3D geologic map of the Summit Lake 7.5-minute quadrangle, Thurston and Mason Counties, Washington

Disclaimer

Citation and link

This 3D geologic map is derived from previously published geologic mapping and analysis. Some of the borehole data are considered preliminary and have not been examined for accuracy of either location or lithologic identification. While lithologic identification for all wells was made by the author of the published geologic map, not all of the wells shown in this 3D product were necessarily used to construct the geologic cross section. The map, cross section, and the borehole data within the 3D model are not intended for analytical use. Instead, the published map and (or) pamphlet should be consulted for original data and interpretation.

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Layer001
Layer002

No Separation | 5% | 50% | 100%

5

Probe

1x Z-Scale | 10x Z-Scale | Default Scale | 10

Web tutorial

PDF3D

WASHINGTON STATE DEPARTMENT OF
Natural Resources
Peter Goldmark - Commissioner of Public Lands

3D PDF INSTRUCTIONS

NAVIGATION
(1 of 2)

- Click inside the window to manipulate the 3D view—the compass will rotate to point towards north
- Hold the left mouse button and move the mouse to tilt the view
- Use the mouse wheel to zoom
- Hold both the right and left mouse buttons to pan the view
- Toggle individual layers in the lower left corner
- Change the vertical scaling or layer separation in the lower toolbar
- Selecting an object will display its data below

OBJECT DATA

undefined

undefined

undefined

undefined

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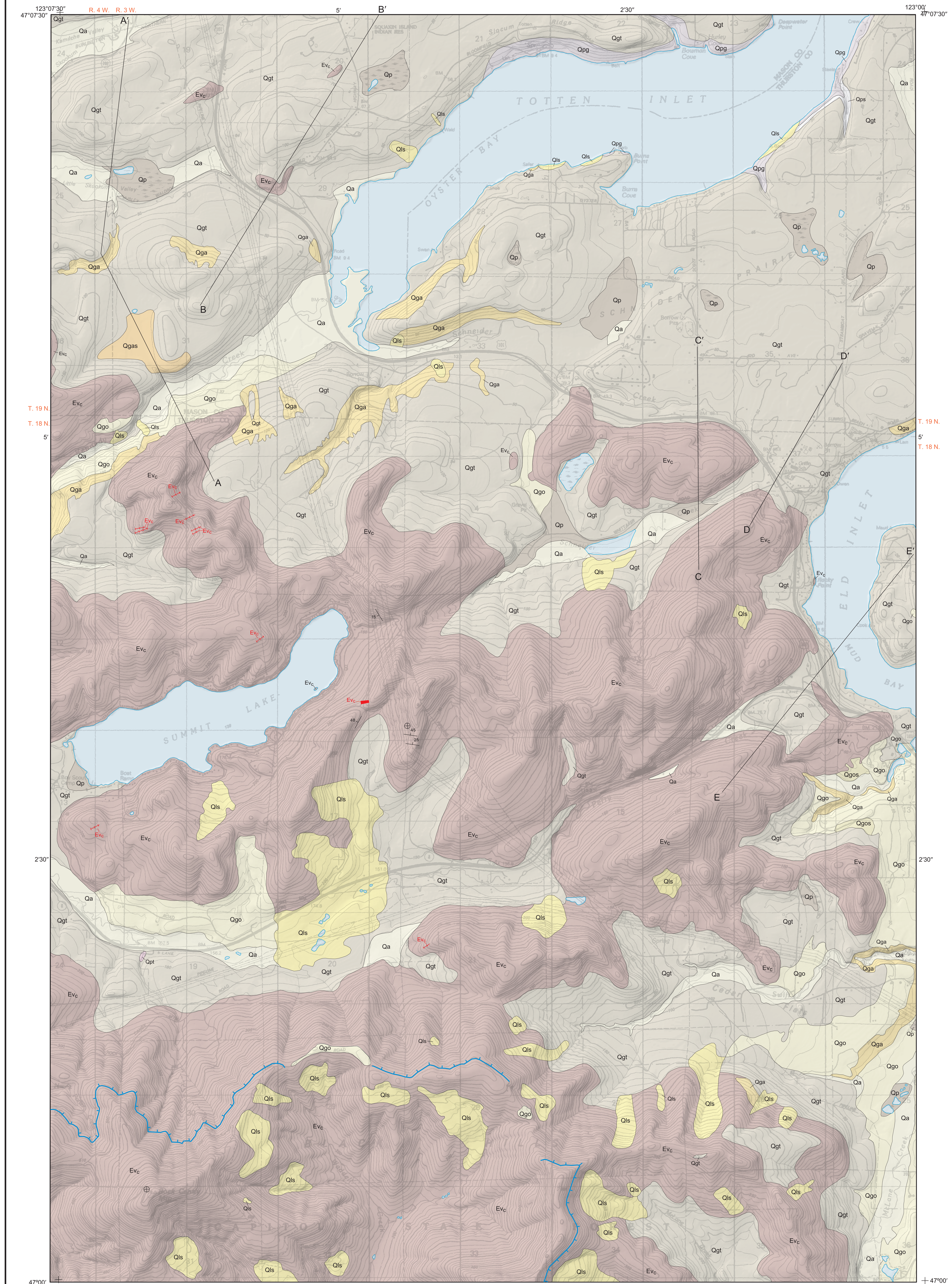
WASHINGTON DIVISION OF GEOLOGY AND EARTH RESOURCES
OPEN FILE REPORT 2004-10

