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.

Columbia Hills structures (Class A) No. 568

Last Review Date: 2016-06-16

citation for this record: Lidke, D.J., and Haller, K.M., compilers, 2016, Fault number 568, Columbia Hills structures, 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	The Columbia Hills structures form the southernmost fault and fold belt in the Washington part of the Yakima fold belt. The structure of the Columbia Hills is primarily expressed as a series of south-verging anticlines, some of which are doubly plunging and cut by or overlie north dipping thrust or reverse faults (Bentley and others, 1980 #4667; Piety and others, 1990 #3733; Geomatrix Consultants Inc., 1995 #3593). These folds largely account for the anticlinal form and topographic high expressed by the Columbia Hills and the folds have been divided into as many as 10 segments (Bentley and others, 1980 #4667; Geomatrix Consultants Inc., 1995 #3593). The easterly trending faults and folds of the Columbia Hills are cut in several places by high-angle, northwest-striking faults that in places about coincide with the ends of the fold segments (Bentley and others, 1980 #4667). Some of these cross faults show apparent right-lateral offsets and some show evidence for Quaternary displacement. The Luna Butte fault [579] is an example of one of theses cross faults that appears to cut easterly trending structures of the

	Columbia Hills and shows evidence for Quaternary offset (Geomatrix Consultants Inc., 1995 #3593), as well as the Arlington and Laurel faults (Anderson and others, 2013 #7411). Right-lateral Quaternary offsets along these northwest-striking faults also fits with seismologic and other evidence that indicates that the principle compressive stress direction is oriented about north-south in the region of the Yakima fold belt (Piety and others, 1990 #3733; Reidel and others, 1994 #3539). Collectively, these local and regional relations may suggest that exposed and buried faults in the Columbia Hills link to capable faults in the subsurface and that the east-trending folds may be active. 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 Toppenish Ridge folds are cored by buried Quaternary fault, the faults are reassigned to Class A as opposed to the prior Class B classification.
Name comments	Folds and faults associated with the Columbia Hills mostly trend and strike east to east-northeast along the similarly trending Columbia Hills. The Columbia Hills structures are mostly thrust faults and folds that are shown on 1:100,00- and 1-250,000-scale maps of this region (Korosec, 1987 #4658; Phillips, 1987 #4660; Schuster, 1994 #4654; Reidel and Fecht, 1994 #4657). These structures include the Columbia Hills anticline and the Columbia Hills and Wishram thrusts, as well as other named and unnamed folds and faults. These structures bound the Columbia Hills along the north side of the Columbia River from northeast of The Dalles, Ore., to northeast of Plymouth, Wash. Coppersmith and others (2014 #7402) define five faults sources 23–56 km long. **Fault ID:** These structures are included in fault number 78 of Geomatrix Consultants, Inc. (1995 #3593).
County(s) and State(s)	KLICKITAT COUNTY, WASHINGTON BENTON COUNTY, WASHINGTON
Physiographic province(s)	COLUMBIA PLATEAU
Reliability of location	Good Compiled at 1:100,000 scale.

	Comments: The location of the Columbia Hills structures are 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 geologic maps by Korosec (1987 #4658), Phillips and Walsh (1987 #4660), Schuster (1994 #4654).
Geologic setting	The Columbia Hills are located in the southern 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). The Columbia Hills structures form a long fault and fold system in the southern Yakima fold belt of south-central Washington. Named and unnamed, easterly striking thrust faults cut the north and south limbs of the Columbia Hills anticlinal uplift. This anticlinal uplift forms one of the many anticlinal ridges that comprise the Yakima fold belt in south-central Washington. Possible fault scarps along the north flank of the Columbia Hills uplift were described by Piety and others (1990 #3733). However, folds and faults of the Columbia Hills are only known to deform Miocene volcanic and sedimentary rocks, which include the Columbia River Basalt Group.
Length (km)	160 km.
Average strike	N75°E
Sense of movement	Thrust *Comments:* The Columbia Hills structures are primarily expressed as anticlinal folds underlain by, or cut by, thrust or reverse faults in Miocene

