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Quaternary Fault and Fold Database of the United States

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Red Canyon fault, Red Canyon section (Class A) No. 657a

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Compiled in cooperation with the Montana Bureau of Mines and Geology

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Synopsis	**General:** Even though the largest historic earthquake in Montana resulted in surface rupture of part of this fault, little is known about its paleoseismic history. The Hebgen Lake earthquake (Mw7.3) of 1959 resulted in surface rupture on this fault and the nearby Hebgen fault [656]. The majority of published data are in reports dating from the early 1960s from studies initiated due to the 1959 Hebgen Lake earthquake. **Sections:** This fault has 3 sections. The sections defined in this compilation are based on distinct differences in timing of most

	recent surface faulting along the strike of the fault. The westernmost section [Red Canyon, 657a] ruptured in the 1959 Hebgen Lake earthquake; the other two sections [Richards Creek 657b, Maple Creek 657c] are prehistoric and are located to the east in Wyoming. The central section [657b] has postglacial offset, and the easternmost section [657c] displaces 0.63-Ma Lava Creek Tuff.
Name comments	**General:** Pardee (1950 #46) noted morphology indicative of a fault-controlled range front along the northeastern side of Hebgen Lake but did not report a fault name. The earliest use of this fault name was probably from the numerous publications resulting from studies following the 1959 Hebgen Lake earthquake (Woodard, 1960 #653; Witkind and others, 1962 #633; Witkind, 1964 #247; Myers and Hamilton, 1964 #250; Witkind and others, 1964 #629; Witkind, 1969 #468). Myers and Hamilton (1964 #250) refer to the part of this fault southeast of the mouth of Red Canyon as the "Corey Spring fault zone." The Red Canyon fault extends from about 1 km northeast of the intersection of Kirkwood Creek and Hebgen fault [656], east to a point about 4 km into Wyoming and Yellowstone National Park. **Section:** This section comprises the 1959 rupture along the Red Canyon fault as mapped by (Witkind, 1964 #247; Myers and Hamilton, 1964 #250). The western end of the section is at Kirkwood Creek about 1 km northeast of Hebgen Lake, where it intersects the Hebgen fault [656] at a high angle. The Red Canyon section extends from about 1 km northeast of the Hebgen fault [656] northeast along the north side of Kirkwood Creek, along the south flank of Kirkwood Ridge and along the northeast side of Red Canyon. At the mouth of Red Canyon, the fault turns abruptly to the east and bounds the Grayling Arm of Hebgen Lake. **Fault ID:** Refers to number 7 (Red Canyon fault) of Witkind (1975 #317), number 43 (Red Canyon fault) of Johns and others (1982 #259) and number 14 (Red Canyon fault) of Stickney and Bartholomew (1987 #85).
County(s) and State(s)	GALLATIN COUNTY, MONTANA
Physiographic province(s)	NORTHERN ROCKY MOUNTAINS
Reliability of	Good

location	Compiled at 1:24,000 scale. *Comments:* Location is based on the 1:62,500-scale map of 1959 deformation (Witkind, 1964 #247; Myers and Hamilton, 1964 #250), 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	This high-angle, down-to-the-southwest, arcuate fault is one in a belt of active faults that extends westward from Yellowstone and that Pierce and Morgan (1992 #539) relate to the easterly track of the Yellowstone hotspot. The fault extends along the southwest flank of Kirkwood Ridge, continuing south along northeastern side of Red Canyon, northern side of Grayling Arm of Hebgen Lake, and extends into the glacial outwash plain west of Yellowstone basin. The fault generally parallels the strike of bedrock units (Witkind, 1964 #247; Myers and Hamilton, 1964 #250). Locally, the western section the fault follows the contact between massive limestone and thin-bedded shale (Doser, 1985 #22). Witkind (1964 #247), indicating that the net cumulative throw is several thousand feet along the central part of main fault section [657a], but the exact amount is indeterminable.
Length (km)	This section is 18 km of a total fault length of 29 km.
Average strike	N57°W (for section) versus N63°W (for whole fault)
Sense of movement	Normal *Comments:* Based on slip from the Hebgen Lake earthquake (Witkind, 1964 #247; Witkind and others, 1964 #629).
Dip	50–85° SW *Comments:* Range in dips from exposures of fault plane (Witkind, 1964 #247); Johns and others (1982 #259) indicate dip is nearly vertical. Modeling of geodetic data suggests that the fault dips 50° SW. (Barrientos and others, 1987 #269).
Paleoseismology studies	The USGS conducted exploratory trenching of the Red Canyon fault and Hegben [656] fault in the summer of 2000. Although preliminary, the investigations by Haller and others (2000 #4603; 2000 #4606) on the Red Canyon fault should yield information on