Geologic Map of the Summit Lake 7.5-minute Quadrangle, Thurston and Mason Counties, Washington

by Robert L. Logan and Timothy J. Walsh

June 2004



INTRODUCTION

Eocene basalt is exposed in the southwestern two-thirds of the Summit Lake quadrangle and Quaternary glacial deposits are mostly exposed in the northeastern one-third. The contact area between the two is the locus of large linear isostatic residual gravity and aeromagnetic anomalies that have been speculated to represent either a monocline dipping to the northeast or a fault (Danes and others, 1965; Gower and others, 1985; Magsino and others, 2003) (Fig. 1). This anomaly is also weakly imaged in seismic tomography at depths shallower than 10 km but is not apparent below that depth, where the model is better constrained (Van Wagoner and others, 2002). We are mapping this quadrangle in part as an investigation of deformation associated with this feature.

PREVIOUS GEOLOGIC MAPPING

The glacial history and geology of south Puget Sound are summarized by Bretz (1913), who mapped the entire Puget Sound basin in reconnaissance. Noble and Wallace (1966) mapped all of Thurston County for a small-scale water resources study and Molenaar and Noble (1970) similarly mapped southeast Mason County. The bedrock geology in the Black Hills was mapped by Globerman (1981) as part of a paleomagnetism study. The Coastal Zone Atlas (Washington Department of Ecology, 1980a,b) provides mapping of a 2000 ft wide strip along the shoreline at a scale of 1:24,000. Logan (1987), Walsh and others (1987), and Palmer and others (1999) compiled and augmented previous mapping. Drost and others (1998) interpreted water well logs for northern Thurston County and developed a groundwater model.

MAPPING METHODS

For the present map, we inspected available construction site excavations, gravel pits, and roadcuts. We surveyed the shorelines by boat and took samples and measured sections at cliff exposures. Outcrop is generally poor throughout the quadrangle, and contacts between map units are commonly not exposed and are only approximately located on this map. They are generally located by outcrop mapping, air photo and Light Detection and Ranging (LIDAR) interpretation (Fig. 2), and interpretations of water well logs from Washington Department of Ecology. U.S. Department of Agriculture soil maps (Pringle, 1990) helped guide the location of peats and the contacts between sandy and gravelly units. Location accuracy of contacts is judged to be about 200 ft in general. In addition, the contacts between some units are gradational. We have tried to consider geotechnical significance in mapping geologic units and have attempted to show units only where they are thicker than 5 to 10 ft or mask the underlying lithology. However, where very thick residual and colluvial soils mask bedrock, as is common on south-facing slopes south of State Route (SR) 8, we have shown only bedrock and landslide deposits on the map.

