

# Geologic Map of the McKenna and Northern Half of the Lake Lawrence 7.5-minute Quadrangles, Thurston and Pierce Counties, Washington

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## ABSTRACT

The map area covers the McKenna quadrangle and the northern half of the Lake Lawrence quadrangle in Washington's southern Puget Lowland. Thirty-one geochronological analyses characterize Eocene volcanic and volcanoclastic rocks of Northcraft Formation bedrock and clasts in Quaternary assemblages of volcanoclastic rocks that were deposited in the map area by lahars from the Cascade Range (originating from Mount Rainier and (or) nearby sources such as the Tahoma Range). Rock types in the map area are mostly andesitic but range from basalt to rhyolite. Rocks of the Northcraft Formation are bi-modal in the map area and the Northcraft Formation includes completely stratified, coarse, bouldery lahar deposits that are kilometers wide and hundreds of meters thick. Seven new radiometric ages from the Northcraft Formation range from about 37 Ma up to about 45.5 Ma. Preliminary analysis of aeromagnetic and gravity potential fields data is consistent with Polenz and others' (2021) idea that the Olympia geophysical lineament has down-to-the-northeast offset along segmented and bifurcated normal faults with a strike-slip component.

A thin veneer of Vashon glacial deposits as well as thicker, underlying Cascade Range-derived sediment, provide productive but easily polluted aquifers for water wells. Abundant Cascade Range-derived lahar deposits along the Nisqually River valley record life-threatening volcanic hazards. Several new age estimates from pre-Vashon sediments along the Nisqually River valley and age estimates from Polenz and others' (2021) work on similar sediment further downstream suggest sediment ages from 26–35 ka to 187–259 ka.