	the timing of the penultimate (prehistoric) event and the amount of throw associated with the faulted Pinedale outwash surface. Their trench site (site 657-1) on the Red Canyon fault was located south of Grayling Creek, near the eastern end of the Red Canyon section [657a].
Geomorphic expression	Historical fault scarps are 0.1–4.6 m high and locally superimposed on prehistoric scarps (Witkind, 1964 #247; Myers and Hamilton, 1964 #250). Wallace (1980 #657) details significant degradation of scarp at two locations.
Age of faulted surficial deposits	Witkind (1964 #247) indicates scarps are all on unconsolidated sediments. Based on mapping, shown on plate 5 of USGS Professional Paper 435 (1964), about 30 percent of the length of the scarps are on upper Quaternary (Pinedale and Bull Lake) alluvium and 70 percent on Precambrian, Cambrian, Devonian, and Mississippian bedrock.
Historic earthquake	Hebgen Lake earthquake 1959
Most recent prehistoric deformation	late Quaternary (<130 ka) *Comments:* Woodard (1960 #653) provided detailed descriptions of scarps on this fault as well as documenting evidence of postglacial (Pinedale) faulting at several locations. Other early papers discussing this fault suggested that there is local evidence of prior faulting (Witkind and others, 1962 #633; Witkind, 1964 #247; Myers and Hamilton, 1964 #250) suggesting at least two pre-1959 surface-faulting events at Blarneystone Ranch. Several 1954-vintage aerial photographs of the Grayling Creek area show clear evidence of a preexisting scarp on deposits that are now known to be latest Pleistocene in age. Preliminary paleoseismic data on the Red Canyon fault suggest that the penultimate event was younger than 10 ka (Schwartz, 2000 #4607), but unpublished radiocarbon dates obtained by Haller in 2001 suggest that the event occurred at about 3 ka, which is similar to the timing estimates for the adjacent Hebgen fault [656] (Pierce and others, 2000 #4609; Hecker and others, 2000 #4610). Morphologic studies by Nash (1984 #343) estimated the age of prehistoric faulting on nearby intrabasin fault scarps [659] to be 2.8±1.0 k.y. Doser (1985 #22) reported a radiocarbon date of 3,250±850 yr B.P. that is attributed to Nash. Alexander and others (1994 #1252) suggested that the migration of the South Fork of the Madison River meander belt to the east is due to recurrent Holocene

	faulting.
Recurrence interval	5.4–29.8 k.y. (<0.6–2.0 Ma) *Comments:* Wheeler and Krystinik (1992 #608) had suggested a recurrence interval of 5.4–29.8 k.y. by considering the maximum age of the fault zone (including the Hebgen fault [656]) to be 0.6–2.0 m.y., the net cumulative throw of 305 m as determined from Witkind's data (1964 #247), and slip events having displacements similar to the 1959 Hebgen Lake earthquake. Ostenaa and Wood (1990 #318) indicated the recurrence interval is less than 10 k.y. for an unspecified time interval. Pierce and Friedman (1996 #3941) indicated that no more that three surface-faulting events including the 1959 earthquake have occurred in about the past 30 k.y. They further suggested that the recurrence interval is 10 k.y. or greater for one or both of the major faults involved in the Hebgen Lake earthquake. Data are poorly constrained and paleoseismic information on individual faults affected by the Hebgen Lake earthquake is not currently available.
Slip-rate category	Between 0.2 and 1.0 mm/yr *Comments:* The preliminary data of Haller and others (2000 #4603) suggests that the slip rate falls within this category (1–2 m of offset, 3 k.y. recurrence). The only other known slip rate published for this fault zone is by Doser (1985 #641) whose estimate of 0.8–2.5 mm/yr is for an unspecified time interval. Based on data that Wheeler and Krystinik (1992 #608) used to determine recurrence intervals, a lower long-term slip rate (305 m in 0.6–2.0 Ma) is suggested for the 1959 rupture zone, which includes the Hebgen fault [656].
Date and Compiler(s)	2010 Kathleen M. Haller, U.S. Geological Survey
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