UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PRELIMINARY GEOLOGIC MAP OF THE MAXWELTON QUADRANGLE, ISLAND COUNTY, WASHINGTON

By

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This map is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

Seattle Washington
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INTRODUCTION

The sediments exposed in the Maxwelton quadrangle (fig. 1) record at least three glaciations in central Puget Sound, in addition to recording deposition and erosion of water-laid sediment between glacial periods, and after the most recent (Fraser) glaciation. Beach cliffs extending from Deer Lagoon southeast to Possession Point expose as much as 300 feet of older (pre-Fraser) glacial and nonglacial sediment, whereas the upland hills and valleys are mostly underlain by material deposited during the Fraser glaciation. The history of the geologic units shown on the map is discussed briefly in the following section. Crandell and others (1965), Armstrong and others (1965), and Easterbrook (1969) give detailed accounts of the Quaternary geologic history of the area, and Minard (unpublished data, 1981) presents general notes about engineering properties of these units.

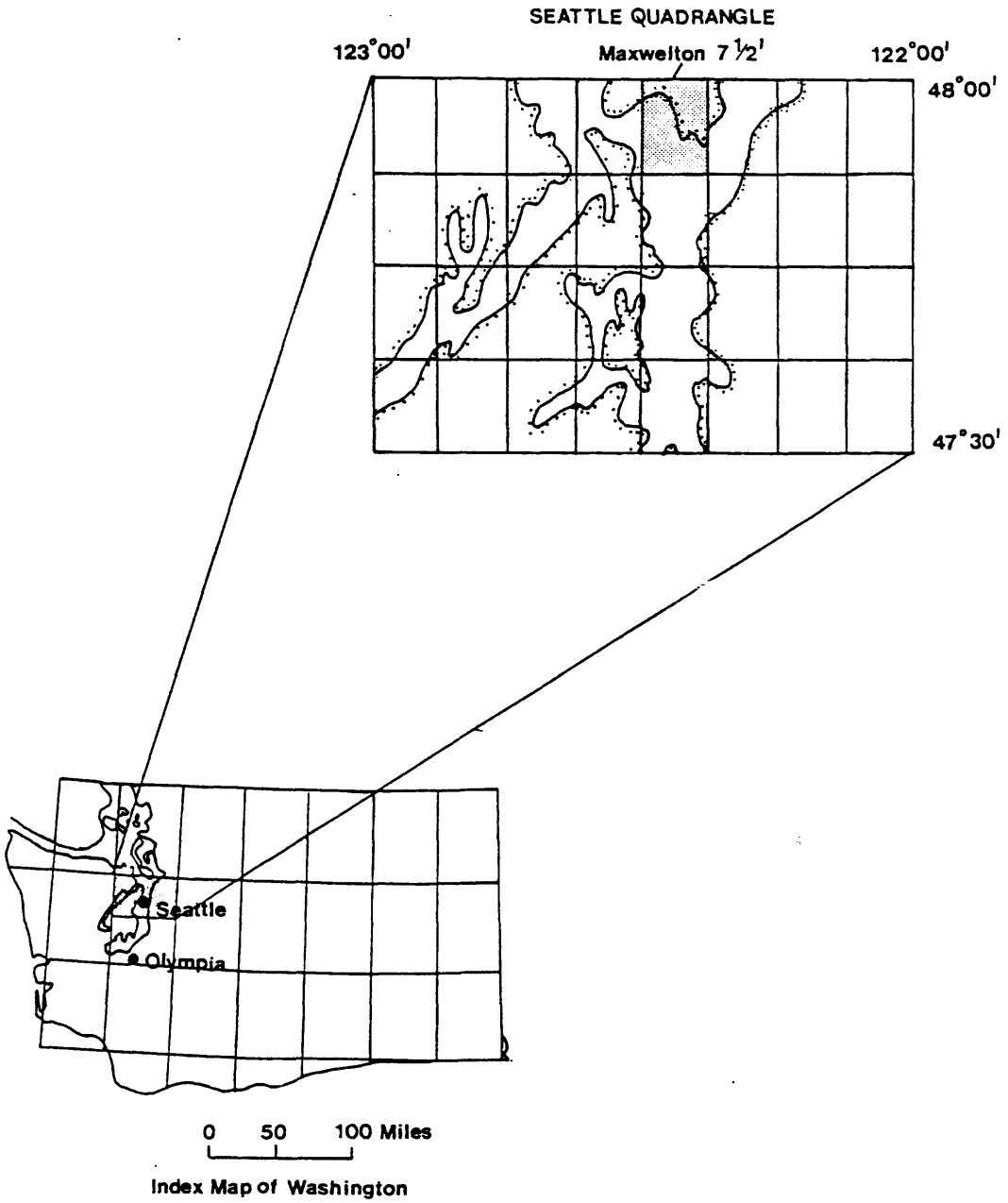


Figure 1.--Map of Washington, showing location of the Seattle 1:100,000 quadrangle, and the Maxwelton 7½' quadrangle.

