Jump to Navigation

Quaternary Fault and Fold Database of the United States

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Umtanum Ridge structures, Central Gable Mountain fault (Class A) No. 563a

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Synopsis	**General:** The Umtanum Ridge-Gable Mountain structures form one of the fault and fold systems in the central to northern 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 ridge topography of Umtanum Ridge, Gable Butte, and Gable Mountain. Quaternary displacements on thrust and reverse faults related to the anticlinal uplift are inferred for most of the structure. The northeast-striking, Central Gable Mountain fault shows evidence of about 6 cm of late Pleistocene to Holocene reverse offset (Washington Public Power Supply System, 1982 #5666), and normal offset on faults on the west side of the uplift are attributed to thrust faulting at depth (Sherrod and others, 2009 #7400, 2011 #7399). Quaternary age growth or tightening of other folds in the Yakima fold

	belt, and perhaps of the Umtanum Ridge-Gable Mountain 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). Bender and others, 2016 #7401) conclude that Umtanum Ridge anticline is actively deforming at modest rates. 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the strain through active folding and possibly faulting (Pratt, 2012 #7397; Bjornstad and others, 2012 #7394 citing unpublished Zachariasen and others, 2006).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 Umtanum Ridge-Gable Mountain 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 of the Umtanum Ridge-Gable Mountain structures are subdivided and discussed as two sections based on the uncertainty of the continued development of folds, and some faults, during the Quaternary. The Central Gable Mountain fault shows evidence for Quaternary activity and it is described as one of the two sections. Anticline segments and most of the exposed and inferred faults of the Umtanum Ridge-Gable Mountain anticlinal uplift are inferred to have been active during Quaternary time. Sections defined here differ in lateral extent from the five fault sources prescribed by Coppersmith and others (2014 #7402).
Name comments	**General:** **Section:** The Central Gable Mountain fault is a northeast-striking, southeast-dipping, oblique-slip fault on Gable Mountain, which is near the east end of the Umtanum Ridge-Gable Mountain structural trend. The fault is shown on 1:100,000- and 1:250,000-scale geologic maps by Reidel and Fecht (1994 #5565) and Schuster and others (1997 #3760), respectively. The fault was studied in detail, and apparently named, during studies reported on in Washington Public Power Supply System (1982 #5666).
County(s) and State(s)	BENTON COUNTY, WASHINGTON
Physiographic province(s)	COLUMBIA PLATEAU
Reliability of	Good

location	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 05/230/2016) attributed to 1:100,000-scale geologic maps by Walsh (1986 #5570), Reidel and Fecht (1994 #5565), and Schuster (1994 #5566).
Geologic setting	Umtanum Ridge, Gable Butte and Gable Mountain appear to define parts of a single anticlinal Ridge that is located in the central part of the Yakima fold and thrust belt, 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 Umtanum Ridge-Gable Mountain anticlinal uplift. The northeast-striking, Central Gable Mountain fault cuts across the axial trend of the uplift. This uplift forms one of the many anticlinal ridges that comprise the Yakima fold belt in south-central Washington. The Central Gable Mountain fault shows evidence for Quaternary activity, but the folds and other faults of the Umtanum Ridge-Gable Mountain structures are only known to deform rocks of the Columbia River Basalt Group (Miocene). Using the top-of-basalt from previous mapping, Coppersmith and others (2014 #7402) estimate average structural relief along Gable Mountain (160 m) and the southeast anticline (90 m).
Length (km)	This section is 2 km of a total fault length of 116 km.
Average strike	N54°E (for section) versus N88°W (for whole fault)

