

Quaternary Fault and Fold Database of the United States

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San Andreas fault zone, Parkfield section (Class A) No. 1f

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Compiled in cooperation with the California Geological Survey

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Synopsis

General: The 1,100-km-long San Andreas fault zone is the principal element of the San Andreas fault system, a network of faults with predominantly dextral strike-slip displacement that collectively accommodates the majority of relative N-S motion between the North American and Pacific plates. Major elements of the San Andreas fault system include the Bartlett Springs [29], Maacama [30], Rodgers Creek [32], Green Valley [37], Calaveras [54], Hayward [55], San Gregorio [60], San Jacinto [125], Elsinore [126], and Imperial [132] fault zones. In this compilation, the San Andreas fault zone is considered to be the

Holocene and historically active dextral strike-slip fault that extends along most of coastal California from its complex junction with the Mendocino fault zone [18] on the north, southeast to the northern Transverse Range and inland to the Salton Sea, where a well-defined zone of seismicity (the Brawley Seismic Zone [124]) transfers slip to the Imperial fault [132] along a right-releasing step. Two major surface-rupturing earthquakes have occurred in historic time: the 1857 Fort Tejon (Sieh, 1978 #5775) and 1906 San Francisco (Lawson, 1908 #4969) earthquakes. Additional historic surface rupturing earthquakes include the unnamed 1812 earthquake along the Mojave section [1h] (Jacoby and others, 1988 #4962; Sieh and others, 1989 #5779; Fumal and others, 2002 #5726) and the northern part of the San Bernardino Mountains section [1i] (Weldon and Sieh, 1985 #5806; Jacoby and others, 1987 #4961; 1988 #4962), and a large earthquake in the San Francisco Bay area that occurred in 1838 that was probably on the Peninsula section [1c] of the San Andreas fault (Topozada and Borchardt, 1998 #5493; Bakun, 1999 #4790). Historic fault creep at rates as high as 32 mm/yr characterizes the 132-km-long Creeping section [1e] in central California (Burford and Harsh, 1980 #4806). The creep rate gradually tapers off to 0 mm/yr at the northwestern and southeastern ends of this section. The northern and southern ends of the Creeping section [1e] are transitional to the surface-rupture termination points of the 1906 earthquake to the north and 1857 earthquake to the south. Creep at rates as high as 4 mm/yr also has been measured on the Coachella section [1j] (Sieh and Williams, 1990 #5780). The San Andreas fault zone is the most extensively studied fault in California, and perhaps in the world. The fault zone first gained international scientific attention immediately following the great 1906 San Francisco earthquake. Lawson's 1908 report summarizing the investigation of the 1906 earthquake contained the first integrated description of the San Andreas fault, which was recognized as extending from Point Delgada in the north to Whitewater Canyon southeast of San Bernardino in the south, and formed the underlying basis for our modern studies of paleoseismology and earthquake geology (Prentice, 1999 #5755). More than 5,000 articles, maps, and publications describing various aspects of the San Andreas fault that have been produced since Lawson's pioneering work. In addition, there are about 1,000 site-specific fault rupture investigation reports (and maps) filed with the California Geological Survey in compliance with the Alquist-Priolo Earthquake Fault Zoning Act (Hart and Bryant, 1997 #4856). For

