Jump to Navigation

Quaternary Fault and Fold Database of the United States

As of January 12, 2017, the USGS maintains a limited number of metadata fields that characterize the Quaternary faults and folds of the United States. For the most up-to-date information, please refer to the interactive fault map.

Owens Valley fault zone, 1872 rupture section (Class A) No. 51b

Last Review Date: 2002-10-01

Compiled in cooperation with the California Geological Survey

citation for this record: **Bryant, W.A., and Sawyer, T.L., compilers, 2002, Fault number 51b, Owens Valley fault zone, 1872 rupture section, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, https://earthquakes.usgs.gov/hazards/qfaults, accessed 12/14/2020 03:07 PM.**

Synopsis	**General:** This historically active, major Basin and Range dextral-normal fault zone is located in Owens Valley, its namesake. For this compilation, the Owens Valley fault zone is divided into two sections (Keough Hot Springs [51a] and 1872 Rupture [51b]) principally based on the location and extent of the great 1872 Owens Valley earthquake. The Owens Valley earthquake, which caused about 100 km of surface rupture (Beanland and Clark, 1994 #103), has been assigned various magnitudes ranging from M_W7.5–7.7 by Beanland and Clark (1994 #103) to about M_S8 based on earthquake intensity (Wells and Coppersmith, 1994

#546). At the time of this compilation, there were seven detailed study sites along the Owens Valley fault zone that are summarized herein. Little is know about the prehistoric earthquake history for the Keough Hot Springs section [51a] although Envicom (1976 #5609) excavated trenches across scarps on Holocene alluvium and documented Holocene vertical displacement. This section may have a dextral component of displacement based on geomorphic expression, but the amount of displacement is not known. The 1872 Rupture section [51b] extends from near Klondike Lake to south of Owens Lake. Beanland and Clark (1994 #103) documented average dextral-normal offset of 6.1±2.1 m associated with the 1872 earthquake. They inferred a Holocene slip rate of 2±1 mm/yr and a middle to late Quaternary (0–300 ka) slip rate of 1.5±1 mm/yr. Martel and others (1989 #5620) and Zehfuss and others (2001 #5623) calculated a vertical displacement rate of 0.24±0.04 mm/yr for past 300 k.y. for the associated Fish Springs fault, a normal fault that is part of the northern 1872 Rupture section [51b]. Lubetkin and Clark (1988 #144) reported a Holocene slip rate of 0.4–1.3 mm/yr for the Lone Pine fault, a strand of the 1872 Rupture section [51b] near Lone Pine. Lee and others (2001 #5611) reported a dextral displacement rate between 1.2±0.1 and 3.6±0.2 mm/yr, based on measured deflections of a stream channel near site 51-7, although Bacon and others (2001 #5612) have disputed the tectonic origin of these stream deflections. Beanland and Clark (1994 #103) and Lubetkin and Clark (1988 #144) identified two prehistori, in addition to 1872, surface-rupturing earthquakes in thesince 10–21 ka. Lee and others (2001 #5611) reported that the penultimate event occurred between 3.3±0.3 ka and 3.8±0.3 ka based on OSL dating at site 51-5. Recurrence intervals for the 1872 Rupture section [51b] are not well constrained. Beanland and Clark (1994 #103) reported a preferred recurrence interval of about 5 k.y. based on observations that two events occurred prior to the 1872 earthquake, probably in Holocene time. Lee and others (2001 #5611) reported a preferred recurrence interval of 3–4.1 k.y. based on sream deflections, the age of the penultimate event at site 51-5, and an assumed uniform temporal recurrence of events. Bacon and others (2001 #5612) argue that structural and stratigraphic evidence is certain for only two earthquakes (including the 1872 event).

Sections: This fault has 2 sections. The northern section, here named the Keough Hot Springs section [51a], extends from just south of Bishop south to the vicinity of Klondike Lake, which is

