Active Faults of the northern Los Angeles Basin Field Excursion

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(From Yerkes et al., 1965)

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ROUTE OVERVIEW

Our excursion to observe several active fault zones of the northern Los Angeles basin begins at the Natural History Museum of Los Angeles County and then heads to the Baldwin Hills Scenic Overlook in the Baldwin Hills. Here (weather permitting) we will get a general view of the fault zones we will see in greater detail later in the day. Some of our ‘stops’ will actually be ‘roll-by’ stops to observe rather than disembark the vehicle but we will make several stops to stretch the legs, use restroom facilities, and have a lunch break.

In subsequent order of stops and roll-bys we will observe traces of the Santa Monica fault at University High School and at the Veterans Administration Medical Center in West Los Angeles. Then we will head east through West Los Angeles, Beverly Hills, West Hollywood, and Hollywood to observe traces of the Hollywood fault zone. Our stop at the Griffith Observatory will (again weather permitting) afford a sweeping view of the Los Angeles basin from the ocean to East Los Angeles and the fault zones we have just seen. We will also point out other features to be seen later. The Observatory has a cafeteria-style lunch area and our stop will be for about an hour total to eat, stretch the legs, shop in the planetarium store, and use the restroom facilities.

Back aboard the bus we will travel through the center of one of the anticlines of the Elysian Park folds on Glendale Blvd. to see steeply dipping strata of the middle Miocene Puente Formation. Traveling east once again we will observe several other fault zones en route to Arcadia and make a roll-by stop on the east side of the Santa Anita Racetrack to see a scarp of the Raymond fault where it is crossed by Colorado Blvd. Our next stop at Lacy Park in San Marino we will observe a trace of the Raymond fault, stretch the legs again, and use restroom facilities if necessary. The final roll-by stop will be at the Evergreen Cemetery in Boyle Heights to observe a portion of the Elysian Park thrust system.

GEOLOGY OVERVIEW

On our excursion we will observe anticlines, synclines, and faults of the northern Los Angeles region (Figure 1). Faults and folds of the area broadly occur as two regional anticline-syncline structures. The northern most fold system consists of the Santa Susana-Sierra Madre fold thrust system (anticline) and the San Fernando Valley (syncline). The southern system includes the Santa Monica-Hollywood-Elysian Park system (anticline) and the Los Angeles basin (syncline). The same compressive forces that have formed these prominent geologic structures have also caused the 1971 Mw 6.6 San Fernando and the 1994 Mw 6.7 Northridge earthquakes. Although our trip does not include the northern San Fernando Valley it is one of the more structurally complex areas in southern California. Other moderate earthquakes have occurred in the eastern edge of the fieldtrip area including the 1987 Mw 6.0 Whittier Narrows, the 1988 Mw 5.0 Pasadena, and 1989 Mw 4.6 Montebello earthquakes.

En route to Stop 1: It is a short 15-20 minute drive west on Exposition Blvd/Rodeo Rd. to Culver City and Stop 1.

STOP 1. Baldwin Hills Scenic Overlook and Nature Center, Culver City

Weather permitting we can observe the Santa Monica Mountains, which are part of the Transverse Ranges, a nearly E-W range that forms an anticline bounded on the south side by the Malibu Coast-Santa Monica and Hollywood fault system. This range extends from Griffith Park to Pt Mugu (~80 km) and continues offshore and re-emerges as the northern Channel Islands (Anacapa, Santa Cruz, Santa Rosa, and San Miguel). The Santa Monica Mountains include Jurassic metamorphic rocks, Cretaceous granitic rocks, and Late Cretaceous to late Miocene sedimentary and volcanic rocks.