## DESCRIPTION OF MAP UNITS

### Holocene to Pleistocene Nonglacial Deposits

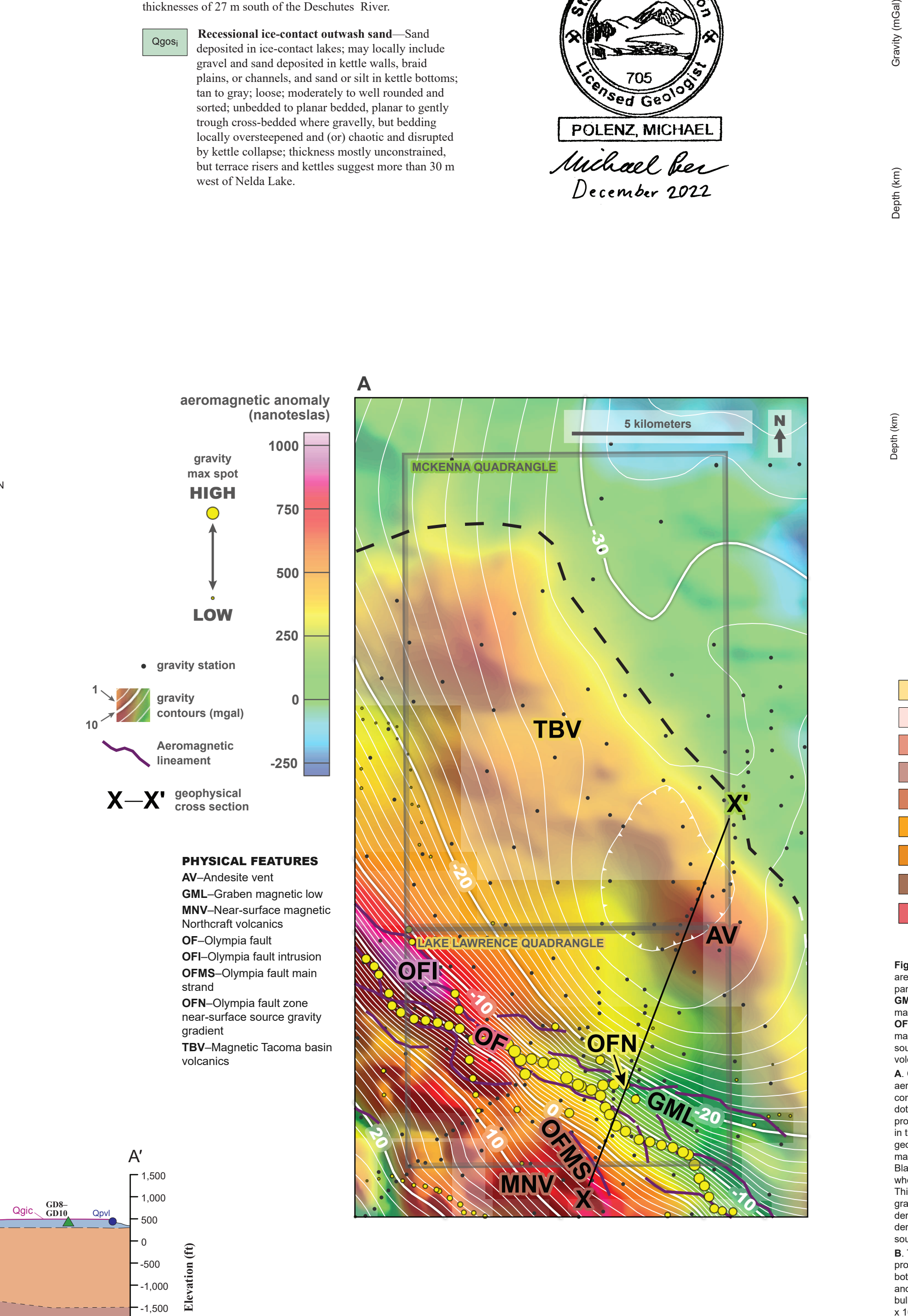
- Artificial fill (Holocene)**—Cobbles, pebbles, sand, silt, clay, and boulders, all in various amounts, engineered and non-engineered, placed to raise roadbeds and other surfaces. Excludes small or shallow fills (less than 1.5-m thick) such as most road-related deposits.
- Modified land (Holocene)**—Locally derived soil, cobbles, pebbles, sand, silt, clay, and boulders, all in various amounts, reworked by excavation and (or) redistribution that modified topography, includes gravel pits and other developments. Excludes small or shallow reworking such as most residential site preparation and road-related modifications with excavations or deposits less than 1.5 m deep or thick.
- Peat (Holocene to late Pleistocene)**—Organic and organic-matter-rich sediment (peat, gyttja, muck, silt, clay, and sand) in flat-bottomed depressions or other poorly drained flat areas; mostly mapped where lahar reveals such landforms and we interpret true-color or infrared aerial photos as evidence of hydrophilic vegetation and (or) wet conditions.
- Alluvium (Holocene to late Pleistocene)**—Fluvial and channel sediment of mostly andesitic pebbles, cobbles, boulders, sand, silt, clay, and peat, all in various amounts; loose, mostly well-sorted and moderately to well-sorted; mostly reworked from unit QpC; locally includes Mount Rainier-derived debris flow diamictites, inter-lake deposits, and lahar-runout deposits. Unit Qa forms a highly permeable and productive, generally unconfined aquifer. Unit Qa is mapped where alluvial transport appears active; unit QaA identifies alluvial deposits that no longer receive sediment.
- Alluvial fan (Holocene to Pleistocene)**—Pebbles, sand, silt, cobbles, and boulders, all in various amounts, deposited in broad fans where confined channels spill out onto broader surfaces; gray to brown, loose, subsiding to rounded, moderately to poorly sorted, bedded to unbedded. Unit QaF was mostly mapped from fan-shaped landforms.
- Landslide deposits (Holocene to Pleistocene)**—Sand, silt, clay, pebbles, cobbles, and boulders, all in various amounts, derived from local steep slopes; weathering varied; particles angular to rounded, mostly loose, unsorted, and unbedded; stratified and (or) compact in some blocks; mostly mapped from landforms (for example, hummocky slopes, damaged and disrupted drainages, disrupted or irregular slopes, tilted benches in hillsides, and concave upper and lower slope forms).
- Colluvium (Holocene to Pleistocene)**—Loose soil, rocks, sand, silt, and clay, all in various amounts, deposited by shallow ravel and soil creep; locally includes small landslides and alluvial fans, but fan-shaped deposits in unit QaF are typically steeper than those in unit QaF; shows where colluvium marks the underlying geology but may locally include exposures of underlying deposits, especially where there are volcanic; not mapped where creeping, clayey soils appear to mantle otherwise undisturbed, smooth slope surfaces (mapped as the underlying units).
- Lahar deposits and lahar-runout deposits (Holocene to late Pleistocene)**—Diamict and gravel of all sizes, sand, prominent boulders up to 3 m in diameter; clasts mostly andesitic, followed by other Cascade Range-sourced rocks; matrix mostly sand; medium gray to variegated; mildly to moderately weathered; generally loose but commonly somewhat stiff; clasts mostly rounded to well rounded, ranging to angular; unsorted in diamict, unsorted to poorly sorted in gravel, poorly to moderately sorted in sand; unbedded, less commonly poorly bedded, and in hypocoenetic flow deposits (observed in polygonal equivalent unit QaV) marked by locally overstepped bedding with swirly patterns; matrix rich in lapilli, pumice, and glass fragments; observed unit thicknesses 1.5–10.5 m; commonly but intermittently exposed within or adjacent to unit QpC and mostly shown as map unit points. Interbedding indicates that the age of unit QpV is similar to that of unit QpC.

