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Garlock fault zone, Western Garlock section (Class A) No. 69a

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Synopsis	**General:** Major Holocene active, east to northeast-striking sinistral strike-slip fault that forms the boundary between the Tehachapi Mountains, Sierra Nevada, and Basin and Range province on the north and the Mojave Desert province to the south. Aseismic fault creep has been reported along the westernmost 60 km of the Garlock fault zone (Rodgers, 1979 #6071; Snay and Cline, 1980 #6070; Louie and others, 1985 #5731). However, U.S. Geological Survey quadrilateral sites spaced at 15 km intervals along this part of the fault zone have not detected evidence of fault creep (M. Clark, personal communication in McGill, 1992). There are seven paleoseismic study sites involving trenching along the western and central Garlock fault sections described in this compilation, with additional slip rate sites involving geomorphic analysis (Burke, 1979 #2985; Carter, 1980 #6043; LaViolette, 1981 #6051;

Roquemore and others, 1982 #2993; McGill and Sieh, 1991 #6062; McGill, 1992 #6053; McGill and Sieh, 1993 #6063; McGill, 1994 #6056; McGill and Rockwell, 1998 #6064; McGill, 1999 #6060; McGill, in preparation #6061). A Holocene slip rate for the western Garlock fault section of 1.6–3.3 mm/yr was reported by LaViolette (1981 #6051) for the Oak Creek Canyon site. McGill and others (in preparation #6061) reported a preferred minimum Holocene slip rate of at least 6.8±1.5 mm/yr at the Lone Tree Canyon site. Clark and others (1984 #2876), based on data reported by Carter (1980 #6043), calculated a preferred long-term sinistral slip rate of 11 mm/yr near Mesquite Canyon. Near Koehn Lake a sinistrally offset 11- to 15-ka lake bar indicates a slip rate of 5–8 mm/yr (radiocarbon years) (Clark and others, 1984 #2876). McGill and Sieh (1991 #6062), using the calibration of Bard and others (1990 #6042), re-calculated the slip rate reported by Clark and others (1984 #2876) at Koehn Lake to be 4–7 mm/yr. McGill and Sieh (1993 #6063) reported a slip rate of 5–11 mm/14Cyr or 4–9 mm/yr after calibration of the radiocarbon dates. Their preferred slip rate was 6–8 mm/14Cyr (or 5–7 mm/yr in calibrated years) calculated from the southern Searles Valley site. McGill and Sieh (1991 #6062) and McGill (1992 #6053) concluded that some sinistral slip is transferred to the Owl Lake fault [70]. The slip rate of the Garlock fault east of its intersection with the Owl Lake fault [70] is not known with any certainty. Recurrence intervals for the Garlock fault zone are 800–2,700 yr for the western Garlock fault section (McGill, 1994 #6056); 190–3,405 yr for the central Garlock fault section (McGill and Rockwell, 1998 #6064); and 200–3,000 yr for the eastern Garlock fault section (McGill and Sieh, 1991 #6062). McGill and Rockwell (1998 #6064) noted that recurrence intervals are irregular at the El Paso Peaks site and reported preferred average recurrence intervals of 1,230 yr assuming 5 events or 700 yr assuming 8 events. In a deeper re-excavation at the El Paso Peaks site, Dawson (2000 #6047) confirmed the irregular nature of recurrence, but eliminated one of McGill and Rockwell's events, and added an older event that was not exposed in the original trench.

Sections: This fault has 3 sections. Garlock fault zone is divided based on McGill (1992 #6053). The western Garlock fault section extends from the complex intersection with the San Andreas fault [1g] near Frazier Park east-northeast to a 3-km-wide left-releasing step-over in the vicinity of Koehn Lake. The central Garlock section extends from the left-releasing step-over near Koehn Lake