	rocks of the Columbia River Basalt Group (Bentley and others, 1980 #4667; Phillips, 1987 #4660; Schuster, 1994 #4654; Schuster and others, 1997 #3760).
Dip	2–80° S *Comments:* The thrust or reverse faults that underlie the Columbia Hills are exposed in Miocene volcanic rocks along the western part of the Columbia Hills. The emergent frontal fault is observed to be a thrust fault dipping 2–20° to the south; it steepens to become a high-angle reverse fault (steeper than 80° dip) within the core of the fold (Anderson, 1987 #3492; Tolan and others, 2002 #7689). Mège and Reidel (2001 #7407) report a mean fault dip of 10–20° for the Columbia Hills thrust fault based on a combination of field measurements and accessible seismic profiles.
Paleoseismology studies	
Geomorphic expression	These structures are coincident with the Columbia Hills, a series of low hills underlain by resistant Miocene volcanic rocks of the Columbia River Basalt Group. The topographic high expressed by the Columbia Hills is the principle geomorphic expression of the anticlinal uplift and related folds and faults of the Columbia Hills. Piety and others (1990 #3733) identified a section of possible scarps that extends for about 12 km along the north side of the Columbia Hills at Alder Ridge. According to Piety (1990 #3733), these possible scarps have slope angles of 10–30° and surface displacement of as much as 10 m could be inferred across one of the scarps. Piety and others (1990 #3733) also report that along the north side of Canoe Ridge, lineaments of undetermined origin are visible on aerial photographs. Much of the northern and southern flanks of the Columbia Hills are buried by thick Quaternary loess and landslide deposits and covered by the Columbia River (Walsh and others, 1987 #3579; Phillips, 1987 #4660; Schuster, 1994 #4654; Schuster and others, 1997 #3760), which may bury and obscure evidence for faults along these flanks. Coppersmith and others (2014 #7402) report average structural relief across the Columbia Hills anticline of 375 m, 230 m, 135 m, 55 m, 105 m structural relief for their three fault sources from west to east.
Age of faulted surficial deposits	The Columbia Hills structures are primarily expressed in Miocene rocks of the Columbia River Basalt Group and are covered by Quaternary loess and landslide deposits and by the Columbia River along much of their length (Walsh and others, 1987 #3579; Phillips, 1987 #4660; Schuster, 1994 #4654; Schuster and others, 1997 #3760). A northeast-trending, 12-km-long section of possible fault scarps on the north side of the Columbia

	Hills at Alder Ridge was described Piety and others (1990 #3733). They reported possible offset of loess deposits, perhaps correlative with the Palouse loess (approximately 100 ka), along one of these features, and reported that a young (late Holocene ?) fan deposit showed no evidence of offset (Piety and others, 1990 #3733). Along the eastern part of the Columbia Hills at Sillusi Butte, Foundation Sciences Inc. (1980 #5722) report that an unnamed, north-northeast-striking fault [569] offsets upper Pleistocene Touchet beds. Piety and others (1990 #3733) later reported that this fault was not identified during their examination of the Sillusi Butte area and apparently has no surface expression. Several authors have reported that northerly striking faults, like the fault at Sillusi Butte, are at least in part younger features that cut and offset easterly trending, Yakima fold belt structures (Myers and others, 1979 #5175; Bentley and others, 1980 #4667; Geomatrix Consultants Inc., 1995 #3593).
Historic earthquake	
Most recent prehistoric deformation	undifferentiated Quaternary (<1.6 Ma) *Comments:* No definitive evidence of Quaternary displacement has been described along the Columbia Hills structures, although possible fault scarps described by Piety and others (1990 #3733) along the north side of the Columbia Hills at Alder Ridge may offset late Pleistocene (approximately 100 ka) loess deposits. Geomatrix Consultants Inc. (1995 #3593) speculated that part of these structures possibly were active in the Quaternary to late Quaternary. The Columbia Hills anticline and other folds of the Columbia Hills are only known to deform rocks of the Miocene Columbia River Basalt Group. Quaternary age growth or tightening of other folds in the Yakima fold belt, and perhaps of the Columbia Hills folds, has 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).
Recurrence interval	 *Comments:* Geomorphic or stratigraphic data needed for recurrence estimates have not been reported.
Slip-rate category	Less than 0.2 mm/yr *Comments:* No definitive slip data from Quaternary deposits has been reported for structures associated with the Columbia Hills. Piety and others (1990 #3733) report possible fault scarps that may show surface offsets of as much as 10 m and displace late Pleistocene (approximately