GEOLOGIC HISTORY

Double Bluff drift is the oldest deposit in the map area and is exposed near Possession Point. It consists of till, gravelly outwash, and glacial-marine units. The base of the Double Bluff drift is below sea level, and the contact with the overlying Whidbey Formation is depositional in some places and erosional in others. No dates are yet available for the Double Bluff, but it is likely older than 100,000 years, and could be as old as several hundred thousand years. A more complete understanding of the pre-Fraser history of the map area will require new methods of dating and correlation of older units, and more detailed sedimentologic and stratigraphic work such as that reported by Stoffel (1980).

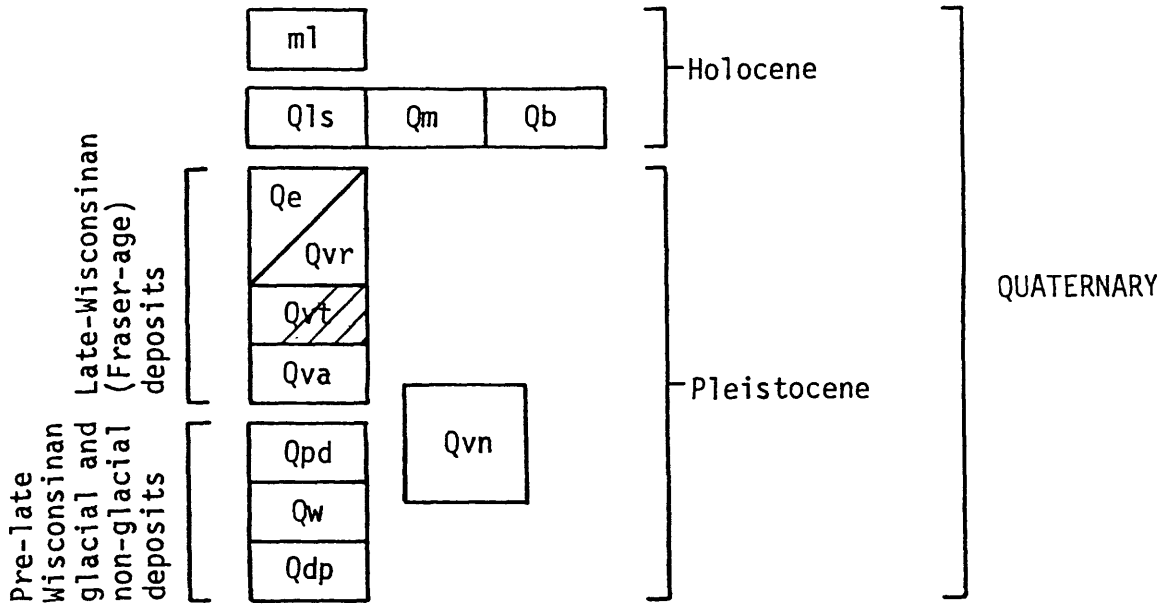
The Whidbey Formation, which overlies Double Bluff drift, gives a good record of conditions in the central Puget lowland during at least some of the period between the Double Bluff and Possession Glaciations. Studies of fossil pollen and the style of deposition in the sand and silt of the Whidbey Formation suggest a low-energy depositional environment somewhat similar to modern river deltas of the region. Peat beds, which are common in the unit, were deposited as organic debris in extensive swamps, and sand units probably represent old channel deposits. The sand and gravel layers between silt units in the Whidbey are aquifers which are tapped by many wells in the map area. Other aquifers occur in the lower part of the Vashon advance outwash deposits. Much of the area west to at least Port Townsend was apparently filled with sediment during the Whidbey interval (Heusser and Heusser, 1981), so that marine waters were confined to the Strait of Juan de Fuca. Neither the age of the Whidbey Formation nor the interval of time the deposit represents are well-known. The unit is older than 60,000 years (the limit of best radiocarbon dating) and probably younger than about 140,000 years, a time of extensive glaciation in the northern hemisphere (Porter, 1979).