	eastward to the Quail Mountains where the Owl Lake fault [70] intersects the Garlock fault zone. The eastern Garlock fault section extends from the Owl Lake fault [70] eastward to the complex intersection with the southern extent of the Southern Death Valley fault zone [143b].
Name comments	**General:** **Section:** Name and section boundaries proposed by McGill (1992 #6053). Section extends from the complex intersection with the San Andreas fault [1] near Frazier Park east-northeast to a large left-releasing step-over in the vicinity of Koehn Lake. Aseismic fault creep has been reported along the westernmost 60 km of the Garlock fault (Rodgers, 1979 #6071; Snay and Cline, 1980 #6070; Louie and others, 1985 #5731). However, U.S. Geological Survey quadrilateral sites spaced at 15 km intervals along this part of the fault zone have not detected evidence of fault creep (M. Clark, personal communication in McGill, 1992 #6053). **Fault ID:** Includes 270 (Garlock fault zone), 272 (ground breaks in Fremont Valley), 274 (triggered slip associated with 1952 Arvin-Tehachapi earthquake), and 310 (South Branch Garlock fault) of Jennings (1994 #2878).
County(s) and State(s)	LOS ANGELES COUNTY, CALIFORNIA KERN COUNTY, CALIFORNIA
Physiographic province(s)	CASCADE-SIERRA MOUNTAINS BASIN AND RANGE PACIFIC BORDER
Reliability of location	Good Compiled at 1:62,500 scale. *Comments:* Locations based on digital revisions to Jennings (1994 #2878). Original mapping by Samsel (1962 #5632) is at 1:48,000; mapping by Wiese (1950 #6453), Dibblee (1952 #6048; 1959 #6454; 1963 #6457), and Dibblee and Louke (1970 #6455) is at 1:62,500; mapping by Clark (1973 #483) is at 1:24,000.
Geologic setting	The Garlock fault zone, one of the principal Holocene active faults of California, is an east-northeast striking sinistral strike-slip fault that separates the Tehachapi-Sierra Nevada and Basin and Range provinces on the north against the Mojave Desert province on the south. The Garlock fault extends from its complex intersection with the San Andreas fault zone [1g] at its

	western end northeastward, curves to a more easterly strike east of the Koehn Lake area and extends to the Avawatz Mountains near the south end of Death Valley. Maximum cumulative sinistral strike-slip displacement of 48 km to 64 km has been documented (Smith, 1962 #6066; Smith and Ketner, 1970 #6069; Davis and Burchfiel, 1973 #1492; Carr and others, 1993 #6452). Hill and Dibblee (1953 #923) suggested that the sinistral Garlock and Big Pine [86] faults and the dextral San Andreas fault [1] are conjugate shears resulting from a north-south oriented regional contractional strain pattern. Later workers (Hamilton and Myers, 1966 #1531; Troxel and others, 1972 #6075; Davis and Burchfiel, 1973 #1492) considered the Garlock fault to be an intracontinental transform fault accommodating extension in the Basin and Range province to the north relative to the more stable Mojave block to the south. However, McGill (1992 #6053) stated that a simple transform model is inadequate to explain this relationship because the extension direction of the portion of the Basin and Range province north of the Garlock fault is not parallel to the fault (Stewart, 1983 #1653; Burchfiel and others, 1987 #1454; Minster and Jordan, 1987 #3288; Jones, 1987 #6050; Wernicke and others, 1988 #1686). It is possible that the extension component parallel to the Garlock fault is driving sinistral slip on the fault and the component normal to the fault has rotated the central and eastern Garlock fault clockwise (Carter and others, 1987 #6045; Jones, 1987 #6050; Dokka and Travis, 1990 #3188). (Smith and others, 1968 #6456) (Clark and Lajoie, 1974 #6046)
Length (km)	This section is 110 km of a total fault length of 257 km.
Average strike	N55°E (for section) versus N68°E (for whole fault)
Sense of movement	Left lateral *Comments:* Western Garlock fault zone is delineated by geomorphic features indicative of sinistral strike-slip offset (Clark, 1973 #483). Long term sinistral displacement has been documented by Smith (1962 #6066), Smith and Ketner (1970 #6069), and Davis and Burchfiel, (1973 #1492).
Dip Direction	V *Comments:* Focal mechanisms indicate steeply dipping to vertical dips on east-northeast striking fault planes (Astiz and Allen, 1983 #1215). Local seismicity presumably on secondary faults exhibits

	reverse-slip mechanisms with a northeasterly dip (Astiz and Allen, 1983 #1215).
Paleoseismology studies	69-2 by LaViolette (1981 #6051) and LaViolette and others (1980 #6052) involved the excavation of four fault-normal trenches and the employment of four geophysical profiles (gravity, electrical resistivity, magnetic, and seismic refraction) at the Castac Lake site. Trenches exposed unfaulted interbedded fine-grained lacustrine deposits and coarse-grained alluvial deposits. Radiocarbon dates of charcoal at 1 m below the surface had 14C date of 8050±300 yr BP Seismic refraction profiles show 2 minor low velocity zones that could be interpreted as eroded fault scarps in older alluvium. 69-3 by LaViolette (1981 #6051) and LaViolette and others (1980 #6052) involved the excavation of 2 fault-normal trenches at the Twin Lakes site. Trenches traversed a closed depression and exposed laterally continuous mid to late Holocene lacustrine deposits consisting of alternating clays, sands, and gravels. Ages of deposits are based on 14C dating of detrital charcoal and range from 2,800±165 yr BP to 890±195 yr BP. Their trench 1 exposed a steeply south-dipping to vertical, 1.5- to 2.5-m-wide fault zone that displaces all units including a 10YR2/1 clayey silt to silty clay (A horizon ?). LaViolette (1981 #6051) concluded that 2 surface rupturing earthquakes were recorded in trench 1. 69-4 by LaViolette (1981 #6051) and LaViolette and others (1980 #6052) was a geomorphic evaluation of sinistrally offset drainages in western Oak Creek Canyon (Oak Creek Canyon site), where the average sinistral offset is about 0.3 km. Age control was based on soil profile development. 69-8 by McGill (1994 #6056) and McGill and others (in preparation #6061) involved the excavation of seven trenches (both fault normal and fault parallel) and four soil pits at the Lone Tree Canyon site. The site is characterized by a sinistrally offset stream channel that has incised into an older alluvial fan. Trenches exposed latest Pleistocene and Holocene alluvial fan and fluvial deposits. Trench 2 exposed a 15-m-wide fault zone and the fault parallel trenches were excavated to better constrain the location and amount of sinistral offset of the incised stream channel.
Geomorphic	Traces of the Western Garlock section are delineated by

