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Geomorphic Surfaces and Soils, Northwestern Whatcom County, Washington

Abstract

The geomorphology and soils of northwestern Whatcom County reflect a sequence of depositional and erosional events resulting from glacial and fluvial processes. Four geomorphic surfaces were identified and correlated to soil taxa. They range in age from late Holocene to late Pleistocene. The lower flood plain supports Entisols, the upper one Entisols and Mollisols, the outwash terraces Spodosols and some Alfisols, and the glacialmarine drift plains Alfisols. Radiocarbon dates of organic deposits (9,920 ± 760 to 9,300 ± 250 years B.P.) and seashells (12,090 ± 350 to 10,370 + 300 years B.P.), topographic position, relative age, and the presence or absence of volcanic ash from Mount Mazama (6,600 years B.P.) are used to identify the surfaces.

Introduction

The geomorphology and soils of northwestern Whatcom County reflect a sequence of depositional and erosional events resulting from glacial and fluvial processes (Goldin in press). Each episode of landscape development can be delineated as a geomorphic surface (Parsons *et al.* 1970). The soils associated with a particular surface are differentiated primarily by contrasts in drainage and the texture of the parent material.

The purpose of this paper is to examine the interrelationships among soils, geomorphology, and time.

Methods

Geomorphic surfaces for about 80,000 ha were mapped on 1:63,360 aerial photographs (Figure 1). Sequential field relationships among surfaces, elevations, and photo interpretation of tonal patterns were used to map the surfaces. The soils were studied according to standard procedures and terminology (Soil Conservation Service 1981, Soil Survey Staff 1975). Twelve of the 13 soils on the outwash terraces, all 4 on the glacialmarine drift plains, and the 2 soils on the delta have their series type locations in the study area. All of the soils in the study area are established series.

Results

Soils

None of the soils have significant accumulations of translocated organics, clay, sodium, or carbonates in the subsoil. The annual precipitation of 750 to 1500 mm has leached most of the soluble materials below the zone of observation. Whatcom soils have some carbonates. These are present in the marine sediments and are difficult to leach because of the slow permeability of the soils. They also have some argillans.

The structure is weak in most of the soils. The strongest structure in the subsoil occurs in soils with high clay contents (Bellingham soils) and in the Spodosols with iron cementation (Edmonds and Woodlyn soils).

The major distinctive horizons in the study area are the E and upper Bsm horizons in the poorly drained Spodosols and the Ap and Bg horizons on the cultivated poorly drained soils. The well drained and moderately well drained soils on the two older surfaces have silt pellets and cracked coatings within the B horizon.

Geomorphic Surfaces

Surface 1 This surface is the lower, active flood plain of the Nooksack River and is the depositional and erosional environment of the river channels and associated point bars and channel fillings (Figure 2). The surface is generally underlain by coarse alluvium and is subject to annual flooding. The deposits are pebbles, sand, and silt. The landscape configuration is not stable and changes rapidly as a result of the cutting of new channels, abandonment of older channels, and downstream movement of alluvial deposits.

The age of the surface is late Holocene. Elevation ranges from sea level to 50 m. Slopes are 0 to 3 percent. The principal soils on this surface are the Pilchuck soils, which are very deep, somewhat excessively drained, and composed of unweathered sand. Pilchuck soils have no

