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Lemhi fault, Warm Creek section (Class A) No. 602d

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Compiled in cooperation with the Idaho Geological Survey

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Synopsis	**General:** The Lemhi fault is a 135-km-long, southwest-facing, normal fault along the southwestern base of the Lemhi Range. Several workers have defined differing numbers of segments; thus, the extent to which large ruptures of various ages have crossed or stopped at the various proposed segment boundaries remains undetermined. Accordingly, the Lemhi fault was divided into six sections based on mapping, morphological data, dating, and trenching of scarps and the surfaces they offset. The four southern sections are better studied than the two northern sections. All but the two end sections are known to have had

	Holocene or postglacial surface ruptures. The few determinations of individual recurrence intervals of large surface ruptures vary from approximately 6 to 20 k.y. The central part of the fault appears to have had higher slip rates than the end parts. **Sections:** This fault has 6 sections. Numerous investigators have attempted to define segments of Lemhi fault based on a variety of methodologies. Baltzer (1990 #432) defines four segments along the northern 80 km of fault based on trenching studies and mapping of Quaternary deposits, Turko (1988 #4642) and Turko and Knuepfer (1991 #227) define a minimum of six to nine segments based on analysis of scarp-morphology data, Haller (1988 #27) and Crone and Haller (1991 #186) define six segments based on scarp-morphology studies, and Stickney and Bartholomew (1987 #85) provide descriptions of scarps at six localities. The segmentation model of Baltzer (1990 #432) is used in this compilation for the northern part of fault because of its recency and level of detail of the investigation. The middle section boundary of the Lemhi fault, that between sections 602c (Big Gulch) and 602d (Warm Creek), was located in essentially the same place by Haller (1988 #27), Turko (1988 #4642), and Baltzer (1990 #432). South of that section boundary, the three section names of Turko and Knuepfer (1991 #227) and Baltzer (1990 #432) are used. However, for the southern boundaries of these three sections (602d, 602e, and 602f), the locations of Haller (1988 #27) are used, because they are described in the greatest geographic detail and are, therefore, the easiest to identify on topographic maps and in the field for future study and testing. These locations, which Haller (1988 #27) showed on a 1:250,000-scale topographic base, are consistent with those of Turko and Knuepfer (1991 #227) within the spacing of their data points along the Lemhi fault.
Name comments	**General:** Both Anderson (1934 #595) and Baldwin (1951 #427) recognized Basin and Range style of faulting in this area, as well as large amounts of throw across this and nearby faults and the recency of their movement. Baldwin (1951 #427) is probably one of the earliest to use the name Lemhi fault for this structure. The fault extends entire length of Lemhi Range, although study area of Baldwin did not encompass entire fault. **Section:** The name "Warm Creek segment" is used by Turko (1988 #4642) and Turko and Knuepfer (1991 #227); Baltzer (1990 #432) uses the same name for part of Turko's segment within study area. The northern boundary as defined by Turko and

	Knuepfer (1991 #227) is between Bear Canyon and Sawmill Canyon. This boundary coincides with prominent range-front embayment. Janecke (1993 #6550) indicates that the location of this boundary is controlled by the intersection of the Lemhi fault with the nearly vertical, north-trending Paleogene Sawmill Canyon fault. Investigators generally agree on the location of southern boundary between Williams Creek and Horse Creek (Haller, 1988 #27; Crone and Haller, 1991 #186; Turko and Knuepfer, 1991 #227). The Warm Creek section, herein, contains southern part of the Sawmill Gulch segment of Haller (1988 #27) and Crone and Haller (1991 #186). Discussion of this part of section in Stickney and Bartholomew (1987 #85) uses the name of Mahogany Creek scarp. It is also shown as Mahogany Creek segment in Montana Bureau of Mines and Geology digital database (Stickney, written commun., 1992). **Fault ID:** Refers to number 115 ("unnamed series of faults along southwest flank Lemhi Range") in Witkind (1975 #320).
County(s) and State(s)	BUTTE COUNTY, IDAHO LEMHI COUNTY, IDAHO
Physiographic province(s)	NORTHERN ROCKY MOUNTAINS
Reliability of location	Good Compiled at 1:24,000 scale. *Comments:* Location of the scarps is based on 1:250,000-scale maps of Haller (1988 #27; original mapping at 1:24,000 or 1:62,500), 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 (1,000 m).
Geologic setting	This part of east-central Idaho and southwest Montana is made of Precambrian and Paleozoic rocks that were shortened by folding and faulting and were thrust northeastward during the late Mesozoic. Mid- to late Cenozoic extension broke the thrust complex into northwest-trending basins and ranges and continues today. The Lemhi fault is a high-angle, down-to-the southwest, range-front normal fault that separates the Lemhi Range to the northeast from the Pahsimeroi and Little Lost River valleys to the southwest.

