Jump to Navigation

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.

Ahtanum Ridge structures, Ahtanum Creek fault (Class A) No. 564a

Last Review Date: 2016-05-12

citation for this record: **Lidke, D.J., and Haller, K.M., compilers, 2016, Fault number 564a, Ahtanum Ridge structures, Ahtanum Creek fault, 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 03:03 PM.**

Synopsis	**General:** The Ahtanum Ridge structures form one of the fault and fold systems in the central part of the Yakima fold belt of south-central Washington. An east-striking anticlinal uplift is the principle structural feature of these structures and it is mostly responsible for the east-striking topographic high expressed by Ahtanum Ridge. Evidence is generally lacking for Quaternary displacements along many of the faults related to the anticlinal uplift. However, the east-striking, Ahtanum Creek fault and normal faults that may be related to it, show evidence for Quaternary offsets. Repasky and Campbell (1998 #5554) reported evidence for late Pleistocene to early Holocene movement along normal faults of a graben south of the Ahtanum Creek fault and they suggested that the normal faults probably are tensional features related to movement along the underlying Ahtanum Creek fault. Quaternary age growth or tightening of other folds in the Yakima fold belt, and perhaps of the Ahtanum Ridge folds, has also been suggested and inferred from several local and regional

	geologic relations in the Yakima fold belt (Campbell and Bentley, 1981 #3513; Reidel, 1984 #5545; Reidel and others, 1994 #3539). Contemporaneous contraction across the region suggests that the Yakima folds are favorably oriented in the current strain field and accommodate the strain through active folding and possibly faulting (Pratt, 2012 #7397; Bjornstad and others, 2012 #7394 citing unpublished Zachariasen and others, 2006). As summarized by Bjornstad and others (2012 #7394), global positioning system (GPS) "data indicate relatively low (<1 mm/yr) but non-zero convergence across the Yakima fold belt…. In general, these rates are higher than those calculated on Quaternary faults." Based on the growing consensus that the Ahtanum Ridge folds are cored by buried Quaternary fault, the faults are reassigned to Class A as opposed to the prior Class B classification. **Sections:** This fault has 2 sections. Faults and folds associated with the Ahtanum Ridge are subdivided and discussed as two sections based on the uncertainty of the continued development of folds, and some faults, during the Quaternary. The Ahtanum Creek fault and normal faults south of it show evidence for Quaternary activity and are described as one of the two sections. Anticline segments and some east-striking thrust faults and northwest-striking faults of the Ahtanum Ridge uplift can only be inferred to have been active during Quaternary time. Sections defined here differ in lateral extent from the fault sources prescribed by Coppersmith and others (2014 #7402).
Name comments	**General:** **Section:** The existence of the east-striking Ahtanum Creek fault was originally inferred by Rigby and Othberg (1979 #3738). Bentley and others (1980 #4693) named the fault and mapped its inferred trace based mostly on stratigraphic relations and structural relief. The mapped trace of the fault is mostly in thick, highly mobile, late Pleistocene to Holocene loess deposits (Bentley and others, 1980 #4693; Walsh, 1986 #5570; Walsh and others, 1987 #3579; Schuster, 1994 #5566; Schuster and others, 1997 #3760). Geomatrix Consultants Inc. (1988 #1311; 1990 #5550) noted that scarps and graben structure south of the trace of the Ahtanum Creek fault have a subdued similarity to those that have been better studied near the Mill Creek fault [566a] along Toppenish Ridge and they reported some evidence suggestive of Pleistocene deformation along and south of the Ahtanum Creek fault for about 30 km west of Union Gap and about 6 km east of Union Gap. Campbell and others (1995 #5552) also noted the similarity of features near the Ahtanum Creek fault to those along Toppenish Ridge. Repasky and Campbell (1998 #5554) reported evidence for late Pleistocene to early Holocene movement along normal faults of a graben south of the Ahtanum Creek fault and suggested that

