Jump to Navigation

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San Gregorio fault zone, San Gregorio section (Class A) No. 60a

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Synopsis	**General:** Holocene active, structurally complex transpressional fault zone as much as 5 km wide. The fault zone is mainly located offshore, west of San Francisco Bay and Monterey Bay, with onshore locations at promontories, such as Moss Beach, Pillar Point, Pescadero Point, and Point A?o Nuevo. Cumulative dextral displacement may total about 155 km (Dickinson, 1996 #5397), but a component of west-vergent reverse displacement also characterizes the fault zone (Lewis, 1994 #5405). Simpson and others (1998 #5414) reported a late Pleistocene dextral slip rate of 3.5-4.5 mm/yr along the Seal Cove fault [60a, San Gregorio

	section], based on displaced paleochannel deposits at Moss Beach. This is a partial slip rate because faults offshore to the west are also considered active and may contribute an unknown amount of dextral slip. Weber (1994 #5420) calculated a late Quaternary slip-rate of about 10 mm/yr, based on correlation of dextrally offset marine terrace deposits at Point A?o Nuevo. Conversely, dextrally offset stream channels near Point A?o Nuevo indicate a late Pleistocene slip-rate of 4-10 mm/yr (Weber, 1994 #5420). Alternatively, Sedlock, (1999 #5411) argues that piercing points are not well constrained across dextrally offset stream channels and suggests that a lesser dextral slip rate of 1-3 mm/yr better characterizes the San Gregorio fault zone. Clark and Rosenberg (1999 #5394) estimated late Quaternary and Holocene dextral slip rates of between 0.4 and 3.5 mm/yr, based on offset streams, shoreline angles, and colluvial deposits. The most recent earthquake along the San Gregorio fault zone occurred after 1270 AD to 1400 AD, but prior to the arrival of Spanish missionaries in 1775 AD (Simpson and others, 1997 #5413). **Sections:** This fault has 2 sections. There is insufficient data to document seismogenic segments. Petersen and others (1996 #4860) and Working Group on Northern California Earthquake Potential (1996 #1216) modeled the fault zone with two segments. Their segment boundary was placed in the north-central part of Monterey Bay. Fault segments designated by Petersen and others and Working Group on Northern California Earthquake Potential herein are considered as sections.
Name comments	**General:** The San Gregorio fault zone was first mapped and named by Lawson (1908 #4969) for the on-land portion from Pescadero Point to A?o Nuevo Point, although Graham and Dickinson (1978 #5398) erroneously reported that Branner and others (1909 #5381) first named the fault. The San Gregorio is a complex fault zone that consists of several named faults, including the Seal Cove, Frijoles, Coastways, Greyhound Rock, Carmel Canyon, Denniston Creek, and A?o Nuevo faults. The fault zone extends from Bolinas Lagoon south to the Point Sur region. The Sur and Palo Colorado fault zones (first named by (Trask, 1926 #5416) are herein considered a part of the southern section of the San Gregorio fault zone. Greene and others (1973 #1323) and McCulloch and Greene (1990 #5406) used the name Palo Colorado-San Gregorio fault zone for the fault where it is offshore west and south of Monterey Bay. Jennings (1994 #2878) modified this nomenclature and named the offshore fault south of Monterey Canyon the Palo Colorado fault.

	Section: Defined as the San Gregorio segment (section) by Petersen and others (1996 #4860) and Working Group on Northern California Earthquake Potential (1996 #1216). The section extends from the Bolinas Lagoon to Golden Gate region south to the north-central part of Monterey Bay. This section is comprised of subparallel fault traces in a complex zone as much as 5 km wide (Weber, 1980 #5419). Onshore traces of the San Gregorio section are comprised by the Seal Cove fault and Denniston Creek faults north of Half Moon Bay and the Frijoles, Coastways, A?o Nuevo, and Greyhound Rock faults in the Pescadero Point to A?o Nuevo Point area. **Fault ID:** Refers to numbers 230 (Palo Colorado fault zone) and 237 (Sur fault zone) of Jennings (1994 #2878) and number A5 (San Gregorio, Sur Region) of Working Group on Northern California Earthquake Potential (1996 #1216).
County(s) and State(s)	SANTA CRUZ COUNTY, CALIFORNIA SAN MATEO COUNTY, CALIFORNIA
Physiographic province(s)	PACIFIC BORDER
Reliability of location	Poor Compiled at 1:250,000 scale. *Comments:* Most of the faults are offshore; their traces are based on mapping compiled by McCulloch and Greene (1990 #5406) at 1:250,000 scale but without topographic control (i.e., poorly located). Locations of the onshore traces are based on digital revisions to Jennings (1994 #2878) map at 1:750,000 scale using original mapping by Weber and Lajoie (1980 #5422), Bedrossian (1979 #5391), Smith (1981 #5415), and Pampeyan (1994 #5409) at 1:24,000 scale.
Geologic setting	Convergent dextral fault predominantly located offshore on the continental shelf of north-central California. The northern end of the fault has a complex interconnection with the San Andreas fault zone [1] over an approximately 15-km-long zone from the Golden Gate north to Bolinas Lagoon. The southern (offshore) extent of the fault zone is conjectural. Greene and others (1973 #1323) projected the southern part of thefault zone into the onshore Palo Colorado fault. Graham and Dickinson (1978 #5398) and Weber (1980 #5419; 1994 #5420) interpreted the San