The geologic history of the map area following deposition of the Whidbey Formation is not well understood, but there is strong evidence for a glaciation (the Possession), followed by deposition of early Vashon and pre-Vashon fine-grained sediments similar to those of the Whidbey Formation. Geologic materials are well-exposed along shorelines and deep valleys, but much of the record has been obscured by erosion. The glacial drift deposited during the Possession interval, which probably occurred between 60,000 and 80,000 years before present (YBP) (Clague, 1981), has been eroded in all except a few places, where it underlies fine sediment which probably was deposited before and during the early parts of the Fraser Glaciation. Similar fine sediment near Scatchet Head is dated at >40,000 (Stoffel, 1980), so at least some deposition took place relatively soon after the Possession Glaciation. The Possession drift appears similar to Fraser drift except that shell-bearing sediment deposited by floating ice (glacialmarine drift) is also present. Similar sediment occurs with Fraser drift on central and northern Whidbey Island. Exposures near Possession Point and southeast of Sunlight Beach suggest that there was considerable erosion of the Whidbey Formation and Possession drift in the more than 40,000 years that separate the Fraser and Possession Glaciations.

Regional studies suggest that the Puget lowland has been overridden by a lobe of Cordilleran ice at least four times during the Pleistocene (Crandell et al, 1965), the "Ice Age" of the past two million years. The most recent ice advance--the Fraser Glaciation--left deposits which are well exposed in the map area. Glaciers formed in the mountains of British Columbia about 30,000 YBP (Clague, 1981). However, it was not until about 18,000 YBP that the ice sheet crossed the international border, and ice probably did not arrive in the map area for at least another 2,000 years (Stoffel, 1980). As the ice advanced south, drainage westward out of the Strait of Juan de Fuca was blocked, creating lakes which subsequently filled with fine-grained sediments (early Vashon fine-grained deposits). Sediment-rich meltwater streams flowing from the front of the ice sheet deposited thick layers of sand of the Vashon advance outwash deposits over the lake sediment. These coarse and fine sediments were overridden and partly eroded by the advancing ice. The ice incorporated large amounts of sand as it overrode the advance outwash, depositing a compact, concrete-like mixture called Vashon till. Excellent exposures of these sediments occur along the cliffs west of Scatchet Head. After advancing south to Olympic about 15,000 YBP, the ice thinned and melted back, exposing Whidbey Island about 13,500 years ago (Dethier, unpublished data, 1981). Although some recessional outwash sediment was deposited near Deer Lake during the retreat, the main effect of water flowing from the ice was erosion of till and outwash, particularly in the northern part of the map area.

The weight of 3,000 to 5,000 feet of ice caused downwarping of the earth's crust in the map area. The area covered by this map remained depressed by some 100 to 140 feet relative to sea level immediately following ice retreat, allowing marine waters to invade the land, forming elongate bays north of Useless Bay and Maxwelton. The land surface rebounded within about 1,500 years of ice retreat, exposing shallow marine silt and sand near Miller Lake, and uplifted beach deposits east of Sunlight Beach and northeast of Maxwelton. Organic and inorganic sediments probably began accumulating in depressions soon after the land was exposed, and filling of marsh and bog areas continues to the present. Coastal bluffs began to slide as soon as they were exposed to wave attack from below and the destabilizing influence of infiltrating water from above. At present, landsliding is most prevalent near Possession and along other coastal bluffs, but slides also exist on steep slopes away from the ocean. Substantial modification of the land surface commenced as soon as settlers arrived in the area, but substantial diking and cut-and-fill operations of the coastal zone did not occur until after 1920.

CORRELATION OF MAP UNITS



ml-Modified land
Qls-Landslide deposits
Qm-Marsh, swamp, or bog deposits
Qb-Beach deposits
Qe-Everson glacialmarine deposits, undivided
Qvr-Vashon recessional outwash deposits
Qvt-Vashon till
Qva-Vashon advance outwash deposits
Qvn-Early Vashon and pre-Vashon fine-grained deposits
Qpd-Possession Drift
Qw-Whidbey Formation
Qdb-Double Bluff Drift

DESCRIPTION OF MAP UNITS

Modified land

ml — Beach sand and gravel, fine-grained dredged sediment, till, riprap, and other material comprising fill and dikes in modified beach areas; till, sand, other rock materials, and organic matter in reclaimed gravel pits. Thickness generally ranges from 1 to 15 feet, but fill in some reclaimed gravel pits may exceed 20 feet. Beach communities like Sandy Hook, Maxwelton, and Sunlight Beach are built on extensively modified beach deposits.

Marsh, swamp, or bog deposits

Qm — Fibrous to woody peat, and much deposited in upland areas in numerous small, shallow bogs and in several extensive bogs near Miller Lake. Also includes extensive coastal marshes at the head of Cultus Bay, northeast of Maxwelton, and at the head of Useless Bay. Dike and tidegate construction have modified the original water flow to the marsh areas. Thickness is highly variable, but upland bogs may contain more than 20 feet of peat and muck.