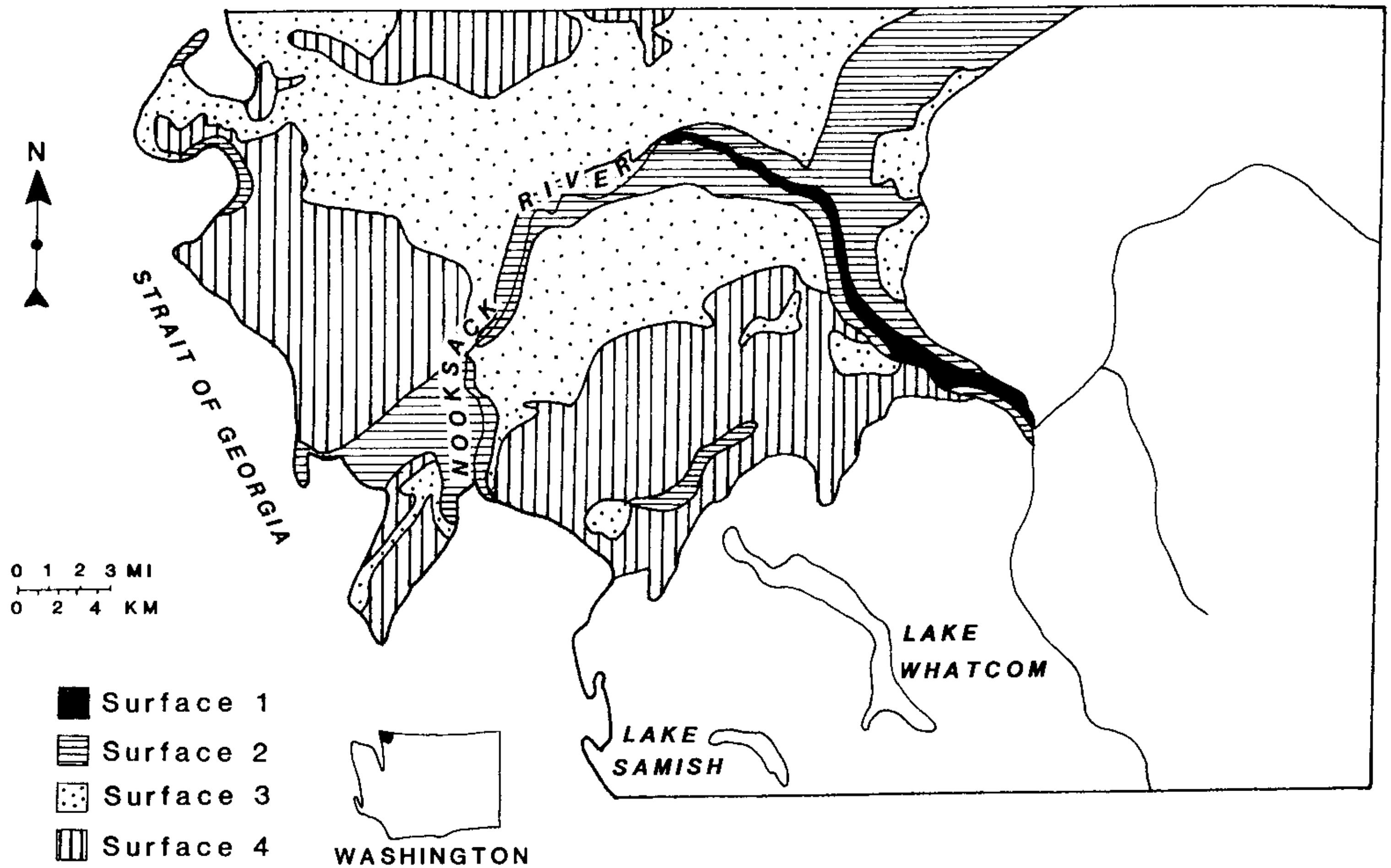

Figure 1. Map of the geomorphic surfaces in northwestern Whatcom County, Washington.