### Late Pleistocene Glacial and Nonglacial Sediments

#### VASHON DRIFT

- Recessional or preglacial outwash, undivided**—Pebble gravel, less commonly cobble and boulder gravel, pebbly sand or sand; gray to pale gray, or mildly weathered to pale brown, brown, or variegated with iron stains; loose and commonly cohesionless; well rounded to subrounded; moderately sorted to well sorted and in gravel facies clastic bedding; locally with matrix and interbeds of silt and sand; otherwise faintly bedded or unbedded. Unit QpD tends to form flat to gently sloping terraces with relief, mostly beveled channel forms. Locally divided into:
  - Recessional or preglacial outwash gravel**—Loose pebbles, cobbles, and boulders, in various amounts, commonly with sandy matrix and sand lenses or interbeds; debris flow deposits (diamict) not definitively observed but probably present in unit; tan to gray; variably sorted; well rounded. Unit thickness is mostly unconstrained, but commonly appears to be between 1.5 and 10 m. Isolated clusters of minor mounds in the map area appear to rest only on unit QpD.
  - Recessional or preglacial outwash sand**—Sand and silt, locally pebbly, clayey, or containing interbeds of gravel; gray to brown; loose; clasts moderately to well rounded; generally well sorted; unbedded to planar bedded; sand and silt composition rich in polyhedral quartz. QpDS unit thickness is mostly unconstrained, but we observed 2.5 m minimum thickness near the northwestern map corner, and well log W-3 suggests 8 m thickness just south of the contact between the Lake Lawrence and McKenna quadrangles.
  - Recessional ice-contact outwash, undivided**—Sand and gravel deposited in ice-contact broad plains or channels; also sand or mixed sand and gravel in kettle walls, and sand or silt in kettle bottoms, some of which are draped with post-glacial peat where kettles bottoms are flat; tan to gray; loose; moderately to well rounded and sorted; unbedded to planar or gently cross-bedded in lake settings, and gently cross-bedded in channels or broad plains, but locally overstepped and (or) chaotic and disrupted by kettle collapse; unit thickness mostly unconstrained, but kettle depths, swales, and terrace rises suggest minimum unit thicknesses of 27 m south of the Deschutes River.
  - Recessional ice-contact outwash sand**—Sand deposited in ice-contact lakes may locally include gravel and sand deposited in kettle walls, broad plains, or channels, and sand or silt in kettle bottoms; tan to gray; loose; moderately to well rounded and sorted; unbedded to planar bedded, planar to gently trough cross-bedded where gravelly, but bedding locally overstepped and (or) chaotic and disrupted by kettle collapse; thickness mostly unconstrained, but terrace rises and kettles suggest more than 30 m west of Noble Lake.

