

Quaternary Fault and Fold Database of the United States

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Hayward fault zone, Southeast Extension section (Class A) No. 55c

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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_w 7.1 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]. Topozada 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 (Lienkaemper 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_w 7.1 1868 earthquake and the southern boundary of rupture associated with the 1836 (Working Group on California Earthquake Probabilities, 1988 #5494; 1990 #549). Topozada 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

	<p>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.</p>
<p>Name comments</p>	<p>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).</p> <p>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).</p> <p>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).</p>
<p>County(s) and State(s)</p>	<p>ALAMEDA COUNTY, CALIFORNIA SANTA CLARA COUNTY, CALIFORNIA</p>
<p>Physiographic province(s)</p>	<p>PACIFIC BORDER</p>
<p>Reliability of location</p>	<p>Good Compiled at 1:24,000 scale.</p> <p><i>Comments:</i> Location based on digital revisions to Jennings (1994 #2878) at 1:750,000 using original mapping by Bryant (1980 #5473; 1981 #5474), Dibblee (1972 #5477; 1972 #5478; 1972 #5479; 1973 #5480), Herd (1977 #5484); unpublished mapping shown in (Bryant, 1980 #5473; 1981 #5474), and Lienkaemper</p>

	(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 30 km of a total fault length of 107 km.
Average strike	N46°W (for section) versus N39°W (for whole fault)
Sense of movement	Right lateral <i>Comments:</i> The Southeast Extension section consists of a broad, complex zone of both dextral strike-slip and east-dipping reverse faults (Dibblee, 1972 #5477; 1972 #5478; 1972 #5479; 1973 #5480; Bryant, 1982 #5475). Slip may be transferred from the Hayward fault zone to the Calaveras fault zone [54] along a complex left restraining step marked by this broad, complex zone of reverse and dextral strike-slip faults.
Dip	20° NE. to 90° <i>Comments:</i> Trench exposures and geologic mapping show a wide variation in dip angles. The Crosley, Mission, and parts of the Quimby generally are northeast-dipping reverse faults with reported dips ranging from 20° NE. to near vertical (Dibblee, 1972 #5477; 1972 #5478; 1973 #5480; Bryant, 1980 #5473; 1981 #5474).
Paleoseismology studies	There is one detailed study site for the Southeast Extension section that consisted of two trenches excavated across the Evergreen fault on the Evergreen Valley College campus (site 55-

4) by Fenton and others (1994 #5476). Faulted late Quaternary alluvium was observed along east-dipping reverse to dextral-reverse oblique slip faults. The most recent event apparently did not extend to the surface, but was manifested as warping and folding.

Several site-specific fault rupture investigations involving trenching done in compliance with the Alquist-Priolo Earthquake Fault Zoning Act (Hart and Bryant, 1997 #4856) have been performed along traces of the Southeast Extension section.

Geomorphic expression

The Southeast Extension section comprises a wide, complex zone of reverse, dextral-reverse, and dextral faults (Bryant, 1982 #5475). Locally, faults are marked by moderately to well defined geomorphic features indicative of dextral strike-slip displacement, such as dextrally offset and linear drainages, closed depressions, side-hill benches, and linear scarps on alluvium. Geomorphic evidence of reverse displacement is less well defined, but locally is expressed as curvilinear scarps on alluvium. Large-scale landslides obscure significant portions of the fault traces along this section.

Age of faulted surficial deposits

Faults that comprise the Southeast Extension have different, generally poorly known displacement histories. The Hayward fault (SE extension) is characterized by geomorphic features indicative of dextral strike-slip faulting developed locally on alluvial deposits mapped by Dibblee (1972 #5478; 1973 #5480). The Evergreen fault offsets late Pleistocene alluvium (Fenton and others, 1994 #5476) and at one locality extends into soil of presumable Holocene age (Reid, 1979 #5491) and forms scarps on late Pleistocene to Holocene alluvial fans (Bryant, 1981 #5474). Significant portions of the Evergreen fault are concealed by alluvium of unknown, but presumable Holocene age (Dibblee, 1972 #5478; 1972 #5479; 1973 #5480). The Crosley fault locally offsets late Pleistocene alluvium and overlying soil horizons, but elsewhere is concealed by alluvium and landslide deposits (Bryant, 1980 #5473; 1981 #5474). Hart (1979 #5514) did not find geomorphic evidence of Holocene displacement along the Mission fault and reported that site-specific trenching studies have not exposed evidence of faulting. Wong and Hemphill-Haley (1992 #5496) reported that microseismicity previously associated with the Mission fault is characterized by a vertical dextral-strike-slip fault and thus may not be associated with the Mission fault. Traces of the Quimby fault are mostly concealed by late

	Pleistocene alluvium (Dibblee, 1972 #5479; 1973 #5480).
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) <i>Comments:</i> Timing of the most recent event has not been determined along the Southeast Extension. Several site-specific investigations done in compliance with the Alquist-Priolo Earthquake Fault Zoning Act report latest Pleistocene and Holocene displacement along this section.
Recurrence interval	
Slip-rate category	Between 1.0 and 5.0 mm/yr <i>Comments:</i> Fenton and others (1994 #5476) reported a preferred late Quaternary displacement rate of 0.4 mm/yr for the Evergreen fault, an east-dipping reverse to dextral-reverse oblique slip fault. Alluvial and colluvial deposits overlying sediment of the Pliocene-Pleistocene Santa Clara Formation are offset, but the most recent event is marked by warping and folding of deposits estimated to be greater than 100 ka and did not offset the ground surface. This reported rate is a minimum because it accounts for only the Evergreen fault, one of several faults in this section. Additional faults to the east comprise the Southeast Extension section in this area. Neither the total slip rate across the Southeast Extension nor the slip rate on individual fault strands has been determined.
Date and Compiler(s)	2000 William A. Bryant, California Geological Survey Sereyna E. Cluett, California Geological Survey
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