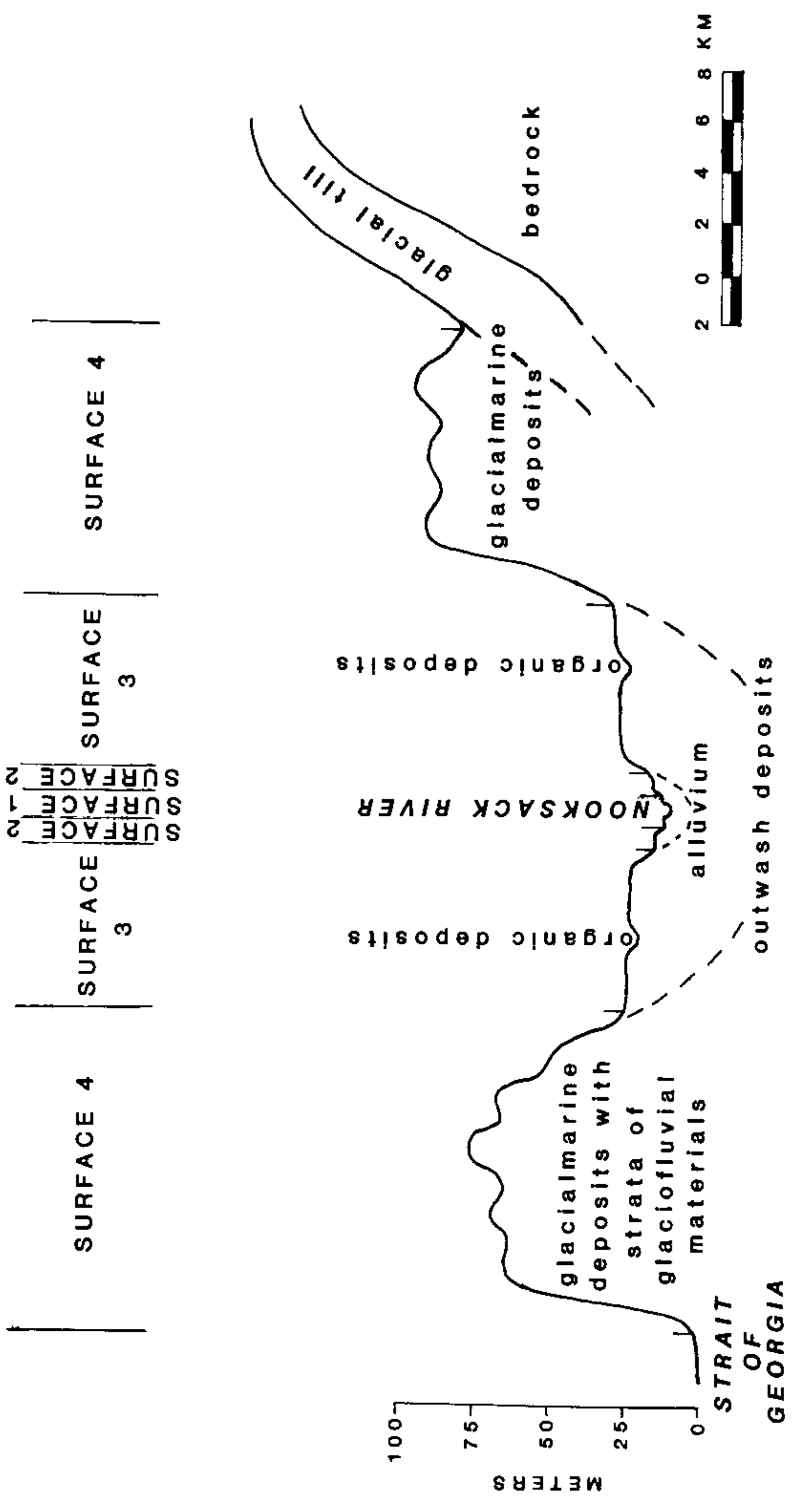

Figure 2. Idealized topographic profile and geomorphic surfaces in northwestern Whatcom County, Washington.

diagnostic features other than an ochric epipedon (Soil Survey Staff 1975) and are Dystric Xeropsamments (Soil Survey Staff 1984). Riverwash is also a major component of this surface.

Surface 2 This surface is the higher of the two flood plains and includes the levees, the valley flat, and the modern delta of the Nooksack River. The deposits generally are stratified sand, silt, and clay. The alluvium is derived from a variety of rocks, but is dominated by andesite and metasedimentary materials (Easterbrook 1971). Alluvial fans and coastal beach deposits are included in this surface. Some organic deposits occur in former quiet backwater areas. Elevation ranges from sea level to 60 m. Slope is dominantly 0 to 2 percent but is as steep as 8 percent on alluvial fans.

