

Modern Sediments in Lowlands

Most of the Fraser Valley is flat, floor-level land below 15 m elevation (mainly the floodplains of the Fraser River and its tributaries). This is a uniform to loose, water-saturated sediment that is less than 10,000 years old (to Holocene age). Fraser River floodplain sediments consist mainly of gravel and sand from fluvio-lacustrine, sand and silt from glacial till, and silt and clay from glacial till and silt. Poorly drained areas of floodplains are irrigated by peat, and landfills have locally extended shorelines. Floodplains contain rich agricultural soils, but are generally poorly drained due to the flat terrain and shallow water table. Although silt and clay are present, some lowlands are areas of rapid urban growth (Richmond). Most communities of floodplains are protected by dykes from all but the largest floods.

Landfill

Landfills are natural deposits of human waste. Fill materials have been dumped in shallow waters and on flood flats and other wetlands to extend the area of useable land. Recent recognition of the ecological importance of areas destroyed by this practice has led to limitations on placements of fill. Landfills in the Vancouver area is found mainly along shorelines, both marine (False Creek and Burrard Inlet) and river (Aurora Island). It is heterogeneous and includes sand and gravel, till, and/or crushed rock. Landfills also include waste materials disposed of in municipal dumps (Burns Bog in Delta, Port Mann landfill); these dumps can contribute leachate to local surface and groundwaters and therefore require containment systems. Poorly designed and compacted landfills can be problematic for foundations, and could liquefy and settle during a strong earthquake.

Peat

Peat is highly decomposed plant material found below bogs, swamps, and marshes. Peat up to 5 m thick covers much of the Fraser delta east of Highway 99 and the Nicomac-Serpentine lowland. It also occurs locally on the Fraser River floodplain between New Westminster and Mission, at the base of some scarp escarpments, at mountain fronts, and within poorly drained depressions in upland areas. Several bogs (e.g. Pitt Meadows bog, Burns Bog) have been mined for sphagnum peat moss, and the peatlands on the Fraser delta are important producers of burlberries and cederberries. Because of their high compressibility, peats are generally poor foundation materials. Recognition of the ecological importance of bogs has led to increased efforts to protect them from development.

Silt and clay

Silt, clay, and loam (finest silt, silt, and sand) are common on the Fraser River floodplain below Mission, the Pitt River floodplain (Pitt River), the Fraser delta, and the Nicomac-Serpentine flats. These sediments were deposited over thousands of years by seasonal floodwaters that spread across these lowlands. Silt and clay beneath the Nicomac-Serpentine flats are ancient marine deposits. They were formed by the slow settling of the fine-borne sediments and silt and clay from the Fraser River estuary. These sediments have a high bearing capacity, but are generally not prone to liquefaction. They are important agricultural soils, although poor drainage can be a problem.

Sand and silt

Interfused sand, silt, and loam underlie parts of Sumas Prairie, the Fraser River floodplain downstream of Mission, and the Fraser delta. Similar sediments also occur along some small streams. The sand and silt unit, the stratified silt and clay, was deposited during floods. Construction of dykes has greatly reduced such flooding and interrupted the natural deposition of these materials. Sand and silt are important structural soils and are important shallow groundwater reservoirs (aquifers). Sand-rich deposits have moderate to high bearing capacity and are good foundation materials, but could liquefy during a strong earthquake.

Gravel and sand

Deposits of gravel and sand occur along steep-gradient streams in mountain valleys (Chilliwack Valley), on alluvial fans and marine deltas at valley mouths (Capilano and Seymour rivers, North Vancouver), and on islands and peninsulas of the Fraser River estuary (e.g. False River, Fraser Delta). Gravel and sand also occur as beach deposits (Jericho, White Rock) and debris cones and fans at the base of mountain slopes. Most are mapped as gravel and sand and are at risk of flooding and have a moderate to high liquefaction potential. Gravel and sand deposits are generally (they transmit water), and are thus important shallow aquifers. They are also potential sources of aggregate, but shallow water tables limit their use for this purpose.