	100 ka) loess deposits along the north flank of the Columbia Hills at Alder Ridge. An offset of 10 m in the last 100 ka supports the assigned slip-rate category. Some data is also available on uplift rates of Miocene volcanic rocks across the Columbia Hills folds. Geomatrix Consultants Inc. (1995 #3593) used uplift of 365 m and horizontal offset of 1000 m of 10.5 and 16.0 Ma volcanic rocks along estimated fault dips of 30°, 45°, and 60° to estimate long-term slip rates of 0.014–0.165 mm/yr for an inferred principle fault underlying the Columbia Hills.
Date and Compiler(s)	2016 David J. Lidke, U.S. Geological Survey Kathleen M. Haller, U.S. Geological Survey
References	#3492 Anderson, J.L., 1987, The structural geology and ages of deformation of a portion of the southwest Columbia Plateau, Washington and Oregon: University of Southern California, Ph. D dissertation, 283 p., 7 pls., scale 1:24,000. #7411 Anderson, J.L., Tolan, T.L., and Wells, R.E., 2013, Strike-slip faults in the western Columbia River flood basalt province, Oregon and Washington, in Reidel, S.P., Camp, V.E., Ross, M.E., Wolff, J.A., Martin, B.S., Tolan, T.L., and Wells, R.E., eds., The Columbia River Flood Basalt Province: Geological Society of America Special Paper 497, p. 325–347, doi:10.1130/2013.2497(13). #4667 Bentley, R.D., Powell, J., Anderson, J.L., and Farooqui, S.M., 1980, Geometry and tectonic evolution of the Columbia Hills anticline, Washington-Oregon: Geological Society of America Abstracts with Programs, v. 12, no. 3, p. 97. #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. #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. #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.

#5722 Foundation Sciences Inc., 1980, Geologic reconnaissance of parts of the Walla Walla and Pullman, Washington, and Pendleton Oregon 1° x 2° AMS quadrangles: Technical report to U.S. Army Corps of Engineers, Seattle, Washington, 83 p., 3 pls.

#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.

#4658 Korosec, M.A., compiler, 1987, Geologic map of the Hood River quadrangle, Washington and Oregon: Washington Division of Geology and Earth Resources Open-File Report 87-6, 42 p., 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.

#5175 Myers, C.W., Price, S.M., Caggiano, J.A., Cochran, M.P., Czimer, W.J., Davidson, N.J., Edwards, R.C., Fecht, K.R., Holmes, G.E., Jones, M.G., Kunk, J.R., Landon, R.D., Ledgerwood, R.K., Lillie, J.T., Long, P.E., Mitchell, T.H., Price, E.H., Reidel, S.P., and Tallman, A.M., 1979, Geologic studies of the Columbia Plateau—A status report: Technical report to U.S. Department of Energy, under Contract DE-AC06-77RL01030, October 1979, variously paginated, 36 pls.

#4660 Phillips, W.M. and Walsh, T.J., 1987, Geologic map of the northwest part of the Goldendale quadrangle, Washington: Washington Division of Geology and Earth Resources, Open File Report 87-13, 9 p., scale 1:100,000.

#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.

#4657 Reidel, S.R., and Fecht, K.R., 1994, Geologic map of the Richland 1:100,000 quadrangle, Washington: Washington Division of Geology and Earth Resources Open-File Report 94-8, 21 p., scale 1:100,000.

#4654 Schuster, J.E., 1994, Geologic maps of the east half of the Washington portion of the Goldendale 1:100,000 quadrangle and the Washington portion of the Hermiston 1:100,000 quadrangle: Washington Division of Geology and Earth Resources Open-File Report 94-9, 17 p., scale 1:100,000.

#7689 Tolan, T.L., Beeson, M.H., and Lindsey, K.A., 2002, The effects of volcanism and tectonism on the evolution of the Columbia River system: Northwest Geological Society Field Trips, Guidebook 18, 74 p.