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Lost River fault, Arco section (Class A) No. 601f

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Compiled in cooperation with the Idaho Geological Survey

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Synopsis	**General:** The Lost River fault is a 130-km-long, southwest-facing, normal fault along the southwestern base of the Lost River Range. Most investigators agree that the main fault has six segments, but the extent to which large ruptures of various ages have crossed or stopped at the various segment boundaries remains unresolved. Accordingly, the Lost River fault was divided into sections based on mapping, morphological study, dating, and trenching of scarps and the surfaces they offset—the six sections (a–f) correspond to the segments that make up the main fault. The seventh section consists of a complex of discontinuous scarps [601g] that link the main Lost River fault to the smaller, antithetic Lone Pine normal fault [604] to the west.

	Work during the years following the 1983 Borah Peak earthquake concentrated on the northern sections where surface ruptures formed during the earthquake, whereas work during the late 1960s and 1970s, followed by additional studies during the 1990s concentrated on the southern sections. All but the northernmost and the two southernmost sections show evidence of latest Quaternary surface ruptures. The few determinations of individual recurrence intervals of large surface ruptures vary from 1 to nearly 100 k.y. Slip rates determined at specific points along the fault vary between less than 0.1 mm/yr to approximately 0.2 mm/yr, and the southern sections appear to have had slower late Quaternary rates than the middle sections. Paleoseismic data suggest that the three central parts of the fault possibly ruptured within a few thousands of years of each other during the early Holocene. **Sections:** This fault has 7 sections. Scott and others (1985 #76) defined segmentation of Lost River fault and is the source of section names except northernmost segment [601a], which was renamed by Crone and others (1985 #18; 1987 #19) to be consistent with other segment names. Scarps formed during Borah Peak earthquake across Willow Creek hills [601g] are included as part of this fault. The on-trend, discontinuous scarps south of range (as mapped by Kuntz and others, 1984 #293) are described separately as part of the Idaho Rift systems fault [3501].
Name comments	**General:** Anderson (1934 #595) first reported that the southwest side of the Lost River Range was bounded by a fault. However, Baldwin (1951 #427) later recognized Basin and Range style faulting in this area, as well as recent movement and large amounts of throw across this and nearby faults. Baldwin's 1951 article is probably one of earliest to use the name Lost River fault for this structure, which extends along the entire length of the southwest flank of Lost River Range from near Arco, Idaho, on the south to near Challis, Idaho, on the north **Section:** Originally defined and named by Scott and others (1985 #76) as extending from approximately 3 km north of King Canyon to southern end of Lost River Range. More recent lines of evidence suggest the northern boundary should be at Ramshorn Creek (Crone and others, 1987 #19; Janecke, 1993 #6550; Olig and others, 1995 #1278); although it is clear from the morphology of the range that King Mountain (which lies between Ramshorn Creek and King Canyon) is significantly higher than the Arco

	Hills to the south. It has peak elevations that are similar to the range bounded by the Pass Creek section of the fault. Malde (1971 #6537) was the first to study the faulting history of this area, and he called this part of the Lost River fault the Arco scarp. Along-trend, discontinuous scarps possibly of similar age that extend into northern Snake River Plain are included in this compilation as part of the Idaho rift system faults [3501]. Also referred to as the Arco fault by Kuntz and others (1984 #293).
County(s) and State(s)	BUTTE COUNTY, IDAHO
Physiographic province(s)	NORTHERN ROCKY MOUNTAINS
Reliability of location	Good Compiled at 1:50,000 scale. *Comments:* Location of the scarps is based on the 1:24,000-scale maps of Crone (unpublished data), further constrained by satellite imagery and topography at scale of 1:50,000. 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 Lost River fault is a high-angle, down-to-the-southwest, range-front normal fault, with a minor sinistral component of slip. The fault bounds the southwest side of the Lost River Range and separates the range from Round Valley, Antelope Flat, Thousand Springs Valley, Barton Flat, and the Big Lost River. In its north-central portion, the Lost River fault is joined from the west by the much shorter, northeast-dipping Lone Pine fault [604]. The two normal faults bound an intervening graben. The much greater length and larger topographic relief of the Lost River fault indicate that it is probably the master fault, and that the Lone Pine fault probably terminates against it at depth. Hypocentral locations and focal mechanisms of earthquakes in 1983 and 1984 and their numerous aftershocks support this suggestion (Doser and Smith, 1985 #276; Jackson, 1994 #833). Densmore and others (2005 #7016) suggest that maximum throw across the Lost River fault is 4–6 km.

