Stanley Park GeoTour

A collaboration between

MineralsEd

and the

Geological Survey of Canada

Led by

Bob Turner, Marianne Quat and Chris Loewen

MineralsEd

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MineralsEd |900-808 W. Hastings St. | Vancouver, BC | V6C 2X4 | Tel. (604) 682-5477 | Fax (604) 681-5305

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Burrard
Inlet
Prospect
Point
Lions
Gate
Bridge
N
rock
cliffs
5
6
7
4
8
Siwash
Rock
3
Park
Drive
Stanley
Park
2
Third
Beach
Stanley
Park
Causeway
Beaver
Lake
Ferguson
Point
parking
Teahouse
Restaurant
Lost
Lagoon
pool
0
500
metres
1
Second Beach
Seawall walk

Introduction

Welcome to the Stanley Park GeoTour!

Learning about our Earth, geological processes and features, and the relevance of it all to our lives is really best addressed outside of a classroom. Our entire province is *the* laboratory for geoscape studies. In the Lower Mainland, Vancouver's Stanley Park, is a readily accessible and safe destination to observe learn about Earth processes and the local geologic history.

This professional development field trip for teachers makes a clockwise circuit around Stanley Park along the seawall making stops at key features that are part of the geological story - demonstrating surface processes, recording rock – forming processes, revealing the tectonic history, and evidencing glaciation. The important interplay of these phenomena and later human activity is highlighted along the way.

This walking tour is foremost intended to show teachers how Stanley Park can be a great local field trip for your students who are learning about Earth Sciences in school, particularly Grade 5 and older. While using rocks and minerals as the theme, this field trip will also integrate local human history, transportation, reading maps, and will, therefore support curriculum more broadly. It will also introduce activities you might like to repeat when doing this field trip with your students.

The field trip stops are chosen to demonstrate the compositions, textures and internal structures that are key to interpreting how rocks form, and to build understanding of the rock cycle. Along the way, we hope to cover the following geoscience concepts and vocabulary:

ATTENTION!

AS THERE ARE IMPORTANT OUTCROPS IN THE INTERTIDAL ZONE, IT IS IMPORTANT TO PLAN THIS TRIP WHEN TIDE IS LOW! CHECK WITH FISHERIES & OCEANS CANADA:

HTTP://WWW.TIDES.GC.CA/

THE SEAWALL IS A POPULAR PLACE FOR WALKERS, SKATERS AND BIKE RIDERS. AS YOU EXPLORE THE ROCKS, PAY ATTENTION!

- Igneous: plutonic, volcanic, granite/granodiorite, basalt (columnar jointing)
- Sedimentary: sandstone (grain-size, cross-bedding), coal, marine and non-marine fossils, trace fossils, depositional environments, lithification
- Metamorphic: gneiss, contact metamorphism
- Weathering: chemical (oxidation), biological (marine organisms, roots), mechanical (water, ice)
- Southwest BC geologic setting, subduction zone, earthquakes, volcanoes, other natural hazards
- Mineral resources and products: sulphur, metal concentrates; sea wall, Lion's Gate Bridge

Acknowledgments

We are grateful to our Geological Survey of Canada partners, geologists Bob Turner and Marianne Quat, and to W.J. Mouat Secondary teacher Chris Loewen for guiding this geotour. The guide itself draws many descriptions from Bob Turner's soon to be completed *Geotour Vancouver - Where Mountain and Valley Meet River and Ocean*, included with permission herein in brown text, as well as J. E. Armstrong's *Vancouver Geology* (1990). Chris Loewen has also kindly provided a complete copy of his *Geology 12 Stanley Park Student Activity* included in the final 10 pages of this guide.

Sheila R. Stenzel, MineralsEd Director
MineralsEd (Minerals Resource Education Program of BC)
900-808 West Hastings St., Vancouver, BC V6C 2X4
604-682-5477
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GeoTour Vancouver

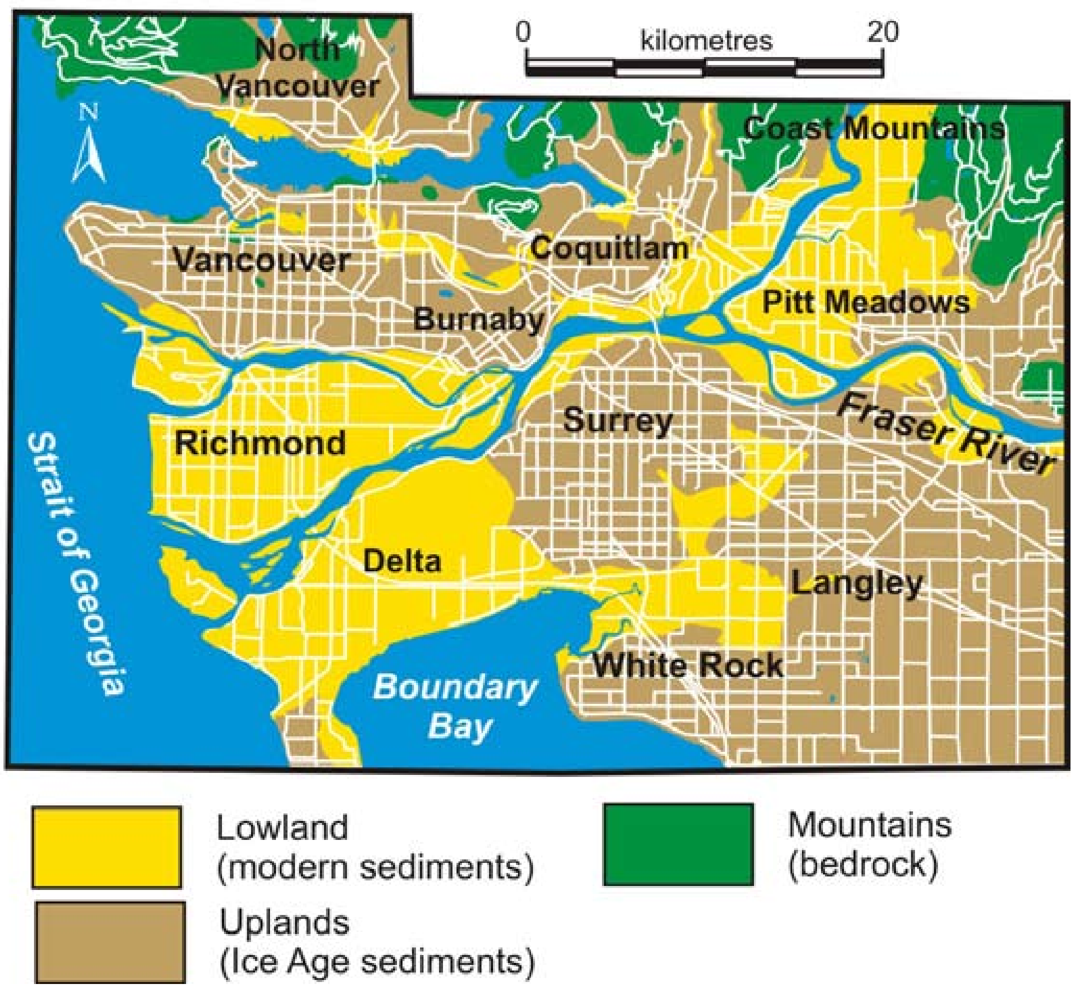
Vancouver metropolitan area, home to more than two million people, lies at a conjunction of geography– where Coast Mountains and Fraser Valley meet Fraser River and the Salish Sea. From early First Nations times to the present, the shores and coastal waters of this region have been the focus of settlement, commerce and life. Today Vancouver is Canada's western gateway and third largest metropolitan area.