expression	moderately to well-defined geomorphic features indicative of Holocene sinistral strike-slip displacement (Clark, 1973 #483). Geomorphic features include aligned benches and notches, shutter ridges, linear valleys, sinistrally offset ridges and drainages, closed depressions, linear vegetation and soil contrasts in alluvium, ponded alluvium, linear scarps delineating predominantly strike-slip offset, and somewhat more sinuous scarps delineating predominantly normal displacement in the vicinity of Koehn Lake (Clark, 1973 #483; Pampeyan and others, 1988 #1211; Wills, 1989 #6077).
Age of faulted surficial deposits	Strands of the Western Garlock section offset lacustrine clays, sands, and gravels at the Twin Lakes paleoseismology site that range in age from 2800±165 14C yr BP to 890±195 14C yr BP, based on detrital charcoal (LaViolette, 1981 #6051). Farther west at Castac Lake, near the intersection with the San Andreas fault [1g], the Western Garlock fault is concealed by alluvium that is 8,050±300 14C yr BP (LaViolette, 1981 #6051). Near Lone Tree Canyon, the fault offsets alluvium that ranges in age from 19.1–2.5 ka (McGill, 1994 #6056).
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* LaViolette (1981 #6051) reported that the most recent paleoevent on the western Garlock fault zone occurred between 890 yr BP and 200 yr BP. This is based on the observation that faulting at the Twin Lakes site post-dates a sedimentary deposit that is 890 14C yr BP, based on dating of detrital charcoal. The minimum age of the event is based on the observation that the Western Garlock fault lacks evidence of a large historical earthquake.
Recurrence interval	800 to 2,700 yr *Comments:* Recurrence interval reported by McGill (1994 #6056) and McGill and others (in preparation #6061), based on the occurrence of 2 and possibly 3 surface-rupturing earthquakes in the past 2.36–2.75 k.y. Preferred recurrence interval is 1,300–2,700 yr, assuming two events, but if additional events have gone undetected the interval could be shorter.
Slip-rate	Greater than 5.0 mm/yr

category	*Comments:* LaViolette (1981 #6051) and LaViolette and others (1980 #6052) calculated a minimum late Pleistocene sinistral slip rate of 1.6–3.3 mm/yr at the Oak Creek Canyon site, based on 0.3 km sinistral offset of drainages incised into an older, southward-dipping alluvial plain. Based on soil profile development LaViolette (1981 #6051) estimated an age of 90–190 ka for the older alluvial plain. McGill (1994 #6056) reported a late Pleistocene sinistral slip rate of 3–11 mm/yr at the Highway 14 (Lone Tree Canyon), based on the 60?5 m sinistral offset of a stream channel incised into 18, 295±143 14C yr BP alluvial fan. The channel fill is buried by colluvium that is 5,950 14C yr BP, based on a charcoal sample from a burn layer in the colluvium. McGill and others (in preparation #6061) revised the slip measurement of the offset early Holocene channel to be at least 66±3 m. New radiocarbon dates from the alluvial fan and from channel fill deposits constrain the age of incision of the channel to be between 11.5 ka and 7.2 ka. These constraints result in a left-lateral slip rate of at least 7.1±2.2 mm/14C yr (2-sigma) and the calibrated rate is at least 6.3±2.0 mm/yr (2-sigma). McGill (1998 #6059) provides an additional summary of slip rate estimates for the Garlock fault. Slip rate assigned to this part of the Garlock fault by Petersen and others (1996 #4860) for probabilistic seismic hazard assessment for the State of California was 6.0 mm/yr (with minimum and maximum assigned slip rates of 3.0 mm/yr and 9.0 mm/yr, respectively).
Date and Compiler(s)	2000 William A. Bryant, California Geological Survey
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