Jump to Navigation

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Hood Canal fault zone (Class B) No. 552

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Synopsis	The northerly striking, Hood Canal fault zone was originally inferred from gravity anomalies and some aeromagnetic data for the Puget Lowlands and the Olympic Mountains directly to the west. Much of the length Hood Canal marks the eastern edge of a prominent gravity high. Interpretation of seismic-reflection data suggests that Quaternary sediments are deformed along a north-northeast-striking zone of faults beneath the northern part of the canal. The presence of an active fault zone, beneath the southern part of the canal and onland north of the canal, are more speculative and based principally on geophysical anomalies. Interpretation of seismically imaged stratigraphic relations implies considerable deformation of Tertiary bedrock and complex depositional patterns in Quaternary deposits that have been affected by high-angle faulting. In seismic-reflection profiles, these high-angle faults appear to be principally normal faults associated with some reverse faults. Possible strike-slip offsets along these faults, however, might not be apparent in these profiles, and several regional studies infer from regional relations

	that this fault zone is principally characterized by right-lateral strike-slip movement. Some interpretations of regional tectonic relations may also suggest that the most recent movement along faults of this zone is as young as late Holocene in age. Inferences of right-lateral strike-slip movement and the possibility of late Holocene movement along this fault zone are based mostly on the apparent westward termination of the Seattle fault zone [570] near Hood Canal. Late Holocene activity along the Seattle fault zone is well documented. The age, character, and origin of faults that appear to deform Quaternary sediments beneath Hood Canal, however, are not tightly constrained. For example, some apparent faults and faulted relations imaged from seismic data, might instead reflect inherited Tertiary topography enhanced and modified by multiple episodes of Quaternary glacial erosion and glacial and marine deposition. Possible slip rates and recurrence intervals for this fault zone have not been reported. Consequently, at this time this largely inferred fault zone is classified herein as a Class B structure until more detailed studies and characterization of this zone is reported.
Name comments	The Hood Canal fault zone is a northerly trending feature that is defined largely by geophysical anomalies and seismic-reflection data that collectively suggest the feature is a major active fault zone (Dragovich and others, 2002 #5715). Based on surface geology, gravity data and limited magnetic observations, Danes and others (1965 #4723) concluded that an unnamed, major active fault separates the Puget Lowlands from the Olympic Mountains and noted that northern Hood Canal developed along this fault. Gower and others (1985 #4725) and Yount and others (1985 #4746) showed this linear geophysical anomaly as probable fault on a 1:250,000-scale seismotectonic map and 1:100,000-scale depth to bedrock map, respectively, but they did not name the feature. Gower and others (1985 #4725) did, however, label and refer to this feature as their probable fault "J." Some regional tectonic interpretations infer or suggest a connection between a fault or faults in Hood Canal and faults in the Straight of Juan de Fuca to the north, particularly with the Discovery Bay fault (e.g., Roberts, 1991 #6522; Johnson and others, 1994 #4730; Pratt and others, 1997 #6238; Haug, 1998 #6520). Such a connection is not well documented or constrained. Several studies, however, infer this connection and refer to these connected faults as the Hood Canal-Discovery Bay fault zone (*e.g.*, Pratt and others, 1997 #6238; Haug, 1998 #6519; Haug, 1998 #6520) or as the "Discovery Bay-Hood Canal fault" (Roberts and Engebretson,

	1987 #6523; Roberts, 1991 #6522). Other studies and maps retain a distinction between the Hood Canal fault and the Discovery Bay fault (e.g., Brocher and others, 2001 #4718; Dragovich and others, 2002 #5715; Blakely and others, 2002 #6516). This distinction is retained herein and the name "Hood Canal fault zone" is used for the seismically imaged zone of faults in Hood Canal and Dabob Bay, and used for the inferred on-land continuation of the zone north of Dabob Bay. As shown on maps by Gower and others (1985 #4725), Rogers and others (1996 #4191), Dragovich and others (2002 #5715), and herein, a single, northeast-striking fault trace represents the Hood Canal fault zone. As shown herein, the Hood Canal fault zone extends northward from directly east of Potlatch, Washington, near the southern end of Hood Canal, through Hood Canal and Dabob Bay and is inferred to extend farther northward on land to about 5 km east of the southern end of Discovery Bay. Other northerly striking faults have been mapped and inferred a few to several kilometers east of the northern part of the Hood Canal fault zone, where they are mapped as largely inferred faults in and along Discovery Bay (Gower and others, 1985 #4725; Johnson and others, 2000 #4755; Dragovich and others, 2002 #5715). With the exception of one northerly striking fault in Discovery Bay, which is shown and included herein with the group of faults referred to as the "unnamed faults in the Strait of Juan de Fuca and Puget Sound [551]", these other northerly striking faults are not included herein. The northerly striking fault in Discovery Bay might be the "Discovery Bay fault" mentioned above, and it might connect in some manner to the Hood Canal fault zone to the south and (or) connect to one or more unnamed faults in the Strait of Juan de Fuca [551] to the north. Such connections, however, are not apparent from currently available map relations. The Discovery Bay fault and other faults near Discovery Bay are also briefly discussed in the unnamed faults in the Strait of Juan de Fuca and Puget Sound [551].
County(s) and State(s)	JEFFERSON COUNTY, WASHINGTON MASON COUNTY, WASHINGTON (offshore) KITSAP COUNTY, WASHINGTON (offshore)
Physiographic province(s)	PACIFIC BORDER
Reliability of location	Good Compiled at 1:250,000 scale. *Comments:* Fault trace is from the 1:250,000-scale geologic map