Deposition started on this surface after the Sumas Stade of the Fraser Glaciation about 10,000 years B.P. No properties associated with volcanic ash are evident in the soils. Since the ash in western Whatcom County originates from Mount Mazama (Easterbrook 1971, Lidstrom 1972), the lack of Mazama ash within this surface indicates that it is younger than 6,600 years. This surface is probably middle to late Holocene.

Soils of this surface have few prominent morphological features; they are differentiated mainly by the texture of the parent material. Most have a fluctuating water table, as indicated by the mottling in the underlying material within a depth of 0.5 m.

The soils of the levees are very deep, nearly level, and have a mollic epipedon. They are the well drained Puyallup and the moderately well drained Mt. Vernon soils, which are Fluventic and Fluvaquentic Haploxerolls, respectively.

The soils of the delta are very deep, very poorly drained, and contain sulfidic materials. The principal soils are the Eliza and Tacoma soils (Sulfic Fluvaquents), which are subject to salt intrusion as a result of their proximity to the sea.

The soils of the valley flat are very deep and poorly drained Aeric Fluvaquents, represented by the Briscot and Oridia series. These soils and those on the delta have no diagnostic horizon other than an ochric epipedon.

Surface 3 This surface is dominantly outwash terraces, but also includes proglacial lacustrine terraces. The outwash terraces consist of sand with various amounts of gravel. Depressions in the outwash terraces, both channels and kettles, commonly contain organic deposits. Lake beds and low-relief, abandoned channels filled with organic materials are typical of surfaces of this age in western Oregon (Parsons *et al.* 1970) and southcentral Washington (Goldin and Parsons 1983), although these latter surfaces are not developed in glacial materials. The glaciolacustrine deposits consist of silt and clay, which are distinctly varved in some areas. A thin layer of aeolian materials, which include volcanic ash, mantles this surface (Armstrong 1981).

Surface 3 is the oldest surface related to the present drainage system. The ancient drainage pattern parallels that of the modern flood plain indicating that the Nooksack River is a remnant of the preexisting glacial drainage system. The competence of the proglacial streams was greater than that of the modern Nooksack River and the valley was broader. This is indicated by the deposits, which are coarser and more extensive than the modern alluvial materials. The texture of the soils reflects this difference.

The highly competent glacial streams deposited materials high in rock fragment content, in which the Kickerville, Barnhardt, and Clipper soils formed. Slower moving waters deposited stratified sands and some silts low in rock fragment content; these sediments were later reworked by wind. The Lynnwood, Lynden, Laxton, Tromp, Hale, Edmonds, and Woodlyn soils formed in these deposits. The admixture of silty aeolian deposits and organic matter into these soils has markedly increased their fertility (Goldin 1983). Elevation ranges from 15 to 100 m, and slopes range from 0 to 15 percent.

Carbon 14 dates obtained from the base of the organic deposits range from 9,920 ± 760 to 9,300 ± 250 years B.P. (Easterbrook 1971, Armstrong 1981). The outwash and glaciolacustrine deposits are slightly older than these dates, and the surface is slightly younger, corresponding to late Pleistocene. Deposition occurred during the Sumas Stade of the Fraser Glaciation. The organic soils commonly contain strata of volcanic ash (Rigg 1958) from the eruption of Mount Mazama as do similar aged soils reported from other areas of the Pacific Northwest (Balster and Parsons 1968, Goldin and Parsons 1983).

The soils of the outwash terraces are very deep to shallow, somewhat excessively drained to poorly drained, and nearly level to gently sloping. The lower part of the profile is sandy and contains 0 to 60 percent coarse fragments. The upper part of the profile of most of these soils formed in aeolian deposits that include volcanic ash. Each of the soils on this surface has a spodic horizon. The principal soils are the well drained Lynden and Kickerville soils, which are Typic Haplorthods, and the moderately well drained Tromp and somewhat poorly drained Hale soils, which are both Aquic Haplorthods. The poorly drained Edmonds and Woodlyn soils are Typic Sideraquods. A continuous hardpan (ortstein layer) strongly cemented with iron has developed within a depth of 0.5 m in Woodlyn soils. This layer, which formed from the deposition of iron at the water table, is fragmented in the Edmonds soils.

