BUT IT LOOKS LIKE A LANDSLIDE IN LIDAR! GEOLOGIC MAPPING OF PUGET LOWLAND GLACIAL RECESSIONAL LANDFORMS ALONG HOOD CANAL

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Previous geologic mapping and landslide inventories mapped benches along Hood Canal and adjacent drainages as landslides. However, recently published 1:24,000-scale lidar-based geologic mapping suggests many of these landforms may instead be the result of ice-marginal drainages and recessional lake shorelines.

Lidar data highlights benches with similar elevations, and field observations find sorted sediment interpreted to be shoreline or fluvial deposits on these surfaces. The benches may be glacial recessional shorelines at one location, and kames or lateral moraines at the other. Furthermore, the strata below these landforms are undeformed, all suggesting they are not deep-seated rotational landslides

Shorelines Near Lofall on the Kitsap Peninsula

Previous work:
Less than one mile southwest of Lofall, an unnamed drainage (Fig. 1) has benches at an elevation of approximately 130 feet—45 to 70 feet below surrounding topography. They've been mapped as landslides by McKenna and others (2008), and Haugerud (2009). Polenz and others (2013) mapped relict shorelines attributed to Lake Bretz (Wait and Thorson, 1983) in the adjacent Poulsbo quadrangle to the south.

The mapping by Haugerud (Fig. 2) depicts an alluvial flat, graded to glacial Lake Bretz (unit owb) and a delta face (unit df), just northeast of the mapped drainage. To the southeast, in Big Valley, unit owb is also mapped up to approximately 40 meters in elevation. To the southwest, possible late Pleistocene shorelines are mapped at approximately 50 and 60 meters in elevation.

Haugerud mapped outwash flats graded to the marine limit (unit owm) approximately one mile northeast of the Big Valley drainage to an elevation of approximately 120 feet. Deither and others (1995) suggested that the marine limit at the north end of the Kitsap Peninsula is now approximately 30 m above modern sea level.

Previous field-based geologic mapping by Deeter (1979) mapped the area as recessional sands or Vashon-age till, not landslides.

Observations:
The modern drainage appears deeply incised into both glacial and nonglacial deposits. We visited exposures within the drainage and observed loose, oxidized pebbley sand on top of dense, gray silts and clays. We mapped the nonglacial clays and silts as Whidbey Formation based on stratigraphic relations and sparse luminescence dates.

Approximately 0.5 miles to the east, a gravel pit has exposures of recessional delta deposits of pebble gravel and sand, which were deposited into a lake at an elevation of approximately 275 feet.

In the bottom of the drainage, at about 80 feet in elevation, we found intact laminated silt and clay layers with no dropstones, that were nearly level bedded. The 60-foot-thick bench in the drainage consists of loose, light brown, slightly oxidized, subrounded pebbly sand. We did not observe obvious evidence of landslides within the drainage, such as exposed soils, bent trees, and chaotic landslide diamicts.

Interpretation:
We interpret the drainage to be the result of subglacial erosion. While the ice was receding, glacial lakes formed and lowered in elevation as drainage paths were opened. The 60 feet of moderately well sorted pebbly sand was deposited within the existing drainage, likely into a recessional lake.

If the deposits represent deep-seated landslides, we'd expect the silts exposed in the bottom of the drainage to be disrupted and deformed. Because no evidence exists to suggest that these are landslides, we believe they may be related to recessional shorelines.

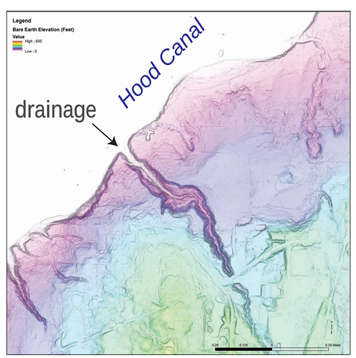

Figure 1. Lidar hillshade of Lofall area.