this compilation, 51 detailed paleoseismic study sites along the fault zone are summarized. The fastest, generally accepted Holocene slip rate for the San Andreas fault is along the Cholame-Carrizo section [1g], which lies in the medial portion of the 1,100-km-long fault zone. Here, Sieh and Jahns (1984 #5778) reported a preferred late Holocene dextral slip rate of 33.9 ± 2.9 mm/yr. In and south of the San Francisco Bay area, a significant portion of dextral slip is partitioned onto several faults of the San Andreas fault system, including the San Gregorio [60] on the west, and the Calaveras [54] and Hayward [55] faults on the east. Hall and others (1999 #4954) reported a late Holocene slip rate of 17 ± 4 mm/yr for the Peninsula section [1c]. North of the Golden Gate, dextral slip from the San Gregorio fault zone [60] may be transferred to the North Coast section [1b] along a right-releasing step. Reported late Holocene slip rates for the North Coast section [1b] range from a minimum value of 16–18 mm/yr reported by Noller and others (1996 #5748) to a maximum value of 25.5 ± 2.5 mm/yr reported by Prentice (1989 #5754). To the south, the San Andreas fault zone is delineated by an extremely complex zone of dextral strike-slip, reverse-oblique, and thrust faults in the southeastern Transverse Ranges. Fault nomenclature in the San Gorgonio Pass area is complex and different workers have assigned faults different names. West-northwest of San Gorgonio Pass Dibblee (1964 #1340; 1968 #4817; 1982 #4841) termed the principal active strand of the San Andreas fault located along the foot of the San Bernardino Mountains the South Branch San Andreas fault, which is referred to as the San Andreas fault by Allen (1957 #4787) and San Bernardino strand San Andreas fault by Matti and others (1992 #5735). For this compilation, this strand will be referred to as the San Andreas fault (South Branch). A fault that strikes sub-parallel located to the north was called the North Branch San Andreas fault by Dibblee (1964 #1340; 1968 #4817) and is referred to as the Mill Creek fault by Allen (1957 #4787), Matti and others (1992 #5735), and Jennings (1994 #2878). This strand will be referred to as the Mill Creek fault in this compilation. East-southeast of San Gorgonio Pass two principal dextral strike-slip faults comprise the Holocene active San Andreas fault zone. The southern trace has been referred to as the South Branch San Andreas fault by Dibblee (1967 #1345; 1981 #4840) and Jennings (1994 #2878); Matti and others (1992 #5735) refer to this trace as the Coachella Valley segment, Banning fault. This branch will be referred to as the South Branch San Andreas fault (Banning strand) in this compilation. The northern trace is referred to as the North Branch San Andreas

fault by Dibblee (1967 #1345; 1981 #4840) and Jennings (1994 #2878); Mission Creek fault by Allen (1957 #4787); Matti and others (1992 #5735) named this trace the Coachella Valley segment, San Andreas fault and will be referred to as the North Branch San Andreas fault (Coachella strand) in this compilation. Refer to Matti and others (1992 #5735) for a detailed discussion of San Andreas fault nomenclature for the Mojave [1h], San Bernardino [1i], and Coachella [1j] sections. Weldon and Sieh (1985 #5806) reported a Holocene slip rate of 24 ± 4 mm/yr at the northern end of the San Bernardino Mountains section [1i]. Harden and Matti (1989 #4955) reported a preferred Holocene slip rate of 14 mm/yr to 25 mm/yr near Yucaipa along the San Andreas fault (South Branch). Keller and others (1982 #4964) reported a preferred late Quaternary slip rate of 23 mm/yr to 35 mm/yr for the Coachella section [1j] near Biskra Palms. Surface-exposure age constraints (10Be-26Al) of the offset alluvial fan complex at Biskra Palms yields a better constrained late Quaternary dextral slip rate of 23.3 ± 3.5 mm/yr (van der Woerd and others, 2001 #5800). Several average values of recurrence have been reported for the fault zone; in general they range from a little more than 100 to as much as 450 yr. The North Coast section [1b] ranges from 180–260 yr (Niemi and Hall, 1992 #5747) to 200 ± 400 yr for the past 2 k.y. (Prentice, 1989 #5754). The Santa Cruz Mountains section [1d] is 247–266 yr (Schwartz and others, 1998 #5771) and the Cholame-Carrizo section [1g] is 160–450 yr (Sieh and Jahns, 1984 #5778; Grant and Sieh, 1994 #4950; Sims, 1994 #5787; Stone and others, 2002 #5792). Recurrence intervals for the Mojave section [1h] are well-constrained based on paleoseismic studies by Sieh and others (1989 #5779), Biasi and others (2002 #5724) and Fumal and others (1993 #624; 2002 #5725). Sieh and others (1989 #5779) reported an average recurrence interval of 132 yr for the time interval AD 734 to 1857 at Pallett Creek, whereas Biasi and others (2002 #5724) refined the average recurrence interval at 135 yr. Fumal and others (2002 #5725) reported an average recurrence interval of 105 yr for the past 500 yr at Wrightwood. An average recurrence interval of 150–275 yr has been reported for the northern San Bernardino Mountains section by Weldon and Sieh (1985 #5806), Seitz and Weldon (1994 #5772), and Yule and others (2001 #4948). The Coachella section [1j] averages large earthquakes about 207–233 yr based on Sieh (1986 #5777).

