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WASHINGTON STATE DEPARTMENT OF Natural Resources
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Division of Geology and Earth Resources
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Lambert conformal conic projection
North American Datum of 1927. To place on North American Datum of 1983 move the projection lines 23 meters north and 94 meters east as shown by dashed corner ticks.
Base map from scanned and rectified U.S. Geological Survey 7.5-minute McNeil Island quadrangle, 1959, photorevised 1981.
Digital cartography by Charles G. Caruthers, Anne C. Heinitz, and J. Eric Schuster.
Editing and production by Karen D. Meyers and Jaretta M. Roloff.

SCALE 1:24 000

contour interval 20 feet

# Geologic Map of the McNeil Island 7.5-minute Quadrangle, Pierce and Thurston Counties, Washington

by Timothy J. Walsh, Robert L. Logan, and Michael Polenz

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## INTRODUCTION

## GEOLOGIC HISTORY

## PREVIOUS GEOLOGIC MAPPING

## MAPPING METHODS

## DESCRIPTION OF MAP UNITS

### Quaternary Unconsolidated Deposits

#### HOLOCENE NONGLACIAL DEPOSITS

**Qf** **Fill**—Clay, silt, sand, gravel, organic matter, shells, rip-rap, and debris emplaced to elevate the land surface and reshape surface morphology; includes engineered and non-engineered fills; shown only where fill placement is relatively extensive, sufficiently thick to be of geotechnical significance, and readily verifiable.

**Qml** **Modified land**—Soil, sediment, or other geologic material that has been locally reworked to modify the topography by excavation and (or) redistribution.

**Qa** **Alluvium**—Silt, sand, gravel, and peat deposited in stream beds and estuaries; includes some lacustrine and beach deposits.

**Qb** **Beach deposits**—Mud, sand, and gravel deposited in the intertidal zone, or residual gravel on a wave-cut platform.

**Qp** **Peat**—Organic and organic-matter-rich mineral sediments deposited in closed depressions; includes peat, muck, silt, and clay in and adjacent to wetlands.

**Qls** **Landslide deposits**—Rock, soil, and organic matter deposited by mass wasting; depending on degree of activity, location within the slide mass, type of slide, cohesiveness, and competence of materials, may be unstratified, broken, chaotic, and poorly sorted or may retain primary bedding structure; may be cut by clastic dikes or normal or reverse shear planes; surface is commonly hummocky in lower reaches of deep-seated landslides or 'stepped' with forward- or back-tilted blocks in headward areas; deep-seated slides tend to be relatively large. Slow-moving slumps (Varnes, 1978) commonly transform into slump–earth flows, can commonly be recognized by bowed or randomly tilted trees, and most commonly occur at the interface between poorly compacted, poorly cohesive, permeable sands overlying relatively impermeable silt or clay layers; shallow, more rapid debris flows commonly occur at the interface between impermeable substrate, such as till, and shallow, loose, permeable soils that are rich in organic matter. Rock topples and (or) falls that are too small to be shown at the map scale occur wherever near-vertical bluffs are present, typically because silt- or clay-rich layers such as units Qgof or Qps fail along bluffs. Unit Qls is shown only where landslides are large or obscure the underlying geology.

#### PLEISTOCENE GLACIAL DEPOSITS

**Deposits of Continental Glaciers—Cordilleran Ice Sheet**

Vashon Stade of the Fraser Glaciation

Glacial sediments described in this section consist mostly of rock types of northern provenance, most from the Canadian Coast Range. A wide variety of metamorphic and intrusive igneous rocks not indigenous to the Puget Lowland and generally southerly directed current indicators help distinguish these materials from the volcanic-lithic-rich sediments of the eastern Puget Lowland and the Crescent Basalt– and Olympic core–rich sediments of the western Puget Lowland.

Age of maximum Vashon ice advance in the map area was previously estimated to be approximately 14,000 radiocarbon yr B.P., based on apparent post-glacial deposits in the central Puget Lowland that were radiocarbon dated at about 13,600 radiocarbon yr B.P. (Porter and Swanson, 1998). However, five more-recently obtained radiocarbon dates from deposits that directly underlie Vashon till in the southern Puget Lowland indicate a maximum ice advance after about 13,400 radiocarbon years B.P. (Borden and Troost, 2001, and this study), which leaves only about 200 years for the glacial advance into and recession from the southern Puget Lowland. Most exposures mapped as Vashon till lack geochronologic data and are identified based on occurrence at or near the top of the stratigraphic section.

