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San Andreas fault zone, San Bernardino Mountains section (Class A) No. 1i

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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 (Toppozada 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 where 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 San Bernardino Mountains section extends from a few kilometers northwest of Cajon Creek southeast to the area between Thousand Palms and Myoma. This section was

originally designated as the San Bernardino Mountains segment by the Working Group on California Earthquake Probabilities (1988 #5494; 1995 #4945) and was adopted by Petersen and others (1996 #4860). The San Bernardino Mountains section is characterized by a large left-restraining step between the Mojave section [1h] to the northwest and the Coachella section [1j] to the southeast. The San Andreas fault zone is very complex in this restraining step, consisting of dextral strike-slip, thrust, and oblique slip faults. Allen (1957 #4787) reported that various structural complications in the San Gorgonio Pass area make continuity of a through-going dextral fault doubtful. The principal late Quaternary and Holocene faults comprising the San Bernardino Mountains section include the San Andreas fault (South Branch), Mill Creek fault (also named North Branch San Andreas fault), Mission Creek fault, Garnet Hill fault (Allen, 1957 #4787; Hope, 1969 #4960), Gandy Ranch fault (Allen, 1954 #4786; 1957 #4787), and Banning fault (Vaughn, 1922 #5801; Hill, 1928 #4959; Allen, 1957 #4787; Matti and others, 1992 #5735). Matti and Morton (1982 #5733) further divided the Banning fault into the Banning Strand A and Banning Strand B. The San Jacinto fault zone [125] branches from the San Andreas fault zone in the vicinity of Cajon Pass. The north-dipping San Gorgonio Pass fault zone [250] is located in this left-restraining bend, but is be considered separately for this compilation. 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) called 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. Matti and others (1992 #5735) have a detailed discussion of San Andreas fault nomenclature for the Mojave [1h], San Bernardino [1i], and Coachella [1j] sections. **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 BERNARDINO COUNTY, CALIFORNIA RIVERSIDE COUNTY, CALIFORNIA
Physiographic province(s)	PACIFIC BORDER BASIN AND RANGE
Reliability of location	Good Compiled at 1:62,500 scale. *Comments:* Location based on digital revisions to Jennings (1994 #2878) 1:750,00-scale map using original mapping by Hope (1969 #4960), Matti and others (1982 #5734; 1992 #5736), Miller (1979 #5742), Morton (1978 #5743), Morton and Matti (1991 #5744), and Treiman (1994 #5798) at 1:24,000; mapping by Dibblee (1964 #1340, 1965 #4816, 1974 #6605, 1981 #4839, 1981 #4840) at 1:62,500 scale; and mapping by Allen (1957 #4787) at 1: 63,360 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 128 km of a total fault length of 1082 km.
Average strike	N79°W

Sense of movement	Right lateral *Comments:* The northwest and southeastern ends of the San Bernardino Mountains section are characterized by dextral strike-slip displacement. Faults in the San Gorgonio Pass area strike more east-west, resulting in significant compressional (N-S) slip. Traces of the Banning fault in the San Gorgonio Pass area are characterized by high-angle strike-slip (Banning Strand A) and north-dipping reverse displacement (Banning Strand B) (Matti and others, 1992 #5735; Treiman, 1994 #5798). East of San Gorgonio Pass, the North Branch San Andreas fault (Coachella strand) and South Branch San Andreas fault (Banning strand) are the principal strike-slip faults of the San Andreas fault zone.
Dip	90–35° N. *Comments:* Steeply dipping to vertical strike-slip faults include the San Andreas fault (South Branch), Banning fault east and west of San Gorgonio Pass, Gandy Ranch, and Garnet Hill faults (Matti and others, 1992 #5735; Treiman, 1994 #5798). The Banning fault in San Gorgonio Pass dips between 35? and 65? N. (Allen, 1957 #4787; Rasmussen and Associates, 1990 #5762; Sieh and Matti, 1992 #5781). Reverse and thrust faults in the San Gorgonio Pass area (Banning fault) dip to the north (Allen, 1957 #4787; Matti and others, 1992 #5735; Treiman, 1994 #5798).
Paleoseismology studies	There are eight detailed study sites along the San Bernardino Mountains section. In addition, there are over 180 site-specific fault rupture hazard investigations along the section involving trenching done in compliance with the Alquist-Priolo Earthquake Fault Zoning Act of 1972 (Hart and Bryant, 1997 #4856). Lost Lake site (1-10). Weldon and Sieh (1985 #5806) excavated one fault-normal trench across traces of the San Andreas fault (South Branch) at the southeast end of Lost Lake near Cajon Pass. The trench exposed late Holocene colluvium, peat, lacustrine clay, and fluvial sediments. Detailed mapping and radiocarbon dating of Cajon Creek and Lone Pine Creek terrace deposits provided evidence allowing construction of late Holocene fluvial history and dextral slip measurements resulting in estimation of late Holocene slip rates. A total of 14 radiocarbon ages from peat, fluvial terrace, and lacustrine deposits provided age control in order to determine Holocene slip rates and recurrence intervals for large earthquakes on the San Bernardino Mountains section.

Weldon and Sieh concluded that rupture associated with the 1857 Fort Tejon earthquake did not extend as far south as Cajon Creek.

