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Hayward fault zone, Southern Hayward section (Class A) No. 55b

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Compiled in cooperation with the California Geological Survey

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Synopsis	**General:** Historically active dextral strike-slip fault zone that is part of the larger San Andreas fault system. The Hayward fault zone is located along the eastern margin of San Francisco Bay and generally forms the western front of the East Bay Hills. The fault zone has three sections (Working Group on Northern California Earthquake Probabilities, 1996 #1216; Petersen and others, 1996 #4860). The Northern [55a] and Southern Hayward [55b] sections are principally characterized by historically active dextral strike-slip displacement (Herd, 1977 #5484; 1978 #5485; Smith, 1980 #5497; 1980 #5498; 1981 #5499; Lienkaemper, 1992 #5486). The

Southeast Extension section [55c] is characterized by late Quaternary and Holocene dextral, dextral-reverse, and reverse displacement (Bryant, 1982 #5475). The Hayward fault is characterized by fault creep along the Northern and Southern sections. A preferred average creep rate of 4.6 mm/yr was reported by Lienkaemper and Galehouse (1997 #5488). Most of the fault creeps between 3 mm/yr and 6 mm/yr (Galehouse, 1995 #4853; Lienkaemper and Galehouse, 1997 #5488; 1999 #5500), although the historic creep rate has been as high as 9 mm/yr near the southern part of the Southern Hayward fault [section 55b] (Lienkaemper and others, 1991 #5487; Lienkaemper and Galehouse, 1997 #5488). The M_W7 1868 earthquake (Lawson, 1908 #4969; Yu and Segall, 1996 #5492) occurred on the Southern Hayward fault [55b] and extended into the Northern Hayward fault [55a]. Fault creep has not been observed along the Southeast Extension section [55c]. Toppozada and Borchardt (1998 #5493) showed that the June 10, 1836 earthquake, previously thought to have been on the Northern Hayward fault [55a], occurred further south, somewhere east of Monterey Bay. Cumulative dextral offset of the 6 Ma Roblar Tuff is 28?3 km (Sarna-Wojcicki, 1992 #5265). Lienkaemper and Borchardt (1996 #5297) reported a preferred Holocene deformation rate (minimum) of 8.0±0.7 mm/yr based on dextral offset of an alluvial-fan apex in Union City. A dated recurrence interval has not been determined for the Northern and Southern Hayward faults (sections 55a and 55b, respectively), but there have been at least four surface faulting earthquakes in the past 2,250 radiocarbon years along the Northern Hayward section (Leinkaemper and others, 1997 #5482). Williams (1992 #5495) reported that at least 6 and as many as eight events have occurred in the past 2.1 k.y. along the Southern Hayward section.

Sections: This fault has 3 sections. There is insufficient data to determine seismogenic segments. The segment boundary between the Northern and Southern Hayward faults was long considered to be delineated by the location of the northern boundary of rupture associated with the M_W7 1868 earthquake and the southern boundary of rupture associated with the 1836 (Working Group on California Earthquake Probabilities, 1988 #5494; 1990 #549). Toppozada and Borchardt (1998 #5493) re-evaluated the 1836 earthquake and demonstrated that it did not occur on the Hayward fault. Yu and Segall (1996 #5492) and Working Group on Northern California Earthquake Potential (1996 #1216) suggest that 1868 rupture may have extended as far north as northern

	Oakland. Petersen and others (1996 #4860) and Working Group on Northern California Earthquake Potential (1996 #1216) modeled the Hayward fault zone with two segments of equal length. The Northern and Southern sections of the Hayward fault zone were considered to rupture characteristically, with a dextral strike-slip deformation rate of 9 mm/yr. A possible third segment, the Southeast Extension, was modeled with a dextral reverse oblique slip rate of 3 mm/yr. The section boundaries proposed by Petersen and others (1996 #4860) and Working Group on Northern California Earthquake Potential (1996 #1216) are adopted here: from north to south they are the Northern Hayward [55a], Southern Hayward [55b], and Southeast Extension [55c] sections.
Name comments	**General:** The Hayward fault zone was first mapped by Lawson (1908 #4969) who named it for Haywards (now known as Hayward), the site of greatest damage caused by the 1868 earthquake (about M_W7). The southeast extension of the Hayward fault zone consists of several named faults, including the Mission, Evergreen, Quimby, Crosley, and Clayton faults as mapped by Dibblee (1972 #5477; 1972 #5478; 1973 #5480). **Section:** The Southeast Extension section consists of several named faults, including the Hayward (SE extension), Mission, Crosley, Quimby, and Evergreen faults. These faults were mapped and named by Dibblee (1972 #5477; 1972 #5478; 1972 #5479; 1973 #5480). **Fault ID:** Refers to number (Southern Hayward fault) of Jennings (1994 #2878) and number H1 (Hayward, south) of Working Group on Northern California Earthquake Potential (1996 #1216).
County(s) and State(s)	SANTA CLARA COUNTY, CALIFORNIA ALAMEDA COUNTY, CALIFORNIA
Physiographic province(s)	PACIFIC BORDER
Reliability of location	Good Compiled at 1:24,000 scale. *Comments:* Location based on digital revisions to Jennings (1994 #2878) at 1:750,000 using original mapping by Smith (1981 #5499), Bryant (1980 #5473), Hart (1979 #), Herd (1977 #5484; 1978 #5485), Radbruch-Hall (1974 #1243), and Lienkaemper (1992 #5486) at 1:24,000 scale.