GEOLOGIC HISTORY

The Summit Lake quadrangle is underlain by Lower Eocene basaltic breccia, sills, dikes, and possibly flows of the Crescent Formation. The Crescent Formation and related rocks in the coast ranges of Oregon, Washington, and Vancouver Island (Roseburg, Crescent, and Metchosin Formations) are generally interpreted as products of rifting of the margin of North America due to oblique convergence with the Kula plate in Paleocene and earliest Eocene time (Wells and others, 1984; Babcock and others, 1992). The age of the Crescent Formation in this part of the Black Hills is about 52 to 53 Ma (Duncan, 1982; Globerman and others, 1982). A foraminiferal assemblage referable to the Ulatisian Stage was collected on the north side of Rock Candy Mountain (NW¼ sec. 31, T18N R3W) and is characteristic of a shallow-water (<50 m) littoral environment (Rau *in* Globerman and others, 1982). Squires and Goedert (1994) suggested that the depositional environment of this site and a site near Larch Mountain about 3.5 mi to the southwest (off this quadrangle) is rocky intertidal and perhaps supratidal. We have also found foraminifera in interbeds in two quarries (NW¼NE¼ sec. 16, T18N R3W, and NE¼SE¼SE¼ sec. 36, T19N R4W). Pillows, which are characteristic of the lower part of the Crescent Formation (Glassley, 1974; Tabor and Cady, 1978), were observed at only one locality in this quadrangle (NW¼SW¼ sec. 4, T18N, R3W), suggesting that these rocks may be from the upper Crescent Formation. Globerman (1981) suggested that these rocks are more similar to upper Crescent than lower Crescent on the basis of chemistry.

The contact between the Crescent Formation and sediments in the Puget Sound basin slopes moderately to steeply northeastward (see cross sections) so that in the northeast corner of this quadrangle, the basalt is overlain by a thick cover of Pleistocene glacial and nonglacial sediments, capped by late Wisconsinan–age Vashon Drift. For a discussion of the history of the Puget Lowland fill, see Walsh and others (2003c).

At various times during the Pleistocene, glacial ice covered most of the map area north of Rock Candy Mountain. As the ice moved southwestward across the area, it was the source of proglacial outwash that was deposited to depths of several hundreds of feet on the northeast side of the Black Hills (see cross sections) within this quadrangle. As the ice overrode the outwash, it deposited till to variable depths on the advance outwash as well as on bedrock. Glacial deposits are generally thickest in valley bottoms or lower valley walls, thinning gradually upward and becoming patchy at higher elevations. In many upland locations and especially on the ridge on the northwest side of Summit Lake, glacial drift is characterized by scattered granitic boulders generally sitting atop bare basalt outcrops or on thin residual basaltic soil.

In addition to being depositional, the glaciers were also erosional, forming ubiquitous ground moraine characterized by drumlins (Fig 2B) and carving valleys subparallel to the ice-flow direction, including the valleys of the Little Skookum Creek, the lower reach of Kennedy Creek, the upper reach of Schneider Creek and Summit Lake, and the Perry Creek and upper Kennedy Creek valley that is now occupied by SR 8. Of these valleys, only Summit Lake was carved deeply by the ice with no subsequent sediment infilling. The bedrock high at the north end of Summit Lake was likely responsible for preventing the lake from being filled with glacially derived sediment.

The valley currently occupied by SR 8 was filled by ice at least twice during the Pleistocene. A rare outcrop of probable pre-Vashon till in the valley bottom (SW¼NW¼ sec. 19, T18N R3W) is evidence for pre-Vashon glaciation within the valley. Rounded northern provenance rocks are scattered at elevations of 1640 ft (440 m) a mile northeast of Rock Candy Mountain along Army Road, indicating that ice may have spilled over the drainage divide south of SR 8 into the headwaters of Waddell Creek during either a pre-Vashon or the Vashon stade. Part of the same lobe of ice that occupied the SR 8 valley also moved into the Swift and McLane Creek basins and covered most of the ridge between the two basins. Glacial drift, including till, is present to an elevation of at least 1300 ft (400 m) in the headwaters of Swift and McLane Creeks.