	considered the northern extent of surface faulting associated with the 1872 Owens Valley earthquake (Beanland and Clark, 1994 #103). The southern section, here named the 1872 Rupture section [51b], extends from the Klondike Lake area south to just south of Owens Lake and is defined by the 1872 Owens Valley surface fault rupture.
Name comments	**General:** The Owens Valley fault zone was recognized by Whitney (1872 #5641) and Gilbert (1884 #3355) largely as a result of their studies of surface rupture associated with the 1872 Owens Valley earthquake. Traces of the fault zone were first mapped in the Lone Pine area by Johnson (shown in Hobbs, 1910 #5615) and in the Independence area by Knopf (1918 #5616). The fault zone appears to have been first referred to as the Owens Valley fault system by Pakiser (1960 #5622), but he also included the White Mountains fault zone [47] in the system. Slemmons (cited in Hill, 1972 #1207) referred to the fault zone as both the mid-Owens Valley fault zone and mid-Valley fault zone. The Owens Valley fault zone is the most commonly used name in current literature and is used in this compilation. Other named branches or strands of the Owens Valley fault zone include the Fish Springs fault (southwest of Big Pine), probably first named by Martel (1984 #5619), and the Lone Pine fault (west of Lone Pine) first named by Lubetkin (1980 #5618). The Owens Valley fault zone extends for >125 km across the floor of Owens Valley from near Bishop to south of Owens Lake. **Section:** The 1872 Rupture section, informally named in this fault compilation, extends from the Klondike Lake area (about 5 km north of Big Pine) south to just south of Owens Lake. It is defined by surface rupture associated with the great 1872 Owens Valley earthquake (Vittori and others, 1993 #5624; Beanland and Clark, 1994 #103). Named faults in this section include the Owens Valley fault zone, the Fish Springs fault, and the Lone Pine fault. **Fault ID:** Refers to fault numbers 212 (Owens Valley fault) and 212A (Lone Pine fault) of Jennings (1994 #2878) and fault OWV of Piety (1995 #915).
County(s) and State(s)	INYO COUNTY, CALIFORNIA
Physiographic province(s)	BASIN AND RANGE CASCADE-SIERRA MOUNTAINS
Reliability of	Good

location	Compiled at 1:48,000 scale. *Comments:* Locations based on digital revisions to Jennings (1994 #2878) using original mapping by Beanland and Clark (1994) and Bryant (1988) at 1:24,000 scale and Bryant (1984c) at 1:48,000 scale.
Geologic setting	The Owens Valley fault zone is a major, north to north-northwest striking, high-angle, predominantly dextral strike-slip fault zone that extends for more than 125 km across the floor of Owens Valley from near Bishop to south of Owens Lake. Owens Valley is a major structural depression within the Inyo-Mono block of the Walker Lane belt (Stewart, 1988 #1654). The northern end of the Owens Valley fault zone locally borders the Sierra Nevada range front along the Coyote Warp, a zone of mountain-side-(west) down normal faults distributed between the Owens Valley fault zone and the Round Valley fault [45] (Bateman, 1965 #5587). Dawers and others (2002 #5646) suspect that the Coyote Warp may be a fault-propagation fold at the northern tip of the Sierra Nevada extensional fault system. The Owens Valley fault zone is in the western portion of the Basin and Range province, an area characterized by oblique extensional tectonics resulting in both dextral strike-slip and normal dip-slip displacement. Total vertical displacement across the Owens Valley fault zone is 2.5 km, based on gravity data (Hollett and others, 1991 #5617). Total dextral offset has been estimated to be a few kilometers, based on the apparent correlation of the Independence dike swarm (Moore and Hopson, 1961 #5621) and correlation of two Cretaceous plutons (Ross, 1962 #1627). Beanland and Clark (1994 #103) argued that 20–30 km of dextral offset is permissible based on the data of Moore and Hopson (1961 #5621) and Ross (1962 #1627). The 1872 Owens Valley earthquake caused average dextral-normal oblique displacement of 6.1±2.1 m and maximum displacement of 11 m along the 1872 Rupture section [51b] of the Owens Valley fault zone (Beanland and Clark, 1994 #103).
Length (km)	This section is 118 km of a total fault length of 136 km.
Average strike	N9°W (for section) versus N7°W (for whole fault)
Sense of movement	Right lateral *Comments:* Dominantly dextral strike slip with a minor down-to-the-east normal component. Some investigators (for example, Whitney, 1872 #5641; Pakiser, 1960 #5622) thought that Owens