Ice Age Sediments in Uplands

Ice Age sediments deposited during the Pleistocene Epoch (2 million to 11,000 years ago) underlie gently rolling uplands (15 to 200 m elevation) of the Fraser Valley. Most Ice Age sediments in the Vancouver area date to the last glaciation, about 20,000 to 11,000 years ago, and in particular to the period of glacial retreat when areas below 200 m elevation were covered by the sea. These sediments include till deposited directly by glaciers, sand and gravel covered by streams flowing off the melting ice (bedrock), varved clay and silt, and beach deposits. Most cities and towns in this region were built on the uplands to avoid the flood and drainage problems of lowland areas. Upland sediments are good foundation materials and are generally not susceptible to liquefaction. Sites developed on sand and gravel are well drained, whereas those developed on silt, clay, and coarse till deposits are poorly drained. Floodings

Silt and clay

Thick silt and clay of marine origin are the most widespread surface sediments in the Surrey, White Rock, and Langley-Aldergrove uplands. This silt includes massive and bedded sediments with variable bearing capacities, depending partly on whether or not they were overlain and loaded by glaciers. In general, deposits east of Aldergrove have been loaded by ice and thus have higher bearing strengths. Water infiltration is poor because the sediments are fine grained, this can result in poor surface drainage (the land is flat). Silt and clay deposits on steep slopes (>20%) are prone to landsliding. Silt and clay deposits exposed during construction activities erode easily and can be a major source of stream siltation.

Sand

Scattered sand deposits up to 5 m thick occur on the Vancouver, Tweasdale, White Rock, and Surrey uplands; they are absent from uplands east of Langley. The sands are beach deposits that formed when uplands emerged from the sea at the end of the last glaciation. They have good bearing strength, but are generally poor foundation materials. Water passes through sands with ease, thus soils developed on these materials are well drained.

Gravel and sand

Deposits of gravel and sand up to 40 m thick are widespread on uplands between Langley and Abbotsford, and north of the Fraser River between Pitt Meadows and Mission. Important deposits also occur on the Burnaby, Jericho, and the Capilano, Seymour, and Coquitlam rivers, and in the Coquitlam Valley south of Cultural Lake. Gravel and sand have high bearing capacity and excellent drainage. Till gravel and sand deposits are important sources of aggregate, there are numerous gravel pits south and east of Aldergrove, and south of Langley (gravel and sand are also important aquifers (the Abbotsford and Burnaby aquifers). Shallow aquifers are vulnerable to contamination from agricultural and residential activities.

Till

Till is a heterogeneous glacial deposit consisting of clay, silt, sand, and stones ranging from pebbles to boulder size. Till up to 25 m thick is the dominant surface and near-surface material over much of the Vancouver upland, where it is overlain by patchy marine silt and sand. Farther east, till is an important, but less extensive surface material; it is buried by thick silt and clay in the Surrey and Aldergrove areas. The lower slopes of the Coast Mountains are mantled by to several metres of till. Some tills are compact and concrete-like, whereas others are sandy and loose. Till commonly has a high bearing capacity and thus is an excellent foundation material. Compact till is nearly impervious to good drainage; the surface must slope. Silt and clay-bearing the discarded during construction activities can be a major source of stream siltation.

Steep land sediments

Steep escarpments occur locally at the borders of uplands. Escarpments expose Ice Age sediments that, depending on the upland, are covered above. These steeply exposed include clay, silt, sand, gravel, and till. The bases of some escarpments are being actively eroded by ocean waves (Clawson, White Rock, Point Grey) or streams (Chilliwack, Capilano, Seymour, and Coquitlam rivers), making them vulnerable to landsliding. Many residential areas extend to the edges and bases of escarpments; even small slides in these localities can damage or destroy houses, roads, and other structures.

Bedrock in Mountains

Solid bedrock forms the Coast and Cascade Mountains, as well as smaller mountains that protrude through the floodplains in the Fraser Valley (Burnaby Mountain, Grant Hill, Sumas Mountain, Chilliwack Mountain). Bedrock is commonly mantled by several metres of till, sandy gravel, or rock fragments, less than 10% of the mountain area actually exposed rock. Bedrock in this region can be grouped into three main units as described below. Landslides occur where weak rocks are exposed on steep slopes. Rock weaknesses can stem from the presence of faults, fractures, sedimentary layers, or platy mineral layers (bedding) that dip into the direction of the slope. Thin sedimentary or highly velocity bedrock can slide into stream channels during rainstorms, triggering flows of sediment, water, and plant debris (debris flows) that move downstream at high velocity.