**Qgof** **Latest Vashon fine-grained sediments**—Lacustrine clayey and (or) fine sandy silt with sparse, disseminated dropstones; laminated and commonly vertically jointed; medium gray where fresh to pale yellow where dry and oxidized; distinguished by relatively darker (chocolate brown in oxidized exposures) horizontal bands about 1 in. thick that may represent annual winter depositional layers in a varve sequence; no more than about 20 apparent varves were counted in any exposure, suggesting a short life for the glacial lake(s) in which unit Qgof was deposited; present in deposits up to 10 ft thick over much of southern Puget Lowland and most commonly found at elevations below about 140 ft; mapped where it is thought to be at least about 5 ft thick or where it masks the underlying geomorphology; includes deposits of glacial Lake Russell and other lakes of the Vashon glacial recession.

**Qgog** **Vashon recessional outwash gravel (Steilacoom Gravel)**—Pebble to boulder gravel exposed in the southeast corner of the quadrangle. At Dupont, the gravel is about 200 ft thick with large foresets that dip west-northwest toward Puget Sound, forming the Sequalichew Delta of Bretz (1913), who interpreted it as discharge from glacial Lake Puyallup.

**Qgo** **Vashon recessional outwash—**Recessional and proglacial stratified, moderately to well-rounded, poorly to moderately sorted outwash sand and gravel of northern or mixed northern and Cascade source, locally containing silt and clay; also contains lacustrine deposits and ice-contact stratified drift. Some areas mapped as unit Qgo may instead be advance outwash (unit Qga) because it is difficult to tell the difference between the two without the presence of an intervening till.

**Qgt** **Vashon till**—Unsorted and highly compacted mixture of clay, silt, sand, and gravel deposited directly by glacier ice; gray where fresh and light yellowish brown where oxidized; very low permeability; most commonly matrix-supported but may be clast-supported; matrix generally feels more gritty than outwash sands when rubbed between fingers, due to being more angular than water-worked sediments; cobbles and boulders commonly faceted and (or) striated; ranges in thickness from wispy, discontinuous layers less than 1 in. thick to more than 30 ft thick; thicknesses of 2 to 10 ft are most common; till may include outwash clay, sand, silt, and gravel, or ablation till that is too thin to substantially mask the underlying, rolling till plain; erratic boulders are commonly associated with till plains but may also occur as lag deposits where the underlying deposits have been modified by meltwater; typically, weakly developed modern soil has formed on the cap of loose gravel, but the underlying till is unweathered; local textural features in the till include flow banding and apophyses extending 10 to 15 ft downward into underlying sand and gravel (or till) and that are oriented transverse to ice flow direction.

**Qga** **Qgas** **Vashon advance outwash**—Sand and gravel and lacustrine clay, silt, and sand of northern source, deposited during glacial advance; contains some nonglacial sediments, such as cobbles and rip-ups of silt or peat as lag along channel sides and bottoms; gray where fresh, light yellowish gray where stained; sands (unit Qgas) locally 100 ft thick, well sorted, fine-grained with lenses of coarser sand and gravel, generally permeable and porous with low cohesivity relative to overlying and underlying sediments, and subject to deep-seated landsliding.

#### PLEISTOCENE DEPOSITS OLDER THAN VASHON DRIFT

**Qpf** **Pre-Vashon glaciolacustrine deposits**—Parallel-laminated clayey and (or) fine sandy silt with rare dropstones; medium gray where fresh to light tan where dry and oxidized to olive tan where moist and oxidized; very low permeablility and porosity cause this unit to readily perch groundwater; soft-sediment deformation common; locally exceeds 100 ft in thickness; organic matter rare; interpreted to have been deposited in proglacial lakes even where dropstones have not been found, because interglacial conditions in south Puget Sound do not appear to be conducive to large lakes that lack significant amounts of organic matter; may include nonglacial lake deposits. Two new radiocarbon ages obtained from this unit on the east side of Anderson Island are radiocarbon-infinite (Table 1).

