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Centennial fault, Henrys Lake section (Class A) No. 643d

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Compiled in cooperation with the Idaho Geological Survey

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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:** Witkind (1975 #296) calls this the Henrys Lake segment but the part denoted as such extends well beyond the western limit of the mapped fault, which extends from Rock Creek eastward to near Henrys Lake at Bootjack Pass. Myers and Hamilton (1964 #250) also suggest that the fault continues eastward into the southern Madison Range. There are some south-stepping echelon scarps near the southeast shore of Henrys Lake (Stickney, oral commun., 1996) that may be unmapped fault scarps. **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)	FREMONT COUNTY, IDAHO
Physiographic province(s)	NORTHERN ROCKY MOUNTAINS

Reliability of location	Good Compiled at 1:24,000 scale. *Comments:* Location 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. Petrik (2008 #7031) shows numerous faults that extend into bedrock; this compilation only shows the major range-bounding fault.
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 10 km of a total fault length of 62 km.
Average strike	N78°E (for section) versus N78°W (for whole fault)
Sense of movement	Normal *Comments:* (Witkind, 1975 #296; Petrik, 2008 #7031)
Dip Direction	N
Paleoseismology studies	
Geomorphic expression	Fault is mostly concealed but probably consists of a single, east-trending trace (Witkind, 1975 #296). Stickney and Bartholomew

	(1987 #85) report a 1-km-long scarp on Holocene deposits along this part of the fault. Witkind (1975 #296) shows a scarp on Rock Creek moraine, which was inferred to be latest Pleistocene in age. Thirteen scarp profiles at the eastern end of the section indicate offset of 5.9-21.6 m (mean of 11.29 m) of Bull Lake-equivalent (?) alluvial fan gravels.
Age of faulted surficial deposits	Bull Lake-equivalent (?) alluvial-fan gravels (Petrik, 2008 #7031). Witkind, (1975 #296) reports that uppermost Pleistocene till are faulted, but notes that other nearby tills of comparable age are unfaulted.
Historic earthquake	
Most recent prehistoric deformation	late Quaternary (<130 ka) *Comments:* Early publications define age of the most recent movement as postglacial (<15 ka; (Witkind, 1975 #296); Pierce and Morgan (1990 #222; 1992 #539) show faulting on this section as Holocene, and Johns and others (1982 #259) show it as late Pleistocene. Stickney and Bartholomew (1987 #85) document a 1-km-long Holocene scarp on this section. Assigned age category is based on offset late Pleistocene deposits (Petrik, 2008 #7031).
Recurrence interval	
Slip-rate category	Between 0.2 and 1.0 mm/yr *Comments:* Petrik (2008 #7031) estimates slip rates for multiple scarp profiles using both latest Pleistocene ages for the faulted deposits (12 and 14 ka) and late Pleistocene ages (130 and 140 ka). Slip rates range from 0.04 to 1.8 mm/yr for the latest Pleistocene age assignment and 0.11 to 0.17 mm/yr for the late Pleistocene age assignment. Slip-rate category assignment is based on the mean of all of her slip rate estimates. Pierce and Morgan (1992 #539) report ta maximum slip rate of 1.3 mm/yr (<15 ka) for the eastern and central parts of the fault based on as much as 20 m of offset of 15 ka deposits from data of Witkind (1975 #296). A long-term (<2 Ma) slip rate of greater than 0.75 mm/yr (Pierce and Morgan, 1992 #539) is based on 1.5- to 1.8-km minimum offset of Huckleberry Ridge Tuff (Sonderegger and others, 1982 #297). Reilinger and others (1977 #479) show a vertical crustal velocity of 5 mm/yr in this area 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. #250 Myers, W.B., and Hamilton, W., 1964, Deformation accompanying the Hebgen Lake earthquake of August 17, 1959, *in* The Hebgen Lake, Montana, earthquake of August 17, 1959: U.S. Geological Survey Professional Paper 435-I, p. 55-98. #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. #539 Pierce, K.L., and Morgan, L.A., 1992, The track of the Yellowstone hot spot—Volcanism, faulting, and uplift, *in* Link, P.K., Kuntz, M.A., and Platt, L.B., eds., Regional geology of eastern Idaho and western Wyoming: Geological Society of America Memoir 179, p. 1-53, 1 pl.

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#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.