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.

southern Whidbey Island fault zone (Class A) No. 572

Last Review Date: 2016-11-29

citation for this record: Johnson, S.Y., Blakely, R.J., Brocher, T.M., Haller, K.M., Barnett, E.A., Sherrod, B.L., Kelsey, H.M., and Lidke, D.J., compilers, 2016, Fault number 572, southern Whidbey Island fault zone, 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	This northwest-trending fault zone extends more than 65 km across Possession Sound, southern Whidbey Island, Admiralty Inlet into the eastern Strait of Juan de Fuca. The fault zone is up to 5–7 km, correlates with gravity and magnetic anomalies (Finn and others, 1991 #4753; Blakely and others, 1999 #4747), and has been interpreted as a complex zone of transpressional deformation (Johnson and others, 1996 #4751).
Name comments	Gower (1980 #6229) showed and named the "southern Whidbey Island fault," and Gower and others (1985 #4725) showed this fault on their seismotectonic map of the Puget Sound region and briefly outlined its geologic relationships. Wagner and Wiley (1983 #6230) and Wagner and Tomson (1987 #6249) mapped and briefly discussed offshore parts of this

	fault zone and also used the name "southern Whidbey Island fault." Johnson and others (1996 #4751) described multiple sub-parallel strands and referred to the overall structure as the "southern Whidbey Island fault zone," and this name is also used herein for this zone of faults that crosses the southern part of Whidbey Island.
County(s) and State(s)	ISLAND COUNTY, WASHINGTON JEFFERSON COUNTY, WASHINGTON SNOHOMISH COUNTY, WASHINGTON
Physiographic province(s)	PACIFIC BORDER
Reliability of location	Good Compiled at 1:100,000 scale. *Comments:* The offshore location of the southern Whidbey Island fault zone is relatively well constrained, based on interpretation of a dense network of industry and high-resolution seismic-reflection profiles (Johnson and others, 1996 #4751; Dadisman and others, 2000 #4748; Johnson and others, 2000 #4750; 2000 #4755; Liberty and Pape, 2007 #7654; Sherrod and others, 2008 #7652). Onshore, strands of the southern Whidbey Island fault zone are generally concealed beneath a cover of dense vegetation and thick Pleistocene glacial and interglacial deposits. Location of fault is from GER_Seismogenic_WGS84 (http://www.dnr.wa.gov/publications/ger_portal_seismogenic_features.zip, downloaded 05/23/2016) attributed to Wagner and others (1987 #6249), Johnson and others (2000 #4750), Polenz and others (2006 #), and Sherrod and others (2008 #7652).
Geologic setting	The northwest-trending southern Whidbey Island fault zone occurs along a significant terrane boundary between basement blocks underlain by Eocene marine basalts of the Coast Range province to the southwest and pre-Tertiary metamorphic rocks of the Cascades province to the northeast. However, seismic tomography studies (Brocher and others, 2001 #4718) reveal that only the northwestern end of the fault zone in the southeastern Strait of Juan de Fuca is associated with a strong velocity contrast. The southeastern and central parts of the southern Whidbey Island fault zone form the southwest margin of the Everett basin and northeast boundary of the Seattle basin. The northwestern part of the fault zone forms the northeastern limit of the Port Townsend basin (Brocher and others, 2001 #4718).
Length (km)	64 km.
Average strike	N51°W

Sense of movement	Reverse, Left lateral *Comments:* Sense of slip deduced largely from geometry of faults imaged on seismic-reflection profiles (Johnson and others, 1996 #4751). These profiles reveal a complex zone of faulting, including a positive flower structure bounded by reverse faults and thrust faults, which probably also had left- and (or) right-lateral components of offset at various times in the past. Faulting appears to have locally uplifted a block(s) within the fault zone. The northeastern fault in the zone is locally a northeast-dipping thrust fault.
Dip	45–80° NE *Comments:* Dip angles deduced largely from geometry of faults imaged on seismic-reflection profiles (Johnson and others, 1996 #4751).
Paleoseismology studies	Johnson and others (1996 #4751) described the structure and stratigraphy of the southern Whidbey Island fault zone. Excavations across several LiDAR scarps show evidence for multiple post-glacial folding and faulting event on faults with reverse oblique sense of slip. Kelsey and others (2004 #7651) compared sea-level histories at two salt marshes that straddle a northeast strand of the southern Whidbey Island fault zone: Crockett Marsh (site 572-1) located north of the northeastern fault strand is 8 km north of Hancock Marsh (site 572-2), south of the fault strand. Stratigraphy and diatom assemblages of the marsh cores suggest Crockett Marsh underwent a 1–2 m of abrupt uplift relative to sea level at a time that relative sea level remained the same at Hancock Marsh. Radiocarbon ages of macrofossils constrain uplift timing to 2.8–3.2 ka. Kelsey and others (2004 #7651) suggest that the earthquake resulted in 2.5 m uplift of the salt marsh on the north side of the fault strand relative to the marsh on the south side; no fault scarp has been identified between the marshes. Keaton and Perry (2006 #7653) excavated two trenches on the south end of the Brightwater treatment plant (KP1 site 572-3, and KP2 site 572-4). The trenches exposed glacial deposits disrupted by faults and liquefaction features. They conclude the observed features have a glaciotectonic origin and are not seimotectonic. Trenches by Sherrod and others, 2008 #7652) are less than 1 km south of KP1 and KP2 and Sherrod and others (2008 #7652) conclude that deformation in the area is due to surface-rupturing earthquakes. Sherrod and others, 2008 #7652) report results from four trenches located

