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.

Centennial fault, Red Rock Pass section (Class A) No. 643c

Last Review Date: 2010-12-09

Compiled in cooperation with the Montana Bureau of Mines and Geology

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Synopsis	**General:** Until recently, most published discussions on this fault were based on the data of Witkind (1975 #296). Petrik (2008 #7031) completed a comprehensive fault reconnaissance study, which included relocating the fault using field GPS measurements, geologic mapping, and analysis of fault scarps. This recent work identifies scarps on Holocene and upper Pleistocene deposits preserved along most of the Centennial fault. Revised age categories are based on the most recent work. Earlier published data often cited conflicting evidence regarding the recency and rate of activity of this fault.

	Sections: This fault has 4 sections. Three segments of the Centennial fault are shown in the original mapping of Witkind (1975 #296), and other authors (Johns and others, 1982 #259; Stickney and Bartholomew, 1987 #85; Ostenaa and Wood, 1990 #318) have retained the nomenclature. However, it is unclear if the original intent was to identify independent seismogenic segments. Thus, sections of the fault that have similar characteristics are discussed here. Section boundaries are located where scarps on distinctly different age deposits are present or where the fault trace takes echelon steps. The Centennial Valley segment of Witkind (1975 #296) is divided into 2 sections in this compilation, and Witkins's Red Rock Pass and Henrys Lake segments are discussed as 2 additional sections.
Name comments	**General:** The source of the name is probably Pardee (1950 #46), who describes the fault as extending from near Monida, Montana, eastward to Henrys Lake basin. The fault, as shown here, extends from about 2 km southwest of Mud Lake eastward to 2 km east of the southeastern shore of Henrys Lake. The extent of fault has been shown in various forms in previous compilations. **Section:** Shown as Red Rock Pass segment in Witkind (1975 #296). It extends from near Tom Creek to Rock Creek. **Fault ID:** Refers to fault number 4 (Centennial fault) of Witkind (1975 #317); fault numbers 1 (Centennial fault-Centennial Valley segment) and 35 (Centennial fault-Red Rock Pass-Henrys Lake segment) of Johns and others (1982 #259); fault number 9 (Centennial fault) of Stickney and Bartholomew (1987 #85); and Centennial fault of Stickney and Bartholomew (1987 #242; written commun. 1992 #556).
County(s) and State(s)	BEAVERHEAD COUNTY, MONTANA
Physiographic province(s)	NORTHERN ROCKY MOUNTAINS
Reliability of location	Good Compiled at 1:24,000 scale. *Comments:* Location is based on 1:24,000-scale map of Petrik (2008 #7031) further constrained by satellite imagery and topography at scale of 1:24,000. Reference satellite imagery is ESRI_Imagery_World_2D with a minimum viewing distance of 1

	km. Most of the most recent mapping is similar to the original mapping of Witkind (1975 #296).
Geologic setting	High-angle, down-to-the-north, range-front normal fault bounds the north side of Centennial Mountains. The eastern and western parts of the Centennial fault are expressed by nearly continuous scarps on bedrock and Quaternary deposits; whereas the central part of the fault is composed of left-stepping echelon faults. Ross and Nelson (1964 #249) speculate that this fault continues to the east-trending intrabasin scarps formed during the Hebgen Lake earthquake south of Hebgen Lake [659] through Targhee Pass, which they contend is a modified structural depression; however, Fraser and others (1964 #628) argue to the contrary, citing the diminishing amount of displacement from west to east that appears to die out near Henrys Lake, an interpretation supported by Petrik (2008 #7031). Available gravity data suggest that the Centennial fault terminates in the Madison Valley (Schofield, 1981 #314). Sonderegger and others (1982 #297) report a minimum offset of 1.5-1.8 km of the 2-Ma Huckleberry Ridge Tuff and possibly 3 km of vertical displacement in the past 10 m.y.
Length (km)	This section is 11 km of a total fault length of 62 km.
Average strike	N53°W (for section) versus N78°W (for whole fault)
Sense of movement	Normal *Comments:* (Witkind, 1975 #296; Petrik, 2008 #7031)
Dip Direction	NE; SW
Paleoseismology studies	
Geomorphic expression	Northwest-trending en echelon faults in the bedrock that separates Centennial Valley from Henrys Lake basin; trace is marked by aligned springs, marshes, and seeps (Witkind, 1975 #296; Petrik, 2008 #7031). Most scarps are on bedrock; however, at the eastern end of this section, Petrik (2008 #7031) reports that a Pinedale-equivalent deposit is offset more than 10 m.
Age of faulted surficial deposits	Precambrian crystalline rocks (Witkind, 1975 #296). Scarp shown on map on undifferentiated Quaternary deposits; however, they are reported to be on Pinedale-equivalent deposits (Petrik, 2008