Wilson Creek site (1-19). Studies by Harden and Matti (1989 #4955) combined detailed geologic mapping and assessments of soil-profile development to estimate Holocene and late Quaternary slip rates for the San Andreas fault (South Branch) at the Wilson Creek site near Yucaipa. Wilson Creek drains an area containing distinctive red-purple sedimentary rocks of the Miocene (?) Potato Sandstone. These sedimentary clasts were deposited in alluvial fans that cross the San Andreas fault. Harden and Matti described 16 soil profiles on these dextrally offset alluvial fans and estimated ages by comparing them with dated soils from Cajon Pass (Weldon and Sieh, 1985 #5806) and the Central Valley of California using a statistical method of maximum likelihood.

Pitman Canyon site (1-29). Studies by Seitz and Weldon (1994 #5772) and Seitz and others (1997 #5773) involved the excavation of 10 trenches (both fault normal and fault parallel) at Pitman Canyon. The Pitman Canyon site is characterized by 2 strands of the San Andreas fault, the Mill Creek fault and San Andreas fault (South Branch). The San Andreas fault (South Branch) is the principal active trace of the San Andreas fault zone and is delineated here by a downhill-facing scarp, shutter ridge, and groundwater barrier. Trenches exposed late Holocene debris flow and fluvial deposits interbedded with peat layers. Evidence of seven and possibly eight earthquakes during the past 1,150 yr was reported. Event horizons were delineated by fissure fills, upward termination of faults, folding, and incremental down-section increases in separation. About 4 m of dextral slip occurred in each of the past two earthquakes.

City Creek site (1-30). Sieh and others (1994 #5782) identified a suite of fluvial terraces that are dextrally offset by the Mill Creek fault at City Creek. Ages of terrace surfaces were approximated using soil profile development and dextral displacement was measured in order to constrain the late Quaternary slip rate of the Mill Creek fault.

City Creek site (1-36). McGill and others (1998 #5739) excavated a trench across the San Andreas fault (South Branch) within the flood control channel of City Creek. One event horizon was stratigraphically bracketed by fluvial deposits containing detrital charcoal dated at ASD 1020–1260. Because the dated samples were detrital, it is not known to what extent they may overestimate the time of deposition of the layers. Older faulting events may also have been represented within the trench, but the evidence was less clear. There were no visible faults that ruptured higher in the stratigraphic section. However, fault scarps visible on air photos project into a portion of the trench in which massive, bouldery alluvium has filled a large channel that incised into the faulted fluvial deposits that were found farther south in the trench. Thus, the one event horizon that was documented probably was on a secondary splay of the fault zone. Given the dates of prehistoric earthquakes at other sites along the San Bernardino Mountains section, it seems likely that younger events must have occurred on the main strand of the fault, but that the evidence for those younger events was destroyed when the bouldery channel was incised. Alternatively, faults may be present but not visible within the massive, bouldery channel fill.

Plunge Creek site (1-37). Studies by McGill and others (1998 #5739; 2002 #5741) and Dergham and McGill (2000 #4815) included several trenches across traces of the San Andreas fault (South Branch) at the Plunge Creek site. In some trenches the fault juxtaposed early Holocene and latest Pleistocene alluvium and colluvium on the northeast side against late Holocene alluvium on the southwest side. In other trenches the fault zone was located entirely within late Holocene deposits. In all cases, the fault strands were found several to a few tens of meters southwest of the topographic break in slope at the mountain front. McGill and others (1998 #5739) examined five trench logs prepared by Suitt (1992 #5793) in compliance with the Alquist-Priolo Earthquake Fault Zoning Act of 1972, and found relationships suggestive of between two and five faulting events since AD 900–1215. They also excavated or re-excavated five trenches of their own, in which the timing of the most recent earthquake was bracketed by sedimentary layers containing detrital charcoal dating to AD 1510–1730 (dendro-calibrated). They did not find evidence for an the 1812 earthquake or one about AD 1700, although these younger events (especially the AD 1700 event) cannot be conclusively ruled out because the only age control is from radiocarbon dates on detrital charcoal, which could overestimate the ages of the layers from which the samples were collected. Weak evidence for at least one and possibly more older events since AD 1220 was found in two of the trenches.
City Creek site (1-41). McGill and others (1999 #5740) trenched