En route to Stop 2: A short drive west through Culver City past Sony Studios and north along I-405 to Santa Monica and a circuit around University High School crossing the scarp of the Santa Monica fault.
STOP 2 (roll-by). Santa Monica fault & Veterans Administration Medical Center, Westwood (Figures 2 & 3)

The Santa Monica fault is a ~40 km long oblique left-lateral reverse fault. At the VA the focus has been on a trench study by Dolan et al. (2000) that documented at least six surface ruptures in the past 50,000 years. In particular two paleoearthquakes, one between 15,000 and 17,000 years ago and the most recent 1,000 to 3,000 years ago both possibly $M_w$ 7+. The Red Cross and VA buildings sit on top of small hill with a south-facing slope, which marks the trace of the Santa Monica fault. The most recent earthquakes on the Santa Monica and Hollywood faults do not overlap in age and appear to be separate events.

En route to Stop 3: Driving northeast on Santa Monica Blvd note the scarp expression (Figure 4). It is particularly visible at the LA LDS Temple where it “looms over famous Santa Monica Blvd. in Westwood” and can do this as it is on the up-on-the-north displacement of the Santa Monica fault. Our route crosses the west Beverly Hills lineament (WBHL), which marks an approximate 1.5 km left stepover between the Santa Monica and Hollywood faults. As we cross Beverly Hills and turn on Sunset Blvd. heading east we will be driving along the surface of the Hollywood fault to reach Stop 3.

STOP 3 (roll-by). Hollywood Fault at Runyon Canyon Park, Hollywood (Figure 5)

This is one of the best-studied parts of the Hollywood fault (also an oblique left-lateral reverse fault). Metro rail borings, LA County storm drain trenches, and a paleoseismic study (Dolan et al. 1997) placed the main strand of the fault perpendicular to Fuller Ave. and just south of Hillside Ave. A lack of a scarp is due to recent alluvial fan deposition in the area. Unbroken strata bury and preserve broken strata which indicate two ruptures here, one 7,000 to 9,000 years ago and a previous rupture between 11,000 and 20,000 years ago. Alone the Hollywood fault is likely to generate a $M_w$ 6.6 quake. However, a $M_w$ 7 (or greater) quake could result if the entire Santa Monica-Hollywood-Raymond fault system ruptures at once.

En route to Stop 4: In downtown the Hollywood fault splits into several strands but tends to be parallel to, and just north of Hollywood Blvd. (look to the north up most of the cross streets to view the scarp). At Hollywood Blvd. and Vine St. the famous Capitol Records building can be observed at the foot of the Hollywood fault scarp. As we near the 101 freeway, Cahuenga Pass can be observed where the 101 crosses the Santa Monica Mountains. Cahuenga Pass is a wind gap where the ancestral LA River flowed towards the downtown area. Tectonic uplifts caused the SMM to grow at a rate that exceeded the river’s ability to erode a channel. This caused an abandonment of this channel and an eastward shift to the present LA River course.

East of the 101 we turn north on Western Ave. and then east on Franklin Ave. Older un-reinforced masonry buildings in the area were heavily damaged by the Northridge earthquake. The surface trace of the Hollywood fault is about ¼ mile north of us here. Continuing east on Franklin, the street climbs a gentle slope that is the western slope of one of many, young alluvial fans that were deposited across the Hollywood fault prior to 20th century urban development. Approaching Normandie Ave. the road is cut into the south facing fault scarp. Look north as we cross Normandie at the small hill that forms the Hollywood fault scarp.

STOP 4. Griffith Observatory, Griffith Park

On a clear day the view from the observatory can be spectacular. To the west we can observe the southern flank of the Santa Monica Mountains bordered by the Hollywood fault (Stop 3) in the near distance and the Santa Monica fault in the far distance (Stop 2). These two faults end at a left stepover known as the west Beverly Hills lineament (WBHL), which may be the northward extension of the Newport-Ingleswood fault [NI], a right lateral strike slip fault. The NI can be observed, if the view permits, as low hills. These hills occur at compressive stepovers in the fault. On exceptionally clear days the Palos Verdes Hills and Santa Catalina Island can be
observed. The south-dipping dextral-reverse Palos Verdes fault borders the northeast edge of the Palos Verdes Peninsula. To the south and southeast, the hills north of downtown were formed as a result of slip on a series of blind thrust faults. At Stop 7 we will observe the surface expression of these structures. The southern edge of these hills near Montebello was uplifted about 5 cm during the 1987 $M_w$ 6.0 Whittier earthquake which ruptured a small part of the north-dipping Puente Hills blind thrust fault.