Geologic setting	Major dextral strike-slip fault of the larger San Andreas fault system. This fault is located in the eastern San Francisco Bay region and generally trends along and bounds the western side of the East Bay Hills (Aydin, 1982 #5467). The fault zone extends from San Pablo Bay southeast to the Evergreen area in eastern San Jose. The northern end of fault probably connects with the Rodgers Creek fault [32] via a 6-km-wide, right-releasing stepover beneath San Pablo Bay (Wright and Smith, 1992 #5258). Slip is eventually transferred to the central part of the Calaveras fault [54b] in a complex manner. Andrews and others (1993 #5466) suggest that slip is transferred to the Calaveras fault zone [54] along a dextral reverse fault in the vicinity of Calaveras Reservoir. Dextral offset estimated to be 28±3 km in the past 6 m.y., based on offset of the Roblar Tuff (Sarna-Wojcicki, 1992 #5265).
Length (km)	This section is 42 km of a total fault length of 107 km.
Average strike	N36°W (for section) versus N39°W (for whole fault)
Sense of movement	Right lateral *Comments:* Geomorphic expression, stream channel offsets, and fault-creep displacement document predominantly dextral strike-slip displacement (Hart, 1979 #; Bryant, 1980 #5473; Smith, 1981 #5499; Lienkaemper, 1992 #5486; Galehouse, 1995 #4853; 1997 #5488; 1999 #5500). Historic Mw~ 7 1868 earthquake is characterized by 1.9±0.4 m of dextral displacement (assuming a rupture length of 52 km), based on geodetic modeling by Yu and Segall (1996 #5492)
Dip Direction	V *Comments:* Oppenheimer and others (1992 #5490) reported that the dip of the Hayward fault is near vertical, based on focal mechanisms of earthquakes. However, there are secondary reverse mechanisms adjacent to the principal Hayward fault.
Paleoseismology studies	There are three detailed studies along the Southern Hayward section: Tule Pond (site 55-2). Williams (1992 #5495) study involved the excavation of five fault-normal trenches across the eastern trace of the Hayward at Tule Pond, a 100 m-wide fault-bounded, pull-

	apart graben in Fremont. This study was principally focused on obtaining recurrence-interval data. Williams reported that at least 6 and as many as 8 events have been recognized in the past 2.1 k.y. This site was reinvestigated by the U.S. Geological Survey. Fremont City Hall (site 55-3). This study by Borchardt and others (1992 #5472) is a slip rate investigation involving three fault-normal trenches and seven fault-parallel trenches across the eastern trace of the Hayward fault just north of Fremont City Hall. A dextrally offset gravelly-sand channel fill was identified and allowed the determination of partial Holocene slip rate. Masonic Home (site 55-5). Lienkaemper and Borchardt (1996 #5297) excavated two fault-parallel trenches on an alluvial fan just west of the Masonic Home in Union City. Their 1996 paper summarizes the results of trenching done in 1989 and 1990. The fault-parallel trenches exposed progressive dextral offset of the apex of alluvial-fan deposits issuing from the mouth of a perennial stream channel just south of the Masonic Home. Geomorphic and stratigraphic evidence indicates that fan-apex abandonment has occurred at least 6 times in the past 20 k.y. A Holocene horizontal displacement rate was calculated from the dextrally offset alluvial-fan apexes.
Geomorphic expression	The Southern Hayward section is delineated by geomorphic features characteristic of Holocene dextral strike-slip displacement such as linear and sidehill troughs, sidehill benches, shutter ridges, linear scarps and vegetation contrasts on Holocene alluvium, closed depressions, and dextrally deflected small and large drainages (Herd, 1978 #5485; Hart, 1979 #; Bryant, 1980 #5473; Smith, 1981 #5499; Lienkaemper, 1992 #5486).
Age of faulted surficial deposits	Trench excavations reported by P.L. Williams (1992 #5495) show that several fault rupturing events have occurred along the Southern Hayward section in the past 2 k.y. Ages of modern to 2.3 ka for sag-pond deposits have been determined using radiocarbon dating. Several site-specific fault-rupture investigations along the Southern Hayward section done in compliance with the Alquist-Priolo Earthquake Fault Zoning Act (Hart and Bryant, 1997 #4856) have reported faulted Holocene alluvium, colluvium, and soil horizons.
Historic earthquake	

Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* The most recent event has not been precisely dated, but Williams (1992 #5495) identified one and perhaps two surface-rupturing earthquakes that have occurred in the past 250 years.
Recurrence interval	150–250 yr (2.1 k.y.) *Comments:* Williams (1992 #5495) reported that at least 6 and as many as 8 events have occurred in the past 2.1 k.y. (site 55-2). Williams stated that an average recurrence interval of 150–250 years characterizes the Southern Hayward section [55b]. However, some of the events identified may be closely paired earthquakes, although the uncertainty estimates in the radiocarbon ages allows the possibility that the events are the same. A longer mean recurrence interval can be derived using 6–8 events in about 395 yr.
Slip-rate category	Greater than 5.0 mm/yr *Comments:* Lienkaemper and Borchardt (1996 #5297) reported Holocene horizontal displacement rates of 8.0±0.7 mm/yr and 9.2±1.4 mm/yr for the Southern Hayward section. The former rate was derived from a dextrally offset alluvial-fan apex near the Masonic Home in Union City. Fan apex G contained abundant charcoal representing either a burn layer or detrital deposits located at the stratigraphic top of the lowest gravel (unit G) and was determined to be 8.27±0.05 ka based on radiocarbon dating. Fan apex G is dextrally offset 63–69 m. Younger fan apex E has been dextrally offset about 42±6 m (46.5 +0.6 m, -4.9 m for the assumed position of the channel northeast of the fault). Detrital charcoal recovered from the basal apex unit E yielded 14C calibrated age of 4.58±0.05 ka. The rate based on offset of fan apex E is 9.2±1.4 mm/yr. Principal uncertainty reported by Lienkaemper and Borchardt is establishing the position of the stream channel northeast of the fault and the projection of the fan apex into the fault. Multiple radiocarbon dates for stratigraphic units E and G minimize age uncertainties. Lienkaemper and Borchardt concluded that the long-term Holocene horizontal displacement rate of 9 mm/yr may be a minimum. This is because additional deformation may not be accounted for because the site did not span the entire fault zone. Borchardt and others (1992 #5472) reported a minimum horizontal displacement rate of

	5.0±0.5 mm/yr near Fremont City Hall. A gravelly sand channel fill thought to be 7.99±0.16 ka is displaced 44.5±4.1 m dextrally. This displacement is based on projecting the channel into the fault, but the projection is complicated by drag folding and soft-sediment deformation. The resulting 5 mm/yr horizontal displacement rate is considered a minimum by Borchardt and others (1992 #5472) because other (untrenched) fault traces in a 150- to 200-m-wide zone of distributive deformation probably have additional displacement.
Date and Compiler(s)	2000 William A. Bryant, California Geological Survey Sereyna E. Cluett, California Geological Survey
References	#5466 Andrews, D.J., Oppenheimer, D.H., and Lienkaemper, J.J., 1993, The Mission Link between the Hayward and Calaveras faults: Journal of Geophysical Research, v. 98, no. B7, p. 12,083-12,095. #5467 Aydin, A., 1982, The East Bay hills, a compressional domain resulting from interaction between the Calaveras and Hayward-Rodgers Creek faults, *in* Hart, E.W., Hirschfeld, S.E., and Schulz, S.S., eds., Proceedings, Conference on Earthquake Hazards in the Eastern San Francisco Bay Area: California Department of Conservation, Division of Mines and Geology Special Publication 62, p. 11-21. #5472 Borchardt, G., Lienkaemper, J.J., and Budding, K.E., 1992, Holocene slip rate of the Hayward fault at Fremont, *in* Borchardt, G., and others, eds., Proceedings of the Second Conference on Earthquake hazards in the Eastern San Francisco Bay Area: California Department of Conservation, Division of Mines and Geology Special Publication 113, p. 181-188. #5473 Bryant, W.A., 1980, Hayward fault, Milpitas and Calaveras Reservoir quadrangles: California Division of Mines and Geology Fault Evaluation Report FER-105, microfiche copy in Division of Mines and Geology Open-File Report 90-11, scale 1:24,000. #5475 Bryant, W.A., 1982, Southern Hayward fault zone, Alameda and Santa Clara Counties, California, *in* Hart, E.W., Hirschfeld, S.E., and Schulz, S.S., eds., Proceedings, Conference on Earthquake Hazards in the Eastern San Francisco Bay Area: California Department of Conservation, Division of Mines and Geology Special Publication 62, p. 35-44.

