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Quaternary Fault and Fold Database of the United States

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Wallula fault system (Class A) No. 846

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Synopsis	The Wallula fault system is a prominent northwest-striking fault zone that extend from near Milton-Freewater, Ore., to near Kennewick, Wash., including the fault adjacent to The Rattles. This fault zone is collocated with several regional-scale lineaments, including the Cle Elum-Wallula deformed zone (CLEW), the Rattlesı Wallula trend, alignment, or lineament (RAW), and the Olympic-Wallowa lineam (OWL). In the northwest, movement on the fault system results in anticlinal folds up to 250 m of structural relief (Coppersmith and others, 2014 #7402) in rocks of Miocene Columbia River Basalt Group. The Wallula fault system is variously ma as linear, steeply dipping strike-slip, normal, or reverse faults in Quaternary surfic deposits and rocks of the Miocene Columbia River Basalt Group. The mapped fa pattern, local observations of subhorizontal slickensides, and north-south compre stress regime support a right-lateral strike slip sense of slip on the Wallula fault. T age of most-recent faulting in the Wallula fault system is poorly known; several s suggest latest Quaternary displacement at least one location.
Name	The Wallula fault system is a prominent northwest-striking fault zone that include

comments	several named faults in Oregon: the Bade, Barrett, Dry Creek, Forks, Little Dry C Milton-Freewater, Pine Creek, Promontory Point, Umapine, Wallula, and Wallula faults (Kienle and others, 1979 #3728; Mann and Meyer, 1993 #3535; McQuarrie 1993 #4337; Reidel and others, 1994 #3539). **Fault ID:** These structures are included in fault number 11 of Pezzopane (1993 # and fault number 77 of Geomatrix Consultants, Inc. (1995 #3593).
County(s) and State(s)	BENTON COUNTY, WASHINGTON WALLA WALLA COUNTY, WASHINGTON UMATILLA COUNTY, OREGON
Physiographic province(s)	COLUMBIA PLATEAU
Reliability of location	Good Compiled at 1:100,000 scale. *Comments:* Location of fault in Oregon from ORActiveFaults (http://www.oregongeology.org/arcgis/rest/services/Public/ORActiveFaults/MapS downloaded 06/02/2016) attributed to 1:100,000-scale mapping of Maden and Ge (2007 #7804). Location of fault in Washington 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 Schuster 1994 #4 and Reidel and Fecht (1994 #5565). Magnetic surveys show that the Wallula faul located 350 m to the southwest of the trace shown on published maps, passes dire through deformed late Pleistocene or younger deposits exposed at Finley quarry, extends uninterrupted over 120 km; Sherrod and others (2016 #7690) illustrate th mislocation of the fault in figure 4 at detail greater than the metadata mapping accuracy.
Geologic setting	The Wallula fault system is a prominent northwest-striking fault zone in the southeastern part of the Yakima fold belt and appears to link with northwest-strik folds and thrust faults of the Rattlesnake Hills structures [565] in the Rattlesnake directly to the north. The Wallula fault system is included in several regional-scal lineaments, including the Cle Elum-Wallula deformed zone (CLEW), the Rattlesn Wallula trend, alignment, or lineament (RAW), and the Olympic-Wallowa lineam (OWL) (Reidel and others, 1994 #3539). The Yakima fold belt consist of anticlin folds and thrust faults in Miocene Columbia River Basalt Group. Strain across the Yakima fold belt at this latitude appears to be locally confined to the narrow Wall fault zone south of the Pasco gravity low (Blakely and others, 2014 #7406). The Wallula fault system is mostly mapped as linear, steeply dipping strike-slip, norm reverse faults in Quaternary surficial deposits and rocks of the Miocene Columbia River Basalt Group (Kienle and others, 1979 #3728; Swanson and others, 1981 # Tolan and Reidel, 1989 #3765; Walker and MacLeod, 1991 #3646; Hutter, 1997 #5650). Coppersmith and others (2014 #7402) estimate average structural relief a

