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.

Red Rock fault, Timber Butte section (Class A) No. 641b

Last Review Date: 2011-01-21

Compiled in cooperation with the Montana Bureau of Mines and Geology

citation for this record: **Haller, K.M., compiler, 2011, Fault number 641b, Red Rock fault, Timber Butte section, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, https://earthquakes.usgs.gov/hazards/qfaults, accessed 12/14/2020 02:03 PM.**

Synopsis	**General:** Trenching at one site on the southern part of the fault, along with clear differences in fault-scarp morphology, geologic relations between faulted and unfaulted deposits, and basin geometry defined by Residual Bouguer gravity data indicate that the three parts of the fault probably have different faulting histories. The northern part, as shown in this compilation by a valleyward echelon step in the fault at its southern end, has been the subject of little study. **Sections:** This fault has 3 sections. Sections are defined by the

	apparent differences in the times of the most recent prehistoric deformation. The two southern sections were first identified by Stickney and Bartholomew (1987 #85). They defined segments from geomorphic data of Johnson (1981 #30) even though Johnson divided this part of the fault into four segments (it is unclear if Johnson meant seismogenic segments). Later studies (Greenwell, 1997 #7035; Harkins and others, 2005 #7034) suggested alternative segment boundaries leading to segments as short as 8-km long (see figure 2 Harkins and others, 2005 #7034). In contrast, Bartholomew and others (2004 #6899) suggest that the two, more active sections of the fault [641b and 641c] rupture together.
Name comments	**General:** The source of the name Red Rock fault is probably from Pardee (1950 #46), who defined the fault as extending from near Clark Canyon Reservoir to southwest of Lima, Montana, along the east flank of the Tendoy Montains. Pardee also referred to this structure as the Lima fault, whereas Scholten and others (1955 #69) used Red Rock fault zone. The fault, as shown in this compilation, extends from about 2 km north of Limekiln Canyon southward to near Birch Creek. Other compilations show only the southern two-thirds of the fault shown in this compilation (Witkind, 1975 #317; Stickney and Bartholomew, 1987 #242). **Section:** Named and defined as the Timber Butte segment by Stickney and Bartholomew (1987 #85; 1987 #242) based on geomorphic data of Johnson (1981 #30). It extends from near Kelmbeck Creek southeastward to about midway between Big Sheep Creek and Dry Canyon (Haller, 1988 #27). The part of fault Johnson (1981 #30) defined that most closely coincides with Timber Butte segment extends from Kelmbeck Creek to Garr Canyon, about 6 km south of southern segment boundary given in this compilation. Bartholomew (1989 #294) believed the Timber Butte-Sheep Creeks segment boundary is farther north than Haller's based on a Holocene scarp at Little Water Canyon. Crone and Haller (1991 #186) argue that this young scarp is small and uncharacteristic of older scarps at this site and is probably the result of partly ineffective barrier to ruptures at the segment boundary. **Fault ID:** Refers to number 8 (Red Rock fault zone) of Witkind (1975 #317); number 4 (Red Rock fault) of Stickney and Bartholomew (1987 #85); and Timber Butte and Sheep Creeks segments of Red Rock fault in Montana Bureau of Mines and Geology digital database (Stickney, written commun., 1992) and

	Stickney and Bartholomew (1987 #242).
County(s) and State(s)	BEAVERHEAD COUNTY, MONTANA
Physiographic province(s)	NORTHERN ROCKY MOUNTAINS
Reliability of location	Good Compiled at 1:100,000 scale. *Comments:* Location of fault based on map referenced to 1:24,000 base of Bartholomew and others (2009 #7041) and 1:250,000-scale maps of Haller (1988 #27), original mapping at 1:24,000 scale, further constrained 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. The location of the fault is depicted in a similar manner on 1:100,000-scale geologic map of Lonn and others (2000 #7055).
Geologic setting	High-angle, down-to-the-northeast, range-front normal fault bounding northeast side of Tendoy Mountains. There is no evidence of young faulting south of mapped trace even though the mountain front extends farther south. The total vertical separation may be 1 km based on gravity data (Johnson, 1981 #313) and displacement?length relations (Harkins and others, 2005 #7034). Hurlow (1995 #1063) also suggests about 1 km of structural relief. However, Bartholomew and others (2009 #7041) state that the Red Rock basin is smaller and very shallow (3,600-m deep) compared to other basins of the northern Basin and Range; in addition, the basin does not contain a thick sequence of Eocene-Miocene sediments.
Length (km)	This section is 9 km of a total fault length of 41 km.
Average strike	N33°W (for section) versus N34°W,N33°W (for whole fault)
Sense of movement	Normal *Comments:* (Witkind, 1975 #317)
Dip Direction	NE
Paleoseismology studies	
Geomorphic	The section is characterized by steep composite fault scarps with

expression	well-preserved triangular-faceted bedrock spurs (Pardee, 1950 #46; Scholten and others, 1955 #69). Pardee (1950 #46) recognized that the young fault scarps, which characterize most of Red Rock fault, result from recent movement because of their steep slopes (30?-33?). Scarps on alluvium are discontinuous; single-event scarps are 1- to 3-m high and multiple-event scarps can be as high as 20-25 m. Harkins and others (2005 #7034) show on figure 9 that the overall offset is smaller along this part of the fault compared to the Sheep Creeks section to the south [641c].
Age of faulted surficial deposits	Red Rock fault is mapped at the contact between bedrock and alluvium (Lonn and others, 2000 #7055).
Historic earthquake	
Most recent prehistoric deformation	late Quaternary (<130 ka) *Comments:* Most authors agree that the most recent faulting occurred at about or prior to 15 ka. Because there is no definitive data, we use a conservative estimate of less than 130 ka. Most recent faulting event occurred between 10 and 15 ka according to Haller (1988 #27) and Crone and Haller (1991 #186), based on morphology of scarps and inferred ages of faulted and unfaulted deposits. Stickney and Bartholomew (1987 #85) suggest latest Pleistocene deposits are not faulted and, thus, faulting might predate 12-15 ka. Johnson (1981 #30) believed youngest faulting may be as old as 100 ka. Comparison of a number of geomorphic measures, suggest that the southern part of the fault is tectonically more active than the central part (Bartholomew and others, 2009 #7041).
Recurrence interval	12-25 k.y. (<25 ka) *Comments:* Recurrence interval from Ostenaa and Wood (1990 #318); time for which this interval is valid (25 k.y.) is assumed from their discussion.
Slip-rate category	Less than 0.2 mm/yr *Comments:* Harkins and others (2005 #7034) show slip rates based on the offset from the most recent event and acknowledge they represent maximum rates, as shown on figure 9. The slip rates presented are an order of magnitude larger than suggested

	rate based on the overall morphology of the fault and probably is the basis of the 1.5 mm/yr slip rate reported by Majerowicz and others (2007 #7036). In contrast, a low slip rate category is assigned in this compilation based on 1- to 3-m-high scarps on upper Pleistocene deposits (Stickney and Bartholomew, 1987 #85).
Date and Compiler(s)	2011 Kathleen M. Haller, U.S. Geological Survey
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