Beach deposits

Qb — Sand and gravel including limited areas of fine sand and silt, forming beaches that lie as much as 6 feet above mean high tide. Most deposits in the map area also include large amounts of wood, and minor quantities of shell material. Beaches in the map area generally comprise material eroded from adjacent or nearby (usually within several miles) bluffs, and the texture of beach material is usually similar to the coarse fraction of adjacent bluffs. Where erosion rates are high, the landward part of the beach lies directly against resistant Quaternary materials, but landslide deposits overlie this contact in most areas. Unmodified beach deposits wider than about 40 feet at mean high tide are included. Extensively modified beach deposits are included in the modified land unit.

Landslide deposits

Qls — Poorly sorted, nonstratified deposits comprising blocks of resistant material like till or compact silt in a matrix of sand, or comprised mainly of a single material like till. Includes material from slumps, debris flows and avalanches, and talus accumulation. Landslide material is present at the foot of beach cliffs in the entire map area, and small slides commonly form thin surface exposures in cliff areas. Only large slides are shown on the map. Thickness may be as great as 200 feet in the large slides near Possession, but is more commonly several feet to several tens of feet. Areas mapped as landslide deposits near Possession include isolated areas of other units too small to show at the map scale. Landslide deposits generally occur downslope from gullies or source-area scars which resemble cirques, but these features may not be visible because of thick vegetative cover. All steep (>30 percent) slopes, cliffs, and areas above and below bluffs in the coastal area should be considered unstable until site-specific investigations are performed.

Everson-age glacialmarine deposits, undivided

Qe — Medium to well-sorted, massive to laminated marine sand, silt, and clay, and thin, poorly stratified sand and gravel deposits which discontinuously overlie till, advance outwash, and older deposits. Coarse deposits are present as a discontinuous cover up to an elevation of at least 140 feet in the northern part of the map area, and at least 120 feet near Maxwelton, but most of these deposits are not shown because they are less than 5 feet thick. In a few places uplifted beach deposits form distinct strandlines, and are shown as dashed lines on the map. In the trough south of Miller Lake, and in isolated areas in the northwest part of the map, gravel deposits overlie 6 to 10 feet of fine-grained deposits. The fine-grained deposits accumulated in marine waters following retreat of the Vashon ice, but the sediment source was probably nearby cliff material eroded by wave and stream activity, rather than ice. The Everson interval probably began about 13,500 YBP, and as the land surface rose through sea level before about 12,000 YBP (Balzarini, 1981), beach deposits, wave-cut features, and other strandlines were formed. Everson-age deposits are generally poorly drained, and may underlie marsh deposits near Miller Lake and in coastal areas.

Vashon recessional outwash deposits

Qvr — Oxidized sand and gravel deposits which include lenses and thin beds of silt and fine sand. Deposits are generally 6 to 10 feet thick and overlie till at the margins of recessional outwash channels. Near Deer Lake and north of Possession recessional deposits show evidence of faulting and collapse after deposition, and must have been deposited over blocks of ice during retreat of the Vashon ice. Most outwash channels are cut into till, and contain only a thin, patchy cover of sand and gravel.

Vashon till

Qvt — Nonsorted, nonstratified, compact, sandy till consisting of subrounded cobbles and boulders in a matrix of medium and fine sand, and silt. Vashon till forms a discontinuous mantle over much of the upland area, and originally covered the sides of the larger valleys before it was removed by erosion. Over much of the map area till is only 3 to 10 feet thick, although it approaches 80 feet at one location near Possession Point. Oxidation and fabric disruption by soil-forming processes often extends 6 feet below the surface, about twice the depth of weathering commonly observed in silt-rich till. Till generally overlies Vashon advance outwash, but near Possession Point and at many exposures between Maxwelton and Sunlight Beach, till directly overlies older sediments like the Whidbey Formation. Areas of thin (<6 feet) and patchy till are shown with a lined overprint on the map. These areas are mapped as till, but are easy to excavate, have high percolation rates, and exhibit many of the physical properties of sand and gravel. Till below an elevation of 120 feet generally has been completely eroded or persists only as isolated patches where it was exposed to strong wave action during rebound of the land surface some 13,000 years ago. A good example of this process is 0.5 mile east of Sunlight Beach. In sections 20 and 21, recessional meltwater apparently removed much of the till cover, and this is probably true in other areas where channels are cut into the till surface. It is also likely that till is thin or discontinuous at certain locations outside the lined areas, particularly where slopes are steep.