	movement along those faults probably was related to movement along the Ahtanum Creek fault. These normal faults and the graben are included in this section and discussion of the Ahtanum Creek fault. The mapped trace of the Ahtanum Creek fault extends along the northern flank of the east end of Ahtanum Ridge and western end of the Rattlesnake Hills from about 13 km west of Union Gap along the Columbia River to about 5 km east of Union Gap.
County(s) and State(s)	YAKIMA COUNTY, WASHINGTON
Physiographic province(s)	COLUMBIA PLATEAU
Reliability of location	Good Compiled at 1:100,000 scale. *Comments:* Location of fault from GER_Seismogenic_WGS84 (http://www.dnr.wa.gov/publications/ger_portal_seismogenic_features.zip, downloaded 05/23/2016) attributed to 1:100,000-scale maps of Walsh (1986 #5570), and Schuster (1994 #5566), and Repasky and Campbell (1998 #5554).
Geologic setting	Ahtanum Ridge is located in the west-central part of the Yakima fold belt, a structural-tectonic sub province of the western Columbia Plateaus Province (Reidel and others, 1989 #5553; 1994 #3539). The Yakima fold belt consists of a series of generally east-trending narrow asymmetrical anticlinal ridges and broad synclinal valleys formed by folding of Miocene Columbia River basalt flows and sediments. In most parts of the belt the folds have a north vergence with the steep limb typically faulted by imbricate thrust faults. According to Reidel and others (1989 #5553) these frontal faults are typically associated with the areas of greatest structural relief. In the few places where erosion exposes the frontal faults deeper in the cores of the anticlinal ridges the faults are seen to become steeper with depth (as steep as 45–70°). Along their lengths the anticlines are commonly broken into segments ranging between 5 and 35 km long with boundaries defined by abrupt changes in fold geometry. Anticlinal ridges of the Yakima fold belt began to grow in Miocene time (about 16–17 Ma), concurrent with eruptions of Columbia River basalt flows, and continued during Pliocene time and may have continued to the present (Reidel and others, 1989 #5553; 1994 #3539). Named and unnamed, east-striking thrust faults cut the north and south limbs of the Ahtanum Ridge uplift. This uplift forms one of the many anticlinal ridges that comprise the Yakima fold belt in south-central Washington. The south-dipping Ahtanum Creek fault is a poorly exposed

	and inferred thrust fault that cuts the north limb of the Ahtanum Ridge uplift. Unnamed normal faults, interpreted to be subsidiary faults of the Ahtanum Creek fault, form a ridge-top graben along the east end of the uplift. The Ahtanum Creek fault and the unnamed normal faults show evidence for Quaternary faulting events, but the folds and other faults of Ahtanum Ridge are only known to deform rocks of the Columbia River Basalt Group (Miocene).
Length (km)	This section is 18 km of a total fault length of 59 km.
Average strike	N88°E (for section) versus N88°E (for whole fault)
Sense of movement	Thrust *Comments:* The Ahtanum Creek fault is largely an inferred fault that is interpreted to be a thrust fault based on deformation exposed near the inferred trace of the fault and based on regional relations that show thrust faults are common along the limbs of anticlines in the Yakima fold belt (Bentley and others, 1980 #4693; Reidel and others, 1989 #5553; 1994 #3539). Repasky and Campbell (1998 #5554) studied and reported on normal faults and graben features directly south of the Ahtanum Creek fault trace and suggested that movement along these normal faults probably was related to movement along the Ahtanum Creek fault.
Dip	322–36° S. *Comments:* Few dip measurements have been reported for the Ahtanum Creek fault. Mège and Reidel (2001 #7407) report a mean fault dip of 22–36° for the Rattlesnake Hills-Ahtanum Ridge fault based on a combination of field measurements and accessible seismic profiles. Geomatrix Consultants Inc. (1988 #1311; 1990 #5550) describe an exposed east-striking fault at Union Gap that dips 43° north and places Miocene volcanic rocks on late Pleistocene gravels; they suggest the fault may be a back thrust related to the south dipping Ahtanum Creek fault. An annotated photograph of a trench studied by Repasky and Campbell (1998 #5554), suggests that normal faults south of the Ahtanum Creek fault dip steeply, about 60–90°, both to the north and south.
Paleoseismology studies	Detailed studies have not been made across the inferred trace of the Ahtanum Creek fault. However, Repasky and Campbell (1998 #5554) mapped and dated a sequence of colluvial wedges in a ridge-top graben they trenched directly east of Union Gap (site 564-1) and investigated a possible scarp on the north side of Ahtanum Ridge at RSH-1 trench (site 564-2). Based on the results of the trench investigation, Repasky and