	across the Mill Creek fault about 1.6 km west of City Creek. Within the trench, latest Pleistocene sediments on the north side of the fault were juxtaposed against a subsurface ridge of severely fractured plutonic and metamorphic basement rock on the south side, along a 10- to 60-cm-wide zone of fault gouge. The zone of gouge strikes N. 78° W., dips 60–70° N. and extends up to the ground surface. A second fault zone was also found about 20 m farther north, with a strike of N. 73° W. and an apparent dip of 77° SW. Stratigraphic and structural relationships exposed in the trench imply that multiple earthquakes have occurred on the Mill Creek fault. Radiocarbon dates on detrital charcoal indicate that the fault has been active within the past 14,160±80 14C yr BP. No deposits of known Holocene age were encountered in the trench. Burro Flats site (1-43). Yule and others (2001 #4948) excavated 10 trenches across the San Andreas fault (South Branch) at the Burro Flats site. A 7.5-m-thick section of well stratified distal-fan, pond, peat, and peaty-soil deposits were exposed. Trenches exposed two fault zones and associated folding that provide evidence of four rupture events and perhaps three additional events. AMS radiocarbon dates of the exposed stratigraphic section range from AD 1900 near the top to 1600 BC at 1 m above the base.
Geomorphic expression	The San Andreas fault (South Branch) is delineated by well-defined geomorphic features indicative of Holocene active dextral slip, including dextrally deflected drainages, shutter ridges, linear ridges, linear scarps and vegetation contrasts on Holocene alluvium, linear troughs, closed depressions, and sidehill benches (Hope, 1969 #4960; Treiman, 1994 #5798). Reverse and thrust faults in the San Gorgonio Pass area are delineated by sinuous scarps on late Pleistocene and Holocene alluvial fans, faceted spurs, and vertically offset and deflected drainages (Treiman, 1994 #5798). Scarp-slope angles range from 11? to 25? (Treiman, 1994 #5798). Compound scarp slopes along some traces of the Banning fault (Banning Stand B) indicate multiple Holocene events (Treiman, 1994 #5798). Geomorphic evidence of Holocene dextral offset is less obvious for the Mill Creek fault (Matti and others, 1992 #5735).
Age of faulted surficial deposits	Weldon and Sieh (1985 #5806) reported that Holocene colluvium, peat, lacustrine clay, and fluvial deposits are offset. Ages of faulted deposits at the Lost Lake site in the Cajon Creek area range in age from 8,150±550 yr BP to 580±80 yr BP based on

	dendro-corrected radiocarbon dates. Faulted peat deposits at the Pitman Canyon site range in age from 1,170±60 yr BP to 200±50 yr BP (corrected ages) (Seitz and Weldon, 1994 #5772). Faulted deposits at the Plunge Creek site range in age from AD 900–1640 (dendro-corrected ages of detrital charcoal) (McGill and others, 1998 #5739; Dergham and McGill, 2000 #4815; 2002 #5741).
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* The 1812 (unnamed) earthquake is the most recent event on the northern part of the San Bernardino Mountains section of the San Andreas fault (Weldon and Sieh, 1985 #5806; Jacoby and others, 1987 #4961; 1988 #4962). The penultimate event recognized at the Pitman Canyon site occurred between AD 1649 and AD 1753 (Seitz and Weldon, 1994 #5772). McGill and others (1998 #5739; 2002 #5741) reported that the most recent event recognized at the Plunge Creek site occurred between AD 1510 and AD 1730, and preferred a date of AD 1630. McGill and others (2002 #5741) did not find evidence for either the AD 1812 or 1700 event, although it is not known to what extent the detrital charcoal might overestimate the depositional ages of the layers that bracket the youngest event at Plunge Creek. Yule and others (2001 #4948) identified the most recent paleoevent (their event I) at the Burro Flats site as occurring between AD 1650–1850. Yule and others (2001 #4948) reported that the timing constraints for event I currently are not sufficient to correlate with either the AD 1680 event or the 1812 event.
Recurrence interval	150–275 yr (<1 k.y.) *Comments:* Weldon and Sieh (1985 #5806) reported an average late Holocene recurrence interval of about 150 to 200 yr at the Cajon Creek site. They recognized two and as many as four earthquakes between AD 1290 and AD 1805 and perhaps as many as six events in the past 1 k.y. Seitz and Weldon (1994 #5772) reported an average late Holocene recurrence interval of about 147 yr at the Pitman Canyon site. Seitz and Weldon reported that seven and as many as eight events occurred in the past 1,150 yr based on radiocarbon dates of offset fluvial and peat deposits exposed at the Pitman Canyon site. They inferred that the most recent event recorded at Pitman Canyon was the 1812 earthquake. Earlier events identified at the Pitman Canyon site include: Event

	2: AD 1649–1753 Event 3: AD 1495–1530 Event 4: AD 1490–1502 Event 5: AD 1267–1326 Event 6: AD 1099–1171 Yule and others (2001 #4948) identified five events at the Burro Flat site. Preliminary event chronology based on 36 AMS radiocarbon dates from 16 different peat layers suggest irregular recurrences of between 100 and 475 yr, with an average recurrence interval of about 275 yr. At the Plunge Creek site, McGill and others (2002 #5741) observed evidence for a surface-rupturing earthquake that occurred between AD 1510 and AD 1730 and an event (event R), which postdates AD 1220, with a preferred date of about AD 1450. McGill and others (2002 #5741) suggest that their event R probably correlates with event 4 (AD 1490–1502) at the Pitman Canyon site.
Slip-rate category	Greater than 5.0 mm/yr *Comments:* Weldon and Sieh (1985 #5806) mapped and correlated dextrally offset terraces in Cajon Creek and Lone Pine Creek (Lost Lake site) using radiocarbon dates on detrital charcoal, and fluvial history reconstruction to calculate slip rates for the northern San Bernardino Mountains section. The longest-term slip rate is based on 350±30 m dextral offset of the eastern channel edge of Cajon Creek (channel in which Qoa-c unit was deposited). Weldon and Sieh's interpretation of the fluvial history of Cajon Creek indicates that Cajon Creek aggraded above its current level at the San Andreas fault at 14±1 ka, preserving the channel edge. The post-14 ka slip rate calculated from these data is 24±4 mm/yr. Post Qoa-c incised streams are dextrally deflected about 300 m. Three stream channels that constitute Prospect Creek, just southeast of Cajon Creek, are dextrally deflected 290±10 m. Weldon and Sieh suggested that the deflections at Prospect Creek can be correlated with the post Qoa-c stream incision, which they show to be sometime after 12.4±1 ka. This age is based on the rate of fill indicated by dendro-corrected radiocarbon ages of samples CC-3 and CC-4, extrapolated to the surface of Qoa-c. The post-12 ka slip rate calculated from these data is 23 mm/yr (+5 mm/yr, -2 mm/yr) based on the dextrally deflected drainages at Prospect Creek divided by the estimated age of the incision of fluvial unit Qoa-c. Weldon and Sieh calculated a mid to late Holocene slip rate of 25 mm/yr (+6 mm/yr, -4 mm/yr) based on a 145±5 m dextral offset of the inner channel of Pink River and dextral offset of their Qt-r terrace riser on the northwest side of Cajon Creek. Timing of the displacement is indicated by the change in character of lake clay deposits in Lost Lake at 5.9±0.9 ka. Rasmussen (1982 #5761) reported a slip