	compilation by Dragovich and others (2002 #5715); the trace was transferred directly onto a registered mylar overlay and digitized at 1:250,000 scale.
Geologic setting	The northerly trending Hood Canal and the Hood Canal fault zone occur directly east of the eastern flank of the Olympic Mountains and about coincide with the physiographic boundary between the Olympic Mountains to the west and the Puget Lowlands to the east. Paleogene to Neogene deformation, which was related to subduction of the Juan de Fuca plate to the west, resulted in complex fold and thrust relations among Tertiary rocks exposed in and along the flanks of the Olympic Mountains (Tabor and Cady, 1978 #6221; 1978 #6222; Dragovich and others, 2002 #5715). The adjacent Puget Lowlands is a topographically low region that was occupied several times during the Pleistocene by the Puget lobe of continental ice sheets (Booth, 1994 #4719; Porter and Swanson, 1998 #6237). Bedrock of this lowland region is largely covered by Pleistocene glacial and glacio-marine deposits, which were deposited during advances and retreats of these ice sheets. Beneath the floor of Hood Canal, these Pleistocene deposits are overlain by 10–50 m of fine-grained Holocene sediments (Haug, 1998 #6520). Structures in bedrock of this region are largely inferred from gravity and magnetic anomalies and from seismic-reflection studies (*e.g.*, Danes and others, 1965 #4723; Gower and others, 1985 #4725; Harding and others, 1988 #6515; Haug, 1998 #6520; Johnson and others, 1999 #4729; Dragovich and others, 2002 #5715). The east-striking Seattle fault zone [570], which occurs east of Hood Canal, does not appear to continue west of Hood Canal. The Hood Canal fault zone may cut or somehow link with east-striking thrust faults and folds of the Seattle fault zone [570] (Johnson and others, 1994 #4730; Pratt and others, 1997 #6238; Johnson and others, 1999 #4729). Late to latest Quaternary activity along the east-striking Seattle fault zone [570] is well documented (*e.g.*, Johnson and others, 1999 #4729; Nelson and others, 2003 #5868). This activity along the Seattle fault zone [570] provides some of a larger body of evidence that indicates crustal stress regimes of the Puget Lowlands and adjacent regions include late Quaternary-recent, and perhaps older, components of north-south compression (Magee and Zoback, 1992 #6246; Ma and others, 1996 #6247; Wells and others, 1998 #4742; Wells and Johnson, 2000 #4743). The origin of north-south compression in this region is not completely understood, but may be related to broad northwest-southeast shearing between the Pacific and North America plates or to the

	margin-parallel component of oblique convergence between the Juan de Fuca and North American plates (McCrory, 1996 #6321; 1997 #6323). In a north-south compressive stress regime, the north-northeast orientation of the Hood Canal fault zone suggests that failure along the zone would include a strike-slip component of offset, possibly right-lateral slip (*e.g.*, Johnson and others, 1994 #4730).
Length (km)	77 km.
Average strike	
Sense of movement	Unspecified *Comments:* Sense of movement along the Hood Canal fault zone is not well known or tightly constrained. Roberts and Engebretson (1987 #6523) reported that two-dimensional modeling of gravity and magnetic data indicates probable steep normal or reverse faulting along the "Discovery Bay-Hood Canal fault." Roberts (1991 #6522) later modeled the fault as a down-to-the-west, east-dipping, high-angle reverse fault. In some regional tectonic interpretations and sketch maps, the Hood Canal fault zone is also shown and interpreted as an east-dipping thrust or reverse fault (*e.g.*, Snavely and Wells, 1996 #4290). Other tectonic interpretations suggest it is principally a strike-slip fault that may cut or somehow link with and bound the west side of east-striking thrust faults and folds of the Seattle fault zone [570] (*e.g.*, Johnson and others, 1994 #4730; Pratt and others, 1997 #6238; Haug, 1998 #6520; Johnson and others, 1999 #4729; Brocher and others, 2001 #4718). Based on seismic-reflection data from the northern part of Hood Canal, Haug (1998 #6520) reported that fault structures include horst and graben features, classic normal faults, pressure ridges, and probable remnant thrust fault structures. According to Haug (1998 #6519; Haug, 1998 #6520), the seismic-reflection data also shows abruptly terminated, east-dipping reflectors at depth in the southern and central parts of Hood Canal. He noted that these reflectors probably are east-dipping basaltic flows of the Eocene Crescent Formation that are cut by down-to-the-east normal faults that have as much as about 100–200 m of vertical offset. He also noted that seismic-reflection data suggest northern Hood Canal-Dabob Bay occupy a broad north-northeast-plunging graben that may represent normal faulting and the formation of a pull-apart basin in response to right-lateral slip along principal faults of the zone. Based in part on the westward termination of the Seattle fault zone [570],