	Campbell (1998 #5554) report that two and possibly three faulting events affected the graben, which is located south of the inferred trace of the Ahtanum Creek fault, in past 95–109 k.y. They interpret faulting related to the graben as a response to movement along the Ahtanum Creek fault based on the similarity of this graben to grabens along the crest and north flank of Toppenish Ridge that are interpreted similarly.
Geomorphic expression	The Ahtanum Creek fault is inferred to be a thrust fault at the base of the north flank of a long anticlinal ridge that is expressed by Ahtanum Ridge to the west and by the western end of the Rattlesnake Hills to the east (Bentley and others, 1980 #4693; Geomatrix Consultants Inc., 1988 #1311; 1990 #5550). The northern flank of the anticline is covered with late Pleistocene to Holocene loess, landslide debris, and alluvial fans and large parts of the surface are disturbed by agricultural activity and urban development (Geomatrix Consultants Inc., 1988 #1311; 1990 #5550; Repasky and Campbell, 1998 #5554). Geomatrix Consultants Inc. (1988 #1311) report a scarp that branches into two strands west of Union Gap and report a single scarp east of Union Gap. Geomatrix Consultants Inc. (1988 #1311) note that these scarps may be erosional features related to Ahtanum Creek and the Yakima River, but their position on the steep limb of an anticline is similar to that of known thrust faults along other Yakima fold belt anticlines. Campbell and others (1995 #5552) and Repasky and Campbell (1998 #5554) discuss en echelon scarps related to a ridge-top graben directly east of Union Gap and they note the similarity of these features to those present along Toppenish Ridge. Average structural relief from folding is 330 m, with maximum relief of 775 m (Coppersmith and others, 2014 #7402).
Age of faulted surficial deposits	No exposures of the Ahtanum Creek fault are reported and no trench studies across the inferred trace of the fault are known. Geomatrix Consultants Inc. (1988 #1311; 1990 #5550) describe a 43° north-dipping fault at Union Gap that puts Miocene volcanic rocks on gravels that have a questionable age of 30±3 ka based on U/Th dating (Campbell, 1983 #5664); they also noted that Touchet beds containing the Mount St. Helens set S tephra (about 13 ka) are draped across the fault and apparently not faulted. Geomatrix Consultants, Inc. (1988 #1311; 1990 #5550) suggested that this north-dipping fault might be a back thrust related to the Ahtanum Creek fault. Repasky and Campbell (1998 #5554) present the results of TL and IRSL dating and soil stratigraphy for a sequence colluvial wedge deposits in a ridge top graben they trenched east of Union Gap. The results of these studies by Repasky and Campbell (1998 #5554) imply that soils, dated at about 39-43 ka, are faulted in the graben and they interpret that faulting as a response to movement along

	the underlying Ahtanum Creek fault.
Historic earthquake	
Most recent prehistoric deformation	late Quaternary (<130 ka) *Comments:* Based on analysis of aerial photography and aerial and field reconnaissance studies, Geomatrix Consultants Inc. (1988 #1311) concluded their is some evidence of possible scarps near and south of the trace of the Ahtanum Creek fault, which may indicate late Pleistocene faulting and deformation, but little or no evidence for Holocene faulting. Geomatrix Consultants Inc. (1988 #1311; 1990 #5550) also describe a 43° north-dipping fault at Union Gap that puts Miocene volcanic rocks on gravels that have a questionable age of 30±3 ka based on U/Th dating (Campbell, 1983 #5664); they also note that Touchet beds containing the Mount St. Helens set S tephra (about 13 ka) are draped across the fault and apparently not faulted. Geomatrix Consultants Inc., (1988 #1311; 1990 #5550) suggest that this north-dipping fault might be a back thrust related to the Ahtanum Creek fault. Based on TL and IRSL dating and soil stratigraphy of colluvial wedge deposits in a ridge-top graben south of the trace of the Ahtanum Creek fault, Repasky and Campbell (1998 #5554) presented evidence that indicates that the latest graben offsets are 12–41 ka. Repasky and Campbell (1998 #5554) infer that offsets along the graben-forming faults are related to offsets along an underlying thrust fault (Ahtanum Creek fault).
Recurrence interval	<50 k.y. (<100 k.y.) *Comments:* Piety and others (1990 #3733) used uplift rates calculated from 15 Ma volcanic rocks to estimate recurrence intervals of 600–50,000 years based on displacement per events of 0.02–1.0 m. Repasky and Campbell (1998 #5554) concluded from their trench studies of a ridge-top graben south of the Ahtanum Creek fault, that faulting in the graben was a response to movement along the Ahatanum Creek fault and they reported evidence for three faulting events that affected the graben. Repasky and Campbell (1998 #5554) reported the ages of the three events and quality of the evidence for the events as follows: (1) 12–41 ka, good; (2) 41–95 ka, good; (3) 95–109 ka, fair. Bjornstad and others (2012 #7394) reports a slightly different chronology and provide recurrence of 30–50 k.y. in table 2.4 based on two and possibly three faulting events occurred on faults in the graben in the past 95 to 109 k.y. However, Bjornstad and others (2012 #7394) acknowledge that because of overlap and uncertainty in age dates, recurrence intervals could be up to 30 k.y. on this fault.

