Jump to Navigation

Quaternary Fault and Fold Database of the United States

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Ahtanum Ridge structures, unnamed faults of the Ahtanum Ridge uplift (Class A) No. 564b

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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the strain through active folding and possibly faulting (Pratt, 2012 #7397; Bjornstad and others, 2012 #7394 citing unpublished Zachariasen and others, 2006).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:** Refers to easterly trending anticline segments and some of the faults that are associated with the similarly trending Ahtanum Ridge uplift. This uplift is commonly divided into two anticline segments: a short eastern segment called the Tampico anticline and a longer western segment called the Cowboy Parking Lot anticline (Bentley and others, 1980 #4693). These anticlines are the most prominent structural features of the Ahtanum Ridge structures and they mostly account for the anticlinal ridge form of Ahtanum Ridge. These two east-striking anticlines are associated with named and unnamed, east-striking thrust-reverse faults and normal faults and with north- to northwest-striking faults, which are shown 1:100,000- and 1:250,000-scale geologic maps of this region (1986 #5189; Walsh, 1986 #5570; Walsh and others, 1987 #3579; Korosec, 1987 #5568; Schuster, 1994 #5566; Schuster and others, 1997 #3760). The Ahtanum Creek fault [564a] is one of the east-striking thrust faults associated with the Ahtanum Ridge uplift, but it is discussed as a separate section of the Ahtanum Ridge structures. The Ahtanum Ridge uplift

	extends from the Klickitat River Valley, east and northeast about 65 km along Ahtanum Ridge to Union Gap along the Columbia River. From Union Gap, the uplift extends about another 10 km east along a southern prong of the Rattlesnake Hills and structures associated with the Ahtanum Ridge uplift appear to merge with or join those that are associated with the Rattlesnake Hills uplift [565].
County(s) and State(s)	YAKIMA COUNTY, WASHINGTON
Physiographic province(s)	COLUMBIA PLATEAU CASCADE-SIERRA MOUNTAINS
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 #5189; 1986 #5570), Schuster (1994 #5566), Schuster and others (1997 #3760), 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 59 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:* Structures associated with the Ahtanum Ridge uplift are primarily expressed as east-striking anticlines that are underlain and cut by east-striking thrust-reverse faults, and cut by north- to northwest-striking faults that show some right-lateral offsets (Bentley and others, 1980 #4693; 1986 #5189; Walsh, 1986 #5570; Walsh and others, 1987 #3579; Korosec, 1987 #5568; Geomatrix Consultants Inc., 1988 #1311; Schuster, 1994 #5566; Schuster and others, 1997 #3760).
Dip	22–36° S. *Comments:* The Tampico anticline is the eastern anticline, or anticline segment, of the Ahtanum Ridge uplift and this anticline is box-shaped and plunges east (Bentley and others, 1980 #4693). The Cowboy Parking anticline, the western anticline segment, is a sinuous east-plunging fold that is associated with several parallel subsidiary folds and northwest-striking faults that cut the folds (Bentley and others, 1980 #4693). The thrust-reverse faults and northwest-striking faults, which cut and underlie these anticlines, are poorly exposed or buried and dip measurements for these faults have not been reported. 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.
Paleoseismology studies	Site-specific and folds included in this section of the Ahtanum Ridge structures have not been conducted.
Geomorphic expression	The slightly sinuous, east-trending Ahtanum Ridge is the principal geomorphic expression of the anticlinal, Ahtanum Ridge uplift. Miocene volcanic rocks, which form the core of the Ahtanum Ridge uplift, are obviously deformed in the Tampico and Cowboy Parking Lot anticlines. Expression of these folds in Quaternary sediments or in the

	geomorphology developed on Quaternary units has not been reported. However, much of the northern flank of the uplift 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). Possible scarps and a ridge-top graben appear to be part of the geomorphic expression of the Ahtanum Creek fault [#564a] (Geomatrix Consultants Inc., 1988 #1311; Repasky and Campbell, 1998 #5554) and these features are discussed in the Ahtanum Creek fault section [#564a] of the Ahtanum Ridge structures. Geomorphic expression of the Ahtanum Ridge faults included in this section has not been reported. Average structural relief from folding is 330 m, with maximum relief of 775 m (Coppersmith and others, 2014 #7402).
Age of faulted surficial deposits	Other than evidence for late Pleistocene deformation along, and related to, the Ahtanum Creek fault [564a], little or no evidence for Quaternary deformation along other faults and folds of the Ahtanum Ridge uplift has been reported (Geomatrix Consultants Inc., 1988 #1311; Repasky and Campbell, 1998 #5554). Bentley and others (1980 #4693) report that interbedded, Pliocene-Pleistocene flows, colluvium, and breccia dip several degrees away from the Crest of the Cowboy Parking Lot anticline. Bentley and others (1980 #4693) noted, however, that the dip of these units may be primary and not a product of later folding. Other evidence suggestive of deformation of Quaternary units related to growth or tightening of the Ahtanum Ridge anticlines has not been documented or described. Deformation of Quaternary deposits along faults included in this section of the Ahtanum Ridge structures has not been reported.
Historic earthquake	
Most recent prehistoric deformation	undifferentiated Quaternary (<1.6 Ma) *Comments:* Other than evidence for late Pleistocene deformation along, and related to, the Ahtanum Creek fault [564a], little or no definitive evidence for Quaternary deformation along the folds and other faults of the Ahtanum Ridge uplift has been reported (Geomatrix Consultants Inc., 1988 #1311; Repasky and Campbell, 1998 #5554). Bentley and others (1980 #4693) report that interbedded, Pliocene-Pleistocene flows, colluvium, and breccia dip several degrees away from the Crest of the Cowboy Parking Lot anticline, however, they also note that the dip of these units may be primary and not a product of later folding. Quaternary growth or tightening of other ridge-anticline features of the Yakima fold belt, related to movement along underlying thrust faults, has been inferred from the following local and regional relations: (1) correlation of uplift

	rates of Miocence volcanic rocks (Reidel, 1984 #5545); (2) the north-south orientation of the principle stress direction and active seismicity of the region (Reidel and others, 1994 #3539); and (3) interpretations of geometric relations of the folds relative to normal or strike-slip faults that show Quaternary offsets (Campbell and Bentley, 1981 #3513). No unequivocal evidence for Quaternary growth or tightening of the Ahtanum Ridge anticlines and related folds has been documented, however, and no evidence for Quaternary deformation along faults included in this section of the Ahtanum Ridge structures has been reported.
Recurrence interval	*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 along an inferred principle fault underlying the Ahtanum Ridge anticlinal uplift.
Slip-rate category	Less than 0.2 mm/yr *Comments:* The rate of slip is probably low based on the lack of evidence for Quaternary deformation along the faults and folds of the Ahtanum Ridge uplift (Geomatrix Consultants Inc., 1988 #1311; Repasky and Campbell, 1998 #5554). 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 uplift rates 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]. These estimates suggest relatively low rates for possible Quaternary slip and folding along these faults and folds of the Ahtanum Ridge structural trend.
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. #5189 Walsh, T.J., compiler, 1986, Geologic map of the west half of the Toppenish quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 86-3, 8 p., 1 pl., 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.