	Johnson and others (1994 #4730) interpret the "Hood Canal fault" as a right-lateral fault zone that may link with north-directed thrusting along the Seattle fault zone. Pratt and others (1997 #6238) also inferred strike-slip movement along northerly striking faults beneath Hood Canal, based on abrupt terminations near Hood Canal of west- and northwest-trending gravity anomalies associated with the Seattle fault zone and other Quaternary thrust faults and folds directly east of the canal. Brocher and others (2001 #4718) reported seismic-refraction and other data that suggest both down-to-the east and strike-slip components of offset along the fault zone. On the 1:250,000-scale geologic map by Dragovich and others (2002 #5715), the inferred "Hood Canal fault" is shown as a down-to-the-west fault, but the sense of movement is not indicated or discussed.
Dip Direction	E; W *Comments:* Dip measurements and surface exposures of faults of the Hood Canal fault zone have not been reported. Roberts and Engebretson (1987 #6523) reported that two-dimensional modeling of gravity and magnetic data indicates probable steep normal or reverse faulting along the "Discovery Bay-Hood Canal fault." Roberts (1991 #6522) later modeled the fault as a steeply east-dipping, down-to-the-west, reverse fault. In numerous seismic-reflection profiles and in discussion of these data and profiles, Haug (1998 #6520) shows and discusses a zone of steep-dipping faults beneath Hood Canal. In these profiles, individual fault strands appear to range in dip from about 70–90°, and they dip both to the east and west.
Paleoseismology studies	No scarps have been identified north of Dabob Bay along the inferred onland part of the trace of the Hood Canal fault zone, and paleoseismology investigations have not been conducted along this onland part of the fault zone. Seismic-reflection studies (*e.g.*, Harding and others, 1988 #6515; Haug, 1998 #6519; 1998 #6520; Johnson and others, 1999 #4729) provide the most detailed information on the character and nature of the fault zone, but paleoseismology studies are also lacking along inferred parts of this fault zone beneath Hood Canal.
Geomorphic expression	Other than the topographic low occupied by Hood Canal (Roberts and Engebretson, 1987 #6523; Roberts, 1991 #6522) and the abrupt physiographic boundary between the Olympic Mountains

	and Puget lowlands, there is no unambiguous geomorphic expression of the Hood Canal fault zone. Where the trace of the fault zone is shown on land, north of Dabob Bay, it is mapped as an inferred fault that is covered or obscured by Pleistocene glacial and glacio-marine and some Holocene deposits (Dragovich and others, 2002 #5715). This region, however, is part of Washington's Puget Lowland that was occupied at least five times during the Pleistocene by lobes of the continental ice sheet, with the most recent ice retreat occurring about 16 ka (Porter and Swanson, 1998 #6237). Most of the present landscape reflects this dynamic glacial history (Booth, 1994 #4719) and, as a result, tectonic landforms are generally buried or otherwise obscured. The presence of the fault zone beneath northern Hood Canal and Dabob Bay is inferred from gravity and aeromagnetic anomalies, as well as from seismic-reflection data (*e.g.*, Danes and nine others, 1965 #4723; Gower and others, 1985 #4725; Harding and others, 1988 #6515; Haug, 1998 #6520; Johnson and others, 1999 #4729). In the region where Hood Canal joins Dabob Bay, Harding and others (1988 #6515) reported that seismic-reflection data shows a 74-m-high, west-facing step in the sea bottom that lies above a steep reflection discontinuity. They also noted that the step coincides with the trace of an inferred fault in Hood Canal as previously shown by Gower and others (their inferred fault "J" 1985 #4725). Other investigators have also shown or alluded to irregular topography of the sea bottom in Hood Canal and Dabob Bay as revealed in seismic-reflection profiles (e.g., Haug, 1998 #6520). A tectonic origin, however, for the step noted by Harding and others (1988 #6515) and other irregularities in the sea floor of Hood Canal and Dabob Bay has not been demonstrated. These irregularities in sea-floor topography could also result from differential consolidation and compaction of unconsolidated sediments and (or) reflect inherited Tertiary topography enhanced and modified by multiple episodes of Quaternary glacial erosion and glacial and marine deposition (Yount and others, 1985 #4746; Haug, 1998 #6520; Johnson and others, 1999 #4729).
Age of faulted surficial deposits	Where the trace of the Hood Canal fault is shown on land, north of Dabob Bay, the fault zone is mapped as an inferred fault covered by Pleistocene glacial and glacio-marine and some Holocene deposits (Dragovich and others, 2002 #5715). North-trending faults present directly west of the northern end of the mapped trace of the fault zone cut early and middle Tertiary rocks (Gower and others, 1985 #4725; Dragovich and others, 2002 #5715). Haug (1998 #6519; 1998 #6520) reported that