Volcanic rock

Dark, fine grained volcanic rocks, chiefly basalt and andesite, are exposed at the northern edge of the Fraser Valley. These rocks formed as lava, shallow intrusions, and volcanic ash deposits. Most volcanic rocks are resistant to erosion and form prominent hills in the Fraser Valley (Sentinel Hill, Queen Elizabeth Park, Grant Hill). Many volcanic rocks 25-17 million years old occur as thick tabular sills, parallel to the strike of the rocks along which they were injected (Grant Hill) and as smaller subvertical dykes that cut across rock lying Prospect Point, Stanley Park. Much older (145 million years) volcanic rocks are exposed on Sumas Mountain and near the confluence of the Harrison and Fraser rivers.

Sandstone

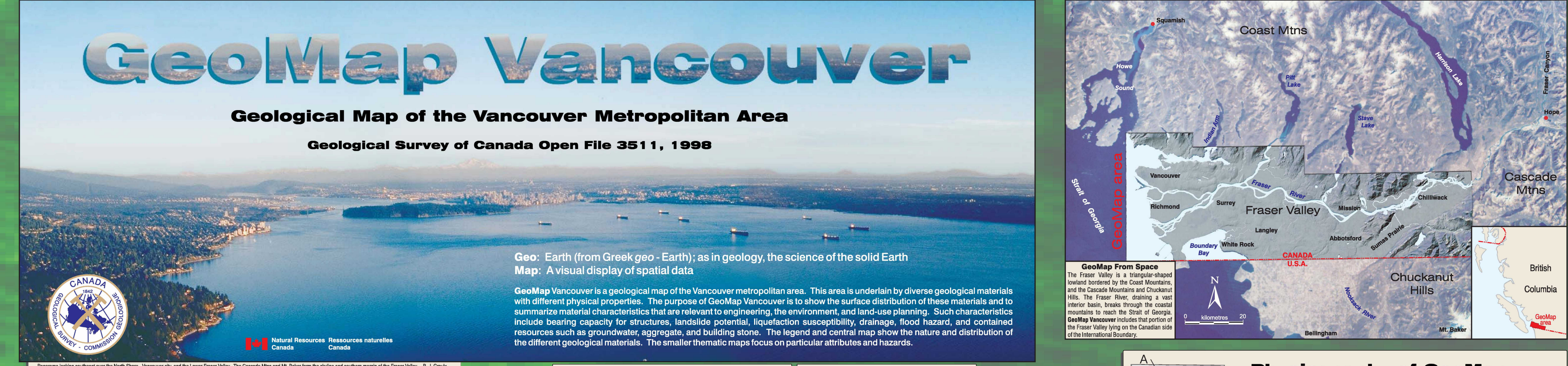
Quartzite, calcareous, and conglomerate (85-57 million years old) occur as scattered outcrops in Vancouver, Burnaby, and on the North Shore (Stanley Park, Kitsilano, Burnaby Mountain, Capilano River). These rocks also occur along much of the Fraser River valley. Sandstone is resistant to erosion and forms prominent hills in the south from ridges with steep north-facing flanks and gentler south-facing slopes (Burnaby Mountain, Stanley Park). Ridges are separated by valleys eroded into softer tillstone (East Harrison, Burnard Inlet). These rocks are weakly cemented and can be eroded and transported by streams. Sandstone is a common source material for deep buried sandstones potential natural gas reservoirs.

Granitic rock

Granitic rocks are a family of medium- to coarse-grained igneous rocks (granite, gneiss, quartz diorite, diorite). They consist of interlocking light-colored grains of feldspar and quartz, and dark-colored biotite and hornblende, which give the rock a distinctive salt-and-pepper texture. Granitic rocks in the map area range from 165 to 95 million years old. Where not extensively fractured and faulted, granitic rock is resistant to erosion and can form steep mountain slopes. Granitic rock is locally quarried for use as building stone and crushed rock (Pitt River).

Foliated sedimentary and volcanic rock

Metamorphosed sedimentary and volcanic rocks occur widely in the Cascade Mountains, and also form hills in the eastern Fraser Valley (Chilliwack Mountains). These rocks are characterized by a planar fabric (bedding) formed during burial, deformation, and metamorphism of the rocks. This fabric reduces rock strength, causing some rock types to weather into thin platy layers. Bedrock exposed on Vender Mountain and east of Cultural Lake is made of highly eroded, dark argillite, and local phyllite, gneiss, limestone, and sheet. Volcanic rocks with interlayers of limestone, argillite, and sandstone is exposed on mountain slopes in the upper Chilliwack River basin.