Length (km)	This section is 15 km of a total fault length of 127 km.
Average strike	N5°W (for section) versus N35°W (for whole fault)
Sense of movement	Normal *Comments:* (Scott and others, 1985 #76)
Dip Direction	W
Paleoseismology studies	Two trenches have been excavated on the Arco section. Site 601-1 excavated in 1969 by Malde (1971 #6537; 1985 #37; 1987 #38) is located on the south side of unnamed stream approximately 10 km north of Arco, Idaho. The 8- to 11-m-deep trench crosses a 15-m-high scarp that has evidence of at least two faulting events (Malde, 1971 #6537). The oldest event resulted in 4.6–6 m of displacement and the younger event resulted in at least 3 m of displacement. Olig (1995 #1278) revisited the trench site in 1994 and found evidence of at least seven surface-faulting earthquakes since deposition of old alluvial gravels at 160±35 ka (601-13). The four most recent ruptures postdate deposition of 80±30 ka alluvial gravels, and at least five events postdate a 70–110 ka Yellowstone ash layer. The first two events occurred between deposition of the old alluvial gravels and the ash. Net tectonic displacement per event is 1.2-1.5 m with noncharacteristic deviation of 1:4–5 times in the past 60 ka. Trench 601-14, the Arco Peak trench of Olig and others (1995 #1278), is 4.8 km north of Arco and 5 km south of Malde's trench. A 21-m-high scarp faces west across a 65- to 75-m-wide graben, which is bound on the west by two small antithetic scarps. The antithetic scarps are approximately 10 m apart and are too small to affect 1-m topographic contours. The faults offset an older late Pleistocene alluvial-fan surface, which Olig and others (1995 #1278) estimated as 100–130 ka. The 1.5- to 5-m-deep trench crossed the entire fault zone. Analyses of stacked, faulted colluvial wedges led Olig and others (1995 #1278) to conclude that four events offset the 100–130 ka fan, with a possible, smaller fifth event after the first. All four (or five) events also postdated deposition of loess at 58.0±10 ka.
Geomorphic expression	Section is generally characterized by faceted bedrock spurs (Malde, 1971 #6537) and high, dominantly west-facing scarps on alluvium along much of range front. Scarps range from 2- to 25-m

	high (Pierce, 1985 #52), but most are about 12 m (Malde, 1971 #6537; 1985 #37; 1987 #38). High scarps are on deposits thought to be less than 600 ka, whereas 2- to 3-m-high scarps are on 30-ka deposits (Pierce, 1985 #52). Deposits thought to be about 15 ka are unfaulted (Pierce, 1985 #52; Scott and others, 1985 #76); although Malde (1971 #6537) suggested the unfaulted deposits were possibly only several hundreds to several thousands of years old. Olig and others (1995 #1278) estimate that single event displacements are 1.2–1.5 m based on 6 m of total offset thought to represent four or five events.
Age of faulted surficial deposits	Undifferentiated Holocene and upper and middle Pleistocene alluvium and colluvium (Scott, 1982 #278). Scarps along the southern part of section are on 30 ka and older deposits; along northern part of the section, the scarps are on bedrock (Malde, 1985 #37). Kuntz and others (1994 #1277) map the fault scarps on upper and middle Pleistocene, no younger units are mapped along this part of the fault.
Historic earthquake	
Most recent prehistoric deformation	late Quaternary (<130 ka) *Comments:* From evidence at both the Malde and Arco Peak trenches, Olig and others (1995 #1278) estimated that the most recent surface rupture occurred shortly before deposition of wash facies colluvium at 20.0±4 ka, and after the penultimate surface rupture that shortly followed deposition of older wash facies colluvium at 21.0±4 ka. Thus, they placed the most recent paleoevent at approximately 20 ka. This is roughly consistent with the recent end of the age range (23 ka) of Pierce (1985 #52), which was estimated from the thickness of carbonate rinds. Olig and others (1995 #1278) also recalculated the carbonate-rind age estimate using variable accumulation rates of rinds (Vincent and others, 1994 #839), and obtained consistency with their age estimate of 20.2±4 ka.
Recurrence interval	1–40 k.y. (<160 ka) *Comments:* Olig and others (1995 #1278) report that recurrence intervals between the six or seven events interpreted at site 601-1 vary from 1–40 k.y.; however on figures 9a and 9b, they suggest that intervals may be as long as 85 or 95 k.y. They state that by comparing the paleoseismic record at the two exposures, this part

	of the fault clearly has a pattern of temporal clustering. The shortest intervals occur between the most recent and penultimate event and preceding the third event back, and the longest interval is marked by a period of quiescence between about 60 to 100–130 ka. Furthermore, Olig and others (1995 #1278) provide some average recurrence intervals to illustrate the change in the faulting behavior over time: seven events in 160 k.y. gives an average recurrence interval of about 20 k.y.
Slip-rate category	Less than 0.2 mm/yr *Comments:* Because recurrence intervals are highly variable along this part of the fault, so are the associated slip rates. The assigned slip-rate category is based on all published rates with the excavation of Olig and others (1995 #1278) highest rate of 1.1 m of offset in 1 k.y. The average slip rate at the Arco Peak site (trench 601-14) for the past 130 ka is 0.05±0.01 mm/yr and for the past 58 k.y. is 0.1 +0.03, -0.02 mm/yr; however, the slip rate for the most recent complete seismic cycle is 20 times faster, at 1.1 mm/yr (Olig and others, 1995 #1278). The reported slip rate for the interval between 20–58 ka is intermediate at 0.12 mm/yr (Olig and others, 1995 #1278). Earlier published slip rates for section are (1) 0.12 mm/yr for past 160 k.y. based on 19 m of displacement of deposits thought to be 160 ka (Pierce, 1985 #52), (2) 0.07 mm/yr based on 70- to 110-ka volcanic ash displaced 8 m, (3) 0.15 mm/yr excludes past 30 k.y. of quiescence (Scott and others, 1985 #76). 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 the results of campaign GPS surveys, and they furthermore 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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Questions or comments?