Vancouver's shorelines are a focus of industry, commerce, and recreation. Some are modified by engineered structures, some remain natural. There are constructed shores along Vancouver harbour, False Creek, and parts of the Fraser Delta. But many remain in their natural state - beaches and rocky shores - and they are rich places to observe nature at work. Scour of waves and tide expose the geological foundations of the landscape. Geological materials – sand, mud, and gravel – are in motion here, and tell stories about wave, tide and river flow.

Rocky points, sand cliffs, or beaches – why do shorelines differ?

The Vancouver region is underlain by three major geological materials: bedrock, Ice Age sediments, and modern sediments. Each material produces a unique form of landscape. Slow erosion of bedrock produces rugged hills and mountains, while a thick blanket of Ice Age sediment forms rolling uplands. Since the Ice Age, sediment from flooding rivers has created broad lowlands across valleys or as shoreline deltas. Each of these three landscape types in turn are carved by ocean waves into distinctive shoreline types: rock shores are rugged and irregular; glacial sediments erode into sand cliffs and beaches; and shoreline lowlands have broad intertidal zones of sand, mud, or gravel.

STOP 1: SECOND BEACH



Second Beach is a favourite for summer swimmers and sun bathers, a great place to rest beside a jumbo log and gaze out over English Bay to see the moored ships. It's one of two, super sandy beaches, both on the west, English Bay side of Stanley Park.

Stanley Park.

Shoreline deserts

We live in a rainforest and here at the coast you are standing on a landscape more like a desert. Why is this so? Sand beaches are largely barren of life because they are often too dry, too unstable, energetic, too variable, and too saline for most life forms.

Where does all this sand come from?

Second Beach sand comes from the Fraser River and the eroding sand cliffs at Point Grey. Storm waves carry the sand eastwards, supplying Vancouver's beaches and offshore sand shoals all the way to Stanley Park. Eventually the sand is dispersed into the tidal flows of First Narrows and swept into deep water.

In recent years sand dredged from the Fraser River to maintain a deep-water shipping channel, jetties constructed at the river mouth to maintain the position of the shipping channel direct river sand into deep water, and the Point Grey cliffs have been armoured with rock to reduce erosion. These human activities have likely reduced the supply of sand to English Bay.

Sand - Eroded bits of southern BC

Pick up a handful of sand and take a close look. The sand is a mix of dark- and light-coloured grains of various colours – black, grey, white, pink, brown, and green. This sand represents eroded bits of rock, mineral grains and soil gathered by the Fraser River and its tributaries from a drainage area that covers one quarter of the area of British Columbia. Within a handful of the sand there may be grains of grey feldspar and white quartz from granite in the Coast Mountains, pink feldspar from Kamloops, black volcanic basalt grains from the Chilcotin, rusty orange quartz from copper deposits near Williams Lake, green metamorphosed volcanic rocks from Prince George, grey limestone from the Rockies, and even rare grains of jade from Lillooet or gold from Barkerville. The Fraser has brought a representative sample of much of southern BC to your feet.

Things to Investigate:

Discuss what processes are operating on the beach?

Dig a trench to see what kind of sedimentary structures are present.

Introduce the stratigraphic principle:"oldest at the bottom, youngest at top"

Look for evidence of creatures living on or in the beach sand.

What do you call the tracks and trails of living things in soft sediment?

Introduce 'trace fossils'.

Interpret the behaviors of tracks/trails in the sand.

Examine and collect a sand sample to determine its composition.

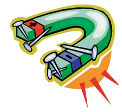
Determine if any of the grains are magnetic.

Discuss where the sand may have come from.

Alternative: carry out this discussion at Third Beach

Photo, left: Close up of sand from Iona Beach. Penny for scale.

STOP 1A: SECOND BEACH - THE SEAWALL TELLS A STORY



Second Beach is a good location to look closely at the rock materials used to build the seawall. Take your magnifiers and magnets to the wall and determine what types of rocks are there, interpret how they formed, consider where they would have come from, and why they were used instead of another rock material.

Things to Investigate:

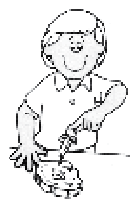
Examine the rocks making up the seawall.

Using a magnet explore the minerals making up the rocks to identify what % of the black minerals are magnetite.

Interpret how these rocks formed, discuss where they may have come from and why they were chosen .

STOP 1B: SECOND BEACH - IMPORTANT PEBBLES

The beach on the north side of the swimming pool is different from the main Second Beach - it has boulders and pebbles! Pebbles and boulders here are a cross-section of rock types carried by Pleistocene ice and deposited as *till* over the region, left behind now on the beach by wave erosion. These pebbles tell us about the terrane scoured by the glaciers, the same bedrock broken down and making up the surrounding beach sand.



Things to Investigate:

Examine the pebbles on the beach.

Note their colours and shapes. Sort them.

Discuss what they reveal about where they came from, what shaped them and how they got there.

Use the variety of pebbles to illustrate the rock cycle.

Discuss what the size of the grains indicates about how they were transported and why they are concentrated there.

STOP 1C: BOULDER PATCH

Near this seawall pullout with semi-circle of signs there is a stairway down to the boulder-strewn beach. When accessible and exposed at low tide this is a good location to look at the boulders as samples of the bedrock terrane over which glacial ice moved. Those that are not encrusted or have a masking veneer of oxidation or marine mung can be examined to see the textures and structures that reveal what type of rock they are. Is there a type that is dominant? Is there a type that appears to not be present?

Things to Investigate:

What types of rocks make up this field of boulders?

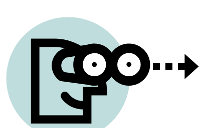
Is there a dominant types or types?

Are some types not present?

Is it the same general make up as the pebbles?

How did the boulders get to this location?

Boulder patch point between Second Beach and Ferguson Point.



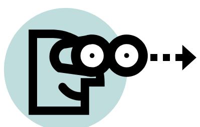
As you walk along the seawall ... keep your eyes peeled on the beach for changes in appearance. Does it correspond to what is seen along the landward side?

STOP 2: FERGUSON POINT

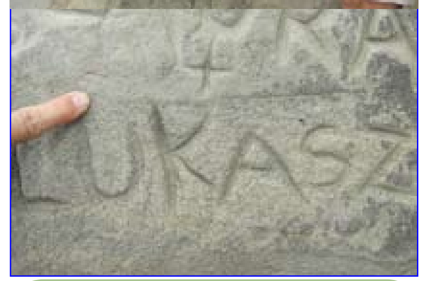
Approaching from the South, this promontory reveals our first encounter with **bedrock** cropping out in the intertidal and in the cliffs bordering the walk way. Does the appearance of the intertidal rocks provide any clue as to what rock type it is?

