Glacial Geology of the Puget Lowland

Dale W. Cole
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Periods of cooler climate during the Pleistocene caused the accumulation and advance of glacial ice into the area, which is now western Washington

Knowledge of the activity of former glaciers can be obtained by a study of the landforms and sediments, which remain after the ice has left. As a glacier advances it is capable of both erosion and deposition. Perhaps at a given point the glacier could first erode, then deposit some rocks and sand, and even later re-erode those depositions. The advance of the glacier may thus considerably shape the land over which it travels.

The movement of a glacier is due to the properties of ice. Under tremendous pressure, there is a change in the crystal structure of ice, and it will flow, both by melting and refreezing, and the sliding of one crystal past another. Glaciers will flow when greater than 200 feet in thickness. Rate of flow will depend on the pressure behind the ice, and the steepness of the downward slope.

Glaciers are formed where there is an annual excess of snowfall over melting for a long period of time. With a general cooling of the world climate, the glaciers formed in what is now the temperate region, including all of what is now Canada. The ice built up to a great thickness, and the tremendous pressure at the center of the ice mass caused flow towards the edges. Such was the nature of the continental glacier, which covered all of Canada and parts of the northern United States.

There was a small lobe of the continental glacier, which extended into the region, which is now the Puget Sound in western Washington.

There is evidence from some parts of the world, including Wisconsin, that there have been at least four major glaciation periods, or "ice ages," possibly more. The most recent of these occurred between 20,000 and 10,000 years ago. The ice built up and advanced over thousands of years, and receded and melted over thousands of years as well. The glaciation is given local names based on local evidence. The name for the most recent glaciation of the Puget Lobe is the Fraser glaciation.

Within the major periods of ice accumulation and advance there may be minor climatic fluctuations, in time periods measured in hundreds of years. The glaciers may respond to these fluctuations (although due to differences in size and activity, each glacier may respond differently). These fluctuations may cause advances and retreats of the terminus of the glacier over several hundred miles (for continental glacier). The time periods represented by these advances are referred to as stades. There is evidence for three stades of the Fraser glaciation of the Puget Lobe. The earliest was the Evans Creek Stade. It was during this period of cooler climate that the glaciers in the valleys of the Cascade Range reached their maximum. The second stade was the Vashon Stade, during which the Puget Lobe itself reached a maximum. At that time the terminus of the glacier had moved as far south as Olympia, Washington, and evidence of a terminal moraine may be seen near there. There was a third stade of lesser extent following a retreat of the ice out of the Puget Lowland and well into Canada. This stade had its maximum at the international boundary near Sumas, Washington, and is called the Sumas Stade.

The record of many advances into the Puget Lowland has largely been eroded by the most recent glaciation, i.e., the advance of the Vashon Stade. The tremendous forces in glacial movement are capable of severe erosion. Moving glaciers carry many eroded rocks and when the glacier ceases to advance and remains stationary for sometime, moraines are built. These are linear piles of rocks and debris that remain after a glacier retreats and provides evidence of the glacier's position. The advancing glacier overrides soil material and regolith, which became incorporated by formation of regelation ice. Abrasion of large rock masses creates fine material and rock flour. Course clasts are acquired by plucking. Transportation occurs within 100 to 200 feet of the bottom. Very fine materials are dispersed upward in the ice sheet from 50 to 200 feet. Coarse silt, sand, and pebbles are transported in bands concentrated near the ground. Lithology determines the frequency of breaking and the shape of the broken products. Deposition must occur either at the bottom of the ice or off the top by ablation. The material deposited is named till. The term till is reserved for the deposition of unsorted material, which has been carried by the ice and deposited directly by it. Basal or lodgement till is the till deposited at the bottom of the ice, it is compacted, and it shows strong fabric nearly parallel to the known striae. Ablation till is generally more sandy, less compact loose, and with pebbles more angular or less striated than basal till. The separation of these two tills is no, however, a clear cut issue. At times advance of the glacier will shape the terrain beneath it. One distinctive shape is the drumlin. Drumlins are elliptical or oblong hills lying parallel to the direction of ice flow. As the glacier ice passes over an obstruction, erosion takes place on the "upstream" side, and the release of pressure on the "downstream" side allows some deposition, which is then overridden by the glacier. Some drumlins are also covered by ablation till as is the one on which the University of Washington campus is located.

There are other types of depositions, which can result from a glacier. Whenever where is melting of a glacier, there are great quantities of water produced. The rivers produced are continually washing the material eroded by the glacier. Near the glacier, the rivers generally flow in narrow channels and with high velocity. Only the large rocks are heavy enough to resist being carried by the current. Downstream, the river may broaden and slow down, allowing the finer materials to settle out. Sand is dropped first and then silts, with overlap on these boundaries.

Clay may remain in suspension for long periods, often until the river reaches a lake or ocean. The river thus sorts the size of the sediment, which is being deposited. The sediments so formed are called outwash.

If the topography is such that a lake is formed when the ice blocks a natural drainage, there can be lacutrine deposits. There lake bottom sediments will often contain the silts and clays which would not have settled out in the fast moving rivers, but do so in the still lake.

The Vashon Stade of the Fraser glaciation was the last extensive advance in the Puget Sound. The sediments and landforms throughout the Puget Lowland have largely been determined by this glaciation and all the above-mentioned features were formed. A statigraphic section at Magnolia Bluff, Fort Lawton, Seattle indicates a proglacial lake formed in front of the lobe as it advanced south and locked the natural drainage though the Strait of Juan de Fuca. As the base of the section is the Kitsap formation: sands deposited by rivers in the non-glacial period of the Olympia inter-glaciation. Above this lies 60 feet of the Lawton clay; very fine and dark colored at the bottom, becoming coarser at the top. This could indicate that the sediments originated with the advancing glacier. As it approached, the sediment particles traveled less distance, and the deposit was of coarser material. Above the Lawton clay is 150 to 200 feet of the Esperance sand, also coarser near the top, with lenses of gravel. Some fluvial as well as lacutrine deposition is evident. The Esperance sand is overlain by the Vashon till. In other cases the till lies directly over the Kitsap formation, indicating considerable erosion as the glacier advanced.

When the terminus of the Puget Lobe reached its maximum, the thickness of the ice was great enough to dam the heads of some Cascade river valleys. Lakes were formed up to the elevation of an alternative outlet. The shorelines of these lakes can be traced from the lacutrine deposits, and are generally at the same elevation as the Puget moraine across the valley mouth. The drainages of these lakes have been traced to empty into the Pacific at Grays Harbor.

As the Puget Lobe retreated, lower outlets were available and the lakes drained. But the ice was still blocking the present south to north drainage to the area. As a result, another set of large, ice-dammed lakes was formed where the ice had been. Torrential streams from the fast melting ice fed these lakes, the overflow from which was through channels carried tremendous amounts of water and deposited their load of stones and boulders in deltas upon entering other lakes. The deltas have indicated past lake levels, and stone lithologies indicate the source of the debris.

Glaciers in the valleys of the Cascade Range responded to the same climatic changes, which induced continental glaciation. The relative ages and positions of moraines is the primary evidence for establishing a glacial chronology in the valleys. Also of use are the positions and interrelationships of outwash terraces and deposits.

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