walk, the northern part of the Hayward Fault, where we are standing, has not ruptured for at least 200 years—and possibly not for 400 years. **Yet we know that deep beneath us, the Pacific Plate is slowly moving northwest at a rate of about one- to two-tenths of an inch every year, as measured at Memorial Stadium where the movement can easily be seen.**

We have seen many houses built right on top of the fault location and many more within the fault zone, which is the corridor within which a surface rupture will likely occur. **Most of these houses, like the ones we can see to our north, were built long before modern building codes mandated certain practices to help them withstand the shaking.** I doubt that one in ten of these houses has been retrofitted to bring them up to code. In all of my walks on and around the fault, I have only ever seen one emergency gas shutoff valve installed.

In spite of the 30-foot defensible-space state law, hardly anybody in the Berkeley Hills has conformed to that requirement. Just look at the houses to our north, and remember what we just noted as we walked along Tamalpais Road. That's a recipe for as devastating a wildfire as we had in the Oakland Hills in 1991, and I am surprised that we haven't had a fire here in Berkeley this year in addition to the thousands we have had elsewhere in California (in 2008).

**We have seen how EBMUD was so worried about the danger that it drained Berryman Reservoir over just two years ago (in 2006); how the Berkeley School Board was so worried about the safety of its pupils that it closed the Hillside Elementary School back in 1983, as soon as it discovered that the fault line ran right under the classrooms; and how PG&E and the other utility companies have undergrounded the electricity, cable, and telephone utilities where they physically cross the fault.**

At the beginning of this walk, we promised to give you every possible opportunity to stand right on the fault itself, and that's what we are doing now. Happily, the earthquake on this fault did not occur today, but I am absolutely sure it will happen within the lifetimes of most of us standing here now.

And, by the way, because both parts of Berkeley on each side of the Hayward Fault are still moving to the left, *nobody* has claimed the twenty-dollar bill I offered for spotting a "John McCain for President" sign!