Look closely at the outcrop along the path way. Note any large scale features that may indicate how the rock formed. Using a hand lens look at the composition and texture for evidence of how it formed and what it is.

As you continue to walk *around the point*, look closely at the rocks exposed in the cliff, paying close attention to any change in exposure, profile or weathering. Pick up a piece of float and compare its features (colour, grain size, hardness) to the rocks exposed in the cliffs.



Spot the scattered lumps in the outcrop. Are they made of made of material different from the surrounding rock?



Things to Investigate:

Examine and collect a sand sample to determine its composition and texture.

Hard or soft?

Fossils or barren?

Determine if any of the grains are magnetic.

Discuss where the sand may have come from.

Is there layering at any scale?

STOP 3: THIRD BEACH

Beyond the north end of Third Beach at low tide you will see a series of seaweed- and barnacle-encrusted outcrops of bedrock that extend like piers perpendicular to the beach. Their low-profile, suitability for marine plants, and repetitive nature suggest they are gently, dipping beds of **sandstone**.

Ancient rivers and rising mountains

These strata are part of a very thick sequence of sandstone, siltstone and shale deposited by rivers flowing from rising mountains 70-40 million years ago. The structures in the sandstones, the presence of coaly lenses and layers, and lack of marine fossils help geologists interpret these rocks to have been deposited by ancient rivers and in deltas across a subsiding landscape. The composition of the sand and pebbles tells geologists about the nature of the bedrock being eroded as the source.

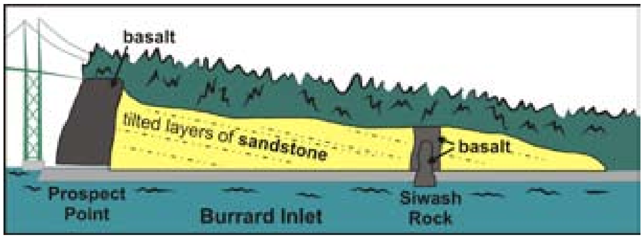
Tilted layers of sandstone form ribs on a rock ridge exposed in the intertidal zone at Third beach.

Here at Stanley Park the sequence is about 1 km thick. In other locations around the Georgia Basin these strata are over 6 km thick! As the deposits were successively buried, groundwaters that flowed through these buried sands precipitated mineral cement between the grains, slowly transforming the sand to sandstone.

Things to Investigate:

Using a compass, measure the strike and dip of the bedding.

At a low tide, when the rocks are best exposed, you will see that the layers are tilted. This tilting happened over the past 10 million years, as tectonic forces lifted the Coast Mountains to the north while the Fraser Valley subsided to the south. The ten degree southward tilt of the sandstone layers records the effects of these Earth forces. Because of the southward tilt of all sandstone layers underlying Stanley Park, as you walk along the seawall from Prospect Point to Third Beach you pass younger and younger layers of sandstone. You start beside sandstone that is 70 million years old and finish beside rocks



Nicolas Steno's (17th century geologist) PRINCIPLE OF SUPERPOSITION: "In a sequence of strata, any stratum is younger than the sequence of strata on which it rests, and is older than the strata that rest upon it." i.e. In a sedimentary sequence, the oldest beds are at the bottom and youngest at the top. As this Stanley Park bedrock dips south, one walks down section to the north into older rocks, at some point walking across the famous Cretaceous-Tertiary boundary – the 'point' in time when dinosaurs and many other creatures became extinct. Can you find it? (See Page 9.)

30 million years younger, a span of geologic time that includes the end of the era of dinosaurs. No dinosaur fossils have been found in these rocks, but fragments of ancient plants, now converted to coal, occur in some sandstone layers.

As you walk north, continue to observe the appearance of the beach and the appearance of the exposed rock next to the path. Do the size and shape of the 'grains' on the beach change? Keep an eye on the low relief landscape before you reach the cliffs. What do you see?

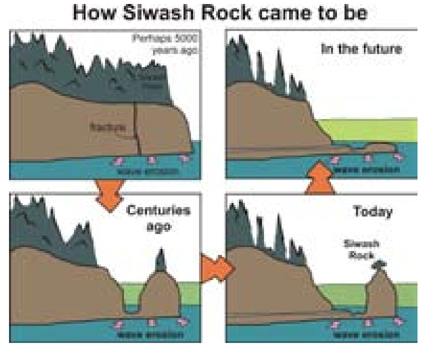
STOP 4: SIWASH ROCK

Carving a pillar from a point

Siwash Rock is the most famous natural feature along the seawall. It stands just offshore, and connected at low tide to a point along the seawall walk. Inspection reveals that, like Prospect Point, it is **basalt** rather than sandstone. Like Prospect Point, the basalt forms a point on the shoreline. How did Siwash Rock come to be?

The basalt occurs in a **dyke,** a slab-shaped rock body that formed by the intrusion of magma into a fracture in the sandstone. The basalt is dated at 31.5 million years old (Oligocene), younger than the youngest sandstone in the sequence. Similar age volcanic rocks form Little Mountain (Queen Elizabeth Park) and crop out on the south side of Great Northern Way east of Main Street. This volcanism is interpreted to be related to subduction of the Farallon Plate below North America (see Page 16.)

How Siwash Rock came to be



Hard basalt at Siwash Rock has resisted erosion better than adjacent sandstone. Hence the basalt forms a point. At a point in the past, Siwash Rock was likely part of a larger point eroded by ocean waves. It is likely some weakness in the point, perhaps a fracture, was exploited by waves, allowing erosion to breach the point. With continued erosion, Siwash Rock became isolated from the remaining point. Siwash Rock will continue to erode to a narrower and shorter pillar, until one day it is only a minor bump on a rock platform in the intertidal zone.

You will note that there is a World War II gun battery on top of this cliff; also one at Prospect Point. Why do you think that these defence structures were built where they were built?

THINGS TO INVESTIGATE:

EXAMINE CLOSELY AND DESCRIBE THE COMPOSITION AND TEXTURE OF THE ROCK.

LOCATE THE CONTACT BETWEEN THIS ROCK AND THE SANDSTONE. IS IT SHARP OR DIFFUSE?

IS THERE EVIDENCE OF CONTACT METAMORPHISM?