	#7031)latest Pleistocene (Petrik, 2008 #7031).
Historic earthquake	
Most recent prehistoric deformation	undifferentiated Quaternary (<1.6 Ma) *Comments:* Early publications define age of the most recent movement as either Holocene (Pierce and Morgan, 1990 #222; 1992 #539) or late Pleistocene (Johns and others, 1982 #259). A conservative age is assigned here because most of the fault is in bedrock at the surface and only one location is identified by Petrik (2008 #7031) as having a scarp on Quaternary alluvium.
Recurrence interval	
Slip-rate category	Between 0.2 and 1.0 mm/yr *Comments:* An 11-m-high scarp are on Pinedale-equivalent deposits indicates a slip rate that would fall within assigned category. Reilinger and others (1977 #479) show a vertical crustal velocity of 2-5 mm/yr in this area, with rates decreasing to the west, based on leveling data from 1934 and 1964 surveys.
Date and Compiler(s)	2010 Kathleen M. Haller, U.S. Geological Survey
References	#628 Fraser, G.D., Witkind, I.J., and Nelson, W.H., 1964, A geological interpretation of the epicentral area—The dual-basin concept, *in* The Hebgen Lake, Montana, earthquake of August 17, 1959: U.S. Geological Survey Professional Paper 435, p. 99-106. #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. #318 Ostenaa, D., and Wood, C., 1990, Seismotectonic study for Clark Canyon Dam, Pick-Sloan Missouri Basin Program, Montana: U.S. Bureau of Reclamation Seismotectonic Report 90-4, 78 p., 1 pl. #46 Pardee, J.T., 1950, Late Cenozoic block faulting in western Montana: Geological Society of America Bulletin, v. 61, p. 359-406.

#7031 Petrik, F.E., 2008, Scarp analysis of the Centennial normal fault, Beaverhead County, Montana and Fremont County, Idaho: Bozeman, Montana State University, unpublished M.S. thesis, 287 p.

#222 Pierce, K.L., and Morgan, L.A., 1990, The track of the Yellowstone hotspot—Volcanism, faulting, and uplift: U.S. Geological Survey Open-File Report 90-415, 68 p., 1 pl.

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#479 Reilinger, R.E., Citron, G.P., and Brown, L.D., 1977, Recent vertical crustal movements from precise leveling data in southwestern Montana, western Yellowstone National Park, and the Snake River Plain: Journal of Geophysical Research, v. 82, p. 5349-5359.

#249 Ross, C.P., and Nelson, W.H., 1964, Regional seismicity and brief history of Montana earthquakes, *in* The Hebgen Lake, Montana, earthquake of August 17, 1959: U.S. Geological Survey Professional Paper 435-E, p. 25-30.

#314 Schofield, J.D., 1981, Structure of the Centennial and Madison Valleys based on gravitational interpretation, *in* Tucker, T.E., ed., Guidebook to southwest Montana: Montana Geological Society, 1981 Field Conference and Symposium, p. 275-283.

#297 Sonderegger, J.L., Schofield, J.D., Berg, R.B., and Mannick, M.L., 1982, The upper Centennial Valley, Beaverhead and Madison Counties, Montana: Montana Bureau of Mines and Geology Memoir 50, 53 p., 4 pls.

#242 Stickney, M.C., and Bartholomew, M.J., 1987, Preliminary map of late Quaternary faults in western Montana: Montana Bureau of Mines and Geology Open-File Report 186, 1 pl., scale 1:500,000.

#85 Stickney, M.C., and Bartholomew, M.J., 1987, Seismicity and late Quaternary faulting of the northern Basin and Range province, Montana and Idaho: Bulletin of the Seismological Society of America, v. 77, p. 1602-1625.

#556 Stickney, M.C., and Bartholomew, M.J., 1992 written commun., Preliminary map of late Quaternary faults in western Montana (digital data): Montana Bureau of Mines and Geology (digital version of MBMG Open-File Report 186), 1 pl., scale 1:500,000.

#296 Witkind, I.J., 1975, Geology of a strip along the Centennial fault, southwestern Montana and adjacent Idaho: U.S. Geological Survey Miscellaneous Investigations Map I-890, 1 sheet, scale 1:62,500.

#317 Witkind, I.J., 1975, Preliminary map showing known and suspected active faults in western Montana: U.S. Geological Survey Open-File Report 75-285, 36 p. pamphlet, 1 sheet, scale 1:500,000.