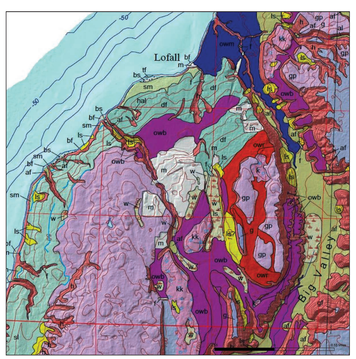

Figure 2. Haugerud (2009) geomorphic map of area.

South of Lilliwaup on the Olympic Peninsula

Introduction:
Two benches on the west side of Hood Canal have been mapped as landslides and look like landslides in lidar hillshades (Fig. 3). One is approximately 1.5 miles northeast of Lilliwaup WA (Fig. 4) and the other is farther north, between Jorsted Creek and Ayok Point (Fig. 6). These benches are between 260 and 300 feet above sea level and have ridges 40 to 50 feet high that roughly parallel Hood Canal.

Previous work:
The 1:62,500- and 1:100,000- scale geologic mapping depicts these landforms as landslides, with the exception of a portion of the northern bench, which is designated as glacial outwash (Carson, 1976; Gerstel and others, 2003; Logan, 2003). The 1980 Coastal Zone Atlas at 1:24,000 scale maps these features as ancient post-glacial landslides (ECY, 1980).

Historic landslides have occurred in this area, and reports of landslide activity along Highway 101 are found in WGS archives.

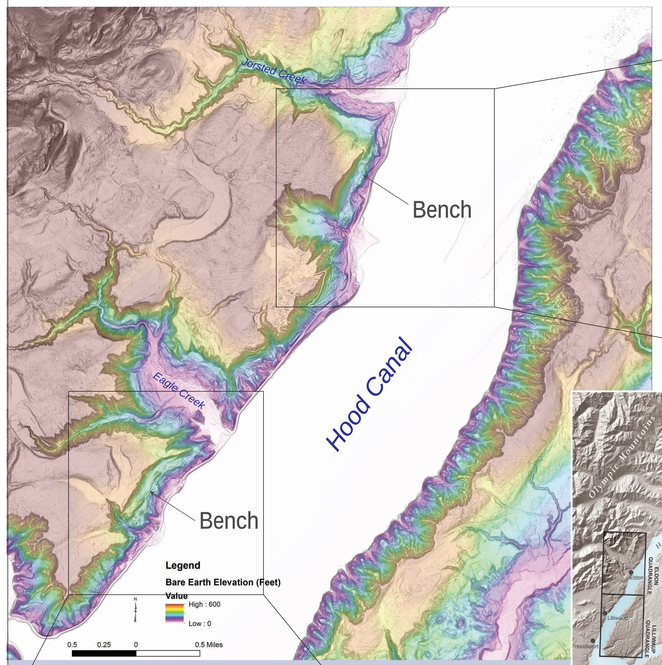

Figure 3. Lidar image of benches on west side of Hood Canal, north of Lilliwaup, WA.

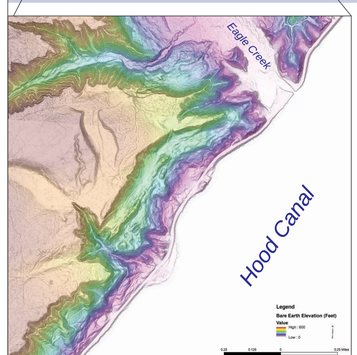

Figure 4. Lidar image of bench south of Eagle Creek.

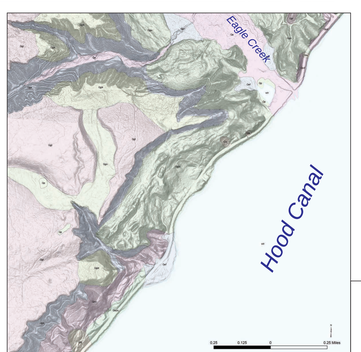

Figure 5. Geologic map of bench south of Eagle Creek.