Geological Map of the Vancouver Metropolitan Area

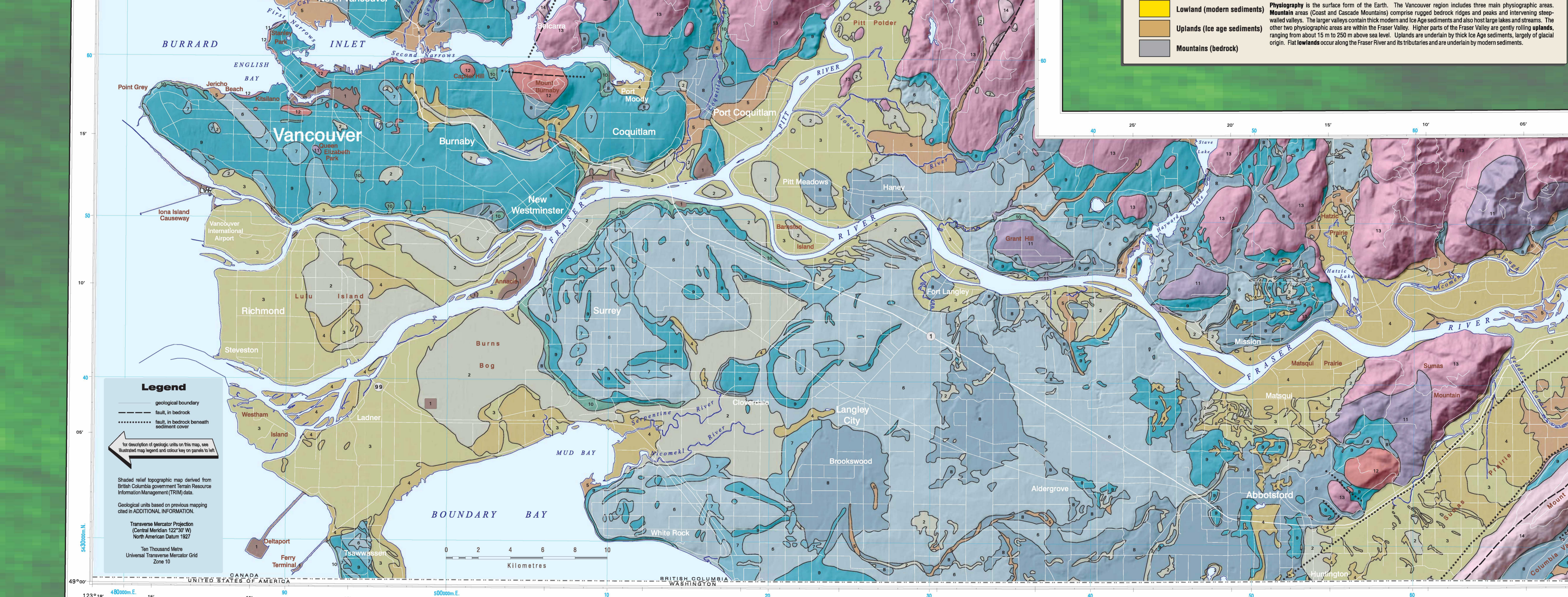
Geological Survey of Canada Open File 3511, 1998

Geo: Earth (from Greek geo - Earth); as in geology, the science of the solid Earth
Map: A visual display of spatial data

GeoMap Vancouver is a geological map of the Vancouver metropolitan area. This area is underlain by diverse geological materials with different physical properties. The purpose of GeoMap Vancouver is to show the surface distribution of these materials and to summarize material characteristics that are relevant to engineering, the environment, and land-use planning. Such characteristics include bearing capacity for structures, landslide potential, liquefaction susceptibility, drainage, flood hazard, and contained resources such as groundwater, aggregate, and building stone. The legend and control map show the nature and distribution of the different geological materials. The smaller thematic maps focus on particular attributes and hazards.

GeoMap From Space
The Fraser Valley is a triangular-shaped lowland bordered by the Coast Mountains, and the Cascade Mountains and Chuckanut Hills. The Fraser River, draining a vast interior basin, breaks through the coastal mountains to reach the Strait of Georgia. GeoMap Vancouver includes the full portion of the Fraser Valley lying on the Canadian side of the International Boundary.

