

KING MOUNTAIN GEOLOGY AND SOILS

Geologic Setting

King Mountain is located in what is commonly referred to as the Fraser-Whatcom Lowlands (Cox and Kahle, 1999). The Fraser-Whatcom Lowlands are located within the transborder region of the United States and Canada. The Lowlands are bounded by the Coast Mountains in British Columbia, the Cascade Mountains, and the Strait of Georgia (Cox and Kahle, 1999). The topography of the Lowlands consists mainly of gently rolling uplands separated by wide relatively flat-bottomed valleys.

The Fraser-Whatcom Lowlands represent the landward extension of a geologic depression referred to as the Georgia Basin (Cox and Kahle, 1999). The Georgia Basin developed in response to tectonic activity beginning in late Mesozoic time (England, 1991). The tectonic activity resulted in the creation of mountain ranges (Cascades and Coast Ranges) and basins (Georgia Basin). Large volumes of sediments, derived from the erosion of the nearby mountain ranges, were deposited into the basins. Much of these sediments have undergone consolidation and lithification, forming the Eocene-age Chuckanut and Huntington Formations (Daly, 1912; McLellan, 1927) which comprise the bedrock that underlies the King Mountain area.

More recent Pleistocene glacial events eroded and modified the bedrock surface forming hills, like King Mountain, and valleys. Each glacial event was accompanied by isostatic adjustments of the land surface as a result of glacial advance and retreat. These isostatic adjustments combined with eustatic changes in sea level resulted in greater than 650 feet of vertical fluctuations in the position of the shoreline (Armstrong, et al., 1965). Consequently, much of the Lowlands were repeatedly invaded by the sea during the Quaternary period resulting in the deposition of marine, glaciomarine and deltaic sediments in complex association with glacial, glaciofluvial and ice-contact sediments (Clague and Luternaur, 1982).

King Mountain is essentially a small knob of Tertiary-age Chuckanut Formation bedrock that is partially covered by a thin layer of Everson-age glaciomarine drift. The bedrock stratigraphy of the Chuckanut Formation has been described in detail by Samuel Y. Johnson (1984, 1991). Johnson indicated that the Chuckanut Formation is comprised of alluvial strata and is one of the thickest (approximately 20,000 feet) nonmarine sequences in North America. The sediments of the Chuckanut Formation were deposited in an extensive fluvial environment of meandering/braided rivers and alluvial fans in a rapidly subsiding basin that was present in western Washington in early Tertiary time. The primary source of these sediments was uplifted metamorphic rocks located to the east of the basin. A secondary source was uplifted fault blocks located to the west of the basin (Johnson, 1984).

The Chuckanut Formation is generally comprised of arkosic sandstone, conglomerate, siltstone, mudstone, and some minor coal beds. Standard fission-track statistical methods and pollen analyses (Reiswig, 1982) were used to determine an approximate age range for the Chuckanut Formation of late Paleocene to late/middle Eocene (40 to 60 million years before present). The Chuckanut Formation has been divided into seven distinct members (Bellingham Bay, Governors Point, Padden, Slide, Maple Falls, Warnick and Bald Mountain) by Johnson (1984). Only the

Padden member appears to be present beneath the King Mountain. The Padden member is approximately 6,000 feet thick and consists of arkosic sandstone, mudstone and metagraywacke-rich conglomerate that was deposited in a braided-river environment (Johnson, 1984, 1991). Paleocurrent data indicates that sediment transport in this unit was to the southeast and southwest.

Following deposition, the Chuckanut Formation was deformed into a series of northwest plunging anticlines and synclines in the middle to late Eocene (Johnson, 1991). The attitude and orientation of this complex fold system have been mapped in Whatcom County by Easterbrook (1976) and Lapen (2000). Based on the limited information presented in the Easterbrook and Lapen studies, it appears that bedding in the Padden Member of the Chuckanut Formation exposed on King Mountain is striking in a northwest-southeast orientation and dipping to the northeast at an angle of roughly 50 degrees.

The Chuckanut Formation is locally overlain by several feet of Quaternary sediments that were deposited during several glacial and nonglacial intervals that occurred repeatedly during the past 2.4 million years in the low-lying region between the Cascade and Olympic mountains. During glacial periods, the southwestern margin of the Cordilleran ice sheet flowed southeastward from British Columbia into the Puget Lowland of western Washington (Blunt et al., 1987). Sediments from the most recent advancement of the Cordilleran ice sheet (Fraser Glaciation) are widely exposed at the surface in western Whatcom/Skagit Counties and in the Puget Lowland.