Although structure or uplift may be, in part, responsible for the current geomorphology of the map area, ice probably took advantage of variations in characteristics of the Crescent Formation basalt while carving the local terrain. Numerous nearly horizontal sills and vertical N60°–80°E trending dikes were observed in the mostly non-directional pile of basaltic breccia that composes the bulk of the bedrock in the Black Hills. Where dikes and sills are most abundant, the bedrock was better defended against glacial erosion. The uplands around Summit Lake contain numerous dikes and sills that are probably more resistant to erosion than the breccia, which is well exposed in the SR 8 valley floor. To the south of SR 8, however, where columnar basalt, possibly emplaced as flows, is probably even more resistant to erosion than the dikes, the uplands are even more prominent.

STRUCTURE

As noted above, the Crescent Formation in the Black Hills was emplaced in shallow marine water. It now stands as high as 2360 ft above sea level at Rock Candy Mountain and therefore must have been structurally uplifted. The Black Hills are bounded on the northeast by a large, northwest-trending linear gravity and magnetic anomaly herein called the Olympia structure (Fig. 1). Danes and others (1965) suggested that this structure was either a monocline or a fault. Using marine seismic reflection data in Puget Sound, Pratt and others (1997) identified a seismic reflector that they interpreted to be Crescent Formation and projected it to outcrop of Crescent, concluding that the Olympia structure is probably a monocline. Sherrod (2001) found trees killed by sudden subsidence about 1100 years ago on the northeast side of the anomaly that he concluded was probably coseismic subsidence, and speculated that the anomaly may be a fault propagation fold above a (presumably) northeast-verging blind thrust. A wood sample from a subsided stump in Mud Bay near the mouth of Perry Creek (NW¼NE¼ sec. 13, T18N R3W) yielded a conventional radiocarbon age of 380 ±50 yr B.P. (Beta-191708). The sample was offset inward from the bark by 5 to 25 rings. The intercept of the radiocarbon age with the calendar year calibration curve (Stuiver and others, 1998) accounting for the offset is A.D. 1495; at two standard deviations, the calendric age is between A.D. 1445 and 1655. We have attempted to map structures that may help to determine the nature of the Olympia structure.

We measured attitudes wherever possible, but few outcrops provided the opportunity. Sedimentary interbeds are rare and are irregular or distorted. We observed no pillow piles that might yield a sense of orientation. Basalt colonnades are commonly lens-shaped and enclosed in breccia, suggesting that magma was injected into breccia piles and inflated, so that flow (or sill) tops were never exposed to become oxidized or vesiculated. Where basalt colonnades have parallel columns that are consistent over significant distances (>100 ft), we measured the orientation of the surface normal to the colonnade. In most outcrops, however, columns are irregular and their orientation changes over short distances, or they fan downward. Many exposures are clearly filled tubes enclosed in breccia and yield no information about strike and dip. In short, we found only seven exposures where we could measure strikes and dips, and we are somewhat uncertain about whether they record primary or structural dip or even if they are truly planar features. Taken together, however, the measured attitudes suggested that these rocks are not highly deformed and may actually be relatively flat-lying.

We also attempted to identify shears that could be measured, but found that the basalt is generally not sheared. A prominent east-west-trending shear was observed in the Crescent Formation on the highwall of the Kennedy Creek quarry (SW¼NW¼ sec. 29, T19N R3W). This shear can be traced only a few hundred feet before it is covered by glacial deposits. Otherwise, shears in Crescent are very local and are associated with joints or contacts between basalt columns and breccia. However, because the Crescent, where well-exposed, is about 60 to 70 percent breccia, shearing might be taken up in breccia and be difficult to discern.

LIDAR imagery (Fig. 2) shows two sets of topographic lineations that trend east-west and about N60°E, respectively. We investigated these on the ground and found that the east-west set typically consists of linear troughs with rounded bottoms cut into basalt or basaltic breccia that is apparently not sheared. These troughs are not stream channels but may carry minor runoff seasonally. The N60°E lineaments, which are much longer, wider, and deeper, are generally filled with sediment or water. We have found no evidence that either set is bounded by particularly competent rock, such as dikes or sills, although all of the dikes that we have found do trend N60°E. In fact, on the north side of Summit Lake, one prominent east-west lineament is apparently cut entirely into breccia.