	rate of 25 mm/yr for the San Andreas fault (South Branch). The rate is based on offsets (amounts not reported) of Elder Gulch and Bledsoe Gulch that are incised into Pleistocene alluvial-fan deposits. The ages are crude estimates based on clast weathering and clay enrichment of the soil horizon. Rasmussen considered the age estimates to be minimum values and, thus, the reported slip rate a maximum rate. Seitz and Weldon (1994 #5772) reported an estimated late Holocene slip rate of about 24 mm/yr for the Pitman Canyon site by assuming that a total of 7-8 m of dextral slip occurred AD 1665–1812. The amount of dextral slip was estimated form apparent vertical separation, accounting for a minor reverse-slip component, and a consistent dip component of bedding. Sieh and others (1994 #5782) reported a preferred late Quaternary slip rate of 2.1±0.5 mm/yr for the Mill Creek fault (North Branch San Andreas fault) at City Creek. Sieh and others identified a suite of fluvial terraces that are dextrally offset along the Mill Creek fault (North Branch San Andreas fault). Ages of terraces were approximated using soil profile development. Harden and Matti's (1989 #4955) best estimates for slip rates along the San Andreas fault (South Branch) at Yucaipa site range from 14 to 25 mm/yr for the past 14 k.y., 22 mm/yr for the past 30 k.y., and 12–16 mm/yr for the past 90 k.y. Their preferred maximum slip rate for the past 14 k.y. is 35 mm/yr, although the data allow a maximum slip rate of 63 mm/yr for the past 90 ka. Harden and Matti (1989 #4955) estimated long-term late Pleistocene to Holocene slip rates near Yucaipa by restoring the dextrally offset medial axis of Wilson Creek alluvial fans. Maximum displacements were also obtained by restoring the westernmost extent of each of the dextrally displaced Wilson Creek alluvial fans. Timing of displacement was constrained by comparing soil profile development of offset alluvial fan surfaces with dated soils from Cajon Pass and the Central Valley of California. They used a statistical method of maximum likelihood and Monte Carlo simulations of larger data populations to account for soil variability, uncertainty of calibration dates, and the limited number of soils sampled and described. Harden and Matti mapped and estimated ages for three displaced alluvial fans (Qyf1, 11–35 ka; Qof2, 14≠49 ka; Qof1, 20–130 ka). Estimated dextral slip is 250–350 m for Qyf1, 670 m for Qof2, and 1,040 m for Qof1.
Date and Compiler(s)	2002 William A. Bryant, California Geological Survey Matthew Lundberg, California Geological Survey
References	#4786 Allen, C.R., 1954, The San Andreas fault zone in San

Gorgonio Pass, California: Pasadena, California Institute of Technology, unpublished Ph.D. dissertation, 147 p.

#4787 Allen, C.R., 1957, San Andreas fault zone in San Gorgonio Pass, southern California: Geological Society of America Bulletin, v. 68, no. 3, p. 315-350.

#4788 Allen, C.R., 1968, The tectonic environments of seismically active and inactive areas along the San Andreas fault system, *in* Dickinson, W.R., and Grantz, A., eds., Proceedings of conference on geologic problems of San Andreas fault system: Palo Alto, California, Stanford University Publications, Geological Sciences, v. XI, p. 70-82.

#4789 Anderson, F.M., 1899, The geology of Point Reyes Peninsula: Berkeley, California, University of California Publications in Geological Sciences, v. 2, p. 119-153.

#5577 Bailey, R.A., 1989, Geologic map of the Long Valley caldera, Mono-Inyo craters volcanic chain and vicinity, eastern California: U.S. Geological Survey Miscellaneous Investigations Series Map I-1933, scale 1:62,500.

#4790 Bakun, W.H., 1999, Seismic activity of the San Francisco Bay region: Bulletin of the Seismological Society of America, v. 89, no. 3, p. 764-784.

#5724 Biasi, G.P., Weldon, R.J., II, Fumal, T.E., and Seitz, G.G., 2002, Paleoseismic event dating and the conditional probability of large earthquakes on the southern San Andreas fault, California: Bulletin of the Seismological Society of America, Special Issue on Paleoseismology of the San Andreas Fault System, v. 92, no. 7, p. 2761-2781.