Observations:
While mapping the Eldon and Lilliwaup quadrangles, Contreras and others (2012 and 2010) found exposures along Highway 101 that suggested limited historic landslide activity in some areas. Other locations appeared to be intact and undisturbed lacustrine silts of the Whidbey Formation (MIS 5 in age) at the base of the benches and both fluvial sands and glacial diamicts along the benches. There are also extensive kame deposits and stagnant ice deposits in nearby drainages (Jorsted and Eagle Creeks).

Adjacent to the northern bench, extensive northern-sourced pebble gravels and diamicts exist and were mapped as pre-Vashon glacial drift, based on the existence of slight oxidation of the clasts.

Profiles of the terrain show distinct benches behind the ridges at approximately 300 feet in elevation.

Interpretation:
The landforms are not large rotational features. If they were, the lacustrine silts would be deformed and back-rotated to coincide with the topography—specifically to account for the ridges. It is possible that they are lateral spreads with failure planes on the undisturbed lacustrine silts. The landforms may be the result of lateral moraines or recessional glacial processes (Fig. 8). We mapped these landforms as stagnant-ice deposits (unit Qgic) and as landslides (unit Qls) only where topographic scarps, historic accounts, and deposits exist.

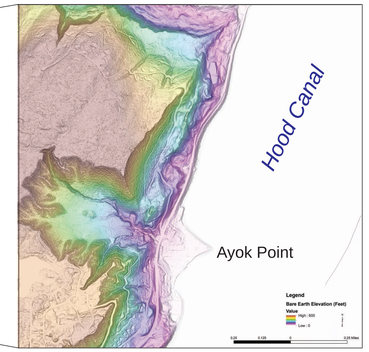

Figure 6. Lidar image of bench north of Ayok Point.

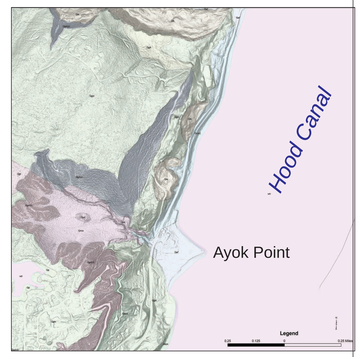

Figure 7. Geologic map of bench north of Ayok Point.

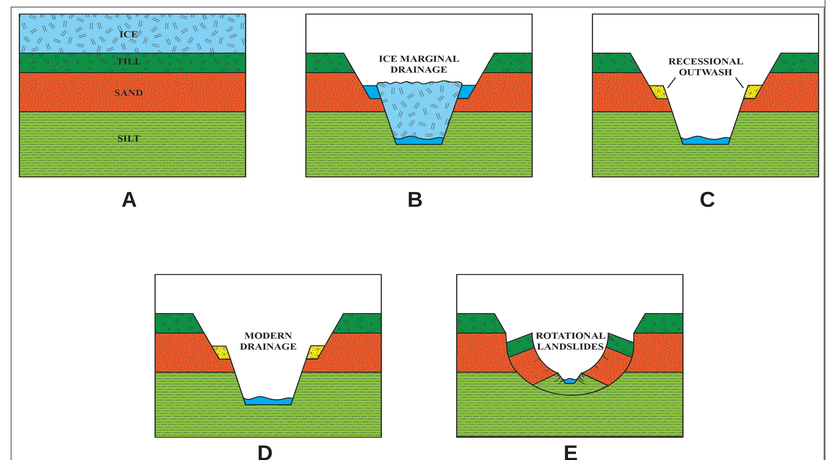

Figure 8. Conceptual model for formation of the stagnant-ice deposits along Hood Canal. A) Generalized Puget Lowland stratigraphy during the Vashon Glaciation. B) As the Puget Lobe stagnated, ice-marginal and subglacial drainages formed. C) After the ice melts, fluvial terraces and ice-marginal debris (moraines and slope deposits) are found above the canal. Simplified comparison of landforms: D) ice-marginal drainage (fluvial and glacial debris), E) deep-seated rotational landslides.

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