Slip-rate category	Less than 0.2 mm/yr *Comments:* Bjornstad and others (2012 #7394) report that slip on faults at Union Gap fall within the normal long-term average net slip rate for Yakima fold belt. They report the rate of deformation as 410 m/m.y. (0.41 mm/yr) However, displacement on this subsidiary structure may not be representative of rates of uplift of Ahjtanum Ridge anticline; slip rates from offsets of Quaternary deposits or surfaces have not been reported for the Ahtanum Creek fault. Some data is available on uplift rates of Miocene volcanic rocks across the Ahtanum Ridge anticline and that data has been used to estimate uplift rates. Piety and others (1990 #3733) report 300–500 m of uplift of 15 Ma volcanic rocks, which yields an uplift rate of 0.02–0.03 mm/yr. Geomatrix Consultants, Inc. (1996 #4676) used uplift of 762 m of 10.5 Ma volcanic rocks and estimated fault dips of 30°, 45°, and 60° to estimate slip rates of 0.084–0.145 mm/yr along an inferred principle thrust fault underlying the adjacent Rattlesnake Hills uplift [#565]. Geomatrix Consultants Inc. (1988 #1311; 1990 #5550) describe a 43°-north-dipping fault at Union Gap that puts Miocene volcanic rocks on gravels that yielded a questionable U/Th age of 30±3 ka (Campbell, 1983 #5664); they also note that Touchet beds, containing the Mount St. Helens set S tephra (about 13 ka), are draped across the fault and apparently not faulted. Geomatrix Consultants Inc., (1988 #1311; 1990 #5550) suggested that the north-dipping fault might be a back thrust related to the Ahtanum Creek fault, and they reported that the fault shows a minimum offset of 7 m. An offset of 7 m in the last 33,000 years yields a slip rate of 0.21 mm/yr for this fault. Based on the limited information available a slip rate of <0.2 mm/yr is assigned herein to the Ahtanum Creek fault. Coppersmith and others (2014 #7402) estimate the average structural relief across the anticline to be 330 m with a maximum of 420 m.
Date and Compiler(s)	2016 David J. Lidke, U.S. Geological Survey Kathleen M. Haller, U.S. Geological Survey
References	#4693 Bentley, R.D., Anderson, J.L., Campbell, N.P., and Swanson, D.A., 1980, Stratigraphy and structure of the Yakima Indian Reservation, with emphasis on the Columbia River basalt group: U.S. Geological Survey Open-File Report 80-200, 73 p., 1. #7394 Bjornstad, B.N., Winsor, K., and Unwin, S.D., 2012, A summary of fault recurrence and strain rates in the vicinity of the Hanford site: Topical report prepared for the U.S. Department of Energy under contract DE-AC05-76RL01830, 90 p. #5664 Campbell, N.P., 1983, Correlation of late Cenozoic gravel deposits

along the Yakima River drainage from Ellensburg to Richland, Washington: Northwest Science, v. 57, p. 179-193.

#3513 Campbell, N.P., and Bentley, R.D., 1981, Late Quaternary deformation of the Toppenish Ridge uplift in south-central Washington: Geology, v. 9, p. 519–524.

#5552 Campbell, N.P., Ring, T., and Repasky, T., 1995, Final report, 1994 NEHRP grant earthquake hazard study of the vicinity of Toppenish Basin, south-central Washington: Technical report to U.S. Geological Survey, Reston, Virginia, under Contract 1434-94-G-249, December 22, 1995, 9 p.

#7402 Coppersmith, R., Hansen, K., Unruh, J., Slack, C., 2014, Structural analysis and Quaternary investigations in support of the Hanford PSHA, Appendix E *in* Coppersmith, K.J., Bommer, J.J., Hanson, K.L., Unruh, J., Coppersmith, R.T., Wolf, L., Youngs, R., Rodriguez-Marek, A., Al Atik, L., Toro, G. and Montaldo-Falero, V., Hanford sitewide probabilistic seismic hazard analysis: Richland, Washington, Pacific Northwest National Laboratory report PNNL-23361, http://www. hanford. gov/page. cfm/OfficialDocuments/HSPSHA.

#1311 Geomatrix Consultants, Inc., 1988, Seismotectonic evaluation of the northern Cascade Mountains geomorphic province for Bumping Lake, Tieton, Keechelus, Kachess, Cle Elum, and Clear Creek Dams: Technical report to U.S. Department of Interior, Bureau of Reclamation, Denver, Colorado, under Contract 6-CS-81-07310, December 1988, 154 p., 12 pls.

