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.

Mad River fault zone (Class A) No. 13

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Compiled in cooperation with the California Geological Survey

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Synopsis	The Mad River fault zone is a major imbricate zone of northeast-dipping thrust faults and associated folds that is 10 km wide and extends at least 43 km onshore southeast from the Trinidad Head. At least 37 subparallel partly interconnected strands have been mapped by Carver (1989 #4936). The principal faults of the zone are designated (from southwest to northwest) as the Fickle Hill, Mad River, McKinleyville, Blue Lake, and Trinidad faults (Carver, 1987 #4918). The zone extends at least 15-20 km to the northwest into the offshore where it steps or bends northward (Clarke, 1990 #4143; 1992 #4092; Carver, 1992 #4919; McCrory, 1996 #1217). Detailed mapping further to the southeast is incomplete, but faults may merge with the Eaton Roughs fault zone [17] (Kelsey and Carver, 1988 #4094). The principal faults

	dip 35??10? NE and may merge at depth as a single strand (Carver, 1992 #4919; McCrory, 1996 #1217). Net dip-slip displacement of sediment of the early Pleistocene Falor Formation by the Mad River zone is estimated to be at least 6 km by Carver (1992 #4919) and 4.4 km by McCrory (1996 #1217). Based on offset of late Pleistocene marine terraces, McCrory (1996 #1217) determined dip-slip rates of 0.4-0.74 mm/yr for individual faults and a total dip-slip rate of 2.3 mm/yr for the entire zone along the coast. Adding the Trinidad anticline increases the total to 4.3 mm/yr. Offshore extension of the Trinidad fault appears on acoustic-reflection records as a moderately to steeply NE-dipping thrust fault that extends upward to near the seafloor (Clarke, 1992 #4092). Paleoseismic studies have identified at least 3 displacement events during Holocene time on the Mad River fault and two events on the McKinleyville fault (Carver, 1992 #4919). Based on similar youthful geomorphic features, the other named faults also were judged to be Holocene by Carver (1992 #4919). Several of the fault strands, judged to be Holocene by Smith (1982 #4943), were subsequently zoned under the Alquist-Priolo Earthquake Fault Zoning Act (California Division of Mines and Geology, 1983 #4935).
Name comments	Mad River fault zone was named and recognized as a late Quaternary feature by Earth Science Associates (1976 #4941) according to Smith (1982 #4943). The principal elements of the zone--Fickle Hill, Mad River, McKinleyville, and Trinidad faults--were mapped and named by 1982 (Woodward-Clyde Consultants, 1980 #4934; Carver and others, 1982 #4939; Rust, 1982 #4942). The Blue Lake fault, named and mapped as a high angle fault by Manning and Ogle (1950 #4903), was remapped as a thrust fault by Carver (1987 #4918; 1989 #4936). **Fault ID:** Refers to numbers 40 (Mad River fault), 42 (Fickle Hill fault), 43 (McKinleyville fault), 38 (Trinidad fault), 39 (Blue Lake fault), 36 (offshore Mad River fault zone), and 35 (offshore Trinidad fault) of Jennings (1994 #2878).
County(s) and State(s)	HUMBOLDT COUNTY, CALIFORNIA
Physiographic province(s)	PACIFIC BORDER
Reliability of location	Good Compiled at 1:250,000 scale.

	Comments: Locations based on digital revisions to Jennings (1994) using fault traces at 1:250,000 scale compiled from Carver (1989 #4936).
Geologic setting	The Mad River fault zone is part of a broad, contractional thrust and fold belt developed in the accretionary wedge above the Cascadia subduction zone [781] (Clarke, 1992 #4092; Carver, 1992 #4919). The 43-km-long onshore zone extends at least 15-20 km into the offshore (Clarke, 1990 #4143; 1992 #4092; McCrory, 1996 #1217). It is a northeast-dipping imbricate thrust fault zone that offsets all late Cenozoic sedimentary units in the Eel River Basin. Faulting and associated folding was initiated in Quaternary time with perhaps as much as 6 km of net dip-slip displacement in the past 0.7 m.y. and continues into Holocene time (Carver, 1992 #4919). Estimates of late Quaternary dip slip vary from 4.4 mm/yr (McCrory, 1996 #1217) to 6.4 mm/yr (Kelsey and Carver, 1988 #4094) and 8.3 mm/yr (Carver, 1992 #4919). Faulting is assumed to have begun about 0.7 Ma (Kelsey and Carver, 1988 #4094; Carver, 1992 #4919) or 1.0 Ma (McCrory, 1996 #1217).
Length (km)	81 km.
Average strike	N38°W
Sense of movement	Thrust *Comments:* Carver and Burke (1988 #4926), Carver (1989 #4936; 1992 #4919), and McCrory (1996 #1217).
Dip	25–40° NE. *Comments:* Dips are reported to be 35??10? NE by Woodward-Clyde Consultants (1980 #4934), Carver and Burke (1988 #4926), Kelsey and Carver (1988 #4094), and McCrory (1996 #1217).
Paleoseismology studies	Two trenches excavated by Carver and Burke (1988 #4926) across a well-defined scarp of the northwesternmost trace of the Mad River fault at the School Road site [13-1] revealed a sharply overturned anticline composed of Franciscan bedrock that truncates and is thrust over a marine terrace deposit (interpreted to be 83 ka) and six overlying colluvial units. Seven displacement events were interpreted in 83 k.y., including at least one Holocene

event based on a minimum radiocarbon date of 10,170±60 yrs B.P. from a buried colluvial unit. Carver and Burke (1988 #4926) determined a fold growth of 0.5–1.2 m per event based on the thickness of colluvial units. Assuming a 25° NE. dip for the fault, they determined slip per event to be 1.2 to 2.3 m. They further noted that the 6-m-high scarp that they trenched was only about 20 percent of the total local offset of the 83 ka terraces, which are offset by three other strands of the Mad River fault to the southwest. Carver (1992 #4919) later stated that three Holocene events occurred at this site, but did not explain the basis for this conclusion. McCrory (1996 #1217) calculated a slip rate of 0.74 mm/yr (assuming a 35° dip) to 0.84 mm/yr (assuming a 30° dip) for the School Road site [13-1].