On the aeromagnetic anomaly map (Fig. 1B) there are several east-west alignments of anomalies that are very high or very low, cut by smaller N60°E-trending anomalies. The east-west anomalies correspond, where data are available, to normally and reversely polarized basalt (Globerman, 1981). Reversely magnetized basalt lies in a belt north of SR 8 and south of Kennedy Creek, while the basalt both north and south of this is normally magnetized (Fig. 1B, Fig. 2). Broadly, these regions are also at different average elevations, separated by deep valleys. The southern belt is generally above 1000 ft, the middle belt between 600 ft and 1000 ft, and the northern belt between sea level and about 1000 ft. The aeromagnetic anomaly associated with the high southern belt (Fig. 1B) continues eastward through the Tumwater and Lacey quadrangles (Walsh and others, 2003b; Logan and others, 2003) and incorporates an anomalous bedrock high that includes Tumwater Hill (Fig. 2).

While we have not found structures specifically associated with the topographic or aeromagnetic lineaments, we speculate that the N60°E dikes may represent intrusion during rifting and that the N60°E alignment may represent normal faulting during or soon after emplacement of the basalts. This orientation of lineaments is compatible with rifting due to oblique convergence of the Kula Plate with the North American plate (Engebretson and others, 1985; Babcock and others, 1992) and could also explain the elevation bands if the lineaments are associated with normal block faulting. To the south of the southern high belt, elevations decrease again and the depth-to-bedrock increases south of Tumwater Hill (Buchanan-Banks and Collins, 1994).

At least some of the uplift of the Black Hills must have occurred in early or middle Eocene time. On the west side of the Black Hills, latest Eocene to Oligocene deep-water Lincoln Creek Formation laps onto the Crescent Formation whereas middle Eocene shallow marine McIntosh Formation laps onto Crescent at the south end of the Black Hills (Walsh and others, 1987). The Black Hills must already have been high enough in McIntosh time to starve the basin to the west. In addition, we found a large piece of fossil wood (0.75 x 2 x 8 in.) in a quarry in the Crescent (NE¼SE¼SE¼ sec. 36, T19N R4W) with intact cellular structure that is not petrified but is weakly coalified (mean maximum vitrinite reflectance 0.48%), suggesting that it was never buried more deeply than a few thousand feet (Walsh and Phillips, 1983; Walsh and Lingley, 1991).

DESCRIPTION OF MAP UNITS

Quaternary Unconsolidated Deposits

HOLOCENE NONGLACIAL DEPOSITS

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

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, cohesion, and competence of materials, may be unstratified, broken, chaotic, and poorly sorted or may retain primary bedding structures; may be cut by clastic dikes or normal or reverse shear planes. Within the field area, slides have occurred as large, slow-moving, deep-seated failures, as small, shallow, rapid failures, or as large fast moving failures. The slide surface may be 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) that commonly transform into slump–earth flows covered by bowed or randomly tilted trees. Along shoreline bluffs, deep-seated slides occur at the interface between poorly compacted, poorly cohesive, permeable sands and underlying, relatively impermeable silt or clay layers; others originate on south-facing slopes in southern part of quadrangle, where Crescent Formation has not been overridden by glacial ice. On the south-facing slopes, the slides consist of residual clay-rich soils that are tens of feet thick with angular cobbles and boulders derived from columnar basalt. In the headwaters of Waddell and McLane Creeks these slides have headscarps up to 200 ft high. A large, probably rapid-moving, deep-seated landslide crossed the valley of SR 8 probably shortly after deglaciation. Relatively small, shallow, 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 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. The contacts of landslides were generally mapped from LIDAR imagery and have been field-verified.

PLEISTOCENE GLACIAL DEPOSITS OF THE VASHON STADE OF THE FRASER GLACIATION

Glacial sediments described in this section consist mostly of rock types of northern provenance, mostly from the Canadian Coast Mountains, that were transported by and deposited by the Puget lobe of the Cordilleran ice sheet during the Vashon Stade of the Fraser Glaciation. A wide variety of metamorphic and intrusive igneous rocks not indigenous to the Puget Lowland, as well as generally southerly directed current indicators, help distinguish these materials from the volcanic-lithic-rich sediments of the eastern Puget Lowland and the Crescent Formation basalt– and Olympic core–rich sediments of the western Puget Lowland.