Upon glacial recession, meltwater flow decreased. Abandoned outwash channels and, to a lesser extent, kettles and other depressions in the flood plains supported wetland plants, such as rushes, sedges, and some woody plants in the stagnant water (Rigg 1958). When the plant material died, it accumulated and became the parent material for the very deep, very poorly drained, nearly level Pangborn (Typic Medisaprists), Shalcar, and Fishtrap soils (Terric Medisaprists).

The soils of the glaciolacustrine terraces are very deep, somewhat poorly drained and poorly drained, and nearly level to gently sloping on ridge-swale topography. Skipopa soils (Aqualfic Haplorthods) on the ridges have a silty aeolian mantle over a clayey substratum. They have a spodic horizon and an argillic horizon. Bellingham soils (Typic Argiaquolls) in the swales have a mollic epipedon and an argillic horizon and are clayey throughout the control section.

Surface 4 This surface consists of glacialmarine deposits with an aeolian mantle that includes volcanic ash (Pevear *et al.* 1984). The rolling topography reflects the deposition from melting ice of debris that ranges in size from clay to boulders. In the western part of the survey area, poorly sorted glaciofluvial materials up to 60 cm thick lie between the aeolian mantle and the glacialmarine deposits. Elevation ranges from 20 to 120 m, and slopes range from 0 to 60 percent.

The age of this surface has been determined from the dating of fossil shells in the glacialmarine deposits. Dates range from 12,090 ± 350 to 10,370 ± 300 years B.P. (Easterbrook 1971, Armstrong 1981). The material was deposited in the late Pleistocene during the Everson Interstade of the Fraser Glaciation prior to the inception of the Sumas Stade. Dates from marine terraces and peat bogs overlying these deposits show that the area was rapidly uplifted isostatically during this time (Easterbrook 1963).

On glacialmarine drift plains not overlaid by the glaciofluvial materials, the soils are very deep, moderately well drained and poorly drained, and nearly level to steep. The Whatcom soils (Aqualfic Haplorthods) have a spodic horizon and an argillic horizon and occupy the higher and steeper parts of the landscape. The Labounty soils (Typic Umbraqualfs) have an umbric epipedon and an argillic horizon and occupy the lower parts.

The soils with interbedded glaciofluvial deposits are very deep, moderately well drained and poorly drained, and nearly level to gently sloping. The Birchbay (Typic Haplorthods) and Whitehorn soils (Typic Umbraqualfs) are similar in morphology and landscape position to the Whatcom and Labounty soils, respectively, but have coarser textures in the upper part of the substratum.

Although clay films in the Whatcom, Labounty, Skipopa, Bellingham, and Whitehorn soils are uncommon, micromorphological evidence in the form of argillans indicates the development of an argillic horizon. The classification of the spodic horizon on surfaces 3 and 4 is based on the discovery by USDA's National Soil Survey Laboratory of silt-sized pellets and some cracked coatings in the B horizon. The soils do not meet the chemical criteria for a spodic horizon.

Summary

The soils of northwestern Whatcom County, Washington show increasing development on each successively older geomorphic surface. The diagnostic horizons requiring the most time to form (argillic horizon and spodic horizon) are on the oldest surfaces (surfaces 3 and 4). The horizon requiring the least time to form (ochric epipedon) is on the youngest surface. The argillic horizon has formed only on the finer textured soils on these surfaces. The horizon requiring intermediate time (mollic epipedon) is on the middle surface (surface 2).

All soils within a geomorphic surface need not exhibit the same degree of profile development since they vary in landscape position or parent material. Examples are the outwash and glaciolacustrine soils on surface 3 and the levee and valley flat soils on surface 2. Geomorphic mapping at a larger scale would help to make these separations. Soil-geomorphic surface relationships also help to estimate the time for the development of a horizon, although it should be understood that other factors besides time are responsible for horizon formation. In this study, the spodic horizon forms in about 9,300 to 9,900 years and the argillic horizon in about 10,000 to 12,000 years.

Acknowledgements

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