	Valley fault zone was predominantly vertical with a sinistral strike-slip component, generally based on reports by Whitney (1872 #5641) that surface rupture associated with the 1872 Owens Valley earthquake had a sinistral strike-slip component. Field notes of Gilbert and Johnson, however, document a dextral strike-slip component (Bateman, 1961 #102; Bonilla, 1968 #5614; Beanland and Clark, 1994 #103).
Dip	80±15° ENE. *Comments:* Beanland and Clark's (1994 #103).
Paleoseismology studies	There are 6 paleoseismic sites along the 1872 Rupture section: Site 51-2. The early studies by Lubetkin and Clark (1988 #144) involved the excavation of one fault normal trench across the historically active trace of the Lone Pine fault and measurement of fault scarp profiles at the Lone Pine Creek site. The trench exposed faulted alluvial-fan deposits and a small in-filled graben. Bierman and others (1995 #5613) dated the offset alluvial-fan surface at Lone Pine Creek using model $^{10}Be/^{26}Al$ exposure dates. Site 51-3. Studies by Beanland and Clark (1994 #103) included the excavation of two fault normal trenches across the historically active trace of the Owens Valley fault, just north of Shepherd Creek. Trenches exposed faulted and folded late Holocene deposits of the Owens River. Beanland and Clark (1994 #103) also mapped the surface rupture associated with the 1872 Owens Valley earthquake in detail, measured fault scarp profiles and offset geomorphic features along the entire 1872 Rupture section. These data were used to determine slip associated with the 1872 earthquake and slip rate and recurrence intervals for the Owens Valley fault zone. Site 51-4. Studies by Zehfuss and others (2001 #5623) included detailed geologic mapping, scarp profile measurements, soil profile development, and ^{10}Be and ^{26}Al model exposure-age dating of an offset cinder cone and offset alluvial fans. These data were used to calculate latest Pleistocene to Holocene vertical displacement rates for the Fish Springs fault. This is the same site where Martel and others (1987 #145; 1989 #5620) determined a vertical slip rate for the Fish Springs fault.

	Site 51-5. Studies by Lee and others (2001 #5611) involved the excavation of one fault normal trench across the historically active trace of the Owens Valley fault zone south of Tinemaha Reservoir in order to document prior surface-rupturing earthquakes. Trench exposed a sequence of Holocene playa and fluvial deposits offset by two faults. The study also involved geomorphic analysis of stream deflections near site 51-7. Sites 51-6 and 51-7. Studies by Bacon and others (2001 #5612; 2002 #5644)) involved the excavation of seven fault normal trenches across historically active traces of the Owens Valley fault zone. Three trenches excavated at the Alabama Gates paleoseismic (site 51-6) exposed hanging-wall deformation that was probably the result of the 1872 earthquake and the penultimate event. Four trenches excavated at the Quaker paleoseismic (site 51-7) exposed deep-water facies in the footwall faulted against probable shallow fluvial to near-shore lacustrine deposits. Trench T4 showed upward termination of faults and sand dikes indicative of the penultimate event. Stratigraphic evidence from these sites indicates only two earthquakes since about 12 ka; the historic 1872 event and the penultimate event at about 9.2±0.3 ka. Vertical offset associated with the historic event is 0.9±0.3 m, whereas during the penultimate event displacement was 1.4 m (+0.3, -0.4 m). Using Beanland and Clark's (1994 #103) H:V slip ratio of 6:1, the calculated a slip rate of 0.4–1.3 mm/yr (0.8 mm/yr preferred) for the past 12 k.y. at this location.
Geomorphic expression	This section of the fault zone is characterized by abundant geomorphic evidence of recent activity, including a nearly continuous zone of well defined to extremely well defined scarps on latest Pleistocene and Holocene alluvium, some scarps with possible free faces (Bryant, 1984 #5597; 1984 #5598) closed depressions (sag ponds), tonal lineaments, grabens, and beheaded and dextrally offset drainages (Bryant, 1984 #5597; 1984 #5598; 1988 #1457; Beanland and Clark, 1994 #103).
Age of faulted surficial deposits	Late Quaternary basalt, late Pleistocene alluvium, and Holocene alluvium and floodplain deposits.
Historic earthquake	Owens Valley earthquake 1872
Most recent prehistoric	latest Quaternary (<15 ka)