Carver (1992 #4919), Clarke and Carver (1992 #4091), and Carver and others (1992 #4937) reported two sudden uplift events at Clam Beach at the mouth of Mad River at McKinleyville [site 13-2]. The first event is dated by C14 on driftwood at about 1,100 yrs B.P. This material is interpreted as being buried by dune sand following uplift. The second uplift event is interpreted from a second dune sequence that buried the lower dune surface about 300 yrs B.P. This site lies close to the trace of the Mad River fault and thus may date the most recent events on the Mad River fault zone.

Three overlapping trenches were dug by Carver and Burke (1988 #4926) across a 4-m-high scarp on a well defined trace of the McKinleyville fault at a site near Blue Lake [13-3]. Terrace gravels radiocarbon-dated at 24,700±150 yrs B.P. (charcoal) and 25,700±1,000 yrs B.P. (peat) are offset 13 m by a fault dipping as much as 27° NE. Two older colluvial units of possible Holocene age are assumed to be offset about 3.2 m each. Based on this data, Carver and Burke (1988 #4926) concluded that the terrace gravels have been displaced 5 or 6 times in the past 26 k.y., with the last one or two events being during the Holocene. They calculated an average slip rate of 0.7 mm/yr for the McKinleyville fault.

Other studies are discussed by McCrory (1996 #1217), including trench sites of Woodward-Clyde (1980 #4934) across the McKinleyville and Trinidad faults and studies of the marine terraces across the Mad River fault zone (Carver and others, 1986 #4938; 1987 #4918; 1988 #4926; 1992 #4919). Eight or more terraces have been identified and dated using soil chronosequences, thermoluminescence dating, and correlations

	with sea level high-stands. McCrory (1996 #1217) also discusses episodic subsidence in Mad River Slough within the Freshwater syncline, interpreted by Vick (1988 #4932), Vick and Carver (1988 #4944), and Clarke and Carver (1992 #4091) as evidence of at least four late Holocene paleoseismic events. Clarke and Carver (1992 #4091) interpret this, along with other data, as evidence of megathrust events on the Cascadia subduction zone [781]. However, McCrory (p. 79 in 1996 #1217) questions this correlation and suggests the possibility that the subsidence on the Freshwater syncline may be related to slip on the Mad River fault zone, which flanks the syncline on the north.
Geomorphic expression	Principal fault traces are at least partly defined by linear scarps, swales and drainages and offset terraces (Woodward-Clyde Consultants, 1980 #4934; Carver and others, 1982 #4939; 1982 #4940; Smith, 1982 #4943; Carver, 1989 #4936; 1992 #4919).
Age of faulted surficial deposits	The Mad River and McKinleyville faults offset Holocene alluvium and soils. All faults in the broader zone offset sediment of the Falor Formation (Pleistocene) and all but the Blue Lake fault offset late Pleistocene marine terraces (Carver, 1992 #4919; McCrory, 1996 #1217).
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* Carver (1992 #4919) states that Holocene displacement on the Mad River and McKinleyville faults has been identified using radiocarbon dating and that youthful scarp morphology on the Trinidad, Blue Lake and Fickle Hill faults also suggest Holocene displacement. In addition, two Holocene uplift events have been recorded in the past 1,100 yrs on the Clam Beach marine platform near McKinleyville (Carver, 1992 #4919).
Recurrence interval	3.5 to 11.9 k.y. *Comments:* Interval cited by McCrory (1996 #1217) for McKinleyville and Mad River faults, based on Carver and Burke's (1988 #4926) trenching and radiocarbon dates. Could be much shorter if subsidence events on the Freshwater syncline are related to faulting on the Mad River fault zone (McCrory, 1996 #1217) based on data by Vick and Carver (1988 #4932).

Slip-rate category	Greater than 5.0 mm/yr *Comments:* Estimates of Quaternary slip across the Mad River fault zone range from 4.4 mm/yr (McCrory, 1996 #1217) to 8.3 mm/yr (Carver, 1992 #4919) based on offset of sediment of the Falor Formation with deformation assumed to commence at 0.7 Ma (Carver, 1992 #4919) or 1.0 Ma (McCrory, 1996 #1217). Slip rates for the five named individual faults range from 0.5-1.0 mm/yr (McCrory, 1996 #1217) to 1.0-3.1 mm/yr (Carver, 1992 #4919) for the same time period. McCrory (1996 #1217) also calculated late Quaternary slip rates based on offsets of marine terraces for individual faults: these range from 0.4 mm/yr for the Trinidad fault to 0.74 mm/yr for the Mad River fault. Her calculated dip slip across the entire Mad River fault zone (4 faults) totals 2.3 mm/yr, or 4.3 mm/yr if the Trinidad anticline component is included. Petersen and others (1996 #4860) gives the following rates for individual faults: Fickle Hill 0.6 ? 0.4 mm/yr, Mad River 0.7 ? 0.6 mm/yr, McKinleyville 0.6 ? 0.2 mm/yr, and Trinidad 2.5 ? 1.5 mm/yr.
Date and Compiler(s)	1999 Earl W. Hart, California Geological Survey
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