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## Late to Middle Eocene Northcraft Formation volcanic rocks

- Undivided igneous rocks**—Dark gray to medium gray lavas, mostly andesitic and basaltic andesite, but ranging from basalt to rhyolite; basaltic trachyandesite, trachyandesite, diatrite, and trachyandesite; interbedded with lahar deposits, pyroclastic tuff, flow breccia, and other volcanoclastics. Locally subdivided into:
  - Basalt flows**—Basaltic black to very dark gray, poorly columnar, vesicular, glassy to slightly porphyritic, with less than 10 percent phenocrysts, including 3–5 percent plagioclase, trace to 1 percent each of clinopyroxene and olivine with pyroxene rims, in a groundmass of 70–75 percent clear glass with amorphous yellowish green clay, 7–10 percent black oxides, 7–10 percent plagioclase microlites, and 5–10 percent subhedral feldspar stubs. Unit Evb was only observed in a small knoll northeast of Jones Hill. The unit is unsorted and more primitive than any previously reported Northcraft lava. We mapped it as Northcraft Formation because the Northcraft Formation also includes (dated) basalt in the adjacent Vail quadrangle, and other members of Northcraft Formation are common in the vicinity.
  - Andesitic and basaltic andesite flows**—Trachyandesite and basaltic trachyandesite are less common, may locally include minor, interbedded volcanoclastic rocks; dark gray to dark olive gray; dense where unweathered, very dense and hard where apatitic, porphyritic with plagioclase up to 4 mm except where locally aphanitic; blocky. Apatitic samples are trachytic—composed of parallel aligned microlites and interstitial glass. Andesitic ridge-top flows west and south of the map area reveal a pattern of unit Evb, underlying and overlying volcanoclastic deposits of unit Evb.
  - Volcanoclastic deposits**—Varied volcanoclastic deposits, including (1) bouldery diamict of mostly andesite and less commonly dacite; mostly lahar deposits but ranging to block and lapilli-silt flow tuff; (2) within unbedded lavas, rare channel fills of rhyolite, immature rhyolite, sandstone with sandy, rounded-pebble conglomerate that locally contains pebbled tuff; (3) centimeter- to decimeter-scale, planar, graded beds of moderately sorted, subangular volcanic lithic sandstone and siltstone, and angular pebble conglomerate with carbonized wood fragments; (4) light brown, tan, or olive devitrified crystal lithic vitric lapilli-silt flow tuff; (5) radially-fractured volcanic bombs. Unit is mostly unsorted but locally ranges to moderately welded. Abundant blocks range from 0.1 to more than one meter. Weathering increases upsection to areolite and homogeneous clay. Highly varied clast weathering at some exposures suggests a varied provenance.
  - Dacite**—Dacite to trachyandesite; pale reddish purple and medium dark to dark gray, gray to blocky. Narrow, sub-millimeter band of very finely crystalline (<0.1 mm) magnetite and hematite lead a pale reddish purple tinge to the rock and accentuate color banding and colorist patterns unique to this unit. Petrography reveals parallel alignment of plagioclase microlites to contribute to mineralogical banding at many locations. Dull, white, elongate feldspar phenocrysts 1–5 mm in length comprise 5–7 percent of the rock, surrounded by gray to pale, reddish-purple groundmass with an early lahar. Sparse black pyroxene crystals 1–2 mm in length comprise less than 1 percent of the rock. Three <sup>40</sup>Ar/<sup>39</sup>Ar ages from unit Evb cluster around 41 Ma, suggesting that dacite outcrops may have been short-lived and several million years of Northcraft volcanism.

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