	Gregorio fault zone as joining with the Sur fault. The general consensus is that the San Gregorio fault zone is a relatively continuous structure, linking to the south with the Hosgri [81] and San Simeon [80] fault zones (Graham and Dickinson, 1978 #5398; Silver, 1978 #5412; Weber, 1980 #5419; 1994 #5420; Dickinson, 1996 #5397). Alternatively, Clark and Rosenberg (1999 #5394) postulate that a component of slip from the San Gregorio fault zone is distributed onshore along intra-Salinian faults. Cumulative dextral strike-slip displacement along the San Gregorio fault zone since middle Miocene time has been reported to be between 115 km (Graham and Dickinson, 1978 #5398) and 156 km (Clark and others, 1984 #5395; Dickinson, 1996 #5397; 1998 #5393) based on stratigraphic and structural correlations.
Length (km)	This section is 131 km of a total fault length of 241 km.
Average strike	N23°W (for section) versus N26°W (for whole fault)
Sense of movement	Right lateral *Comments:* Complex displacement is mainly dextral strike-slip (Graham, 1978 #5398; Weber, 1980 #5419, 1994 #5420). Ross and others (1998 #5410) reported that a broad zone of deformation, including fault and fold features, characterizes the offshore fault zone from Pillar Point south to Pescadero Point. Onshore traces of the fault zone generally are characterized by dextral strike-slip displacement based on geomorphic expression and offset geologic and anthropic deposits (Weber and Lajoie, 1980 #5422; Smith, 1981 #5415; Noller and others, 1995 #5408; Simpson and others, 1998 #5414). The A?o Nuevo fault and some strands of the Coastways fault are characterized by west-vergent reverse displacement (Weber and Lajoie, 1980 #5422). Strands of the Greyhound Rock fault are characterized by west-dipping normal displacement (Weber and Lajoie, 1980 #5422).
Dip	70°E–90° *Comments:* Dip not reported, but assumed onshore A?o Nuevo fault and traces of the Frijoles fault are east-dipping reverse faults assumed to be predominantly vertical to steeply E dipping (i.e., 70?-80?) based on linear strike and geomorphic expression observed on onshore traces of the fault. Offshore imaging of the fault zone suggests east-dipping reverse faults are also present (McNally and Stakes, 1998 #5407).