Sections: This fault has 10 sections. From north to south they are the Shelter Cove [1a], North Coast [1b], Peninsula [1c], Santa

Cruz Mountains [1d], Creeping [1e], Parkfield [1f], Cholame-Carrizo [1g], Mojave [1h], San Bernardino Mountains [1i], and Coachella [1j] sections. Different behavior patterns along different parts of the San Andreas fault were first noticed when Steinbrugge and Zacher (1960 #5791) documented creep along the fault in central California. Since that time, other workers have proposed various segmentation models for the San Andreas fault including five segments by Allen (1968 #4788), eight segments by Wallace (1970 #1423), 12 segments by Sykes and Nishenko (1984 #5794), Petersen and others (1996 #4860), the Working Group on California Earthquake Probabilities (1988 #5494; 1995 #4945; 1999 #4946), and the Working Group on Northern California Earthquake Probabilities (1996 #1216). Some segment boundaries are well documented or constrained for the San Andreas fault zone, whereas others are not. For this compilation, boundaries generally are similar to those described in models adopted by the Working Group on California Earthquake Probabilities (1988 #5494; 1990 #549; 1995 #4945; 1999 #4946), the Working Group on Northern California Earthquake Probabilities (1996 #1216), and Petersen and others (1996 #4860).

**Name
comments**

General: Traces of the San Andreas fault were first mapped in northern California by Lawson (1893 #4967) and were first named the San Andreas rift by Lawson (1895 #4968) after the type locality of the fault in the San Andreas Valley (San Mateo County, California). North of San Francisco, Anderson (1899 #4789) mapped traces of the fault on the Point Reyes Peninsula, but did not name the fault. Schuyler (1896–1897 #5769) described parts of the fault zone in southern California for a 200-mi (about 320-km) length through Kern, Los Angeles, and San Bernardino Counties and referred to the fault not as the San Andreas but as the "great earthquake crack", referring to surface fault ruptures associated with the 1857 Fort Tejon earthquake. The significance and extent of the San Andreas fault was not recognized until after the 1906 San Francisco earthquake. J.C. Branner and S. Tabor proposed the name Portola-Tomales for the fault zone, but A.C. Lawson (1908 #4969) preferred the term "San Andreas fault" (Hill, 1981 #4958). For this compilation, we use San Andreas fault zone owing to the complex nature and multiple strands (or faults) that comprise the structure.

Section: The Parkfield section extends from north of Parkfield in the vicinity of Middle Mountain southeast to the southern end of Cholame Valley near Highway 46. Since 1857, this 35-km-long

section has been the location of several moderate-magnitude earthquakes with recurrence intervals averaging 22 yr (Bakun and Lundh, 1985 #4792). Topozada and others (2002 #5797), however, provide a more complete historical record of M 5.5 to 6.5 earthquakes within 10-80 km of Parkfield, suggesting that the pattern of historical moderate magnitude earthquakes in the Parkfield region does not fit the pattern of repeatable characteristic earthquakes. The extent of the Parkfield section is coincident with the extent of surface fault rupture associated with the June 1966 Parkfield earthquake (Brown and others, 1967 #1328; Lienkaemper and Brown, 1986 #4970). The southern boundary with the Cholame-Carrizo section [1g] is characterized by an approximately 1-km-wide right-releasing step-over, the termination of the 1966 Parkfield earthquake surface rupture, and the termination of surface fault creep. The Parkfield section is transitional between the Creeping section [1e] to the northwest and the locked part of the San Andreas fault (Cholame-Carrizo section [1g]) to the southeast.