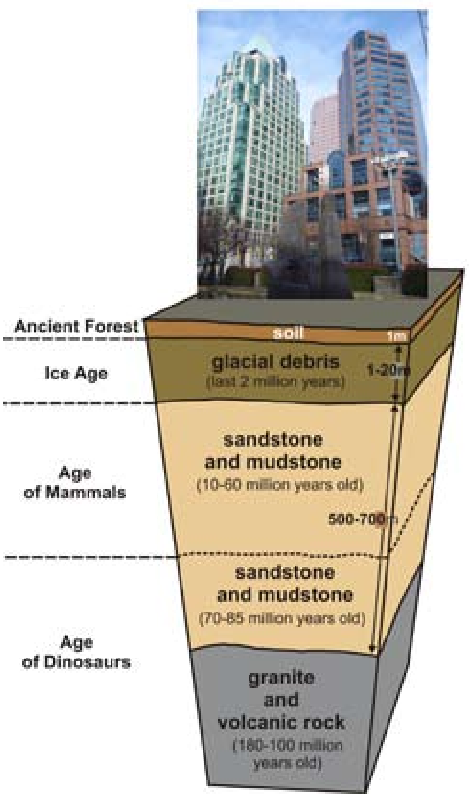
STOP 5: MASSIVE, CRETACEOUS SANDSTONE CLIFFS

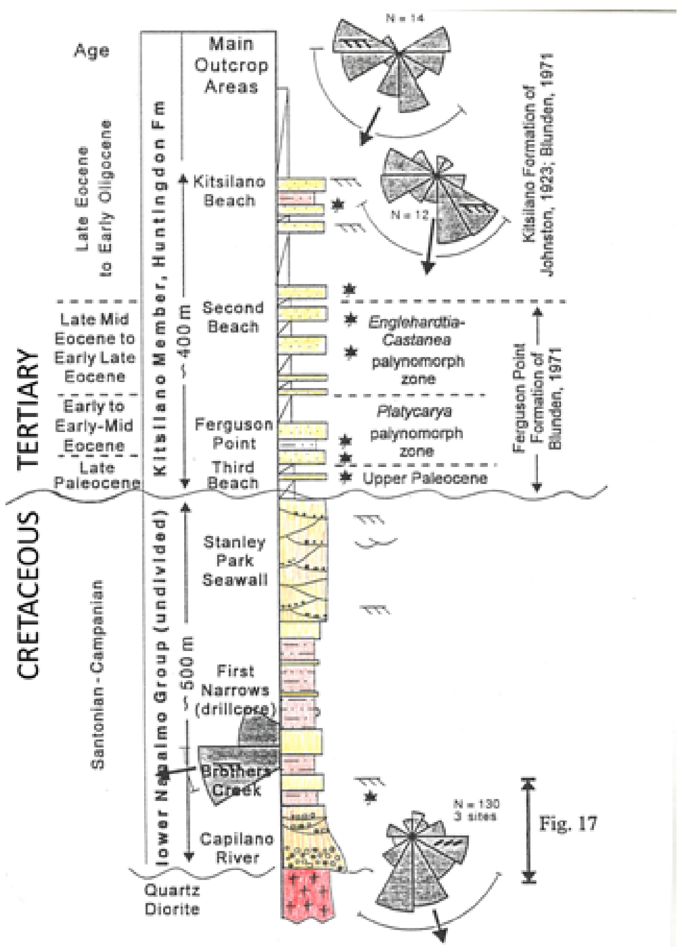
Sandstone: subterranean foundations of Vancouver

Rock cliffs line the seawall from Siwash Rock to Prospect Point. Look closely - they are not the same rock as Siwash Rock, and more like the tan sandstone exposed at Ferguson Point. This massive sandstone, part of the Cretaceous Nanaimo Group sequence, underlies all of Vancouver but is mostly hidden below a blanket glacial debris and soil. It can be seen during excavation of foundations for high rise buildings in the downtown. The Stanley Park seawall provides the best place in the region to look at these scarcely seen rocks that are the basement to the city.

Sandstone cliffs are a tan colour and smooth, lacking the abundant fractures found in basalt. Close inspection reveals that the sandstone is composed of grains of sand and occasional pebbles. The mineral cement that holds the grains together is weak, and grains will fall out if you simply rub the rock. Weak mineral cement is the reason that sandstone erodes readily. This characteristic is of great advantage during construction of high-rise buildings - foundations can be dug largely without blasting.

What's Under Our Feet?





Right: a measured section of Cretaceous-Tertiary age Georgia Basin strata from North Vancouver to Kitsilano, including Stanley Park. (From Mustard and Rouse, 1994)
Pollen types determine the ages of the rocks. The Cretaceous - Tertiary boundary is interpreted to lie between Third Beach and Prospect Point.
Fan shaped figures (rose diagrams) show current directions interpreted from sedimentary structures in the strata.

STOP 6

Sculpting the shore: ocean's relentless attack

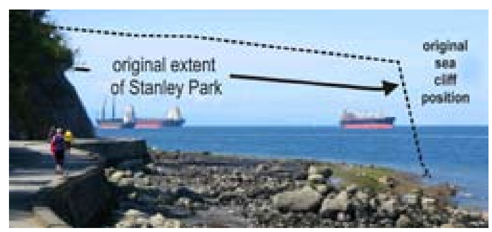
Continue to walk eastwards along the seawall. Though best known as a walkway, construction of the seawall was initiated to protect the shores of Stanley Park from the pounding energy of ocean waves. The seawall, built over a 50 year period from 1914 and 1980, has slowed but not stopped this erosion. As an example, the winter storm in 2006 caused numerous landslides on seaward-facing cliffs above the seawall. The seawall was closed for months as the cliffs were cleared of loose rock and soil, stabilized, and the debris removed from the seawall.

Sandstone cliffs rise above the seawall at a high tide (left). Landslide debris of rock and trees on sea wall after winter storm of 2006 (right).

Stanley Park is losing ground!

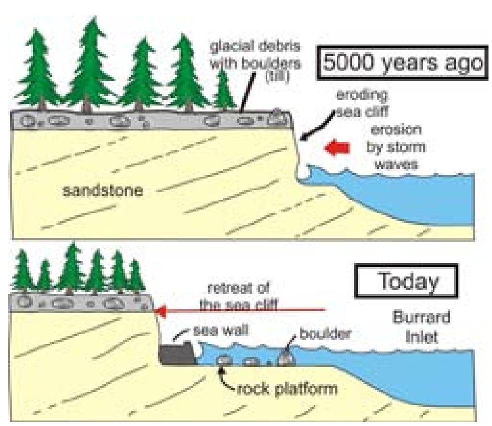
As you walk the seawall during a low tide, you cannot help but notice the abundance of boulders on what appears to be a beach. Closer inspection reveals two surprises. What appears to be a beach is a gently sloping rock platform of sandstone. You might expect the boulders to be sandstone that has been eroded from nearby sandstone sea cliffs. Surprisingly, the boulders are mostly granite. How odd!

Why might there be a sandstone platform? When a sea cliff is battered by storm waves, submarine erosion of the cliff is limited to just a metre or so depth. As the cliff retreats, a flat platform is left behind in the intertidal zone. The distance of cliff retreat is marked by the width of the rock platform. This logic suggests that the sea cliffs of Stanley Park were once located at the outer edge of the platform, and have retreated to their current position. Stanley Park has lost ground!



Wave-cut platform with scattered boulders at low tide.

Where did the boulders come from? If you were to dig into the soil below the forests of Stanley Park, you will find granitic boulders. There is a boulder-rich blanket of sediment underlying all of Stanley Park, as there is throughout the Vancouver region. This sediment, called till, is debris left behind Ice Age glaciers that retreated from the area 10,000 years ago. The boulders were carried south from the granitic Coast Mountains by the flow of glaciers. As the sea cliffs retreat, this layer of boulders is under cut, and boulders topple down to the shore. Fine mud and sand is washed away, while the heavy and durable granite boulders survive the pounding of waves.



THINGS TO INVESTIGATE:

WHAT ROCK TYPES ARE THE BOULDERS MADE OF? WHAT DOES THIS TELL YOU?

