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Quaternary Fault and Fold Database of the United States

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Madison fault, northern section (Class A) No. 655a

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Compiled in cooperation with the Montana Bureau of Mines and Geology

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Synopsis	**General:** Detailed mapping and reconnaissance studies of the morphology of scarps along the fault are the primary source of data for this fault; segmentation models have been proposed based on these data. However, no detailed trenching has been conducted. Short parts of the fault ruptured during the 1959 Hebgen Lake earthquake resulting in displacements of less than 1 m. The southern part of the fault seems to have higher rates of activity than the northern part, where extension appears to be partitioned on sub-parallel faults at the surface.

	Sections: This fault has 3 sections. Several reports discuss the right-stepping echelon nature of this fault as evidence of separate tectonic blocks with Pardee (1950 #46) being the earliest, and later discussed by Shelden (1960 #478). Young (1985 #690) describes 12 segments along the northern 10-12 km of the fault, but each is defined by parts of the fault having a similar strike. Johns and others (1982 #259) and Schneider (1985 #319) defined three segments; the latter discussed the northern two in detail. These previously published boundaries roughly coincide with the section boundaries shown here. Ruleman and Lageson (2002 #7030) indicate that the fault is composed of five segments. The sections shown in this compilation are nearly coincident with the parts of the fault defined by Johns and others (1982 #259); they do not distinguish any difference in timing of paleoearthquakes and assign a single age (Holocene) to the whole fault based on the short ruptures from the 1959 Hebgen Lake earthquake south of Madison Canyon (Witkind, 1964 #247; Myers and Hamilton, 1964 #250). Available data suggest that the timing of the most-recent faulting event does differ along strike.
Name comments	**General:** Pardee (1950 #46) is an early reference to this fault and referred to it as the Madison Range fault. Most of the early literature followed this nomenclature; however, the name "Madison fault" is commonly used now. The fault is also shown on a map as the "Madison Valley fault" (U.S. Coast and Geodetic Survey, 1959 #630). The fault extends from north of Saint Joe Creek southwestward to Garner Canyon. Witkind and others (1964 #629) described the fault as extending farther south to near Big Springs, but they did not show it as such on their map. Young (1985 #690) shows this fault extending farther north (at least another 2 km) to the edge of her map and states that its trace may coincide with the Madison River near the Madison Powerhouse. **Section:** Although Schneider (1985 #319) discusses and defines segments of the Madison fault based on morphologic studies, no names were assigned. This informally named section is probably the same as northern segment of Schneider, which extends from Jack Creek to south of Indian Creek. Scarps north of Jack Creek from Kellogg (1992 #433; 1993 #565) are not included. **Fault ID:** Refers to fault number 5 (Madison Range fault) of Witkind (1975 #317); fault numbers 45 (Madison Range fault-southern segment), 46 (Madison Range fault-middle segment), and 47 (Madison Range fault-northern segment) of Johns and others (1982 #259); fault number 11 (Madison fault) of Stickney

	and Bartholomew (1987 #85); Jack Creek, Cedar Creek, Burger Creek, Bear Creek, and Indian Creek scarps and Madison Canyon segment of the Madison fault of Stickney and Bartholomew (1987 #242); and Jordan Creek, Jack Creek, Cedar Creek, Burger Creek, Bear Creek, Indian Creek, Madison Canyon, and Northern Henrys Lake segments of the Madison fault of Stickney and Bartholomew (written commun., 1992 #556).
County(s) and State(s)	MADISON COUNTY, MONTANA
Physiographic province(s)	NORTHERN ROCKY MOUNTAINS
Reliability of location	Good Compiled at 1:50,000 scale. *Comments:* Location of fault is from Ruleman (2002 #5133) and Kellogg and others (2007 #7097), further constrained by satellite imagery and topography at scale of 1:100,000. Reference satellite imagery is ESRI_Imagery_World_2D with a minimum viewing distance of 1 km.
Geologic setting	The Madison fault is a high-angle, down-to-the-west, range-front normal fault bounding the western side of Madison Range. Maximum depth to basement in northern Madison Valley is about 2.1 km, in central Madison Valley the depth may exceed 4.5 km, and in southern Madison Valley about 1.2 km (Schofield, 1981 #314; Rasmussen and Fields, 1985 #481). Maximum total throw is probably more than 8 km according to Locke and Schneider (1990 #253).
Length (km)	This section is 39 km of a total fault length of 98 km.
Average strike	N8°W (for section) versus N20°W,N26°W (for whole fault)
Sense of movement	Normal *Comments:* (Witkind, 1975 #317). Predominant sense of movement is probably normal; however, Young (1985 #690) documents slickensides that suggest sinistral, dextral, and normal movement on the variously oriented parts of the fault.
Dip Direction	W *Comments:* Dip is inferred to be steep (Johns and others, 1982