Paleoseismology studies	Two detailed study sites are located along the San Gregorio section. Studies at site 60-1 are summarized by Simpson and others (1997 #5413; 1998 #5414). A trench was excavated across the western margin of a sag pond and dextrally displaced anthropic deposits were radiometrically dated. Additional trenches and borings were excavated in order to better constrain amount and timing of dextrally offset San Vincente Creek. Reseach at Site 60-2, summarized by Weber (1994 #5420), is a long-term effort to map and correlate marine terrace deposits and surfaces offset by the Frijoles, Coastways, A?o Nuevo, and related faults. Trenching of the A?o Nuevo fault in 1979 exposed offset sag-pond deposits radiometrically dated at 6,060?105 yrs B.P. Also, natural exposures of these faults were logged in detail.
Geomorphic expression	Onshore traces of the Seal Cove fault are characterized by geomorphic features indicative of dextral strike-slip displacement, including dextral displacement of San Vincente Creek, linear ridges, and a closed depression (Noller and others, 1995 #5408). The Coastways and Frijoles faults form a complex onshore zone predominantly characterized by dextral strike-slip displacement marked by geomorphic features, such as aligned linear ridges and valleys, dextrally deflected stream channels, linear scarps, and linear vegetation contrasts. The northern portion of the Frijoles and Coastways faults are concealed by young alluvial, colluvial, and landslide deposits.
Age of faulted surficial deposits	The Seal Cove fault displaces sedimentary rocks of the Pliocene Purisima Formation against late Pleistocene (oxygen-isotope stage 5a) marine terrace deposits (Kennedy and others, 1981 #5404; Simpson and others, 1997 #5413). Holocene alluvium and prehistoric anthropic deposits radiometrically dated between 1270 AD and 1470 AD are also offset (Simpson and others, 1997 #5413). Between Pescadero Point and A?o Nuevo Point, the San Gregorio fault zone offsets 105 ka marine-terrace deposits and latest Pleistocene to Holocene alluvial-fan deposits (Weber and Cotton, 1981 #5421; Weber, 1994 #5420).
Historic earthquake	
Most recent prehistoric	latest Quaternary (<15 ka)

deformation	*Comments:* Simpson and others (1997 #5413) identified the most recent event along the Seal Cove fault as occurring prior to the arrival of Spanish missionaries in 1775 AD and after deposition of an anthropic deposit (native Californian cooking hearth) radiometrically dated between 1270 AD and 1400 AD.
Recurrence interval	400-1000 yrs (<1 ka) *Comments:* Simpson and others (1997 #5413) identified the most recent event and the penultimate event along the Seal Cove fault. The most recent event occurred prior to the arrival of Spanish missionaries in 1775 AD and after deposition of a native Californian cooking hearth, which has been radiometrically dated between 1270 AD and 1400 AD. The penultimate event occurred between 620 AD and 1400 AD. This suggests a recurrence interval less than 1,000 years and greater than about 400 years. Weber (1980 #5419) estimated recurrence intervals of about 200-400 years for strands of the San Gregorio fault zone in the Point A?o Nuevo area, based on long-term slip rates and assumptions of displacement per event.
Slip-rate category	Greater than 5.0 mm/yr *Comments:* The total Holocene slip rate across the San Gregorio fault zone is not known, mainly owing to multiple fault traces and mainly offshore location of the fault zone. Noller and others (1995 #5408) reported a late Holocene dextral slip rate of 4.5-11 mm/yr for the Seal Cove fault based on a 9-11m dextral offset of the margin of anthropic deposits (shell middens). Simpson and others (1998 #5414) and Weber and others (1999 #5423) reported a post-late Pleistocene dextral slip rate of 3.5-4.5 mm/yr for the Seal Cove fault, based on dextral offset of 300-360 m of a paleochannel of San Vincente Creek. These slip rates are both minimums because an offshore western strand of the San Gregorio fault zone is considered active but has an unknown slip rate. Simpson and others (1998 #5414) and Weber and others (1999 #5423) speculated that the San Gregorio fault zone may have a slip rate of at least 6 mm/yr. Weber (1994 #5420) reported a late Quaternary slip rate of 4.75-10.1 mm/yr for the San Gregorio fault zone at Point A?o Nuevo. This slip rate is based on several observations, including cumulative dextral offset of marine shoreline angles across the Coastways, Frijoles and related faults at Point A?o Nuevo, and dextrally offset of A?o Nuevo and Cascade Creeks. The greatest amount of uncertainty in this

	estimate is the precise correlation and amount of dextral offset of marine-shoreline angles. Weber (1994 #5420) also reported a slip rate of 4-8 mm/yr based on dextrally offset stream channels, but the timing of fault offset is poorly constrained. Kelson and others (1992 #5351) suggested that the San Gregorio fault zone could account for about 7-8 mm/yr of dextral slip, based on a comparison of the relative plate motion in the San Francisco Bay region predicted by the NUVEL-1 model with the amount and orientation of observed geologic slip and creep along mapped faults. Alternatively, Sedlock (1999 #5411) argues that piercing points are not well constrained across dextrally offset stream channels and suggests that a dextral slip rate of 1-3 mm/yr characterizes the San Gregorio fault zone.
Date and Compiler(s)	1999 William A. Bryant, California Geological Survey Sereyna E. Cluett, California Geological Survey
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