	the Wallula structures to be 250 m with a maximum of 300 m.
Length (km)	63 km.
Average strike	N53°W
Sense of movement	Right lateral, Reverse *Comments:* The sense and amount of displacement across this fault is poorly kno The northwestern continuation of the Wallula fault system in Washington consist anticlinal folds and thrust faults, but the fault system is mostly mapped as linear, steeply dipping strike-slip, normal, or reverse faults in Oregon (Kienle and others 1979 #3728; Swanson and others, 1981 #3496; Tolan and Reidel, 1989 #3765; W and MacLeod, 1991 #3646; Hutter, 1997 #5650). The mapped fault pattern, local observations of subhorizontal slickensides, and north-south compressive stress re support a right-lateral strike slip sense of slip on the Wallula fault system (Kienle others, 1979 #3728; U.S. Army Corps of Engineers, 1983 #3480; Mann and Mey 1993 #3535; McQuarrie, 1993 #4337; Kuehn, 1995 #3478; 1996 #3530). Howev Reidel and Tolan (1994 #3536) and Hutter and others (1994 #3525) interpret othe to infer that post-Miocene lateral displacement, if any, must be low. Pratt (2012 # states that at least some right-lateral movement on the Wallula fault is required be of shortening in the Columbia Hills [568] and Horse Heaven Hills [567], in contr the lack of demonstrable shortening northeast of the Wallula fault. However, he n the modern stress field is less favorably oriented to produce strike-slip motion. Bl and others (2014 #7406) interpret magnetic anomalies identified in high-resolutio aeromagnetic data that show clear evidence that Ice Harbor dikes are disrupted b Wallula fault zone; they interpret the disruption to be manifestation of right-later offset of individual dikes on the order of more than 1 km and total offset of 6.9 k the past 8.5 m.y. Further interpretation of aeromagnetic and ground magnetic surv suggest right lateral oblique (reverse) movement on the Wallula fault zone post emplacement of the 8.5-Ma Ice Harbor Member dikes, exhibiting up to 2.2 km of lateral displacement (Sherrod and others, 2016 #7690). In addition, Sherrod and (2016 #7690) reports observing faint striae on the master fault that are subhorizo suggesting reverse-dextral movement.
Dip	70–90°, V *Comments:* Vertical to steeply northeast-and southwest-dipping fault planes have observed along several faults in the Wallula fault system; a few gently-dipping fa planes have also been observed, but these are attributed to flower or "palm tree" f patterns (Kienle and others, 1979 #3728; Mann and Meyer, 1993 #3535; McQua 1993 #4337; Kuehn, 1995 #3478; Hutter, 1997 #5650).
Paleoseismology	Several early sites including Milton-Freewater quarry and Little Dry Creek (Kien

studies	others, 1979 #3728), natural and man-made exposures (Rigby and Othberg, 1979 #3738; Farooqui and Thoms, 1980 #5824; Foundation Sciences Inc. 1980 #5722) three trenches near Yellepit Station Canyon (Gardner and others, 1981 #7691) dic provide conclusive results regarding timing and the number of earthquakes. How studies that addressed an exposure in Finley quarry near Wallula Gap on the Colu River provide a variety of interpretations (Farooqui and Thoms, 1980 #5824; Foundation Sciences, Inc. 1980 #5722; Woodward-Clyde Consultants, 1981 #769 Sherrod and others, 2016 #7690). Sherrod and others (2016 #7690) conclude the formed from tectonic processes rather than flood erosion, and the colluvial depos associated with the scarp. Coppersmith and others (2014 #7402) summarize the findings reported by Sherrod and others (2016 #7690) and other studies and conc that Ice Age erosion and deposition might explain some features inferred to be th result of surface faulting at the Finley quarry; the Quaternary Studies Team favor earlier interpretations that there has been no surface deforming earthquakes that p date the deposition of deposits that are likely 71–58 ka. They do not completely dismiss the idea of younger faulting; they assign low weight to the possibility of post 17±1.8 ka event based on the minimum age of unfaulted deposits based on ^{230}Th/U series dating and very low weight to the possibility of two or three faulti events that post date 17±1.8 ka. Studies over the past few decades focused on an exposure in a quarry at Finley, W (Farooqui and Thoms, 1980 #5824 Site 846-1); more recent studies of the Finley quarry exposure suggest Holocene faulting (Sherrod and others, 2016 #7690 Site 3). The 10-m-high exposure of Columbia River Basalt Group (13.5 Ma) is unconformably buried by late Pleistocene flood deposits. The section is interprete being complexly faulted; Sherrod and others (2016 #7690) presents evidence of f paleoearthquakes in the last 30 k.y., including two earthquakes after the late Pleistocene Missoula floods, based on ^{230}Th/U series ages on these pedogenic carbonates. The timing of the most recent coseismic surface deformation accordi Sherrod and others (2016 #7690) post dates the deposition of Mazama ash; the pr event occurred prior to Mazama ash deposition. A preserved scarp on basalt in th outcrop suggests 1.8–2.8 m of post-flood vertical displacement. The scarp is interpreted to reflect coseismic deformation based on airborne and ground magne data that indicates that the northernmost strand of the Wallula fault zone passes d through Finley quarry (Sherrod and others, 2016 #7690). GSA Data Repository it 2016116 contains a composite log of prior studies of Finley quarry. Site 846-2. The east wall of a gully exposure of the Umapine fault west of Milton Freewater was examined and logged by Mann and Meyer (their site A, 1993 #35 The gully exposed a several meter wide fault zone consisting of several fault stra dipping 55–63° to the north. Brecciated basalt of the Miocene Columbia River B Group was exposed in the footwall. The hanging wall consisted of a 5-m-thick se of ash-bearing gravelly colluvial horizons, interbedded with poorly consolidated Samples of volcanic ash from the hanging wall section have geochemical fingerp