HOW DOES THE COMPOSITION OF THE SAND COMPARE TO THE SAND COLLECTED FROM THE BASE OF THE CLIFF (STOP 5) OR SECOND BEACH (STOP 1)

WHAT MODERN SEDIMENTARY STRUCTURES DO YOU SEE IN THE SAND? HOW DID THEY FORM?

STOP 7: PROSPECT POINT

The durable prow of Stanley Park

At Prospect Point, rock cliffs rise more than 30 m, the highest along the sea wall. The rock is a dark colour, with regular column-like fractures. Where have you seen this before? This is basalt, and the fractures are shrinkage cracks that formed when the basalt cooled and crystallized from molten rock. This basalt outcrop is interpreted to be an extension of the rock body at Siwash Rock. This dyke formed by the cooling and crystallization of magma that was intruded a crack in the sandstone when the sandstone was deeply buried in the Earth. The fact that the basalt forms the highest cliffs, the highest part of the park, and the northern tip of the peninsula suggests that this rock is more durable than the sandstone, and that it is eroding more slowly than the sandstone that underlies most of the park.

Things to Investigate:

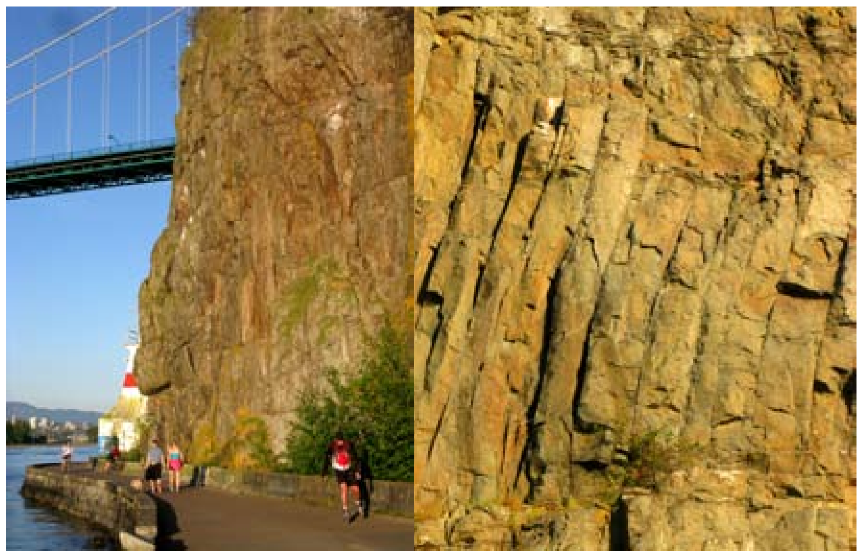
Observe the change in the appearance of the outcrop as you approach Prospect Point.

"Put your finger" of the **contact** between the tan cretaceous sandstone and the brown basalt.

Find a sample of the basalt at the base of the cliff. Describe the colour, texture and composition (dark or light, crystalline or grains, coarse-grained or fine-grained, hard or soft).

What is the orientation of the fractures in the basalt? what does this reveal about the orientation of the cooling surfaces?

Compare weathering of the sandstone and basalt.



Basalt cliffs at Prospect Point (above, left). Columnar joints in the basalt formed by shrinking curing cooling and crystallization (above, right).

STOP 8: LIONS GATE BRIDGE

Vancouver's iconic bridge

The Lions Gate Bridge is Vancouver's most famous and iconic structure, a graceful suspension across the narrows of Burrard Inlet. A walk across the bridge easily combines with connecting walks to Prospect Point lookout in Stanley Park and Ambleside Park in West Vancouver. This venture provides a variety of views of the North Shore, Salish Sea, Stanley Park, and Vancouver harbour and is well worth the effort.

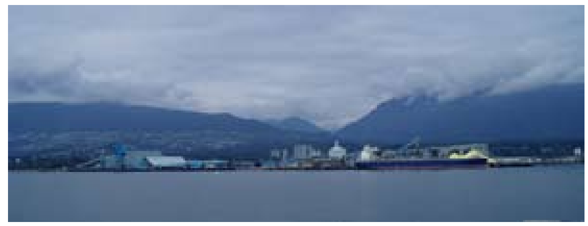
Cliffs of resistant basalt at Prospect Point contrast with gravel plain of the Capilano River delta (center)on the opposite shore of First Narrows.

Why is it narrow at First Narrows?

First Narrows provided an obvious place for a bridge crossing of Burrard Inlet. Two different geological processes, each operating on opposite shores, have created the narrows. On the south shore, the peninsula of Stanley Park juts sharply into Burrard Inlet. Hard volcanic rock underlying Prospect Point has resisted erosion by ocean waves, and protected the adjacent softer and more widespread sandstone, forming Stanley Park peninsula. On the north shore of First Narrows is the broad gravel plain flanking the mouth of the Capilano River. This high energy river descends from the granitic North Shore Mountains with a load of gravel and sand. Over thousands of years, the river has built a broad delta that bulges into Burrard Inlet.

What are those bright yellow hills?

Just east of the bridge is a well known feature of Vancouver harbour, conical yellow hills of sulphur. Sulphur, one of the port's biggest exports, is a by product recovered from the processing of natural gas, petroleum, and oil sands, and carried by rail from NE BC and Alberta. Sulphur, along with potash from SK, another important mineral commodity exported through the port of Vancouver, is used to make fertilizers that are essential in the effort to produce food for an increasingly hungry world.



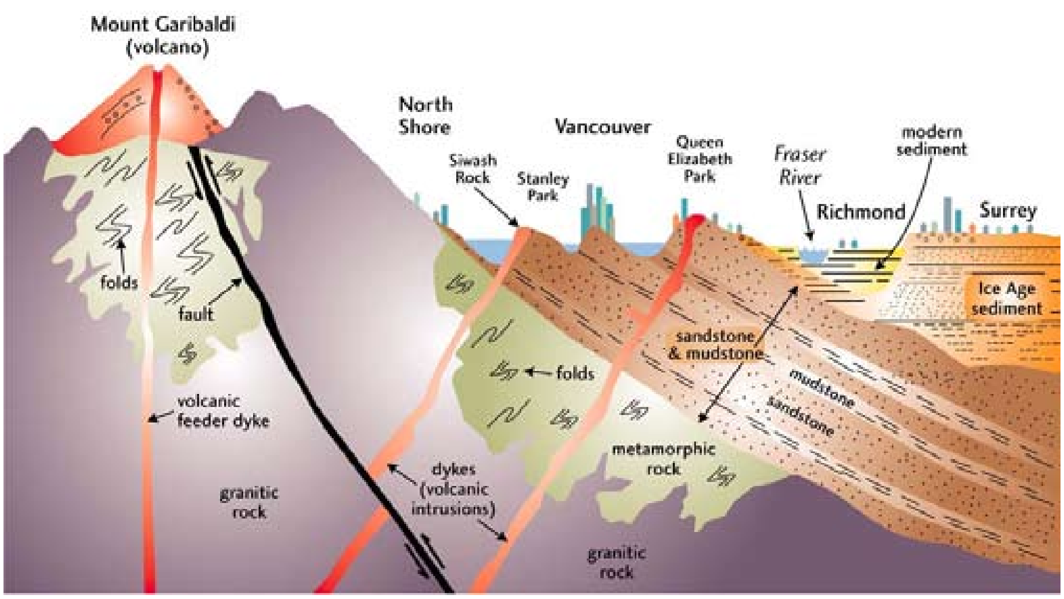
Sulphur is one of several mineral products that are shipped out from bulk handling terminals in North Vancouver.