Fault ID: Refers to Jennings (1994 #2878) numbers 87 (San Andreas fault (SAF) Shelter Cove), 116 (SAF splays), 119 (SAF Fort Ross to Manchester), 145 (SAF offshore), 147 (SAF offshore Bolinas), 162 (SAF boundary faults), 194 (SAF San Francisco to Watsonville), 217 (SAF 1989 ground fractures), 234 (SAF San Juan Bautista to Priest Valley), 240 (SAF historic creep), 278 (SAF Priest Valley to Cuyama), 311 (SAF Cuyama to Palmdale), 358 (SAF Palmdale to Cajon Canyon), 360 (SAF 1812 rupture), 427 (Mill Creek), 427A (SAF Cajon Canyon to Burro Flats), 452 (SAF South Branch), 453 (SAF North Branch), 472 (SAF Indio to Salton Sea), 477 (SAF Bombay Beach and vicinity), 452 (SAF South Branch), 449 (Banning fault western part), and 450 (Mission Creek fault), and numbers A1 (SAF 1906 rupture), A2 (SAF Peninsula), A3 (SAF Santa Cruz Mountains), and A7 (SAF creeping section) of the Working Group on Northern California Earthquake potential (1996 #1216).

County(s) and State(s)

SAN LUIS OBISPO COUNTY, CALIFORNIA
MONTEREY COUNTY, CALIFORNIA

Physiographic province(s)

PACIFIC BORDER

Reliability of location

Good
Compiled at 1:62,500 scale.

Comments: Location based on digital revisions to Jennings (1994

#2878) 1:750,000-scale map using original mapping by Manson (1985 #5732), Sims (1988 #5784; 1990 #5785), and Sims and Hamilton (1991 #5788) at 1:24,000 scale and mapping by Brown (1970 #485) and Dibblee (1971 #4823; 1974 #4830) at 1:62,500 scale.

Geologic setting

The San Andreas fault zone is a major dextral strike-slip fault zone that extends for about 1,100 km along the western side of California. It is near the coast in northern California, but stays entirely inland to the south of San Francisco, extending all the way to the northern Gulf of California in Mexico. The San Andreas fault zone is the principal element of a network of dextral strike-slip faults that constitute the San Andreas fault system that collectively accommodates the majority of relative N-S motion between the Pacific and North American plates (Wallace, 1990 #5804). Wilson (1965 #4947) first proposed that the San Andreas fault was a transform fault connecting two spreading oceanic ridges between the Pacific and North American plates. The San Andreas fault zone extends from the Salton Trough near Bombay Beach northwest to its complex junction with the Mendocino fault zone [18] near Punta Gorda. At the southern end of the fault zone near Bombay Beach, dextral slip is transferred to the Imperial fault [132] along a right-releasing step-over delineated by a zone of seismicity referred to as the Brawley Seismic Zone [124]. The San Andreas fault traverses the length of the Coast Ranges geomorphic subprovince and forms the boundary between the Transverse Range and Mojave Desert geomorphic subprovinces as well as the boundary between the Salton Trough and Mojave Desert geomorphic subprovinces. Noble (1926 #1592) was the first to suggest a large amount of dextral slip (38 km) on the San Andreas fault. Hill and Dibblee (1953 #923) postulated that as much as 560 km of dextral slip has occurred on the basis of proposed correlation of Mesozoic basement rocks. Post-early Miocene cumulative dextral slip is approximately 315 km, based on correlation of the Neenach Volcanic Formation (22.5–24.1 Ma minimum K-Ar age reported in Sims, 1993 #5786) on the east side of the fault zone with early Miocene Pinnacles Formation (24.2±0.5 Ma average K-Ar age reported in Sims, 1993 #5786) on the west side of the fault (Matthews, 1976 #931). Stanley (1987 #5790) reported 325–330 km of post late Oligocene dextral slip and 320–325 km of post-early Miocene dextral slip. Further discussions of the displacement history the San Andreas fault zone are included in Powell (1993 #5753), Weldon and others (1993 #5807), and Matti