Length (km)	This section is 20 km of a total fault length of 136 km.
Average strike	N32°W (for section) versus N51W (for whole fault)
Sense of movement	Normal
Dip	63° SW *Comments:* Dip of fault is from trench exposure (602-5) (Baltzer, 1990 #432).
Paleoseismology studies	Two trenches have been excavated near Warm Creek, at the northern end of the section. Trench 602-5 (located approximately 50 m north of Warm Creek) exposed a stratigraphic evidence of a mid- to late Holocene surface rupture on the fault. Vertical stratigraphic separation was 0.9-1.3 m, depending on which units were correlated across the fault. Trench 602-6 (located approximately 250 m south of Warm Creek) exposes structural and stratigraphic evidence of two surface ruptures of a late Pinedale surface. Each rupture produced 1.7 m of vertical stratigraphic separation. Baltzer (1990 #432) considered that the youngest surface rupture in trench 602-6 to be the same as the single rupture in trench 602-5; this rupture would have had vertical stratigraphic separations of 0.9-1.3 m and 1.7 m at two points 300 m apart along the fault.
Geomorphic expression	
Age of faulted surficial deposits	Generally continuous, morphologically young scarps on alluvium and colluvium (Scott and others, 1985 #76; Baltzer, 1990 #432); locally bedrock is also faulted at the surface (Baltzer, 1990 #432).
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* Timing of most the recent event is based on the position of trenched deposits in the landscape and their soil properties. Trench 602-5 was located on alluvium that has an inferred age of Holocene; trench 602-6 on latest Pleistocene deposits. Trench 602-5 contained evidence of a single surface-

	faulting event, and trench 602-6 contained evidence of two events. No datable material was recovered from either trench.
Recurrence interval	*Comments:* Trench 602-6 contained evidence of two events postdating late Pinedale time (<30 ka); the surface ruptures were separated by enough time for a Bk soil horizon to form (Baltzer, 1990 #432). Haller (1988 #27) suggests that as many as six events may have occurred in the past 150 k.y. based on relations between the assumed ages of deposits and scarp heights.
Slip-rate category	Between 0.2 and 1.0 mm/yr *Comments:* Scott and others (1985 #76) suggested a slip rate of 0.3 mm/yr for central part of Lemhi fault based on an analogy with the central part of the Lost River fault [601] along which 4 m of offset has occurred in the past 15 k.y. More recent, fault specific geomorphic and trenching studies suggest that this part of the fault possibly has a lower slip rate. Trench 602-6 showed structural and stratigraphic evidence of two surface ruptures on a late Pinedale surface (Baltzer, 1990 #432). No dates were obtained from this study. Each rupture produced 1.7 m of vertical stratigraphic separation. Profiles of multiple-event scarps allowed Haller (1988 #27) to document 3.0 m of surface offset since 15 ka in the area north of Mahogany Creek, and 5.6 m of surface offset since the latest Pleistocene at Warm Creek. Gorton (1995 #4643) used thicknesses of carbonate rinds, aided by relative elevations and morphologies of fan-surfaces combined with thermoluminescence dates, to map and estimate ages of seven groups of fan surfaces along sections 602d-f of the Lemhi fault. Gorton estimated that the surface that is offset at trench 602-6 is late Pinedale (25-15 ka) age, which would indicate a slip rate close to the lower cut off of this slip-rate category. However, even lower slip rates are suggested by the reported 5.6 m offset surface north of Mahogany Creek on an early Pinedale (45-25 ka) deposit (Gorton, 1995 #4643). Finally, Gorton estimated that the offset surface at Warm Creek is of late Pinedale (25-15 ka) age. Although the data contain considerable uncertainty, they suggest that the slip rate for this part of the fault falls within the indicated slip-rate category. Payne and others (2008 #7017) report high rates of right-lateral shear resulting from high strain rates in the undeforming Snake River Plain to low strain rates north of the central part of the Lost River and Lemhi Ranges and the

	Beaverhead Mountains based on campaign GPS surveys; furthermore they characterize the rate of differential slip within the Centennial shear zone as increasing from 0.9 ? 0.3 mm/yr near the Lost River fault [601] to 1.7 ? 0.2 mm/yr near the Beaverhead fault [603]. The rate of slip may continue to increase northeastward to the Centennial fault [643]. However, Puskas and Smith (2009 #7018) argue against the high velocities; they conclude the differential motion across this boundary is less than 0.5 mm/yr.
Date and Compiler(s)	2010 Kathleen M. Haller, U.S. Geological Survey Russell L. Wheeler, U.S. Geological Survey, Emeritus
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