#4806 Burford, R.O., and Harsh, P.W., 1980, Slip on the San Andreas fault in central California from alignment array surveys: Bulletin of the Seismological Society of America, v. 70, no. 4, p. 1233-1261.

#4814 Davis, T.L., and Duebendorfer, E., 1987, Strip map of the San Andreas fault, western Big Bend segment: Geological Society of America Map and Chart Series MC-60, 6 p. pamphlet, 2 sheets, scale 1:31,682.

#4815 Dergham, S.A., and McGill, S.F., 2000, Paleoseismic investigation of the San Andreas fault at Plunge Creek, near San Bernardino, California—Four to five centuries of strain accumulation since the most recent earthquake: Geological Society of America Abstracts with Programs, p. A-10.

#1340 Dibblee, T.W., Jr., 1964, Geologic map of the San Gorgonio Mountain quadrangle San Bernardino and Riverside Counties, California: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-431, 3 p. pamphlet, 1 sheet, scale 1:62,500.

#1345 Dibblee, T.W., Jr., 1967, Geologic map of the Morongo Valley quadrangle San Bernardino and Riverside Counties, California: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-517, 4 p. pamphlet, 1 sheet, scale 1:62,500.

#4817 Dibblee, T.W., Jr., 1968, Displacements on the San Andreas fault system in San Gabriel, San Bernardino, and San Jacinto Mountains, southern California, *in* Dickinson, W.R., and Grantz, A., eds., Proceedings of conference on geologic problems of San Andreas fault system: Palo Alto, California, Stanford University Publications in Geological Sciences, v. XI, p. 269-278.

#6605 Dibblee, T.W., Jr., 1974, Geologic map of the Lake Arrowhead quadrangle, San Bernardino County, California: U.S. Geological Survey Open-File Report 73-56, scale 1:62,500.

#4839 Dibblee, T.W., Jr., 1981, Geologic map of the Banning (15 minute) quadrangle, California: South Coast Geological Society, Geologic Map SCGS-2, scale 1:62,500.

#4840 Dibblee, T.W., Jr., 1981, Geologic map of the Palm Springs (15 minute) quadrangle, California: South Coast Geological Society, Geologic Map SCGS-3, scale 1:62,500.

#4841 Dibblee, T.W., Jr., 1982, Geology of the San Bernardino Mountains, southern California, *in* Fife, D.L., and Minch, J.A., eds., Geology and mineral wealth of the California Transverse Ranges—Mason Hill Volume: South Coast Geological Society Guidebook 10, p. 148-169.

#5726 Fumal, T.E., Rymer, M.J., and Seitz, G.G., 2002, Timing of large earthquakes since A.D. 800 on the Mission Creek strand of the San Andreas fault zone at Thousand Palms Oasis, near Palm Springs, California: Bulletin of the Seismological Society of America, Special Issue on Paleoseismology of the San Andreas Fault System, v. 92, no. 7, p. 2841-2860.

#5725 Fumal, T.E., Weldon, R.J., II, Biasi, G.P., Dawson, T.E., Seitz, G.G., Frost, W.T., and Schartz, D.P., 2002, Evidence for large earthquakes on the San Andreas fault at the Wrightwood, California, paleoseismic site—A.D. 500 to present: Bulletin of the Seismological Society of America, Special Issue on Paleoseismology of the San Andreas Fault System, v. 92, no. 7, p. 2726-2760.

#4950 Grant, L.B., and Sieh, K., 1994, Paleoseismic evidence of clustered earthquakes on the San Andreas fault in the Carrizo Plain, California: Journal of Geophysical Research, v. 99, no. B4, p. 6819-6841.

#4954 Hall, N.T., Wright, R.H., and Clahan, K.B., 1999, Paleoseismic studies of the San Francisco Peninsula segment of the San Andreas fault zone near Woodside, California: Journal of Geophysical Research, v. 104, no. B10, p. 23,215-23,236.

#4955 Harden, J.W., and Matti, J.C., 1989, Holocene and late Pleistocene slip rate on the San Andreas fault in Yucaipa, California, using displaced alluvial-fan deposits and soil chronology: Geological Society of America Bulletin, v. 101, p. 1107-1117.

#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.

#4958 Hill, M.L., 1981, San Andreas fault—History of concepts: Geological Society of America Bulletin, v. 92, p. 112-131.

#923 Hill, M.L., and Dibblee, T.W., Jr., 1953, San Andreas, Garlock, and Big Pine faults, California: Geological Society of America Bulletin, v. 64, p. 443–458.

#4959 Hill, R.T., 1928, Southern California geology and Los Angeles earthquakes: Los Angeles, Southern California Academy of Sciences, 232 p.

#4960 Hope, R.A., 1969, Map showing recently active breaks along the San Andreas and related faults between Cajon Pass and Salton Sea: U.S. Geological Survey Open-File Report 69-130, 2 plates, scale 1:24,000, https://pubs.er.usgs.gov/publication/ofr69130.

#4961 Jacoby, G.C., Sheppard, P.R., and Sieh, K.E., 1987, Was the 8 December 1812 California earthquake produced by the San Andreas fault?—Evidence from trees near Wrightwood [abs.]: Seismological Research Letters, v. 58, no. 1, p. 14.