The time 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, including a glaciolacustrine deposit in the Nisqually quadrangle (Walsh and others, 2003a), indicate a maximum ice advance after about 13,400 radiocarbon yr B.P. (Borden and Troost, 2001), 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.

Qgos — **Latest Vashon recessional sand and minor silt (Tumwater sand of the Vashon Drift of Walsh and others, 2003b)**—Moderately well-sorted, moderately to well-rounded, fine- to medium-grained sand with minor silt; noncohesive and highly permeable; thickness inferred from wells reaches up to 420 ft in the adjacent Tumwater quadrangle (Walsh and others, 2003b); deposited in stream channels, inset terraces, and glacial lake deltas; forms terraces along Perry Creek at elevations up to about 160 ft.

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.

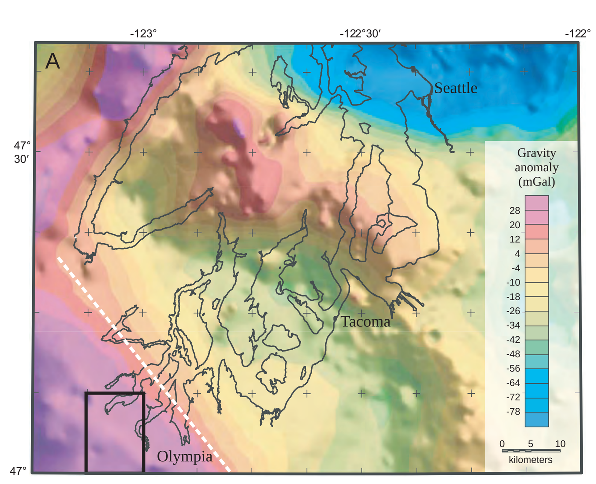
Qgt — **Vashon till**—Unsorted and highly compacted mixture of clay, silt, sand, and gravel deposited directly by glacier ice; gray where fresh and light yellowish brown where oxidized; very low permeability; most commonly matrix supported but may be clast supported; matrix generally feels more gritty 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; 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. Where till is shown on the flanks of the basalt uplands, significant outwash and (or) ablation till may be present.

Qga, Qgas — **Vashon advance outwash**—Sand and gravel and lacustrine clay, silt, and sand of northern source, deposited during glacial advance; may contain some nonglacial sediments, such as cobbles and rip-up clasts of silt or peat, as lag along channel sides and bottoms; gray where fresh, light yellowish gray where stained; sands (unit Qgas) 100 ft thick locally, well sorted, and fine grained with lenses of coarser sand and gravel; locally called Colvos Sand (Garling and others, 1965) and thought to be generally correlative to the Esperance Sand; generally permeable and porous with low cohesion relative to overlying and underlying sediments, and subject to deep-seated landsliding.

PLEISTOCENE DEPOSITS OLDER THAN VASHON DRIFT

Qpt — **Pre-Vashon till**—Unsorted compact mixture of clay, silt, sand, and gravel and of northern provenance; stratigraphically underlies Vashon Drift; weathering rinds on basaltic stones from 1 to 2 mm thick.