Sense of movement	Reverse *Comments:* Washington Public Power Supply System (1982 #5666) reports that the latest movement on the Central Gable Mountain fault was reverse movement, but they infer that the fault probably initially formed as a Miocene tear fault related to the east-trending folds and reverse-thrust faults.
Dip	30–70° SE *Comments:* Washington Public Power Supply System (1982 #5666) describes the fault as a steep-dipping reverse fault. Geomatrix Consultants Inc. (1990 #5550), however, report that the fault dips 30° to the southeast.
Paleoseismology studies	Site 563-1. Washington Public Power Supply System (1982 #5666) reports that an extensive investigation of the Central Gable Mountain fault and other faults on and near Gable Mountain was conducted, and they note that the investigation included trenching and drilling studies. According to Washington Public Power Supply System (1982 #5666), that investigation was by "NESCO for Skagit and described by the applicant from a report on Gable Mountain by Golder Associates" (1981 #7403). Washington Public Power Supply System (1982 #5666) did not discuss precise locations and details of the trenching and drilling sites and studies and we were unable to obtain the reports by NESCO and Golder Associates.
Geomorphic expression	Little is reported concerning the geomorphic expression of the Central Gable Mountain fault. This northeast-striking fault is nearly perpendicular to the east-southeast trend of Gable Mountain and the fault occurs near the crest of the mountain, where it is mapped as an exposed fault that juxtaposes Miocene volcanic rocks against Pleistocene gravels (Reidel and Fecht, 1994 #5565; Schuster and others, 1997 #3760).
Age of faulted surficial deposits	Based on exposures in trenches, Washington Public Power Supply System (1982 #5666) reports that 13–19 ka glacial flood deposits are offset about 6 cm by the fault, and they note that only the basal part of these deposits show the offset.
Historic earthquake	
Most recent prehistoric deformation	late Quaternary (<130 ka) *Comments:* Based on exposures in trenches, Washington Public Power

	Supply System (1982 #5666) reports that 13–19 ka glacial flood deposits are offset about 6 cm by the fault, and they interpret this offset as tectonic in origin.
Recurrence interval	*Comments:* The recurrence interval of faulting along the Central Gable Mountain fault is not tightly constrained. Washington Public Power Supply System (1982 #5666) presents evidence for a latest Pleistocene to early Holocene event, which is constrained by 13–19 ka flood deposits that show about 6 cm of reverse offset along the fault. Based on drill cores, Washington Public Power Supply System (1982 #5666) report that underlying Miocene volcanic rocks show a maximum cumulative offset of about 60 m along the fault, suggesting previous Miocene to Pleistocene events along the fault. Piety and others (1990 #3733) used uplift rates calculated from 10–11 Ma volcanic rocks to estimate recurrence intervals of 940–51,400 years based on displacement per events of 0.02–1.0 m along an inferred principle fault underlying the Umtanum Ridge-Gable Mountain anticlinal uplift.
Slip-rate category	Less than 0.2 mm/yr *Comments:* The 6 cm of vertical displacement of 13–19 ka sediments, which was reported by Washington Public Power Supply System (1982 #5666), suggests extremely low latest Pleistocene to Holocene slip rate for this fault. However, displacement on this subsidiary structure may not be representative of rates of uplift of Miocene volcanic rocks across Umtanum Ridge-Gable Mountain anticline. Published rates of deformation that addresses the Umtanum Ridge structure based on geologic evidence suggest generally low long-term displacement rates in contrast to those modeled using GPS data. Piety and others (1990 #3733) report 214 (?) m of uplift of 10–11 Ma volcanic rocks, and Geomatrix Consultants Inc. (1995 #3593) used uplifts of 102–530 m and horizontal offsets of 300–1,100 m of 10.5–16.0 Ma volcanic rocks along estimated fault dips of 30°, 45°, and 60° to estimate long-term slip rates of 0.011–0.0206 mm/yr for an inferred principle fault underlying this anticlinal uplift. Bjornstad and others (2010 #7394, table 2.1) reports long-term vertical growth rates of 29–54 m/m.y. (0.029–0.054 mm/yr). Total slip on the preferred model fault of Miller (2014 #7404) that best approximates the geometry of the anticline is 440–520 m on a fault that dips about 70°. The reported slip has occurred in the past 15.6 m.y. resulting in a range of slip rates on a 70° fault of 0.028–0.033 mm/yr. Bender and others (2016 #7401) estimate time-averaged shortening rates across south-dipping master reverse faults beneath Umtanum Ridge. These results suggest

	0.03±0.01 mm/yr vertical displacement rate, which has remained relatively stable over the past 1.6–2.9 m.y. They assume the average local rate of differential bedrock fluvial incision across the fold is equal to the corresponding average rates of differential rock uplift.
Date and Compiler(s)	2016 David J. Lidke, U.S. Geological Survey Kathleen M. Haller, U.S. Geological Survey
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