#4962 Jacoby, G.C., Sheppard, P.R., and Sieh, K.E., 1988, Irregular recurrence of large earthquakes along the San Andreas fault—Evidence from trees: Science, v. 241, p. 196-199.

#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.

#4964 Keller, E.A., Bonkowski, M.S., Korsch, R.J., and Shlemon, R.J., 1982, Tectonic geomorphology of the San Andreas fault zone in the southern Indio Hills, Coachella Valley, California: Geological Society of America Bulletin, v. 93, no. 1, p. 46-56.

#4967 Lawson, A.C., 1893, The post-Pliocene diastrophism of the coast of southern California: Berkeley, California, University of California Publications in Geological Sciences, v. 1, p. 115-160.

#4968 Lawson, A.C., 1895, Sketch of the geology of the San Francisco peninsula, California: U.S. Geological Survey Annual Report, v. 15, p. 399-476.

#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.

#931 Matthews, V., III, 1976, Correlation of Pinnacles and Neenach volcanic formations and their bearing on San Andreas fault problem: Bulletin of the American Association of Petroleum Geologists, v. 60, no. 12, p. 2128-2141.

#5733 Matti, J.C., and Morton, D.M., 1982, Geologic history of the Banning fault zone, southern California: Geological Society of America Abstracts with Programs, v. 14, no. 4, p. 184.

#5737 Matti, J.C., and Morton, D.M., 1993, Paleogeographic evolution of the San Andreas fault in southern California—A reconstruction based on a new cross-fault correlation, *in* Powell, R.E., Weldon, R.J., II, and Matti, J.C., ed., The San Andreas fault system—Displacement, palinspastic reconstruction, and geologic evolution: Geological Society of America Memoir 178, p. 107-160.

#5734 Matti, J.C., Cox, B.F., Obi, C.M., Powell, R.E., Hinkle, M.E., and Griscom, A., 1982, Mineral resource potential of the Whitewater Wilderness Study Area, Riverside and San Bernardino Counties, California: U.S. Geological Survey, Miscellaneous Field Studies Map MF-1478-A, scale 1:24,000.

#5735 Matti, J.C., Morton, D.M., and Cox, B.F., 1992, The San Andreas fault system in the vicinity of the central Transverse Ranges province, southern California: U.S. Geological Survey Open-File Report 92-354, 49 p., 2 sheets, scale 1:125,000.

#5736 Matti, J.C., Morton, D.M., Cox, B.F., Carson, S.E., and Yetter, T.J., 1992, Geologic map of the Yucaipa 7.5-minute quadrangle, California: Open-File Report 92-446, 14 p. pamphlet, scale 1:24,000.

#5740 McGill, S.F., Birnhaum, B.B., Reeder, W.R., and Burke, D., 1999, Late Quaternary activity on the North Branch of the San Andreas fault near San Bernardino, California, *in* Cranham, G.T., ed., Water for southern California—Water resources development at the close of the Century: San Diego, San Diego Association of Geologists, p. 31-36.

#5741 McGill, S.F., Dergham, S., Barton, K., Berney-Ficklin, T., Grant, D., Hartling, C., Hobart, K., Minnich, R., Rodriguez, M., Runnerstrom, E., Russell, J., Schmoker, K., Stumfall, M., Townsend, J., and Williams, J., 2002, Paleoseismology of the San Andreas fault at Plunge Creek, near San Bernardino, southern California: Bulletin of the Seismological Society of America, Special Issue on Paleoseismology of the San Andreas Fault System, v. 92, no. 7, p. 2803-2840.

#5739 McGill, S.F., Grant, D., Dergham, S., Suitt, S.C., Meeker, A., and Wells, S.G., 1998, Prehistoric earthquakes on the San Andreas fault, San Bernardino, California [abs.]: Eos, Transactions of the American Geophysical Union, v. 79, no. 45, p. F611.

#5742 Miller, F.K., 1979, Geologic map of the San Bernardino North quadrangle, San Bernardino County, California: U.S. Geological Survey, Open-File Report 79-770, scale 1:24,000.

#5743 Morton, D.M., 1978, Geologic map of the Redlands quadrangle, San Bernardino and Riverside Counties, California: U.S. Geological Survey, Open-File Report 78-021, scale 1:24,000.

#5744 Morton, D.M., and Matti, J.C., 1991, Geologic map of the Devore 7.5-minute quadrangle, San Bernardino County, California: U.S. Geological Survey, Open-File Report 90-695, scale 1:24,000.

#5747 Niemi, T.M., and Hall, N.T., 1992, Late Holocene slip rate and recurrence of great earthquakes on the San Andrea fault in northern California: Geology, v. 20, no. 3, p. 196-198.

#1592 Noble, L.F., 1926, The San Andreas rift and some other active faults in the desert region of southeastern California: Carnegie Institution of Washington Year Book 25, p. 415-428.

#5748 Noller, J.S., Simpson, G.D., and Lightfoot, K., 1996, Paleoseismic and geoarchaeologic investigations of the northern San Andreas fault, Fort Ross, California, *in* National Earthquake Hazards Reduction Program, Summaries of technical reports: U.S. Geological Survey, National Earthquake Hazards Reduction Program External Research Program, Annual Project Summaries, v. 37, http://erp-web.er.usgs.gov/reports/annsum/vol37/nc/g2474.htm.