**Qps** **Pre-Vashon sandy deposits**—Thin- to thick-bedded to cross-bedded sand interbedded with laminated silt and minor peat, diatomite, and gravel; commonly in upward-fining sequences; dominated by varied Cascade-source volcanic-lithic rock types; older than Vashon Drift and generally overlying or interbedded with unit Qpg; interpreted as nonglacial, but may include glacial-stage deposits, particularly from oxygen-isotope stage 4.

These sediments have previously been referred to the Kitsap Formation, and were interpreted to have been deposited during the Olympia nonglacial interval (Garling and others, 1965). Deeter (1979), however, has shown the type locality of the Kitsap Formation to include radiocarbon-infinite sediments of both glacial and nonglacial origin, and we follow his suggestion that the name be abandoned.

Borden and Troost (2001) reported a radiocarbon age of 41,380±1940 yr. B.P. from Solo Point near the southeast corner of the quadrangle, and Walsh and others (2003a) have reported finite radiocarbon ages in the Nisqually quadrangle immediately to the southeast. All ages we have obtained on this quadrangle, however, are radiocarbon-infinite (Table 1).

At the south end of Ketron Island, a highly concentrated, sand-sized crystal-vitric pumice appears to have been deposited during oxygen-isotope stage 7 (T. W. Sisson, U.S. Geological Survey, written commun., 2001; Logan and others, 2002); this sand appears to be part of unit Qps, which continues around the east side of Ketron Island where it interfingers with unit Qpg. Another highly concentrated tephra is exposed near the southern tip of Anderson Island at Thompson Cove and the west shore of Nisqually Reach on the adjacent Lacey quadrangle to the southwest (Logan and others, 2003). Trace amounts of chemically similar pumice have also been found in sands exposed along Totten Inlet, west of this quadrangle. The age of this tephra is uncertain but may be as old as 100 to 200 ka (A. M. Sarna-Wojcicki, U. S. Geological Survey, written commun., 2003).

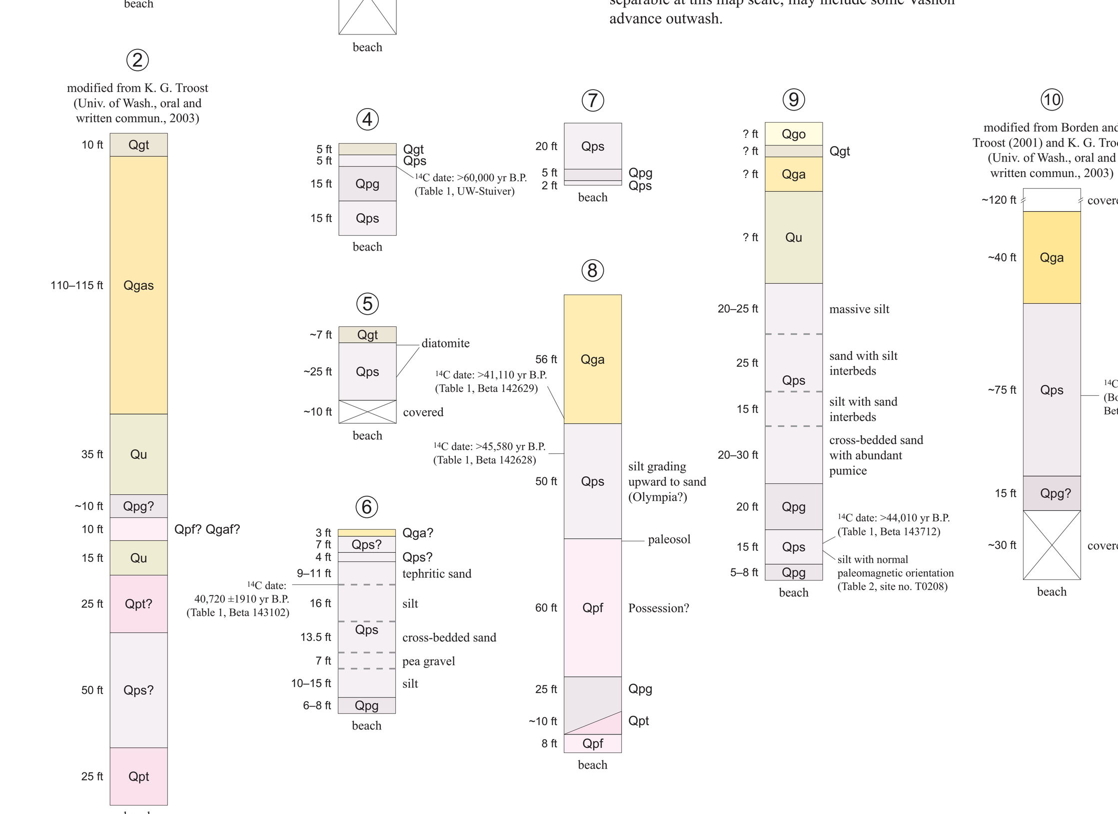
Two sites were tested for paleomagnetic properties during this study, and both were of normal polarity (Table 2).