STOP 9: THE BIG PICTURE

This is a great place to introduce or review many related topics: local geology, geographic features, landforms, commerce and resources shipped, tides, transportation.

To the north you see the North Shore Mountains, part of what geologists call the Coast Plutonic Complex, coalesced bodies of granitic rock that extend from Alaska to Vancouver. These are igneous rocks which formed by slow cooling of magma at great depth. These solid, coarsely-crystalline rocks made of interlocking mineral crystals (feldspar, biotite, quartz, magnetite, et al.) are the magma chambers of ancient volcanoes that formed along the western edge of the continent over 100 million years ago and then were uplifted 10-15 million years ago.

Between here and the mountains is Burrard Inlet, a marine body of water ranging from 15-25 m deep in the harbour, but which reaches over 200 m deep in Indian Arm.



North-South cross-section looking east from the North Shore Mountains to the Fraser River Delta. From Clague and Turner (2003).

To the south behind is Downtown Vancouver, a subdued landscape compared to the mountains, low lying, climbing gently to South. This area is underlain by sedimentary rocks - conglomerate, sandstone, siltstone and shale (Eocene Kitsilano Formation) – which are younger than the granitic rocks and are locally seen to overlie them. Directly to the west is Coal Harbour, a place recognized by Vancouver's pioneers to potentially provide coal to fuel steam ships and trains. The coal is in the sedimentary rock sequence. The same age rocks on Vancouver Island were mined for coal for over 100 years and continue to be mined today at Quinsam Mine near Campbell River.

The North Shore Mountains and their exposed granitic rocks have been uplifted by powerful tectonic forces. While the overall pressures may have been directed westward, the sharp mountain front suggests that here uplift occurred along an E-W fault which lies in Burrard Inlet. Look across the way to the north shore. The profile reveals mountains, valleys, deltas, the cities of North Vancouver and West Vancouver. Vancouver Wharves east of the Lions Gate Bridge ships bulk materials including mineral concentrates (ZnS, MoS, CuS) from Red Dog Mine in Alaska, Highland Valley Copper, Gibraltar and Mount Polley Mines in BC, plus other concentrates from US, Australia, AK and Mexico also destined for Trail, BC. They handle ~1 million tonnes a year that are worth billions of dollars. They also receive and ship out sulphur, a by-product of natural gas refining in northeast British Columbia.

Vancouver is a major port city and Burrard Inlet is a busy harbour for everything from floatplanes, to helicopters and helijets, the sea bus, plus ships with cargo, cruise ships, and tugboats.

Volcano!

On a clear day, there is an excellent view from the Lions Gate bridge of Mount Baker volcano. In the 1880's, small eruptions on its summit created fireworks visible in Victoria. This volcano reminds us that Vancouver sits above a great, slow-moving collision zone between continental and oceanic tectonic plates. Deep within the collision zone, rocks are melting. Every so often this melted rock rises to the surface. One day Mount Baker will erupt again.

Mount Baker volcano rises above the Port of Vancouver.

About 100 km beneath your feet, oceanic plate is slowly moving eastwards. The rocks below Vancouver are under stress. Every day there are tiny earthquakes. We know that bigger earthquakes are coming; we just don't know when. So engineers in the Vancouver region design buildings to withstand even very large earthquakes.

Want to read more?

REFERENCES AND READING LIST

At Risk, Earthquakes and Tsunamis on the West Coast, John Clague, Chris Yorath, Richard Franklin, and Bob Turner, Tricouni Press, 2006, 200 pages. (A focus on earthquake and tsunami hazards that effect the Vancouver region)

Geology tours of Vancouver's Buildings and Monuments, Peter Mustard, Danny Hora, and Cindy Hansen, Geological Association of Canada, 2003

Geoscape Canada website – www.geoscape.nrcan.gc.ca. Geoscape Vancouver, Vancouver Rocks, Vancouver's Landscapes, GeoMap Vancouver (on line photos and figures illustrating landforms, geology, natural hazards, and earth resources of the Vancouver region)

Historical Atlas of Vancouver and the Lower Fraser Valley, Derek Hayes, Douglas and McIntyre, 2005, 192 pages. (Excellent historical maps with companion text and photos chronicle the early shorelines of Burrard Inlet, False Creek and their history of change.)

Nature West Coast – as seen in Lighthouse Park, Kathleen Smith, Nancy Anderson and Katherin Beamish, Sono Nis Press, 1988, 283 pages. (Comprehensive natural history guide).

Oceanography of the British Columbia Coast, Richard Thompson, …. (This comprehensive book includes specific discussion of Burrard Inlet and Howe Sound).

Parks and Nature Places around Vancouver, Nature Vancouver, Harbour Publishing, 2009, 272 p. (This field guide includes a number of coastal sites.)

Sea to Sky GeoTour – Geology and Landscapes along Highway 99 from Vancouver to Whistler, British Columbia, Bob Turner, Melanie Kelman, Malaika Ulmi, Tim Turner and Richard Franklin. Natural Resources Canada, 2010 (A field guide to geology, landscapes, and natural hazards along the Sea to Sky Highway)

Vancouver: A visual history, Bruce Macdonald, 1992, Talonbooks. (a times series of maps of Vancouver region, starting in the 1850's, illustrating development over time, including change to shorelines)

Vancouver, City on the Edge – Living with a dynamic geological landscape, John Clague and Bob Turner, Tricouni Press, 2003, 191 pages. (General geology, evolution, natural hazards, and earth resources of the Vancouver area).

Vancouver Geology, J.E. Armstrong, Geological Association of Canada, Cordilleran Section, 1990, 128 pages with map. (General geology of Vancouver area with descriptions of field trip locations.)

Wilderness on the Doorstep: Discovering Nature in Stanley Park, Vancouver Natural History Society and Nature Vancouver. (Comprehensive natural history guide to Stanley Park).

DISCUSSIONS, ACTIVITIES

1. Second Beach

What do we call this natural feature? What is the main feature? What is noticeably missing?

What processes are operating here?

Is the tide going up or going down? How can you tell?

What feature of sedimentary rocks might you expect to find on the surface of the beach?

What might you see if you dug a trench in the sand?

Dig a trench and look carefully at sand exposed in the wall. What do you see? Sketch it.

Do you see and signs of life on the beach? Look for trails of creatures. What are the creatures who made them doing?

Do you see evidence of anything living below the surface in the beach sand? What are these creatures doing? How woudl burrowing change sedimentary layers?

Collect a sand sample on double sided sticky tape and examine it with your hand lens. What is the size of the grains? Are they well-sorted or poorly-sorted? Are they angular or rounded? What colours do you see? What minerals do they represent?

Colour	Colour of Grains	Grain Size (mm)	Round or Angular	Sorting (well, farily well, poor)

Are any grains organic? What do they look like? Can you identify what they were a part of?

Are there any grains that are ROCK fragments rather than mineral grains? Describe them.

Estimate the percentage of black grains. Are any magnetic?

(If you bring rock samples with you, you can pass them around and ask students to determine what type most closely resembles the sand and could be the source of the sand on the beach.)