GeoMap Vancouver is available from:
Geological Survey of Canada
Sales and Publications
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Vancouver, B.C.
V8B 5J3
Tel: (604) 696-0271 Fax: (604) 696-1337
email address: gpcvancouver@gsc.nrcan.gc.ca
website: www.nrcan.gc.ca/gpcv

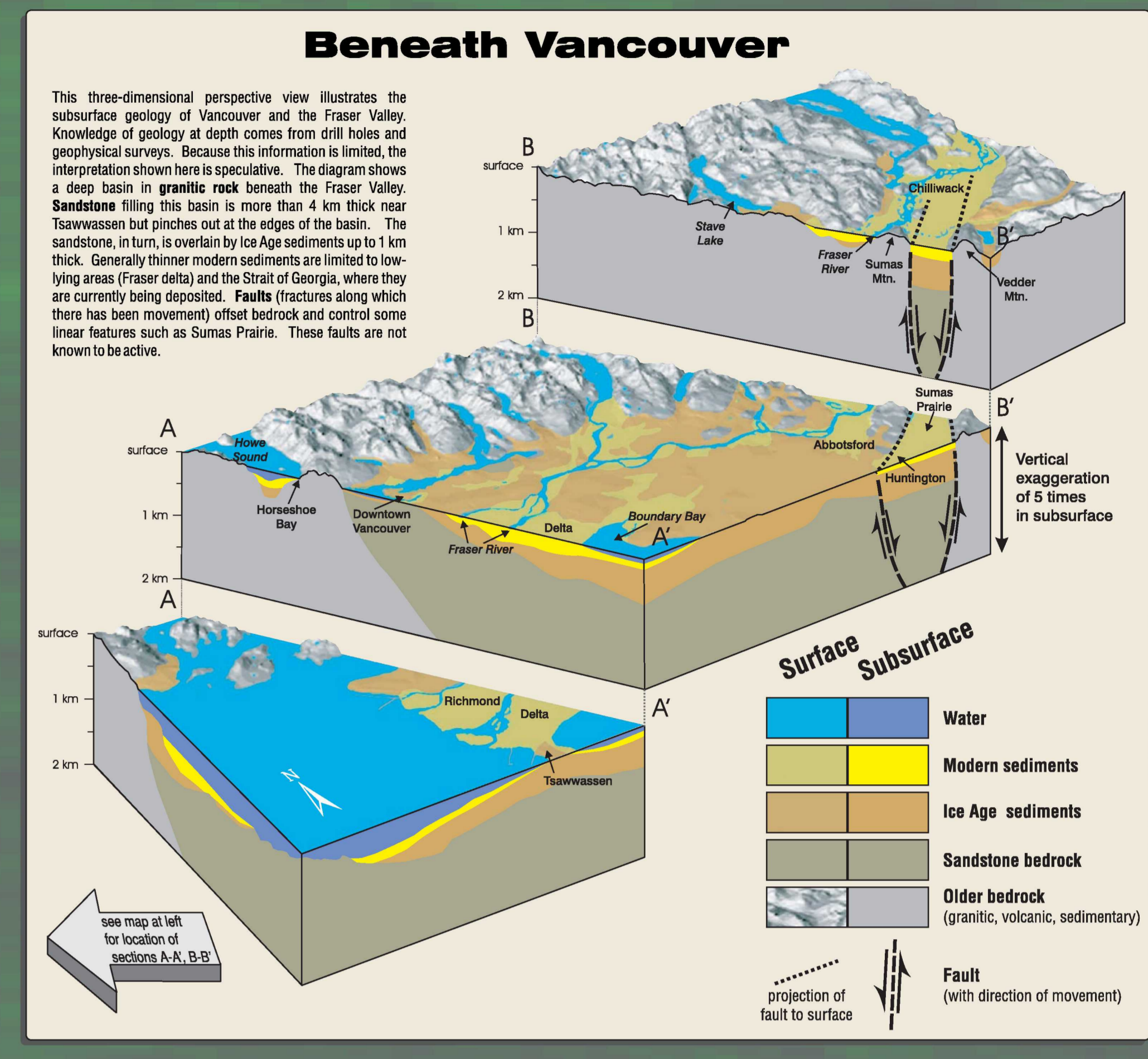


ADDITIONAL INFORMATION

This map is based on the following Geological Survey of Canada bedrock and surficial geology maps:

Arroyo, J.E. 1980. Surficial geology. Geological map of Canada, 1:50,000 scale. British Columbia, map 1064 (1984).
Burlingame, W.E. 1960. Surficial geology. Geological map of Canada, 1:50,000 scale. British Columbia, map 1070 (1970).
Arroyo, J.E. 1980. Surficial geology. Geological map of Canada, 1:50,000 scale. British Columbia, map 1064 (1984).
Burlingame, W.E. 1960. Surficial geology. Geological map of Canada, 1:50,000 scale. British Columbia, map 1070 (1970).
Arroyo, J.E. 1980. Surficial geology. Geological map of Canada, 1:50,000 scale. British Columbia, map 1064 (1984).
Burlingame, W.E. 1960. Surficial geology. Geological map of Canada, 1:50,000 scale. British Columbia, map 1070 (1970).
Arroyo, J.E. 1980. Surficial geology. Geological map of Canada, 1:50,000 scale. British Columbia, map 1064 (1984).
Burlingame, W.E. 1960. Surficial geology. Geological map of Canada, 1:50,000 scale. British Columbia, map 1070 (1970).

Other publications on geology, geological hazards, and groundwater of the Vancouver metropolitan area:
Arroyo, J.E. 1980. Environmental and engineering implications of the surficial geology of the Fraser Valley. Geological Survey of Canada Paper 80-2.
Chapin, J.A. 1995. Paleogeography and sediment basins, southwestern British Columbia. Geological Survey of Canada Bulletin 565.
Holmes, C.C. 1980. Ground water supply - Fraser Valley. British Columbia Environmental Canada, National Planning Commission Report No. 90-1.
Hogre, J.R. 1986. Geology of geological hazards of the Vancouver region, southwestern British Columbia. Geological Survey of Canada Bulletin 661.
Rieck, J.A. 1980. Geology of the Fraser Valley. Geological Survey of Canada Bulletin 661.
Turner, R.J., Chapin, J.A., and Clark, B.J. 1990. Geology of Vancouver - bring with our geological language. Geological Survey of Canada Paper 90-20.



Earthquake Ground Motion

Ground motion, the definitive characteristic of earthquakes, causes damage directly by vibration and indirectly through secondary effects such as landslides and liquefaction. Structural design in earthquake-prone areas such as southwestern British Columbia is based on anticipated peak horizontal ground acceleration and velocity values provided by the Geological Survey of Canada. These parameters are derived from statistical analysis of past earthquakes and require an understanding of the causes of earthquakes in various regions and estimates of ground motion-observation relationship. Following shaking increases with distance from an earthquake. This information is incorporated into the National Building Code of Canada in the form of seismic zoning maps.

The map on the left shows seismic zones in British Columbia. The zones are based on levels of peak horizontal acceleration with 10% probability of being exceeded over a 50-year period. This acceleration zoning map is contained in Section 5 of the National Building Code of Canada. A similar zoning map (not shown) in the National Building Code for peak seismic velocity is based on the frequency that can damage longer-structure (e.g. 10-story buildings). Engineers use this information to design earthquake-resistant structures. These maps represent the intensity of shaking on rock, local geology, and topography may amplify ground shaking and these parameters are not directly shaking or other frequencies. There is no map yet for Vancouver and the Fraser Valley showing areas of expected ground amplification or de-amplification. The map shown here does not include possible effects of rare, very large, subduction-type earthquakes west of Vancouver. Large, shaking produced by these earthquakes will be considered in the next generation of seismic zoning maps.

Earthquake Liquefaction

During an earthquake loose water-saturated silts and sands at shallow depth may lose their strength and transform into a fluid (liquefaction). Deeper sediments are more consolidated, have higher confining pressures, and consequently are less likely to liquefy. When sand beneath a layer of silt or clay liquefies, the capillary water may 'rise' laterally under the influence of gravity towards a slope, such as the bank of a nearby river channel, causing ground cracking. Foundations of highways, bridges, and buildings, as well as buried sewer and gas lines, can be damaged by such movements. Liquefaction can also trigger landslides on the flanks of the Fraser delta. The red zone shows areas of relatively loose, saturated lowland sediments (A lowlands). Liquefaction is likely to occur during a strong earthquake in these areas. In these parts of the red zone where there is shallow subsurface sand and coarse silt, for example the Fraser delta.