The Fraser Glaciation consisted of multiple stades (episodes of glacial advance) and interstades (episodes of glacial retreat). The near surface sediments located in Whatcom County are dominated by deposits of the: 1) Vashon stade, which represented the maximum advance of the Cordilleran Ice Sheet during the Fraser glaciation; 2) the Everson interstade, a period of glacial retreat; and 3) the younger Sumas stade, a minor period of glacial advance. Initial climatic cooling and growth of ice masses in British Columbia began as early as 30,000 years before present (ybp), but the ice maximum during the Vashon stade did not occur until approximately 14,000 to 15,000 ybp. At the maximum Vashon stade extent, the Puget lobe of the Cordilleran Ice Sheet extended a few miles south of Olympia, Washington. The ice is interpreted to have reached a thickness of about 4,000 to 5,000 feet near Bellingham, Washington.

During late stages of deglaciation (12,500 to 10,000 ybp) the Cordilleran Iced Sheet thinned and retreated northward (Kovanen and Easterbrook, 2002). This period of ablation of the ice sheet is termed the Everson interstade (Armstrong et al., 1965). The retreat of the Cordilleran Ice Sheet rapidly increased when the ice sheet vacated the Strait of Juan de Fuca around approximately 12,500 ybp and marine waters entered the Puget Lowland (Easterbrook, 1963, 1992). Shortly after the removal of the ice sheet from the Strait of Juan de Fuca, much of the retreating glacial ice in western Whatcom Counties floated on the influx of marine waters. As the floating ice retreated it deposited a thick layer of glaciomarine sediments (Everson interstade sediments) including glaciomarine drift which overlies the Chuckanut Formation on most of King Mountain. The glaciomarine deposits generally consist of poorly sorted/compacted silty sand gravelly clay, clayey gravel diamicton and moderately sorted sandy silt and clay (Dragovich, et. al, 1998).

Surface Soils

Physical and chemical weathering of surficial glacial deposits and bedrock has resulted in the formation of the surface soils on the project site. Surface soils data were obtained from the U.S. Department of Agriculture NRCS soil survey of Whatcom County. The five factors typically used to define the type, characteristics, and formation of specific soils are: 1) parent material; 2) climate; 3) topography; 4) organisms (biota); and 5) time. The soils on King Mountain formed over young glacial deposits and/or bedrock, and have not had sufficient time to develop the deep weathering profiles present in soils in unglaciated terrains. Instead, they exhibit a direct relationship to the underlying parent material, local climate, topography, and vegetation. The soil characteristics for the on-site soils are summarized in Table 1 below.

Table 1
Summary of NRCS Soils Types

Soil Name	USDA Textural Classification	Percent Slope	Runoff Rate	Erosion Hazard
Nati Loam (108)	Loam	5 to 15	Slow	Slight
Nati Loam (109)	Loam	15 to 30	Slow	Slight
Nati Loam (110)	Loam	30 to 60	Medium	Moderate
Whatcom Silt Loam (179)	Silt Loam	3 to 8	Slow	Slight
Whatcom Silt Loam (180)	Silt Loam	8 to 15	Medium	Moderate

Notes:

USDA = U.S. Department of Agriculture

The Nati Loam is composed of moderately deep, well drained soil that generally forms on foothill backslopes and toe slopes. It generally forms on colluvium and slope alluvium with a mixture of volcanic ash and glacial drift, with the colluvium being derived from Chuckanut Formation sandstone, siltstone, and mudstone, and having a strongly consolidated substratum. The Nati soil is characterized by dark-brown to yellowish-brown loam developed over a substratum of Chuckanut Formation sediments and/or glacial drift. Permeability in the Nati Loam is moderately rapid in the surface layer and subsoil, becoming very slow to nil in the underlying glacial drift and/or Chuckanut Formation, where ground water has a tendency to perch and form an interflow ground water regime during winter months. Runoff is slow to medium, and the erosion hazard is slight to moderate.

The Whatcom Silt Loam is composed of moderately deep, well drained soil that generally forms on glaciomarine drift plains. It generally forms in a mixture of loess and volcanic ash over glaciomarine sediments. The soil is characterized by dark-brown to mottled loam developed over a substratum of Chuckanut Formation sediments and/or glacial drift. Permeability in the Whatcom Silt Loam is moderately rapid in the surface layer and subsoil, becoming very slow to nil in the underlying glaciomarine drift, where ground water has a tendency to perch and form an interflow ground water regime during winter months. Runoff is slow to medium, and the erosion hazard is slight to moderate.

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