1a. Seawall

Look closely at the rock used to build the seawall. Describe the features in the table below.

(give grain size range categories here)

General colour	Grain Size (mm)	Colour(s) of grains & percentage (e.g 15% white)	Texture (crystalline of cemented grains)	Hard/ coherent or soft/crumbly	Special features (e.g. layers, holes, fossils)	Rock Type

What minerals do the colours represent?

Scan the rock with your magnet. Are any grains magnetic? Are all the black grains magnetic?

What type of rock is this? Igneous sedimentary or metamorphic

Why do you think this was used to build the seawall?

Where do you think it may have been quarried?

1c. or 6. Intertidal Boulders

(if accessible at low tide) Explore the boulders in the intertidal. Are they round or angular? What is the grain size range in cm or m. Look at 3--6. Describe them in the table below:

General colour	Grain Size (mm)	Colour(s) of grains & percentage (e.g 15% white)	Texture (crystalline of cemented grains)	Hard/ coherent or soft/crumbly	Special features (e.g. layers, holes, fossils)	Rock Type

Where did these boulders come from ?

How did they get where they are now?

2. or 5. Georgia Basin Strata - Ferguson Point / Seawall Cliffs

Collect a sand sample from the base of the cliff on double sided sticky tape and examine it with your hand lens. Describe the sample using the table below.

Colour	Colour of Grains	Grain Size (mm)	Round or Angular	Sorting (well, farily well, poor)

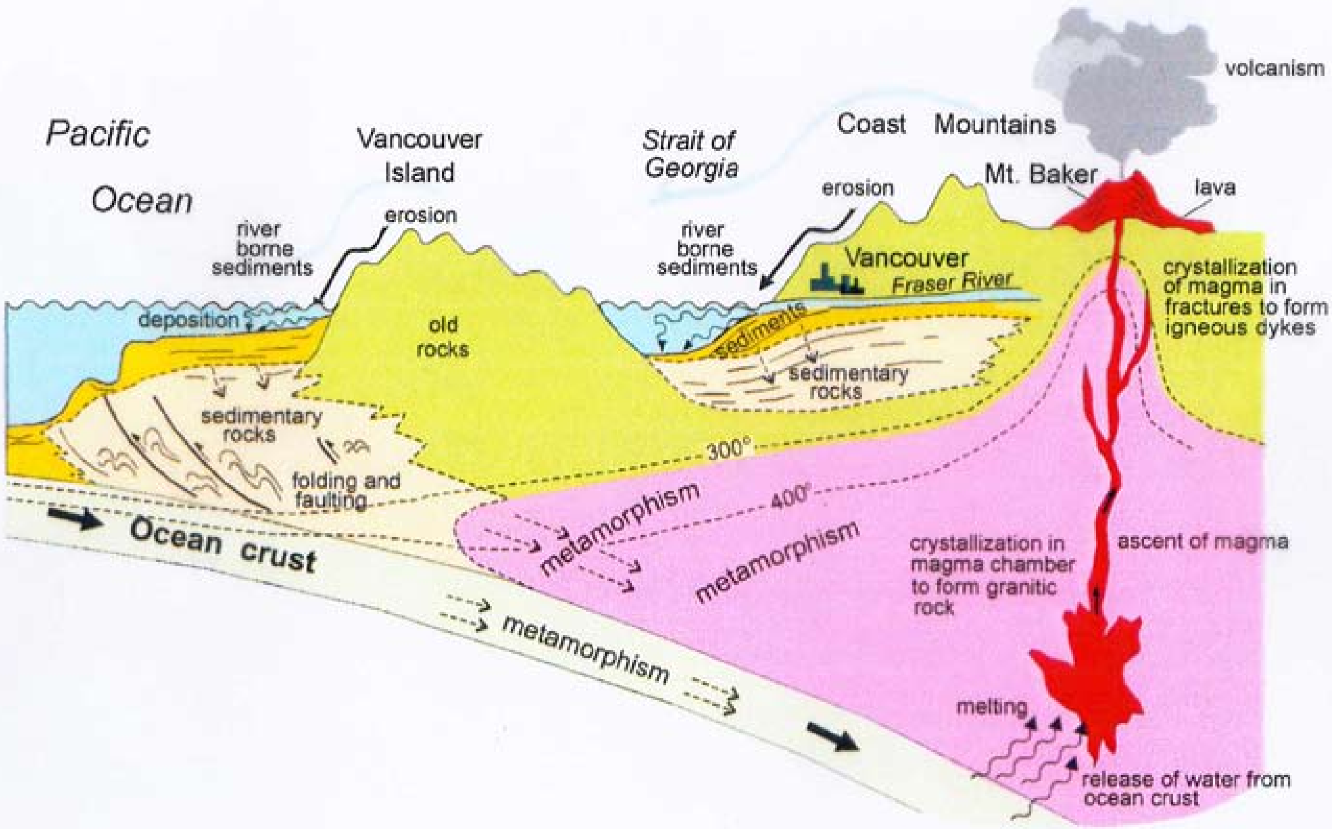
Are there any grains organic? If so, what are they?

Are there any grains that are ROCK fragments rather than mineral grains? Describe them.

Estimate the percentage of black grains. Are any magnetic?

Compare this sand with the sand collected at Second Beach . Is this the source of the sand at Second Beach. Why or why not?

Geologic Processes in Coastal B.C.