The map provides a general interpretation of liquefaction susceptibility during an earthquake and should be used for conceptual evaluation.

Flood Hazard

This map provides a general interpretation of hazard based on the distribution of modern flood deposits. Low-lying areas adjacent to rivers and the sea shore are colored red. These areas are underlain by modern flood and coastal sandstones. The red zone includes floodplains of the Fraser River and its tributaries, and gently sloping areas at the mouths of the Chilliwack, Coquitlam, Seymour, Capilano, and Fraser rivers. This zone also includes poorly drained areas in the Nicomac and Serpentine river valleys. Although most of these areas have been developed for agriculture and industry, they are still at risk from exceptionally large river floods. Low-lying shorelines exposed to waves and strong winds can also be flooded during exceptional storms (the white patch water hazard). Coastal flooding can occur at the foot of the Fraser delta when a storm or high tide coincides with a Fraser River flood. In both the red and grey zones on the map, small streams, which are not shown in this scale, can also overflow their banks. These relatively small floods are triggered by heavy rainstorms.

Slopes and Landslides

The slope of the land surface ranges from nearly horizontal on floodplains to more than 20° through much of the Coast and Cascade Mountains and on steeply sloping areas of the Fraser Valley. Why is slope important? First, it affects surface drainage - in a general sense, drainage improves as the land surface becomes steeper. Second, slope is an important factor in the stability of the land surface - most landslides in the Vancouver area occur on steep slopes. Some ground failure is also related to surface slope. Locations of many of the landslides that have occurred in this century in the Fraser Valley are plotted on this map (landslides in the Coast and Cascade Mountains are not included). Most landslides in the Fraser Valley involve Ice Age sediments and are triggered by intense rainstorms. In contrast, many of the landslides in the Coast and Cascade Mountains are in bedrock (metals and rock). A common type of landslide in both regions is a slide of loose water-saturated debris (debris flows).

Slope Angle
 < 10°
 10 - 20°
 > 20°
 landslide

Groundwater and Aquifers

Aquifers are bodies of sediment or rock that are saturated and sufficiently permeable to provide subsurface water to wells. Most groundwater in the Fraser Valley is derived from aquifers in modern and Ice Age sediments. These aquifers are a major source of high-quality water for drinking and other uses. The British Columbia Ministry of Environment, Lands and Parks has classified 77 aquifers in the Fraser Valley according to current levels of use and vulnerability to contamination. Almost two-thirds of the aquifers are shallow and can be easily contaminated by downward infiltration of waters used for agricultural fertilizers and pesticides, manure, septic effluent, gas and oil from leaking storage tanks. The most heavily utilized of these highly vulnerable aquifers occur in the Abbotsford and Langley/Burnabywood areas. Less developed, but highly vulnerable aquifers occur in sediments below the floodplain and delta of the Fraser River. Deeper aquifers overlie silt, clay, or till of low permeability are less vulnerable to contamination. In the Aldergrove area, others underlie the uplands of Burnaby, Surrey, and Langley, and the lowlands of the Nicomac and Serpentine rivers. Some groundwater is also stored from fractured bedrock, for example at Grant Hill, Mission, and Burnaby. The soil cover over these bedrock aquifers makes them highly vulnerable to contamination. Some aquifers, in both sediments and bedrock, have poor water quality as revealed by elevated levels of naturally occurring substances such as arsenic, iron, sodium, and fluoride.

Aquifers not assessed
 Aquifers in Bedrock
 Aquifers in Sediment

High vulnerability
 moderate to high vulnerability
 low to moderate vulnerability
 low vulnerability
 low to heavy use

Map based on R. Brown and W. Hill, 1984. A proposed aquifer classification system for groundwater management in British Columbia, British Columbia Ministry of Environment, Lands and Parks, Water Management Division (Vancouver, B.C., 1984).
 Locations of landslides from Arroyo and Hogre (1980) and Chapin (1995) using AGS/CIT/RC/NRCAN/CDC and SIA (Urban and J. Chapin, 1991).
 This bedrock map is a generalization of bedrock maps of British Columbia, British Columbia Ministry of Environment, Lands and Parks, Water Management Division (Vancouver, B.C., 1984).
 For more detailed information on flood hazard contact the responsible municipal or regional government or the B.C. Office of the Ministry of Environment, Lands and Parks, Water Management Division (Vancouver, B.C., 1984).