Vashon advance outwash deposits

Qva — Sorted, well-stratified, gray, pebbly sand, commonly with gravel interbeds higher in the section. Most thick exposures display well-developed cross-bedding and cut-and-fill features which are typical of this unit. Fine sand and some silt are common in the lower part of this unit, and also occur locally in the upper part. Deposits are commonly 80 feet thick, but sections as thick as 160 feet are present in the northern part of the map area. In areas where till was removed by wave action or recessional meltwater, deposits may be oxidized to a depth of 6 feet. Sandy outwash deposits commonly overlie fine-grained early Vashon or pre-Vashon sediments. This contact zone is often the site of landslide activity because water moving down through coarse outwash flows laterally to a free face when it encounters the surface of the silt, resulting in water saturation and instability in the overlying unit.

Early Vashon and pre-Vashon fine-grained deposits

Qvn — Well-bedded, moderately well-sorted silt and fine sand containing interbeds of massive, gray sand. Organic-rich sands occur in the lower part of the section at some locations. The unit is as much as 90 feet thick west of Scatchet Head, where it is best exposed, but the thickness at most locations is less than 30 feet. Early Vashon and pre-Vashon fine-grained deposits may include the upper part of the Whidbey Formation, or the basal portion of the Vashon advance outwash deposits. Contacts with both units range from sharp to gradational. At Indian Point, early Vashon and pre-Vashon fine-grained deposits overlie Possession drift, but where this drift is not present, the contact with the Whidbey Formation is drawn at the break between the sandy units of the Whidbey, and the silt-rich units of the early Vashon and pre-Vashon fine-grained deposits. Stoffel (1980) mapped the deposits at Scatchet Head as Whidbey, and found that the organic layers were older than 40,000 years. Minard (unpublished data, 1981) has discussed the stratigraphic setting and lithologies of the early Vashon and pre-Vashon fine-grained deposits in greater detail.

Possession Drift

Qpd — Compact, gray, nonsorted, nonstratified till and glacial-marine sediments. Also includes beds of glacial outwash. Exposed in lenses and in beds of limited extent in seacliffs 0.5 mile east of Possession Point, 0.3 mile southeast of Indian Point, and in the western part of section 29, where drift locally and discontinuously forms the surface layer. Drift thickness ranges from less than 15 feet in section 29 to 120 feet at the Indian Point section; lateral extent of exposed drift is rarely more than 1000 feet. The type exposure near Possession Point (Armstrong et al, 1965) consists of till overlying the Whidbey Formation, and covered with several feet of outwash gravel. At other exposures drift overlies the Whidbey, but consists of till, glacialmarine drift, and outwash; contacts between these units are generally gradational. Possession till resembles Vashon till, and where the surface till overlies the Whidbey Formation, it is possible that some of the exposures mapped as Vashon till are actually Possession drift. The age of the Possession lies beyond the limit of radiocarbon dating and is unknown at present; the drift probably represents an early Wisconsinan or pre-Wisconsinan glaciation.

Whidbey Formation

Qw — Compact, medium- to coarse-grained sand, fine sand and silt, and oxidized sand and gravel. Sand units are massive to cross-bedded, and extensive peat beds and organic-rich layers are a distinctive feature of the unit in the map area. In most exposures the unit is 100 to 150 feet thick, but up to 200 feet of section is exposed between Maxwelton and Sunlight Beach, and even thicker sections are exposed elsewhere on south Whidbey Island (Stoffel, 1980). The base of the formation is exposed only near Possession Point, where it overlies Double Bluff drift. Studies of fossil pollen from the Whidbey Formation suggest that it was deposited under climatic conditions similar to or slightly cooler than present (Hansen and Mackin, 1949; Heusser and Heusser, 1981). Stoffel (1980) suggests that the Whidbey was deposited in a broad floodplain which extended at least as far as the west edge of Whidbey Island. No finite radiocarbon dates exist from this unit, but it is probably pre-Wisconsinan in age, and is likely to be at least 100,000 years old.

• Double Bluff Drift

Qdb — Compact, gray, nonsorted, nonstratified till and glacial-marine drift, and poorly stratified sand and gravel overlying thin-bedded silt containing flattened pieces of wood. Exposed east of Possession Point, where 20 to 70 feet of drift underlies the Whidbey Formation. A diamicton exposed as a lens in seacliffs 0.6 mile northeast of Scatchet Head may be Double Bluff drift. No other exposures are known in the map area. The Double Bluff drift records a pre-Wisconsinan glaciation. These are the oldest sediments exposed in the area; their age is unknown at present but could be as old as 150,000 to 300,000 years.

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