	interpretation of seismic-reflection data from the canal suggests that Tertiary bedrock (Eocene Crescent Formation) beneath Hood Canal and Dabob Bay shows complex faulting patterns expressed by 20° to greater than 40° east-dipping reflectors, V-shaped valleys, and prominent structural relief of the underlying bedrock surface. Overlying this submerged bedrock are two distinct seismically defined facies of sediments (Haug, 1998 #6519; 1998 #6520). The seismic-reflection data implies that the bedrock is overlain by a 10- to 400-m-thick, heterogeneous, massive to hummocky, sub-parallel to discontinuous and disrupted unit inferred to be Quaternary glacial and glacio-marine sediments (Haug, 1998 #6520). According to Haug (1998 #6520), seismic-reflection data also indicates that this heterogeneous unit is disrupted by near-vertical faults. Directly overlying this heterogeneous unit is the youngest seismic unit identified by Haug (1998 #6520), a 10- to 50-m-thick, flat lying, acoustically continuous sequence of sediments inferred to be late Holocene ice-contact deltaic and glacial outwash deposits capped by more recent fine-grained marine sediments. This youngest unit may be faulted, but the faults do not appear to cut the upper part of this unit (Haug, 1998 #6520). Johnson and others (1999 #4729) reported that seismic-reflection profiles through Hood Canal revealed considerable faulting in Tertiary strata and complex depositional patterns in Quaternary deposits that have been affected by faulting.
Historic earthquake	
Most recent prehistoric deformation	undifferentiated Quaternary (<1.6 Ma) *Comments:* Interpretation of seismic-reflection data from northern Hood Canal and Dabob Bay provides the best evidence for faulted Quaternary sediments and for the time of most recent prehistoric faulting along the Hood Canal fault zone. The ages of sediments that appear faulted in these seismic profiles, however, are not tightly constrained and a tectonic origin for the imaged faults in these sediments cannot be demonstrated unequivocally (Haug, 1998 #6520). Several studies interpret gravity and magnetic anomalies and seismic-reflection data to suggest that an active fault zone probably about coincides with the trace of the Hood Canal fault zone (*e.g.*, Danes and nine others, 1965 #4723; Gower and others, 1985 #4725; Harding and others, 1988 #6515; Haug, 1998 #6520; Johnson and others, 1999 #4729; Dragovich and others, 2002 #5715). The apparent westward termination of the

	Seattle fault zone [570] near Hood Canal may also suggest late Holocene activity along this zone (Haug, 1998 #6520), as has been documented for the Seattle fault zone [570]. A late Holocene surface-rupturing earthquake is known to have occurred along the Seattle fault zone [570] (*e.g.*, Bucknam and others, 1992 #602; Atwater, 1999 #4715; Nelson and others, 2003 #5868). Relations of the Hood Canal and Seattle fault zones, however, are not well known and the timing of possible Quaternary faulting events along the Hood Canal fault zone is poorly constrained. At this time, this largely inferred fault zone is classified herein as a Class B structure until more detailed studies and characterization of this zone is reported.
Recurrence interval	*Comments:* At this time, there is no information on prehistoric surface-rupturing earthquakes or recurrence interval for the Hood Canal fault zone.
Slip-rate category	Less than 0.2 mm/yr *Comments:* Existing data and interpretations do not specifically address or constrain slip-rate(s) of the Hood Canal fault zone. Based mostly on this lack of information, a conservative <0.2 mm/yr slip-rate category is assigned herein for possible Quaternary slip along this zone. Data presented by Haug (1998 #6519), which may suggest Holocene movement along the fault zone related to activity along the Seattle fault zone [570], might also imply a slip rate that exceeds the amount assigned.
Date and Compiler(s)	2003 David J. Lidke, U.S. Geological Survey
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