#4860 Petersen, M.D., Bryant, W.A., Cramer, C.H., Cao, T., Reichle, M.S., Frankel, A.D., Lienkaemper, J.J., McCrory, P.A., and Schwartz, D.P., 1996, Probabilistic seismic hazard assessment for the State of California: California Department of Conservation, Division of Mines and Geology Open-File Report 96-08 (also U.S. Geological Open-File Report 96-706), 33 p.

#5753 Powell, R.E., 1993, Balanced palinspastic reconstruction of pre-late Cenozoic paleogeology, southern California—Geologic and kinematic constraints on evolution of the San Andreas fault system, *in* Powell, R.E., Weldon, R.J., II, and Matti, J.C., ed., The San Andreas Fault System—Displacement, palinspastic reconstruction, and geologic evolution: Geological Society of America Memoir 178, p. 1-106.

#5754 Prentice, C.S., 1989, Earthquake geology of the northern San Andreas fault near Point Arena, California: Pasadena, California Institute of Technology, unpublished Ph.D. dissertation, 252 p.

#5755 Prentice, C.S., 1999, San Andreas fault—1906 earthquake and subsequent evolution of ideas: Geological Society of America Special Paper 338, p. 79-85.

#5762 Rasmussen and Associates, 1990, Engineering geology investigation, tentative tract no. 25141 within the E1/2 of the SE1/4 of section 13, T2S, R2W, SBB&M, Calimesa, California: Project no. 2854, March 6, 1990.

#5761 Rasmussen, G.S., 1982, Geologic features and rate of movement along the south branch of the San Andreas fault, San Bernardino, California, *in* Rasmussen, G.S., ed., Geologic hazards along the San Andreas fault system, San Bernardino-Hemet-Elsinore, California—Field Trip 4 in Cooper, T.D., compiler, Neotectonics in southern California: Geological Society of America , Cordilleran Section, 78th Annual Meeting, Anaheim, California, p. 109-114.

#5769 Schuyler, J.D., 1896-1897, Reservoirs for irrigation: U.S. Geological Survey, 18th Annual Report, part IV, p. 711-712.

#5771 Schwartz, D.P., Pantosti, D., Okumura, K., Powers, T.J., and Hamilton, J.C., 1998, Paleoseismic investigations in the Santa Cruz Mountains, California—Implications for recurrence of large-magnitude earthquakes on the San Andrea fault: Journal of Geophysical Research, v. 103, no. B8, p. 17,985-18,001.

#5772 Seitz, G.G., and Weldon, R.J., II, 1994, The paleoseismology of the southern San Andreas fault at Pitman Canyon, San Bernardino, California, *in* McGill, S.F., and Ross, T.M., eds., Geologic investigations of an active margin: Cordilleran Section Annual Meeting, San Bernardino, California, Field trip guidebook, v. 27, p. 152-156.

#5773 Seitz, G.G., Weldon, R.J., II, and Biasi, G.P., 1997, The Pitman Canyon paleoseismic record—A reevaluation of southern San Andreas segmentation, *in* Hancock, P.L., and Michetti, A.M., eds., Paleoseismology—Understanding past earthquakes using Quaternary geology: Journal of Geodynamics, v. 24, no. 1-4, p. 129-138.

#5775 Sieh, K.E., 1978, Large prehistoric earthquakes produced by slip on the San Andreas fault at Pallet Creek, California: Journal of Geophysical Research, v. 83, no. B8, p. 3907-3939.

#5777 Sieh, K.E., 1986, Slip rate across the San Andreas fault and prehistoric earthquakes at Indio, California [abs.]: Eos, Transactions of the American Geophysical Union, v. 67, no. 55, p. 1200.

#5781 Sieh, K.E., and Matti, J.C., 1992, San Andreas fault system between Palm Springs and Palmdale, Southern California, *in* Sieh, K.E., and Matti, J.C., ed., Earthquake geology, San Andreas fault system, Palm Springs to Palmdale: Association of Engineering Geologists, 35th annual meeting, Southern California section, Guidebook, v. 35, p. 1-12.

#5780 Sieh, K.E., and Williams, P.L., 1990, Behavior of the San Andreas fault during the past 300 years: Journal of Geophysical Research, v. 95, no. B5, p. 6629-6645.

#5782 Sieh, K.E., Grant, L.B., and Freeman, S.T., 1994, Late Quaternary slip rate of the North Branch of the San Andreas fault at City Creek, California: Geological Society of America Abstracts with Programs, v. 26, no. 2, p. 91.

#5779 Sieh, K.E., Stuiver, M., and Brillinger, D., 1989, A more precise chronology of earthquakes produced by the San Andreas fault in southern California: Journal of Geophysical Research, v. 94, no. B1, p. 603-623.

#5786 Sims, J.D., 1993, Chronology of displacement on the San Andreas fault in central California—Evidence from reversed positions of exotic rock bodies near Parkfield, California, *in* Powell, R.E., Weldon, R.J., II, and Matti, J.C., ed., The San Andreas fault system—Displacement, palinspastic reconstruction, and geologic evolution: Geological Society of America Memoir 178, p. 231-256.