En route to Stop 5: We descend from Griffith Park and head east to Riverside Dr. and head south and southeast to the Echo Park area. Heading north along Glendale Blvd. we will observe steeply dipping beds of the middle-late Miocene Puente Formation within folds of the Elysian Park anticline. We then head east on the CA 2 freeway and observe more of the hills associated with the Elysian Park folds to the south and east and the Verdugo and Eagle Rock fault zones to the north. Finally we will be heading east on I-210 we will exit at Baldwin Ave. and head east on Colorado Blvd. to Santa Anita Racetrack.

STOP 5 (roll-by). North side of the Santa Anita Racetrack

Here we can observe the Raymond fault scarp and note where Colorado Blvd. crosses the fault in a gentle slope (Figure 6). Prior to the 1988 Pasadena earthquake it was debated whether motion on the Raymond fault was predominantly lateral (strike slip) or vertical (thrust) as there was geological evidence for both. Data analysis after the event demonstrated that motion was primarily left-lateral and a small component of vertical motion. The last surface rupturing on the Raymond fault occurred 1,000 to 2,000 years ago.

En route to Stop 6: We head south on Colorado Blvd. to Huntington Dr. and proceed west though Arcadia and Temple City to San Marino and Lacy Park.

STOP 6. Raymond fault, Lacy Park, San Marino

The surface trace of the Raymond fault is expressed by a series of low hills that extend along an ENE trend from Raymond Hill in South Pasadena to the LA County Arboretum and Santa Anita Racetrack in Arcadia. At Lacy Park, a sag pond developed at a left stepover in the fault and was produced by left-lateral transtension across the same left stepover in the Raymond fault (Jones et al., 1990).

En route to Stop 7: Drive south from Lacy Park and turn right onto Monterey Rd. and go to Oak Knoll Rd. At the stop at Old Mill Rd. we can observe a scarp of the Raymond Fault with the ritzy Pasadena Langham Hotel atop the scarp. Go back south on Oak Knoll Rd. to Huntington Dr. and turn right then left onto Atlantic Blvd. South of I-10 turn right onto W. Garvey Ave. and then bear right onto Monterey Pass Rd. Monterey Pass Rd. goes through a wind gap in the Elysian Hills (formerly a water gap but abandoned due to uplift of the hills). Turn right onto Cesar Chavez Ave. The views to the north (right) show the south-facing fold escarpment above blind thrusts of the Elysian Park fault system.

STOP 7. Evergreen Cemetery, East Los Angeles (Figure 7)

Discussion of the Elysian Park anticlinorium (a series of anticlines and synclines so arranged structurally that together they form a general arch anticline) named for the Elysian Park Hills to the NW of downtown Los Angeles. These hills are deeply incised by several major LA River drainages, including both Silver and Echo Park lakes (dammed drainages) and Chavez Ravine. The wide floodplain of the LA River north of downtown cuts into the core of the anticline. The river has developed a wide floodplain here rather than a narrow gorge indicating the possibility that the fold is no longer active.

At the cemetery, two ‘fold scarps’ are observed that were developed in latest Pleistocene alluvium. These scarps occur south of the Elysian Park anticline and may represent younger south-propagating splays of the thrust fault system. Topographic profiles and boreholes (Oskin et al., 2000) show that growth strata exist beneath the topographic escarpments of East LA and support the interpretation that folding events, presumably related to earthquakes, punctuate the sediment record here.
Figure 1. Faults of the LA Basin