Sediments mapped as unit Qps apparently were deposited during oxygen-isotope stages 3, 5, and 7 (Walsh and others, 2003b), that is, during the Olympia interstade and much older nonglacial intervals. Because we can establish that not all pre-Vashon nonglacial sediments are correlative, we have chosen not to assign them a stratigraphic name.

**Qpg** **Pre-Vashon gravel**—Gravel and sand of northern provenance; stratigraphically underlies the Vashon Drift; most commonly exposed underneath unit Qps; gravelly portions are relatively resistant to erosion; commonly tinted orange with iron-oxide staining; moderately to poorly sorted; commonly cross bedded but may lack primary sedimentary structures; inferred to be of glacial origin because interglacial conditions do not appear conducive to streams with sufficient competency to deposit widespread gravels in most of the Puget Lowland, and because the majority of the exposures include northern-source clasts.

**Qpt** **Pre-Vashon till**

**Qu** **Pre-Vashon sediments, undifferentiated**



## ACKNOWLEDGEMENTS

## REFERENCES CITED

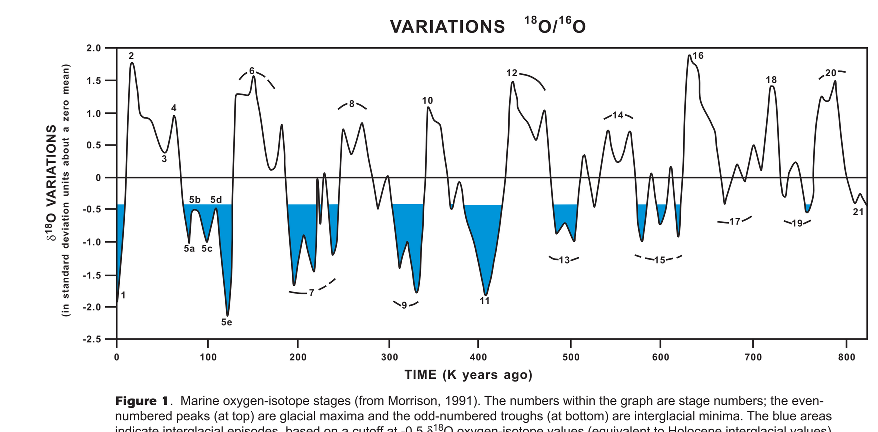
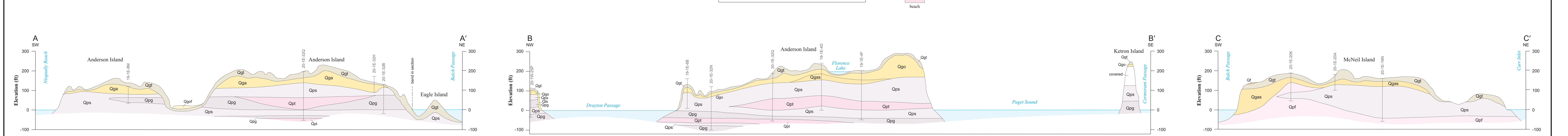


**Figure 1.** Marine oxygen-isotope stages (from Morrison, 1991).

**Table 1.** Radiocarbon ages reported in this study.

**Table 2.** Paleomagnetic data for year 2000.



vertical exaggeration 10x