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Mission fault, Flathead Lake section (Class A) No. 699a

Last Review Date: 2011-01-24

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 (Flathead Lake segment) by Ostenaa and others (1995 #912). The part of the fault shown here originally called the northern segment in an earlier publication (Ostenaa and others, 1990 #540). The section consists of numerous subparallel traces (some of which are sublacustrine) that extend from the Flathead River southward to 6 km east of Pablo, Montana, south of Flathead Lake. **Fault ID:** Refers to fault number 92 (Mission fault) of Witkind (1975 #317).
County(s) and State(s)	FLATHEAD COUNTY, MONTANA LAKE COUNTY, MONTANA
Physiographic province(s)	NORTHERN ROCKY MOUNTAINS
Reliability of location	Poor Compiled at 1:250,000 scale. *Comments:* Source of traces is approximately 1:400,000-scale map of Hofmann and others (2006 #7039). Location of the fault is based on 270 km of high-resolution seismic data, originally collected and described by Kogan (1981 #958). The map shows numerous faults in Flathead Lake basin that generally define a broad, north-trending graben.
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 67 km of a total fault length of 104 km.
Average strike	N7°W (for section) versus N8°W (for whole fault)
Sense of movement	Normal *Comments:* (Witkind, 1975 #317)
Dip Direction	W; E
Paleoseismology studies	
Geomorphic expression	Hofmann and others (2006 #7039) show that the fault has many subparallel traces under Flathead Lake. In contrast, the onshore subparallel traces of the Flathead Lake section as depicted by Ostenaa and others (1990 #540) do not have fault scarps on alluvium or glacial deposits. Most of the onshore traces are inferred from aligned ridge-crest saddles and linear side-hill depressions. The range front is linear. Elevation of the range gradually increases from north to south.
Age of faulted surficial deposits	Pleistocene sediments associated with the last glacial maximum are offset (Hofmann and others, 2006 #7039).
Historic earthquake	
Most recent	latest Quaternary (<15 ka)

prehistoric deformation	*Comments:* Based on seismic reflection imaging of the upper 60 m of sediments in Flathead Lake, Hofmann and others (2006 #7039), Kogan (1981 #958) and Wold, (1982 #957) suggest that displacement on this segment has occurred during post-glacial (<15 ka) time. The most recent study of the available seismic reflection data documents evidence for five phases of tectonic activity in the lake basin in the past 15,000 years (Hofmann and others, 2006 #7039), However, some or all of the features have been ascribed to glacial erosion or post-glacial slumping because similar evidence of recent faulting is absent onshore (Ostenaa and others, 1990 #540; 1995 #912). Based on the same data, Qamar and others (1982 #516) and Ostenaa and others (1995 #912) concluded that the youngest displacement on this segment is at least 10 ka and possibly older than the retreat of the Flathead lobe of the Cordilleran ice sheet from the Polson moraine. Hofmann and others (2006 #7039), suggest that most of the displacement is older than that to the south.
Recurrence interval	
Slip-rate category	Between 0.2 and 1.0 mm/yr *Comments:* The assigned slip rate category is based on Hofmann and others (2006 #7039), who document 14 m of relief along the Mission fault and the Kalispell?Finley Point fault in Pleistocene deposits and indicate average displacement rates as high as 1 mm/yr. Faulting in the Holocene seemingly resulted in only minor displacement and is not reported here. However, the long-term slip rate is likely lower than on Mission Valley section to the south based on lower topographic and structural relief.
Date and Compiler(s)	2011 Kathleen M. Haller, U.S. Geological Survey
References	#6900 Hofmann, M.H., and Hendrix, M.S., 2003, Quaternary history of the Mission Valley, NW-Montana; results of geologic mapping: Geological Society of America Abstracts with Programs, v. 35, no. 6, p. 425. #6901 Hofmann, M.H., and Hendrix, M.S., 2003, Results of geologic mapping of the Mission fault system and associated geology, northwestern Montana: Geological Society of America Abstracts with Programs, v. 35, no. 5, p. 39.

#958 Kogan, J., 1981, A seismic sub-bottom profiling study of recent sedimentation in Flathead Lake, Montana: Missoula, University of Montana, unpublished M.S. thesis, 98 p.

#1022 LaPoint, D.J., 1973, Gravity survey and geology of the Flathead Lake region, Montana: Northwest Geology, v. 2, p. 13-20.

#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.

#516 Qamar, A., Kogan, J., and Stickney, M.C., 1982, Tectonics and recent seismicity near Flathead Lake, Montana: Bulletin of the Seismological Society of America, v. 72, p. 1591-1599.

#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.

#957 Wold, R.J., 1982, Seismic reflection study of Flathead Lake, Montana: U.S. Geological Survey Miscellaneous Field Studies Map MF-1433, 1 sheet.

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