#5550 Geomatrix Consultants, Inc., 1990, Seismotectonic evaluation of the Walla Walla section of the Columbia Plateau geomorphic province for Grand Coulee, North, Dry Falls, Pinto, and O'Sullivan Dams; Soda Lake, north Scooteney, and south Scooteney dikes: Technical report to U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado, under Contract 6-CS-81-07310, April 1990, 129 p.

#3593 Geomatrix Consultants, Inc., 1995, Seismic design mapping, State of Oregon: Technical report to Oregon Department of Transportation, Salem, Oregon, under Contract 11688, January 1995, unpaginated, 5 pls., scale 1:1,250,000.

#4676 Geomatrix Consultants, Inc., 1996, Probabilistic seismic hazard analysis DOE Hanford site, Washington: Technical report to Westinghouse Hanford Company, Richland, Washington, under Contract WHC-SD-W236A-TI-002, Rev.1, February, 1996, 366 p.

#5568 Korosec, M.A., 1987, Geologic map of the Mount Adams quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 87-5, 39 p. pamphlet, 1 sheet, scale 1:100,000.

#7407 Mège, D., and Reidel, S.P., 2001, A method for estimating 2D wrinkle ridge strain from application of fault displacement scaling to the Yakima folds, Washington: Geophysical Research Letters, v. 28, p. 3545–3548, doi: 10.1029/2001GL012934.

#3733 Piety, L.A., LaForge, R.C., and Foley, L.L., 1990, Seismic sources and maximum credible earthquakes for Cold Springs and McKay Dams, Umatilla Project, north-central Oregon: U.S. Bureau of Reclamation Seismotectonic Report 90-1, 62 p., 1 pl.

#7397 Pratt, T.L., 2012, Large-scale splay faults on a strike-slip fault system—The Yakima folds, Washington State: Geochemistry, Geophysics, Geosystems, v. 13, Q11004, doi: 10.1029/2012GC004405.

#5545 Reidel, S.P., 1984, The Saddle Mountains—The evolution of an anticline in the Yakima fold belt: American Journal of Science, v. 284, p. 942-978.

#3539 Reidel, S.P., Campbell, N.P., Fecht, K.R., and Lindsey, K.A., 1994, Late Cenozoic structure and stratigraphy of south-central Washington, *in* Lasmanis, R., and Cheney, E.S., eds., Regional geology of Washington State: Washington Division of Geology and Earth Resources, p. 159-180.

#5553 Reidel, S.P., Fecht, K.R., Hagood, M.C., and Tolan, T.L., 1989, The geologic evolution of the central Columbia Plateau, *in* Reidel, S.P., and Hooper, P.R., eds., Volcanism and tectonism in the Columbia River flood-basalt province: Geological Society of America Special Paper 239, p. 247-264.

#5554 Repasky, T.R., Campbell, N.P., and Busacca, A.J., 1998, Earthquake hazard study in the vicinity of Toppenish Basin, south-central Washington: Technical report to U.S. Geological Survey, Reston, Virginia, under Contract 1434-HQ-97-GR-03013, December 1998, 27 p., 7 pls.

#3738 Rigby, J.G., and Othberg, K., 1979, Reconnaissance surficial geologic mapping of the Late Cenozoic sediments of the Columbia Basin, Washington: State of Washington Department of Natural Resources Division of Geology and Earth Resources Open-File Report 79-3, 88 p., 10 pls.

	#3760 Schuster, E.J., Gulick, C.W., Reidel, S.P., Fecht, K.R., and Zurenko, S., 1997, Geologic map of Washington-southeast quadrant: Washington Division of Geology and Earth Resources Geologic Map GM-45, 20 p. pamphlet, 2 sheets, scale 1:250,000. #5566 Schuster, J.E., 1994, Geologic map of the east half of the Yakima 1:100,000 quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 94-12, 19 p. pamphlet, 1 sheet, scale 1:100,000. #5570 Walsh, T.J., 1986, Geologic map of the west half of the Yakima quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 86-4, 12 p. pamphlet, 1 sheet, scale 1:100,000. #3579 Walsh, T.J., Korosec, M.A., Phillips, W.M., Logan, R.L., and Schasse, H.W., 1987, Geologic map of Washington-southwest quadrant: Washington Division of Geology and Earth Resources Geologic Map GM-34, 28 p. pamphlet, 2 sheets, scale 1:250,000.