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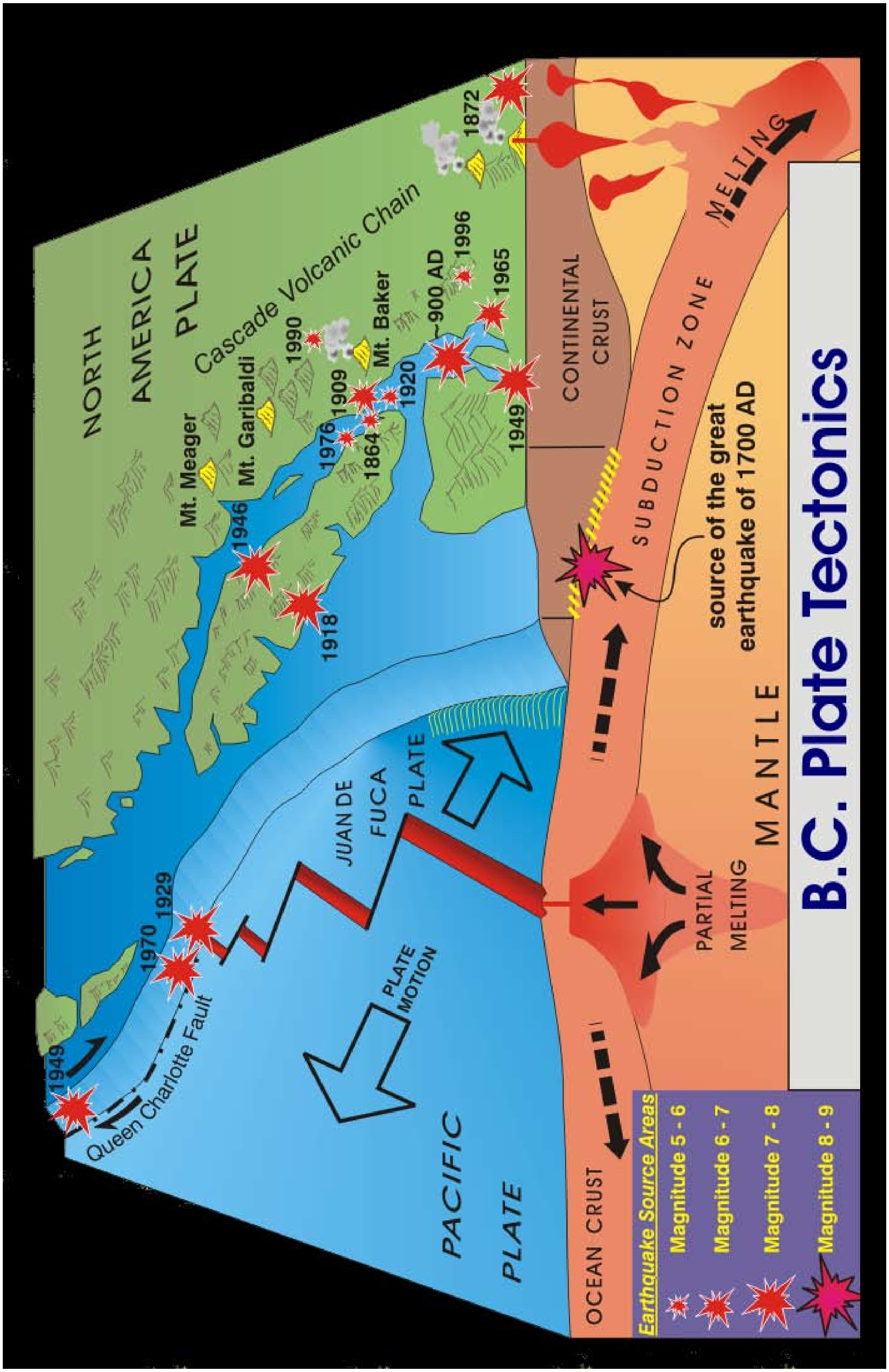
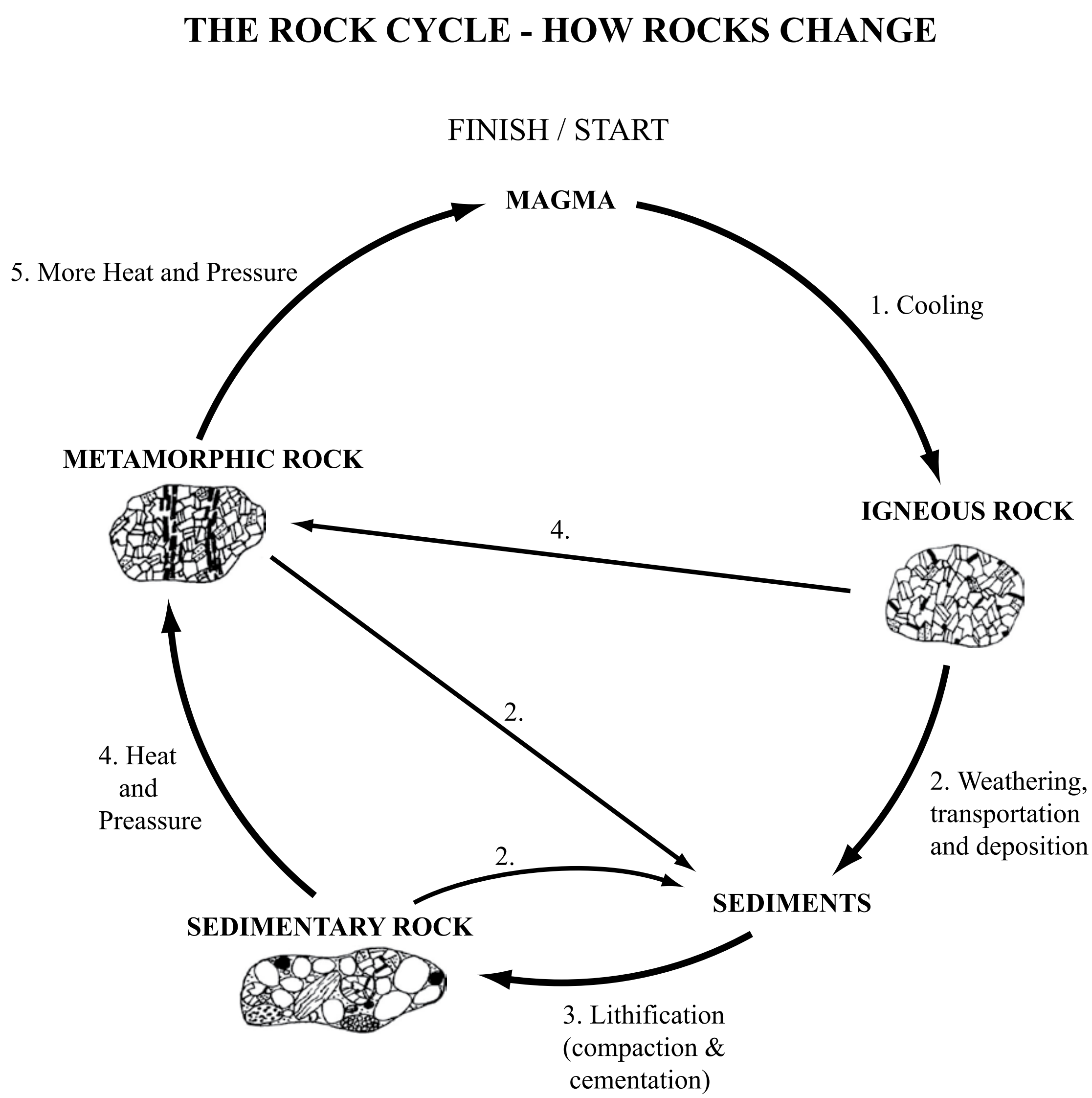
by
Bob Turner and John Clague
Geological Survey of Canada
Vancouver (604) 666-0529

drafting by: Tonia Williams, Kazuharu Shimamura


B.C. Plate Tectonics
NORTH AMERICA PLATE
Cascade Volcanic Chain
Mt. Meager
Mt. Garibaldi
Mt. Baker
JUAN DE FUCA PLATE
PLATE MOTION
PACIFIC PLATE
Queen Charlotte Fault
1949
1970
1929
1946
1918
1976
1864
1909
1920
1990
~900 AD
1996
1965
1949
1872
CONTINENTAL CRUST
OCEAN CRUST
SUBDUCTION ZONE
MELTING
PARTIAL MELTING
MANTLE
source of the great earthquake of 1700 AD
Earthquake Source Areas
Magnitude 5 - 6
Magnitude 6 - 7
Magnitude 7 - 8
Magnitude 8 - 9


THE ROCK CYCLE - HOW ROCKS CHANGE
FINISH / START
MAGMA
1. Cooling
IGNEOUS ROCK
4.
METAMORPHIC ROCK
5. More Heat and Pressure
2.
4. Heat and Preassure
2.
2. Weathering, transportation and deposition
SEDIMENTS
SEDIMENTARY ROCK
3. Lithification (compaction & cementation)