	near Crystal Lake: Flying Squirrel trench (572-5), Mountain Beaver trench (572-6), Beef Barley trench (572-7), and French Onion trench (572-8). The Flying Squirrel and Mountain Beaver trenches cross the Cottage Lake lineament. Stratigraphy in the Flying Squirrel trench showed gentle warping of late glacial and post-glacial sediments; no faults were exposed. A low-angle fault, which is not conclusively earthquake related, separates a diamicton from the overlying recessional outwash deposit. Faulting produced warping at the site of greater than 2 m. Radiocarbon ages provide a maximum age for the folding event of 12,090–11,670 cal yr BP. Beef Barley and French Onion trenches cross the Little Bear Creek lineament. Deformed recessional outwash deposits and Holocene deposits were exposed; three unconformities separated the units. One or possibly two of the unconformities are interpreted as event horizons. If folding on the Little Bear Creek lineament resulted in one or two of unconformities, the poorly constrained timing of the earthquakes is younger than 12,000 yr BP and older than about 2,850 cal yr BP. The French Onion trench exposed glaciolacustrine claystones, till, colluvial deposits, and Holocene soils. The trench did expose faults, but it was not possible to conclusively demonstrate offset of Holocene units.
Geomorphic expression	Early mapping of the three subparallel, northwest trending strands of the southern Whidbey Island fault zone was constrained by borehole data, potential field anomalies, marine seismic reflection surveys. Subtle scarps and topographic lineaments on Pleistocene surfaces are visible on high-resolution LiDAR topography at a number of locations (Sherrod and others, 2008 #7652); the northeast-side-up scarps exhibit 1–5 m of vertical relief
Age of faulted surficial deposits	late glacial and post-glacial sediments (Sherrod and others, 2008 #7652)
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* Based on paleoseismologic investigations of Kelsey and Sherrod (2001 #4757) and Sherrod and others (2008 #7652), the southern Whidbey Island fault had at least four earthquakes since deglaciation (about 16.4 k.y. ago) with the most recent younger than 2,700 yr ago.
Recurrence interval	0.4–9.2 k.y. (<16.4 ka)

	Comments: Recurrence intervals for earthquakes on the southern Whidbey Island fault vary; the longest is 9.2–8.8 k.y. and the shortest is 470 yr (Sherrod and others, 2008 #7652).
Slip-rate category	Between 0.2 and 1.0 mm/yr *Comments:* Preferred rate is 0.6 mm/yr. There is 150 m of structural relief on an anticlinal fold north of Lagoon Point on Whidbey Island, which exposes 250-ka Double Bluff drift at its core (Easterbrook, 1968 #4752; fig. 13 in Johnson and others, 1996 #4751). The fold overlies a positive flower structure imaged on seismic-reflection data just offshore (fig. 12 in Johnson and others, 1996 #4751). Assuming that fold growth reflects offset on an underlying steep fault, the minimum slip rate for faults in this zone is 0.6 mm/yr.
Date and Compiler(s)	2016 Samuel Y. Johnson, U.S. Geological Survey Richard J. Blakely, U.S. Geological Survey, Emeritus Thomas M. Brocher, U.S. Geological Survey Kathleen M. Haller, U.S. Geological Survey Elizabeth A. Barnett, Shannon & Wilson, Inc. Brian L. Sherrod, U.S. Geological Survey Harvey M. Kelsey, Humboldt State University David J. Lidke, U.S. Geological Survey
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