#5787 Sims, J.D., 1994, Stream channel offset and abandonment and a 200-year average recurrence interval of earthquakes on the San Andreas fault at Phelan Creek, Carrizo Plain, California, *in* Prentice, C.S., Schwartz, D.P., and Yeats, R.S., ed., Proceedings of the workshop on paleoseismology: U.S. Geological Survey Open-File Report 94-568, p. 170-172.

#5790 Stanley, R.G., 1987, New estimates of displacement along the San Andreas fault in central California based on paleobathymetry and paleogeography: Geology, v. 15, no. 2, p. 171-174.

#5791 Steinbrugge, K.V., and Zacher, E.G., 1960, Creep on the San Andreas fault—Fault creep and property damage: Bulletin of the Seismological Society of America, v. 50, no. 3, p. 389-396.

#5792 Stone, E.M., Grant, L.B., and Arrowsmith, J.R., 2002, Recent rupture history of the San Andreas fault, southwest of Cholame in the northern Carrizo Plain, California: Bulletin of the Seismological Society of America, v. 92, no. 3, p. 983-997.

#5793 Suitt, S.C., 1992, Feasibility-level geological investigation, 45-acre east Highland parcel, San Bernardino County, California: February 29, 1992.

#5794 Sykes, L.R., and Nishenko, S.P., 1984, Probabilities of occurrence of large plate rupturing earthquakes for the San Andreas, San Jacinto, and Imperial faults, California: Journal of Geophysical Research, v. 89, no. B7, p. 5905-5927.

#5493 Toppozada, T.R., and Borchardt, G., 1998, Re-evaluation of the 1836 "Hayward fault" and the 1938 San Andreas fault earthquakes: Bulletin of the Seismological Society of America, v. 88, no. 1, p. 140-159.

#5798 Treiman, J.A., 1994, The San Grogonio Pass, Banning, and related faults, Riverside County, California: California Division of Mines and Geology Fault Evaluation Report FER-235, 47 p., scale 1:240,000.

#5800 van der Woerd, J., Klinger, Y., Sieh, K., Tapponnier, P., and

Ryerson, F.J., 2001, First long-term slip rate along the San Andreas fault based on 10Be-26Al surface exposure dating—The Biska Palms site, 23 mm/yr for the last 30,000 years [abs.]: Eos, Transactions of the American Geophysical Union, v. 82, p. 934.

#5801 Vaughn, R.E., 1922, Geology of San Bernardino Mountains north of San Gorgonio Pass: Berkeley, California, University of California Publications in Geological Sciences, v. 13, no. 9, p. 319-411.

#1423 Wallace, R.E., 1970, Earthquake recurrence intervals on the San Andreas fault: Geological Society of America Bulletin, v. 81, p. 2875–2890.

#5804 Wallace, R.E., 1990, General features, *in* Wallace, R.E., ed., The San Andreas fault system: U.S. Geological Survey Professional Paper 1515, p. 3-12.

#5806 Weldon, R.J., II, and Sieh, K.E., 1985, Holocene rate of slip and tentative recurrence interval for large earthquakes on the San Andreas fault, Cajon Pass, southern California: Geological Society of America Bulletin, v. 96, no. 6, p. 793-812.

#5807 Weldon, R.J., II, Meisling, K.E., and Alexander, J., 1993, A speculative history of the San Andreas fault in the central Transverse Ranges, California, *in* Powell, R.E., Weldon, R.J., II, and Matti, J.C., eds., The San Andreas fault system—Displacement, palinspastic reconstruction, and geologic evolution: Geological Society of America Memoir 178, p. 161-198.

#4947 Wilson, J.T., 1965, A new class of faults and their bearing on continental drift: Nature, v. 207, p. 343-347.

#5494 Working Group on California Earthquake Probabilities, 1988, Probabilities of large earthquakes occurring in California on the San Andreas fault: U.S. Geological Survey Open-File Report 88-398, 62 p.

#549 Working Group on California Earthquake Probabilities, 1990, Probabilities of large earthquakes in the San Francisco Bay region, California: U.S. Geological Survey Circular 1053, 51 p.

#4945 Working Group on California Earthquake Probabilities, 1995, Seismic hazards in southern California—Probable earthquakes, 1994 to 2024: Bulletin of the Seismological Society of America, v. 85, no. 2, p. 379-439.

#4946 Working Group on California Earthquake Probabilities, 1999, Earthquake probabilities in the San Francisco Bay region; 2000 to 2030—A summary of findings: U.S. Geological Survey Open-File Report 99-517, 60 p.

#1216 Working Group on Northern California Earthquake Potential (WGNCEP), 1996, Database of potential sources for earthquakes larger than magnitude 6 in northern California: U.S. Geological Survey Open-File Report 96-705, 40 p.

#4948 Yule, D., Fumal, T., McGill, S., and Seitz, G., 2001, Active tectonics and paleoseismic record of the San Andreas fault, Wrightwood to Indio: Working toward a forecast for the next "big event", *in* Dunne, G., and Cooper, J., eds., Geologic excursions in the California deserts and adjacent Transverse Ranges: Geological Society of America Fieldtrip Guidebook and Volume prepared for the Joint Meeting of the Cordilleran Section GSA and Pacific Section AAPG, p. 91-126.