	#259); however, Rasmussen and Fields (1985 #481) suggest that the fault is listric and soles into a Laramide thrust based on seismic data.
Paleoseismology studies	
Geomorphic expression	The fault is expressed as discontinuous, high (locally in excess of 35 m) scarps on alluvium with steep (20?-40?, with mode around 30?) maximum slope angles (Schneider, 1985 #319).
Age of faulted surficial deposits	Holocene and upper Pleistocene alluvium, colluvium, and debris flows (Kellogg, 1992 #433; Kellogg, 1993 #565) upper Pleistocene till, and locally, Cretaceous bedrock (Hadley, 1969 #572; Tysdal, 1990 #573).
Historic earthquake	
Most recent prehistoric deformation	late Quaternary (<130 ka) *Comments:* Age assignment is from Stickney and Bartholomew (1987 #85; 1987 #242; written commun., 1992 #556); however, parts of this section (Burger Creek segment and Indian Creek segment) are thought to be Holocene. Geologic mapping indicates that the majority of scarps are on Holocene and upper Pleistocene alluvium, colluvium, and debris flows (Kellogg, 1992 #433; 1993 #565). In contrast, earlier studies by Schneider (1985 #319) indicated that the fault does not appear to displace upper Pleistocene (Pinedale and possibly Bull Lake) deposits. The time of most recent movement along this part of the fault is not well constrained; thus, a conservative estimate is used in this compilation.
Recurrence interval	>10 k.y. *Comments:* Schneider (1985 #319) provides this recurrence interval for an unspecified period of time. Mason (1992 #463) indicates recurrence interval is 15?5 k.y. for an unspecified period of time based on data of Stickney and Bartholomew (1987 #85).
Slip-rate category	Less than 0.2 mm/yr *Comments:* No known published slip rate exists for this section of the fault; a low slip rate is inferred. Schneider (1985 #319) suggests that this section of fault appears to have been less active

	and have a lower late Quaternary slip rate than sections to the south. Comparison of 1923 second-order and 1960 first-order leveling data indicate uplift rate between 1 and 3 mm/yr in this area, with the higher rates to the south (Reilinger and others, 1977 #479).
Date and Compiler(s)	2010 Kathleen M. Haller, U.S. Geological Survey
References	#572 Hadley, J.B., 1969, Geologic map of the Cameron quadrangle, Madison County, Montana: U.S. Geological Survey Geologic quadrangle Map GQ-813, 1 sheet, scale 1:62,500. #259 Johns, W.M., Straw, W.T., Bergantino, R.N., Dresser, H.W., Hendrix, T.E., McClernan, H.G., Palmquist, J.C., and Schmidt, C.J., 1982, Neotectonic features of southern Montana east of 112°30' west longitude: Montana Bureau of Mines and Geology Open-File Report 91, 79 p., 2 sheets. #433 Kellogg, K.S., 1992, Geologic map of the Fan Mountain quadrangle, Madison County, Montana: U.S. Geological Survey Geologic quadrangle Map GQ-1706, 1 sheet, scale 1:24,000. #565 Kellogg, K.S., 1993, Geologic map of the Cherry Lake quadrangle, Madison County, Montana: U.S. Geological Survey Geologic quadrangle Map GQ-1725, 1 sheet, scale 1:24,000. #566 Kellogg, K.S., 1993, Geologic map of the Ennis Lake quadrangle, Madison County, Montana: U.S. Geological Survey Geologic quadrangle Map GQ-1729, 1 sheet, scale 1:24,000. #7136 Kellogg, K.S., Ruleman, C.A., and Vuke, S.M., 2007, Geologic map of the central Madison Valley (Ennis area), southwestern Montana: Montana Bureau of Mines and Geology Open-File Report 543, 19 p., scale 1:50,000. #253 Locke, W.W., and Schneider, N.P., 1990, General geology and geomorphology of the Madison Range and Valley, southwest Montana, *in* Hall, R.D., ed., Quaternary geology of the western Madison Range, Madison Valley, Tobacco Root range, and Jefferson valley: Rocky Mountain Cell, Friends of the Pleistocene, August 15-19, 1990, Guidebook, p. 1-23. #463 Mason, D.B., 1992, Earthquake magnitude potential of active faults in the Intermountain seismic belt from surface

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#319 Schneider, N.P., 1985, Morphology of the Madison Range fault scarp, southwest Montana—Implications for fault history and segmentation: Oxford, Ohio, Miami University, unpublished M.S. thesis, 131 p.

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