#5477 Dibblee, T.W., Jr., 1972, Preliminary geologic map of the Milpitas quadrangle, Santa Clara County, California: U.S. Geological Survey Open-File Report 72-91, scale 1:24,000.

#5478 Dibblee, T.W., Jr., 1972, Preliminary geologic map of the San Jose East quadrangle, Santa Clara County, California: U.S. Geological Survey Open-File Report 72-92, scale 1:24,000.

#5480 Dibblee, T.W., Jr., 1973, Preliminary geologic map of the Calaveras Reservoir quadrangle, Santa Clara County, California: U.S. Geological Survey Open-File Report 73-58, scale 1:24,000.

#4853 Galehouse, J.S., 1995, Theodolite measurement of creep rates on San Francisco Bay region faults: Technical report to U.S. Geological Survey, Reston, Virginia, under Contract 1434-94-G2420.

#5500 Galehouse, J.S., 1999, Theodolite measurement of creep rates on San Francisco Bay region faults: U.S. Geological Survey, Summaries of National Earthquake Hazards Reduction Program, v. 40, USGS Contract 99-HQ-GR-0084 (electronic version available on line at http://erp-web.er.usgs.gov).

#5514 Hart, E.W., 1979, Hayward, Mission, and Calaveras faults, Niles quadrangle: California Division of Mines and Geology Fault Evaluation Report FER-88, microfiche copy in California Division of Mines and Geology Open-File Report 90-11, scale 1:24,000.

#4856 Hart, E.W., and Bryant, W.A., 1997, Fault-rupture hazard zones in California: California Division of Mines and Geology Special Report 42, 38 p.

#5484 Herd, D.G., 1977, Map of Quaternary faulting along the Hayward and Calaveras fault zones, Niles and Milpitas 7.5-minute quadrangles, California: U.S. Geological Survey Open-File Map 77-645, scale 1:24,000.

#5485 Herd, D.G., 1978, Map of Quaternary faulting along the northern Hayward fault zone; Mare Island, Richmond, Briones Valley, Oakland West, Oakland East, San Leandro, Hayward, and Newark 7.5-minute quadrangles, California: U.S. Geological Survey Open-File Map 77-308, scale 1:24,000.

#2878 Jennings, C.W., 1994, Fault activity map of California and adjacent areas, with locations of recent volcanic eruptions: California Division of Mines and Geology Geologic Data Map 6, 92 p., 2 pls., scale 1:750,000.

#4969 Lawson, A.C., chairman, 1908, The California earthquake of April 18, 1906—Report of the State Earthquake Investigation Commission: Washington, D.C., Carnegie Institution of Washington Publication 87.

#5486 Lienkaemper, J.J., 1992, Map of recently active traces of the Hayward fault, Alameda and Contra Costa Counties, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-2196, 13 p. pamphlet, scale 1:24,000.

#5297 Lienkaemper, J.J., and Borchardt, G., 1996, Holocene slip rate of the Hayward fault at Union City, California: Journal of Geophysical Research, v. 101, no. B3, p. 6099-6108.

#5488 Lienkaemper, J.J., and Galehouse, J.S., 1997, Revised Long-term creep rates on the Hayward fault, Alameda and Contra Costa Counties, California: U.S. Geological Survey Open-File Report 97-690, 17 p.

#5487 Lienkaemper, J.J., Borchardt, and Lisowski, M., 1991, Historic creep rate and potential for seismic slip along the Hayward fault, California: Journal of Geophysical Research, v. 96, no. B11, p. 18,261-18,283.

#5482 Lienkaemper, J.J., Kelson, K.I., Lettis, W.R., Schwartz, D.P., Southon, J.R., and Williams, P.L., 1997, The northern Hayward fault, CA—Preliminary timing of paleoearthquakes [abs.]: EOS, Transactions of the American Geophysical Union, v. 78, no. 46(supplement), p.439.