- 1987 Whittier, M5.9
- 1994 Northridge, M6.7
- 1971 San Fernando, M6.7

Figure 1
Figure 2. Tectonic geomorphologic map of the Santa Monica fault zone and environs based on interpretation of 1926 vintage U.S. Geological Survey 6 ft topographic maps (Sawtelle, Topanga Canyon, and Hollywood quadrangles) and field mapping. Note location of trench site just west of Freeway I-405. B—Brentwood; BH—Beverly Hills; PC—Potrero Canyon; PP—Pacific Palisades; SM—Santa Monica; WLA—west Los Angeles; WW—Westwood.
Figure 3. Detailed map of Veteran’s Administration trench site in west Los Angeles showing major geomorphic features and locations of trenches T-1 and T-2. Location is shown in Figure 2. Numbered lines crossing trenches show locations and strikes of the four largest faults. Locations of creek and scarps adjacent to trench site are from 1927 Fairchild air photo; artificial fill emplaced during construction of Red Cross building has largely obliterated the creek and fill has been added to the upper part of the scarp south of Red Cross building to create a building pad. CPL-2 and CPL-3 denote locations of earlier paleoseismologic trenches excavated by Crook et al. (1983; Crook and Proctor, 1992); short lines show strikes of steeply dipping faults exposed in those trenches.
Figure 4. Map of the Hollywood fault zone, showing surficial geology and major tectonic and sedimentary landforms. Major fault and fold scarps are shown in black. Faults are dotted where inferred beneath recent alluvium. Bedrock geology is from Dibblee (1991a, 1991b). Lines with opposing double arrows are crests of youthful folds on the ground surface. The word Hollywood is centered on the main business district of downtown Hollywood, which extends approximately from La Brea Avenue eastward to Western Avenue and from Santa Monica Boulevard northward to the mountain front. A—bedrock fault in Elysian Park Hills (Lamar, 1970); II—eastern end of the Sunset Strip at intersection of Sunset Boulevard and Havenhurst Drive; H2O—shallow ground water along Hollywood fault (F. Denison, 1991, personal commun.); K—Kings Road—Sunset Boulevard intersection; N—intersection of Normandie and Franklin Avenues; Oil—linear oil and water seeps at Greystone Park (Crook and Proctor, 1992); SM FH—Santa Monica fault; BC—Benedict Canyon; BrC—Brushy Canyon; GP—Greystone Park; LC—Laurel Canyon; NC—Nichols Canyon; WBHL—West Beverly Hills lineament; WeHo—West Hollywood.
Figure 5. Geologic map of young features within our detailed study area west of downtown Hollywood. Runyon Canyon, Vista Street, and Outpost Drive fans are shown in shades of gray. Narrow, dark gray horizontal swath shows location of Hollywood fault inferred from subsurface data. Fault scarps inferred from topography are shown by medium gray shading. No scarps are discernible across the recently active parts of the fans. Thick black north-south lines show locations of trenches and borehole transects discussed in text. Secondary strand of Hollywood fault encountered in Fuller Avenue trench is shown by short black line immediately south of borehole OW-34A. Location of Metropolitan Transit Authority subway tunnel excavated as of July 1995 is shown as a dashed line. Triangular facets in northeast corner of figure show possible northeast-trending fault strand. CP-MT—Camino Palermo–Martel Avenue Transect; HA—Hillside Avenue; NLBT—North La Brea transect; WP—Wattles Park; Q shows location of near-surface (<1 m depth) quartz diorite from Crook and Proctor (1992). Topography redrafted from Burbank and Hollywood 1:24 000 6' USGS quadrangles (∼1926). Contour interval is 1.5 m (5 ft) up to the 500 ft contour, above which the interval is 7.6 m (25 ft).
From Jones et al., 1990
Figure 7. Geologic map of the Elysian Park anticline. The anticlinal axis and major bounding structures are depicted by thick black lines. The thinnest black lines represent trends of secondary folds. East-west–trending, parasitic secondary anticlines in east Los Angeles are numbered 1–4. The Coyote Pass escarpment forms the southern limb of structure 3. Two generations of older alluvium, Qg and Qp, are differentiated at the crest of structure 3, whereas structure 4 is capped by only Qg deposits. Compiled from Bullard and Lettis (1993), Dibblee (1989, 1991), Lamar (1970), Thomas et al. (1961), Quarles (1941), and Soper and Grant (1932).
Cited references and suggested reading


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