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Quaternary Fault and Fold Database of the United States

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Lake Creek-Boundary Creek fault (Class A) No. 556

Last Review Date: 2016-12-13

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Synopsis	The Lake Creek–Boundary Creek fault is one of three major, east-west-trending, north-dipping faults on the north flank of the Olympic Mountains in the northeastern part of the Olympic Peninsula. LiDAR data improved mapping of the fault (Haugerud, 2002 #5048; Haugerud and others, 2003 #6211). The fault is expressed as a more than 30-km-long, discontinuous, east-trending topographic lineament that occurs along the north flank of the Olympic Mountains. The north- and south-facing scarps locally offset late Pleistocene glacially fluted surfaces and may offset Holocene landslide deposits. Trenching studies confirm coseismic Holocene surface rupture (Nelson and others, 2007 #6916).
Name comments	The fault is known by a variety of names in the literature. Earlier workers (Tabor and Cady, 1978 #6221; Dragovich and others, 2002 #5715; Schasse, 2003 #7667) inferred that the Lake Creek fault of Brown and

	others (1960 #6213) crossing Morse and Siebert Creeks connected with the Boundary Creek fault of Brown and others (1960 #6213) in the valleys of Indian Creek and Little River. Later Haugerud and others (2003 #6211) referred to it as the Little River fault, which was used in earlier record for this fault (Lidke and others, 2003 #7664). Common usage follows Polenz and others (2004 #7666) and Schasse and others (2004 #7667) whom referred to the north-dipping fault striking east-west through the valleys of Indian Creek and Little River as the Lake Creek–Boundary Creek fault.
County(s) and State(s)	CLALLAM COUNTY, WASHINGTON
Physiographic province(s)	PACIFIC BORDER
Reliability of location	Good Compiled at 1:24,000 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 Nelson and others (2007 #6916).
Geologic setting	The Lake Creek-Boundary Creek fault is located along the northern flank of the Olympic Mountains near the physiographic boundary between the Olympic Mountains and the Straight of Juan de Fuca and Puget lowlands to the north and east, respectively. This physiographic boundary is near the approximate limit of Pleistocene continental ice sheets (*e.g.*, Gower and others, 1985 #4725). The Olympic Mountains are comprised of complexly deformed Eocene and younger Tertiary rocks. Rocks in the core of the Olympic Mountains are part of the Olympic subduction complex that formed during Paleogene subduction of the Juan de Fuca plate to the west (Tabor and Cady, 1978 #6221, 1978 #6222; Dragovich and others, 2002 #5715). In map view, rock units of the Olympic Mountains now show a map pattern that suggests they define a large, east plunging anticline that is superimposed on earlier formed thrust faults and folds related to subduction. The origin of this anticlinal form, the deformed rock units, and thrust faults and folds is not fully understood but may have resulted from Neogene isostatic rebound and doming of the structurally thickened subduction complex (Tabor and Cady, 1978 #6222). Regardless of the origin of the apparently younger anticlinal form, the result is an east-plunging antiformal core of underplated, more highly deformed deep-marine siliciclastic rocks that are bordered by an open-to-the-west, horseshoe-shaped margin of basalt and marginal marine rocks. This unnamed fault occurs in the peripheral rocks and overlying Pleistocene glacial deposits along the northern, north-dipping limb of the

	antiform described above. Haugerud (2002 #5048) reports that the fault nearly coincides with a previously mapped fault that is shown on the geologic map by Dragovich and others (2002 #5715) as a north-dipping thrust fault that appears to be part of the horseshoe-shaped system of deformed (?) thrust faults.
Length (km)	30 km.
Average strike	N78°W
Sense of movement	Left lateral, Thrust *Comments:* Topography based on LiDAR data, shows the fault is expressed as both north- and south-facing scarps (Haugerud, 2002 #5048). Nelson and others (2007 #6916) show the fault as having left-lateral sense of movement as evidenced by Eocene basalt sheared over late Quaternary colluvium along a trenched fault combined with the orientations of the shear features in the fault zone suggesting left-lateral reverse faulting. Joyner (2016 #7663) documents oblique thrust faulting near Lake Crescent.
Dip Direction	V; N *Comments:* Joyner (2016 #7663)
Paleoseismology studies	Nelson and others (2007 #6916) excavated five backhoe trenches across scarps of the Lake Creek–Boundary Creek fault at four sites between Tumwater and Siebert Creeks to assess the post glacial history of surface-deforming earthquakes (younger than 11–17 ka). The trenches exposed Miocene bedrock, late Pleistocene glacial deposits, and overlying postglacial deposits cut by steeply dipping, east-striking faults. Surface offset at the Knee-High trench (site 556-1) is 1.7 m, at the Sapsucker trench (site 556-2) is 1.1–2.1 m, at the Corners trench (site 556-3) is 1.3 m, at the Minicorners trench (site 556-4) is 0.8 m, and at the Daisy trench (site 556-5) is 0.7–1.8 m. Radiocarbon ages on fragments of wood charcoal from two deposits of scarp-derived colluvium in the Minicorners trench suggest two surface-faulting earthquakes between about 2,000 and 600 years ago. Three of the youngest of nine radiocarbon ages on charcoal fragments from probable scarp-derived colluvium in the Sapsucker trench suggest a possible earlier surface-faulting earthquake younger than 5,000 years. Site 556-6. Approximately 75 km of high-resolution CHIRP seismic imagery was collected in Lake Crescent in 2013 (Wegmann and others 2014 #7668) followed by the collection of approximately 63 m of piston

