Quaternary Fault and Fold Database of the United States

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Mission fault, Mission Valley section (Class A) No. 699b

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Compiled in cooperation with the Montana Bureau of Mines and Geology

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Synopsis	**General:** Studies of this fault in the 1990s were the first to document Holocene surface rupture north of the Lewis and Clark line. Recurrent late Quaternary movement is apparent along the southern part of the fault based on geologic mapping, field reconnaissance, and numerous trench studies. The northern section is characterized by the absence of scarps on alluvium and thus is largely unstudied with the exception of geophysical investigations. **Sections:** This fault has 2 sections. Extent of the sections is based

	on similar late Quaternary faulting histories at numerous trench sites along the southern (Mission Valley) section (Ostenaa and others, 1995 #912) and the presence of sub-lacustrine scarps along the northern (Flathead Lake) section (Hofmann and others, 2006 #7039). The boundary between the sections coincides with a change in the depth of the bedrock-alluvial contact in the adjacent basin (Ostenaa and others, 1990 #540).
Name comments	**General:** First recognized by Wilson (1921 #1025) who suggested a late Cenozoic age. The fault, as shown in this compilation, extends from the Flathead River between Creston and Kalispell, Montana, southward to St. Marys Lake. Witkind (1975 #317) shows the location of the fault slightly different than shown here. **Section:** Defined as a seismogenic segment and named as such (Mission Valley segment) by Ostenaa and others (1995 #912). This part of the fault was originally called the southern segment in an earlier publication (Ostenaa and others, 1990 #540). The section extends from 6 km east of Pablo, Montana, southward to St. Marys Lake, and may extend 2-5 km further south (Ostenaa and Levish, 1994 #1013; Ostenaa and others, 1995 #912). **Fault ID:** Refers to fault number 92 (Mission fault) of Witkind (1975 #317).
County(s) and State(s)	LAKE COUNTY, MONTANA
Physiographic province(s)	NORTHERN ROCKY MOUNTAINS
Reliability of location	Good Compiled at 1:250,000 scale. *Comments:* Location primarily based on 1:48,000-scale map of Ostenaa and others (1990 #540) augmented by 1:24,000-scale site maps of Ostenaa and others (1995 #912).
Geologic setting	High-angle, down-to-the-west, normal fault bounding the western side of Mission Range. Evidence of a dextral component of movement is locally recognized along some parts of the fault. Displacement across the Mission fault is smallest along the northern part of the fault and increases to a maximum near the southern end; however, the amount of total displacement is unknown. The Mission fault along the Flathead Lake section

	[699a] consists of several subparallel strands. Beyond the lake basin, bedrock in the valley is buried by a thin (20- to 30-m-thick) alluvial cover (Ostenaa and others, 1990 #540; 1995 #912). LaPoint (1973 #1022) suggests 3-3.5 km of vertical displacement across the northern part of the fault. Pardee (1950 #46) suggested that late Cenozoic vertical offset across the southern part of the fault is at least 2.5 km assuming Tertiary peneplain correlation across the fault is correct. Based on gravity data, the maximum depth to bedrock is generally 300 m but reaches a depth of about 600 m near the southern end of the fault (Ostenaa and others, 1995 #912), and 0.9-1.6 Ga Belt Supergroup rocks may be displaced more than 5 km (Ostenaa and others, 1990 #540).
Length (km)	This section is 40 km of a total fault length of 104 km.
Average strike	N12°W (for section) versus N8°W (for whole fault)
Sense of movement	Normal *Comments:* Sense of movement from Witkind (1975 #317). Along the fault north of Mission Reservoir, the sense of slip appears to be normal based on the displacement of geomorphic features (Ostenaa and Levish, 1994 #1013). Along the southern part of the section where the strike of the fault is N. 45? W, a significant component of dextral slip is reported (Ostenaa and Levish, 1994 #1013; Ostenaa and others, 1995 #912).
Dip Direction	W
Paleoseismology studies	Seventeen trenches have been excavated at five sites on surfaces younger than the highstand of Lake Missoula (less than or equal to 15-19 ka) by Ostenaa and others (1995 #912) and Ostenaa and Levish (1994 #1013). Many of the trenches were excavated on surfaces that record two displacement events and are near older surfaces that record several more events. North Crow Creek (site 699-1), located about 250 m north of North Crow Creek and about 600 m west of North Crow Creek campground, was excavated into an inset moraine thought to be 15-19 ka. The trenched scarp is 6-7 m high with a surface offset of 4-5 m; surface on older deposit nearby has 14-m-high scarp with possible lateral displacement of as much as 20 m. South Crow Creek (site 699-2), located south of South Crow Creek and about 9 km south of the North Crow Creek site; a