deformation	*Comments:* Lee and others (2001 #5611) identified a surface-rupturing earthquake prior to the 1872 Owens Valley earthquake. At site 51-5 south of Tinemaha Reservoir, fluvial unit 28 overlies their fault F1. The age of the base of unit 28, based on optically stimulated luminescence (OSL) dating, is 3.8±0.3 ka and the age of the top of unit 28 is 3.3±0.3 ka. Beanland and Clark (1994 #103) estimated that one, and perhaps two pre-1872 earthquakes occurred in Holocene time (<10 k.y.). Conclusions by Bacon and others (2002 #5644) suggest that the most recent paleoevent occurred at about 9.3±0.3 ka.
Recurrence interval	3.3–9.2 k.y. (<12 ka) *Comments:* On the basis of collective observations at several sites along the 1872 Rupture section, Beanland and Clark (1994 #103) estimated a minimum average recurrence interval of 3.3–5 k.y. (10–21 ka) for the Owens Valley fault zone on the basis of three post-Tioga (<11 ka) surface rupturing earthquakes, including the 1872 Owens Valley earthquake. These observations include the Lone Pine Creek (site 51-2) of Lubetkin and Clark (1988 #144) and Fish Springs (site 51-4) by Martel and others (1987 #145; 1989 #5620) and Zehfuss and others (2001 #5623). Lubetkin and Clark (1988 #144) observed two events in addition to the 1872 event at site 51-2. No age control was available, but relative age-dating techniques indicated that the faulted alluvial fan at Lone Pine Creek is between 10 ka and 21 ka, suggesting recurrence of between 5 k.y. and 10.5 k.y. (Lubetkin and Clark, 1988 #144 preferred 5 k.y.). Bierman and others (1995 #5613) subsequently provided a model $^{10}Be/^{26}Al$ exposure date of 11.6±3.7 ka for the offset alluvial-fan surface. Using this age data, an average recurrence interval of 4–7.7 k.y. can be estimated based on data from Lubetkin and Clark (1988 #144). Bierman and others (1995 #5613) calculated an average recurrence interval of 5.8–8.0 k.y. at the Lone Pine Creek. Martel (1984 #5619) concluded that a Tioga-age alluvial fan was displaced 1.1±0.2 m vertically three times, including the 1872 earthquake and reported a preferred (long-term) recurrence interval of 5.8±1 k.y. for the past 0.4 m.y. Lee and others (2001 #5611) postulated that dextral stream-channel deflections near site 51-7 indicate two events prior to the 1872 earthquake, each with similar dextral displacements. Lee and others reported a preferred recurrence interval of 3–4.1 k.y. based on these stream deflections, the time of their penultimate event at site 51-5, and an assumed uniform temporal recurrence of faulting. Bacon and others (2001 #5612) disagree with Lee and

	others (2001 #5611) conclusions regarding the origin of the stream deflections near site 51-7, arguing that repeated fluctuations of Owens Lake level during the Holocene would have modified these geomorphic features. Bacon and others (2001 #5612) state that structural and stratigraphic evidence is certain for only two earthquakes (including the 1872 event). Their most recent studies suggest a recurrence of about 9.2±0.3 k.y. for their study sites (51-6, 51-7) 4 to 7 km north of Lone Pine (Bacon and others, 2002 #5644).
Slip-rate category	Between 1.0 and 5.0 mm/yr *Comments:* Beanland and Clark (1994 #103) calculated a Holocene slip rate of 2±1 mm/yr and a rate of 1.5±1 mm/yr for the past 300 ka. Lubetkin and Clark (1988 #144) reported a Holocene slip rate of 0.4–1.3 mm/yr for the Lone Pine fault at site 52-2. They estimated that the Owens Valley fault zone at Lone Pine is characterized by an average dextral displacement rate of 0.7–2.2 mm/yr. The Fish Springs fault, a dominantly normal fault within the 1872 Rupture section of the Owens Valley fault zone, has a late Quaternary vertical displacement rate of 0.24±0.02 mm/yr (Martel and others, 1989 #5620; Zehfuss and others, 2001 #5623). Lee and others (2001 #5611) inferred a Holocene dextral slip rate between 1.2±0.1 mm/yr and 3.6±0.2 mm/yr, based on the measured deflections of a stream channel near site 51-7 and assumed ages of the events based on an OSL date at site 51-5 that estimates the age of the penultimate event. Bacon and others (2001 #5612), however, disagree with the interpretation that the stream channel deflections near site 51-7 are tectonic and calculate a slip rate of 0.4–1.3 mm/yr (0.8 mm/yr preferred) for the past 12 k.y. at this location on the fault zone.
Date and Compiler(s)	2002 William A. Bryant, California Geological Survey Thomas L. Sawyer, Piedmont Geosciences, Inc.
References	#5612 Bacon, S.N., Pezzopane, S.K., and Burke, R.M., 2001, Preliminary paleoseismic results on the Owens Valley fault zone and the latest Quaternary stratigraphy in Owens Valley near Lone Pine, eastern California: U.S. Geological Survey National Earthquake Hazards Reduction Program, Project Summary for NEHRP FY 2001, USGS External Grant award no. 01HQGR0013, 12 p. #5644 Bacon, S.N., Pezzopane, S.K., and Burke, R.M., 2002, Paleoseismology on the Owens Valley fault and Holocene

stratigraphy of pluvial Owens Lake near Lone Pine, Eastern California: Geological Society of America Abstracts with Programs, v. 34, no. 6, p. 27.