Tertiary Igneous Rock



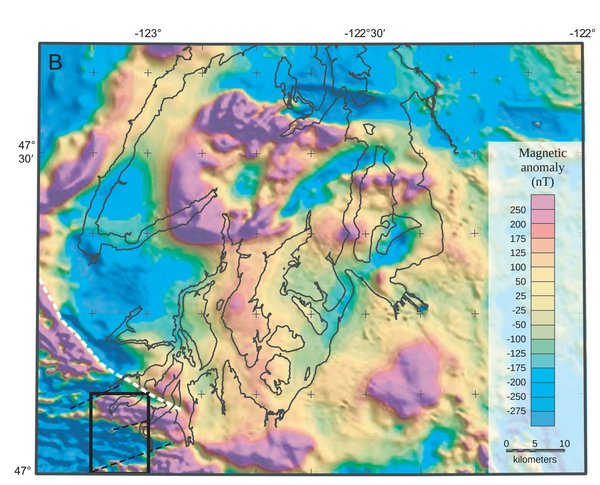


Figure 1. A. Isostatic residual gravity anomaly map of southern Puget Sound (Finn and others, 1991). B. Total field aeromagnetic anomaly map of the same region (Blakely and others, 1999). (Maps modified from Johnson and others, 2004.) The rectangle in the lower left marks the Summit Lake quadrangle. Approximate location of the Olympia structure is shown by white line. Dashed black lines show smaller northeast-trending anomalies. Note that the aeromagnetic anomaly map is of higher resolution than the gravity anomaly map.

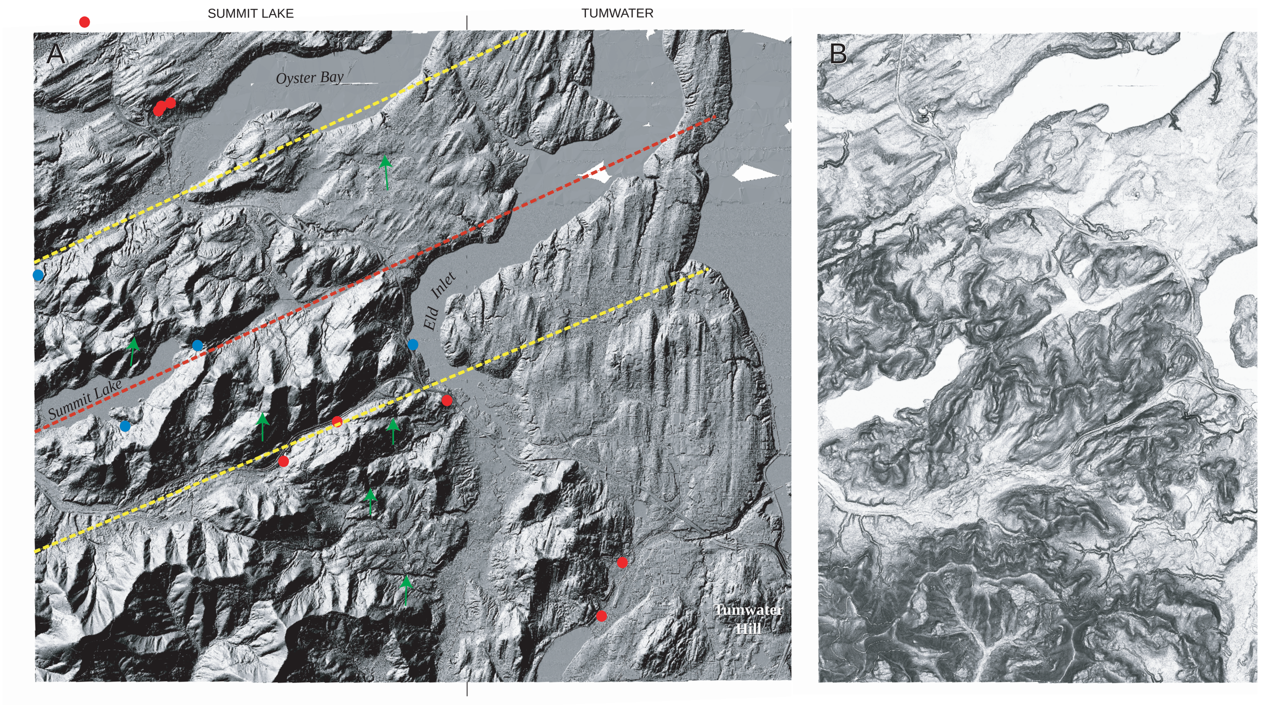


Figure 2. Shaded-relief LIDAR (Light Detection and Ranging) images (vertical exaggeration 6x), scale 1:100,000. A. Low sun angle (35°) image of the Summit Lake quadrangle and the west part of the adjacent Tumwater quadrangle, illuminated from the northwest. Note that low-angle illumination enhances lineaments that are approximately normal to the azimuth of illumination.