	trench was excavated into an inset alluvial surface adjacent to the southern lateral moraine. The trench crosses a 20-m-wide graben with estimated offset of 3.0?9.8 m (the preferred value is 4?6 m); nearby older deposit has a 12.4-m-high scarp. Marsh Creek (site 699-3), located north of Marsh Creek and about 3.7 km south of the South Crow Creek site; a trench was excavated on inset alluvial surface thought to be younger than 15-19 ka. The trenched scarp is about 4.0 m high with a surface offset of about 3.3 m. The complexity of deformation and the more northeasterly strike of the fault at this site might be evidence of a larger lateral component of movement at this site. A second trench was excavated at this site into an inset surface that has no scarp, and was found to be unfaulted. Mission Reservoir (sites 699-4 and 5), located between Mission Creek access road and Mission Creek and about 19 km south of Marsh Creek site; two trenches were excavated about 20 m apart on alluvium thought to be approximately 15-19 ka. The trenches extend across faulted deposits but there is no scarp present. The surface of the nearby southern lateral moraine (possibly 19-23 ka) has a 12.4-m-high scarp that may record possibly 20 m of lateral movement. Movement during the most recent event only is indicated by the relations of deposits in these two trenches, and the absence of a consistent sense of vertical displacement associated with individual faults in trench 699-5 seems to indicate a significant lateral-slip component. Tabor Dam (site 699-6). Eleven trenches were excavated at this site in 1993-1994 (Ostenaa and Levish, 1994 #1013). They document evidence of surface faulting; however, other trenches at this site did not reveal evidence of faulting. Further reassessment of the site included 11 additional trenches excavated in September 1996. The conclusion of this later study is that there is not an "active Quaternary fault" near Tabor Dam (Anderson and Klinnger, 1997 #6902).
Geomorphic expression	Fault section is marked by nearly continuous, fault scarps that coincide with the western limit of bedrock outcrops, morphologically young scarps on Quaternary surfaces in drainage embayments, and aligned, linear, bedrock facets. Elevation of range increases from north to south.
Age of faulted	Late Quaternary moraines, including those that have

surficial deposits	characteristics of deposition into Lake Missoula, and upper Quaternary alluvium (Ostenaa and others, 1995 #912).
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* Ostenaa and others (1995 #912) indicate that the most recent event on this segment of the Mission fault occurred 7.7 ? 0.2 ka. Primary Mazama ash (7.6 ka) is present in scarp-derived colluvium at trenches 699-1 and 2. Unfaulted deposits near 699-3 have an age of 6.7 k.y., and thus define an upper limit on the age of the most recent event. None of the relations in trench 699-3 preclude the interpretation of a early Holocene event. Timing of the single event at trench sites 699-4 and 699-5 is 7.6-8.7 ka, which is bracketed by Mazama ash (7.6 ka) and radiocarbon ages on samples from faulted and unfaulted deposits.
Recurrence interval	<7.3-11.3 k.y. (<15-19 ka) *Comments:* Trench sites 699-1, 699-2, and 699-3 all contain evidence of more than one faulting event; however, the time of earlier faulting is unconstrained. The 11.3 k.y. recurrence interval assumes the penultimate event occurred immediately following oldest inferred time of stabilization of surfaces at these sites (19 ka), and the 7.3 k.y. interval assumes the penultimate event occurred midway between the youngest inferred time of stabilization of surfaces (15 ka) and the most recent event. A shorter average recurrence interval of 4-8 k.y. for the past 19-23 ka is suggested by Ostenaa and others (1995 #912) based on the assumption that the higher scarps on older deposits are the product of 3-4 events. Earlier estimates of recurrence intervals were significantly longer (Ostenaa and others, 1990 #540).
Slip-rate category	Between 0.2 and 1.0 mm/yr *Comments:* There are no known published slip rates for this segment of the Mission fault. The slip data and recurrence intervals in Ostenaa and others (1995 #912) indicate that a vertical slip rate of 0.1-0.5 is reasonable. Most of the rates that can be calculated from the data are greater than 0.2 mm/yr; therefore, the higher of the two possible slip-rate categories was selected here. In addition, no lateral-slip component is included in the calculated slip rate, and thus, the value we use here may be a

	minimum value.
Date and Compiler(s)	2011 Kathleen M. Haller, U.S. Geological Survey
References	#6902 Anderson, L.A., and Klinger, R.E., 1997, Evaluation of surface faulting potential for conceptual design—Tabor Dam, Flathead Indian Reservation, Montana: Bureau of Reclamation Technical Memorandum D8330-97-003, 5 p. #7039 Hofmann, M.H., Hendrix, M.S., Sperazza, M., and Moore, J.N., 2006, Neotectonic evolution and fault geometry change along a major extensional fault system in the Mission and Flathead Valleys, NW-Montana: Journal of Structural Geology, v. 28, p. 1244-1260. #1022 LaPoint, D.J., 1973, Gravity survey and geology of the Flathead Lake region, Montana: Northwest Geology, v. 2, p. 13-20. #1013 Ostenaa, D.A., and Levish, D.R., 1994, Surface faulting investigations for Tabor Dam: U.S. Bureau of Reclamation Seismotectonic Report 94-7, 30 p. #912 Ostenaa, D.A., Levish, D.R., and Klinger, R.E., 1995, Mission fault study: U.S. Bureau of Reclamation Seismotectonic Report 94-8, 111 p. #540 Ostenaa, D., Manley, W., Gilbert, J., LaForge, R., Wood, C., and Weisenberg, C.W., 1990, Flathead Reservation regional seismotectonic study—An evaluation for dam safety: U.S. Bureau of Reclamation Seismotectonic Report 90-8, 161 p., 7 pls. #46 Pardee, J.T., 1950, Late Cenozoic block faulting in western Montana: Geological Society of America Bulletin, v. 61, p. 359-406. #1025 Wilson, R.A., 1921, Geology and physiography of the Mission Range, Montana: Chicago, Illinois, University of Chicago, unpublished Ph.D. dissertation, 107 p. #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.