	that are correlative with the Mount St Helens "J" ash, some have fingerprints correlative with Mount St Helens "M", and others are intermediate between these tephra. The Mount St Helens "J" and "M" ashes are thought to have been deposit 10.7 ka and 20.35 ka (Mullineaux, 1986 #3773). The footwall section consists of possibly discrete packages of fault-derived colluvium, separated by deposits of pu loess at intervals of 1–2 m. Mann and Meyer (1993 #3535) interpret these relatio evidence of four separate Holocene surface-rupturing events with total vertical displacement of about 5 m.
Geomorphic expression	Most faults in the Wallula fault system have youthful geomorphic expressions; th form topographic and vegetation lineaments, scarp-like lineations, and grabens a to offset the youngest geologic units (upper Pleistocene to Holocene?) in the area (Kienle and others, 1979 #3728). Mann and Meyer (1993 #3535) describe numer youthful fault scarps, lineaments, and laterally offset drainages along the fault zo McQuarrie (1993 #4337) describes clastic dikes of Pleistocene Missoula Flood sediments (Touchet beds) cutting basalt bedrock and fault breccia and appear to b genetically related to faulting along the Wallula Gap fault. Weldon and others (20 #5648) observed lineaments across Quaternary deposits on 1:100,000-scale DEM the area.
Age of faulted surficial deposits	Several faults in the Wallula fault system may offset upper Pleistocene to Holoce surficial deposits (Kienle and others, 1979 #3728; Rigby and Othberg, 1979 #373 Piety and others, 1990 #3733). One exposure of the Umapine fault offsets loess a colluvium containing the Mount Saint Helens "J" ash system (Mann and Meyer, 1 #3535) which is thought to have been deposited about 10.7 ka (Mullineaux, 1986 #3773); however, Coppersmith and others (2014 #7402) dispute their conclusions McQuarrie (1993 #4337) describes clastic dikes of Pleistocene Missoula Flood sediments (Touchet beds) that may be related to faulting. Farooqui and Thoms (1 #5824) describe evidence for late Pleistocene offset of colluvial deposits along a striking fault at Finley Quarry, near the apparent northwest end of the Wallula fau system.
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* Age-category assignment based on ORActiveFaults (http://www.oregongeology.org/arcgis/rest/services/Public/ORActiveFaults/Map downloaded 06/02/2016). Mann and Meyer (1993 #3535) report one or more eve that post-date the 10.7 ka age of the Mount Saint Helens "J" ash on the Umapine west of Milton-Freewater. The exposure was re-examined by Coppersmith and ot (2014 #7402), and they conclude faulting of Holocene sediments appears to be d slumping subparallel to the range front rather than tectonic faulting. The bedrock characterized by subhorizontal moulins at this location, trends to the northwest a

	not parallel to the east-west trending Wallula fault. They conclude there is no evid of Holocene faulting on the Wallula fault based on these observations as opposed observations by Kienle and others (1979 #3728) who describe young faulting alo Little Dry Creek fault, where young (<13 ka) and older (Palouse Formation) loess deposits are apparently offset. Kienle and others (1979 #3728), Rigby and Othber (1979 #3738), Piety and others (1990 #3733), and McQuarrie (1993 #4337) descr several locations along splays of the Wallula fault system where Touchet beds (10 ka) are either offset or involved in faulting-related dike injection. Sherrod and oth (2016 #7690, fig. 2) show six locations where Holocene coseismic deformation is interpreted and an additional three location where there is evidence of Pleistocene coseismic deformation. Pezzopane (1993 #3544) and subsequent compilations (Geomatrix Consultants Inc., 1995 #3593; Madin and Mabey, 1996 #3575; Weldo others, 2002 #5648) show most faults in the Wallula fault system as active in the middle and late Quaternary (<700–780 ka) or Quaternary (<1.6–1.8 Ma). The mo conservative age assignment is adopted here until more definitive studies are conducted.
Recurrence interval	 *Comments:* Sherrod and others (2016 #7690) provide a chronology of surface deformation from three earthquakes since 35 ka and additional evidence of latest Pleistocene liquefaction in the Finlay quarry exposure. In contrast, the fault is poo expressed considering the amount of reported vertical offset during the three nota earthquakes.
Slip-rate category	Less than 0.2 mm/yr *Comments:* Very little well-documented slip data are available for structures in th Wallula fault system. Hutter (1997 #5650) measured 310 m of vertical offset and maximum of 1 km of strike-slip displacement in Miocene rocks across the longes in the Wallula fault system; Coppersmith and others (2014 #7402) report similar d Meyer and Mann (1993 #3535) calculate a maximum vertical-displacement rate o 0.47 mm/yr on the Umapine fault, based on vertical offset of about 5 m since deposition of the 10.7 ka Mount Saint Helens ash, and Mann and Meyer (1993) su a long term rate of about 0.3 mm/yr. In contrast, Geomatrix Consultants, Inc. (199 used estimated slip rates of 0.04–0.07 mm/yr for a reverse faulting scenario and r of 0.08–0.2 mm/yr for a strike-slip faulting scenario in their modeling of earthqua hazards along the entire Wallula fault system; the vertical-displacement rate of 0. mm/yr reported by Sherrod and others (2016 #7690) does not include horizontal s Low slip-rate category is assigned based on the poor geomorphic expression of m faults in this zone.
Date and Compiler(s)	2017 Stephen F. Personius, U.S. Geological Survey Kathleen M. Haller, U.S. Geological Survey

	David J. Lidke, U.S. Geological Survey
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