	and Morton (1993 #5737).
Length (km)	This section is 32 km of a total fault length of 1082 km.
Average strike	
Sense of movement	<p>Right lateral</p> <p><i>Comments:</i> Well-defined geomorphic expression of dextral strike-slip faulting (Brown, 1970 #485; Manson, 1985 #5732), dextral displacement associated with 1966 Parkfield earthquake (Brown and others, 1967 #1328; Lienkaemper and Brown, 1986 #4970), dextral displacement associated with surface fault creep (Burford and Harsh, 1980 #4806; Lisowski and Prescott, 1981 #5730; Schulz and others, 1982 #5768), and abundant microseismicity (Hill and others, 1990 #4957).</p>
Dip Direction	<p>V</p> <p><i>Comments:</i> Vertical dip based on linear geomorphic expression of fault; vertical to near vertical fault zone expressed in trench exposures by Sims (1987 #5783). Well-defined seismicity shows vertical fault zone at depth (Hill and others, 1990 #4957).</p>
Paleoseismology studies	<p>Cholame Valley site (1-13). Studies by Sims (1987 #5783) involved the excavation of about 200 m of fault normal and fault parallel trenches across the historically active fault trace in southern Cholame Valley. The Cholame Valley site is located about 1 km south of a 1-km-wide right-releasing step in the fault. Trenches were excavated in a dextrally displaced alluvial fan in order to determine a late Holocene slip rate.</p>
Geomorphic expression	<p>The Parkfield section is delineated by geomorphic features characteristic of Holocene dextral offset such as dextrally deflected and offset drainages, dextrally offset ridges, linear drainages, side-hill benches, closed depressions, linear scarps on alluvium, linear troughs, beheaded drainages, and linear vegetation contrasts (Brown, 1970 #485; Manson, 1985 #5732).</p>
Age of faulted surficial deposits	<p>Faulted late Holocene alluvial fan deposits were identified in the southern part of Cholame Valley by Sims (1987 #5783). AMS 14C dating of detrital charcoal contained in this alluvial fan unit indicates an age of 1,772±143 cal yr BP.</p>
Historic	

earthquake	
Most recent prehistoric deformation	<p>latest Quaternary (<15 ka)</p> <p><i>Comments:</i> The timing of the most recent paleoearthquake has not been determined. Sims (1987 #5783) reported that a faulted alluvial-fan deposit has an AMS radiocarbon date of 1,772 cal yr BP.</p>
Recurrence interval	<p><i>Comments:</i> A geologic recurrence interval has not been determined for the Parkfield section of the San Andreas fault. Historical seismicity since 1857 suggests that moderate magnitude earthquakes occur along the Parkfield section about every 22 yr on average (Bakun and Lundh, 1985 #4792). The most recent surface rupture event occurred June 1966 (the Parkfield earthquake), indicating 40 yr of quiescence since the most recent event. Topozada and others (2002 #5797), however, provide a more complete historical record of M5.5–6.5 earthquakes within 10–80 km of Parkfield, suggesting that the pattern of historical moderate magnitude earthquakes in the Parkfield region does not fit the pattern of repeatable characteristic earthquakes.</p>
Slip-rate category	<p>Greater than 5.0 mm/yr</p> <p><i>Comments:</i> Sims (1987 #5783) reported a late Holocene slip rate of 26.3 mm/yr (+3.9 mm/yr, -3.3 mm/yr) for the Cholame Valley site. This slip rate is based on 46.6±2.6 m dextral offset of a distinctive gravel, sand, and slit unit. This unit contains detrital charcoal that has a radiocarbon date of 1,772±143 yr BP. The slip rate is considered a minimum because displacement may be distributed across the right-releasing bend, or additional slip may be accommodated along other parallel faults in the areas, such as the White Canyon fault (number 260 of Jennings, 1994 #2878).</p>
Date and Compiler(s)	<p>2002</p> <p>William A. Bryant, California Geological Survey Matthew Lundberg, California Geological Survey</p>
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