#102 Bateman, P.C., 1961, Willard D. Johnson and the strike-slip component of fault movement in the Owens Valley, California, earthquake of 1872: Bulletin of the Seismological Society of America, v. 51, p. 483-493.

#5587 Bateman, P.C., 1965, Geology and tungsten mineralization of the Bishop district, California: U.S. Geological Survey Professional Paper 470, 208 p., scale 1:62,500.

#103 Beanland, S., and Clark, M., 1994, The Owens Valley fault zone, eastern California, and surface rupture associated with the 1872 earthquake: U.S. Geological Survey Bulletin 1982, 29 p.

#5613 Bierman, P.R., Gillespie, A.R., and Caffee, M.W., 1995, Cosmogenic ages for earthquake recurrence intervals and debris flow fan deposition, Owens Valley, California: Science, v. 270, p. 447-450.

#5614 Bonilla, M.G., 1968, Evidence for right-lateral movement on the Owens Valley, California, fault zone during the earthquake of 1872, and possible subsequent fault creep, *in* Conference on Geological Problems of the San Andreas fault system: Palo Alto, Stanford University Publications in the Geological Sciences, v. 11, p. 4-5.

#5597 Bryant, W.A., 1984, Northern Owens Valley, Fish Slough, and White Mountains frontal faults, Inyo and Mono Counties: California Division of Mines and Geology Fault Evaluation Report FER-153, microfiche copy in California Division of Mines and Geology Open-File Report 90-14, scale 1:62,500.

#5598 Bryant, W.A., 1984, Owens Valley and White Mountains frontal faults, Big Pine area, Inyo County: California Division of Mines and Geology Fault Evaluation Report FER-159, microfiche copy in California Division of Mines and Geology Open-File Report 90-14, 22 p.

#1457 Bryant, W.A., 1988, Owens Valley fault zone, western Inyo County, California: California Division of Mines and Geology Fault Evaluation Report FER-192, 17 p.

#5646 Dawers, N.H., Sheehan, T.P., and Kirby, E., 2002, Structural nature of a large discontinuity in the Sierra Nevada extensional fault system—The Coyote "Warp" of northern Owens Valley, California: Geological Society of America Abstracts with Programs, v. 34, no. 6, p. 248.

#5609 Envicom, 1976, Seismic safety element for the general plan, Inyo-Mono Association of Governmental Entities: Unpublished report for Inyo and Mono Counties, California, 129 p., 2 appendices.

#7369 Essman, J.E., 2003, The case for NE-SW extension in northeast Oregon: Corvallis, Oregon, Oregon State University, unpublished M.S. thesis, 63 p., 1 plate, 1:24,000 scale.

#3355 Gilbert, G.K., 1884, A theory of the earthquakes of the Great Basin, with a practical application: American Journal of Science, Third Series, v. XXVII, no. 157, p. 49-54.

#1207 Hill, M.R., 1972, A centennial. . . . The great Owens Valley earthquake of 1872: California Geology, v. 25, p. 51-54.

#5615 Hobbs, W.H., 1910, The earthquake of 1872 in the Owens Valley, California: Bertragen zur Geophysik, v. 10, p. 351-381.

#5617 Hollett, K.J., Danskin, W.R., McCaffrey, W.F., and Walti, C.L., 1991, Geology and water resources of Owens Valley, California: U.S. Geological Survey Water-Supply Paper 2370-B, 77 p.

#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.

#5616 Knopf, A., 1918, A geologic reconnaissance of the Inyo Range and eastern slope of the southern Sierra Nevada, California, with a section on the stratigraphy of the Inyo Range by Edwin Kirk: U.S. Geological Survey Professional Paper 110, 130 p.

#5611 Lee, J., Rubin, C., and Calvert, A., 2001, Quaternary faulting history along the Deep Springs fault, California:

	Geological Society of America Bulletin, v. 113, no. 7, p. 855–869. #5618 Lubetkin, L.K.C., 1980, Late Quaternary activity along the Lone Pine fault, Owens Valley fault zone, California: Palo Alto, Stanford University, unpublished M.S. thesis, 85 p. #144 Lubetkin, L.K.C., and Clark, M.M., 1988, Late Quaternary activity along the Lone Pine fault, eastern California: Geological Society of America Bulletin, v. 100, p. 755–766. #5619 Martel, S.J., 1984, Late Quaternary activity on the Fish Springs fault, Owens Valley fault zone, California: Palo Alto, Stanford University, unpublished M.S. thesis, 100 p.