	and gravity sediment cores (Joyner, 2016 #7663). Four meter-scale megaturbidites deposited in response to ground shaking are interpreted in the 8.5-k.y. sedimentary record. The median depositional age of the Lake Crescent megaturbidites are 2,859; 4,015; 5,736; and 7,097 cal yr BP. The 4,015 and 7,097 cal yr BP deposits are correlated with one or more marine turbidites attributed to ruptures of the Cascadia megathrust (Joyner, 2016 #7663). The other two may be attributed to shaking from local earthquakes on the Lake Creek-Boundary Creek fault.
Geomorphic expression	Most of the extent of the Lake Creek-Boundary Creek fault, as described and by Haugerud (2002 #5048) and Haugerud and others (2003 #6211) is located in the east-trending valleys of Indian Creek (west) and Little River (east). Based on features revealed in topography derived from a LiDAR survey, Haugerud (2002 #5048) reports that scarps and gullies mark the trace of this fault. He further reports that the eastern (east of long -123.5°) part of the fault, 2-m-high scarps face south but scarps face north west of that longitude. Haugerud and others (2003 #6211) report that topographic features are ambiguous along the west-end of this lineament. Along this west end, they report a 10- to 20-m-high, north-facing scarp on bedrock that probably is a fault-line scarp eroded along an older weakness, and report apparent surface offset in a Holocene landslide deposit that suggests young deformation. Along the eastern part of the fault, they report a 1- to 2-m-high south-facing scarp that shows south-side-down offset of a late Pleistocene glacially fluted surface. Polenz and others (2004#7666) noted that because faults scarps recognized through airborne laser swath mapping methods are found on outwash terraces deposited about 13 ka and are not found on late Pleistocene alluvium thought to closely postdate the outwash, surface faulting on the Lake Creek–Boundary Creek fault may have occurred shortly after 13 ka.
Age of faulted surficial deposits	Based on features apparent in topography derived from a LiDAR survey, Haugerud (2002 #5048) and Haugerud and others (2003 #6211) report that scarps offset late Pleistocene (Vashon) glacially fluted surfaces and may offset Holocene landslide deposits.
Historic earthquake	
Most recent prehistoric deformation	latest Quaternary (<15 ka) *Comments:* Polenz and others (2004 #7666) and Schasse and others (2004 #7667) reported the first evidence for post-glacial ground rupture of the Lake Creek-Boundary Creek fault south and east of Port Angeles. Nelson and others (2007 #6916) confirm Holocene activity along these faults.

Recurrence interval	Radiocarbon ages reported by Nelson and other (2007 #6916) suggest recurrence of possibly a few thousand years during the late Holocene. Joyner (2016 #7663) speculates the ages of the megaturbidites, separated by 1,100–1,700 years, can constrain recurrence on the western segment of the Lake Creek-Boundary Creek fault; however, the interval is longer if the deposits suspected to have been associated with earthquakes on the Cascadia subduction zone are ignored. *Comments:* At this time, there are no reports of evidence for multiple Quaternary events or other data that might constrain the recurrence interval(s) of this fault.
Slip-rate category	Less than 0.2 mm/yr *Comments:* Existing data and interpretations do not specifically address or constrain the rate of deformation on the Lake Creek-Boundary Creek fault. Based mostly on this lack of information, most conservative slip-rate category is assigned herein. The amount of post-glacial vertical displacement reported by Nelson and others (2007 #6916) suggests a low slip rate.
Date and Compiler(s)	2016 David J. Lidke, U.S. Geological Survey Kathleen M. Haller, U.S. Geological Survey Elizabeth A. Barnett, Shannon & Wilson, Inc.
References	#6212 Brown, R.D., Jr., 1970, Geologic map of the north-central part of the Olympic Peninsula, Washington: U.S. Geological Survey Open-File Report 70-43, 2 sheets, scale 1:62,500. #6213 Brown, R.D., Jr., Gower, H.D., and Snavely, P.D., Jr., 1960, Geology of the Port Angeles-Lake Crescent area, Clallam County, Washington: U.S. Geological Survey Oil and Gas Investigations Map OM-203, 1 sheet, scale 1:62,500. #5715 Dragovich, J.D., Logan, R.L., Schasse, H.W., Walsh, T.J., Lingley, W.S., Jr., Norman, D.K., Gerstel, W.J., Lapen, T.J., Schuster, J.E., and Meyers, K.D., 2002, Geologic map of Washington—Northwest quadrant: Washington Division of Geology and Earth Resources Geologic Map GM-50, 72 p. pamphlet, 3 sheets, scale 1:250,000. #4724 Easterbrook, D.J., 1994, Stratigraphy and chronology of early to late Pleistocene glacial and interglacial sediments in the Puget Lowland, Washington, *in* Swanson, D.A., and Haugerud, R.A., eds., Geologic field trips in the Pacific Northwest (published for the 1994 Annual Meeting of the Geological Society of America): Seattle, University of Washington, p.

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