Downtown Vancouver Geotour

A teacher's guide to some of the best rocks and mineral resources
in the city center and their connections to
geologic processes and local history.

A collaboration between the
MineralsEd
and the
Geological Survey of Canada

mineralsed
Mineral Resources Education Program of BC

CANADA 1842 GEOLOGICAL SURVEY - COMMISSION GÉOLOGIQUE

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Introduction

Welcome to the Downtown Vancouver GeoTour!

Our learning about the Earth, geological processes and features, and the relevance of its mineral resources to everyday life is really best addressed outside of the classroom. While there is much to be said for a back-country field trip, we can often just go out into our own “backyards” to observe, appreciate and consider these Earth-focused topics.

This professional development field trip for teachers will introduce the local geologic setting and will visit several historical buildings that use locally quarried stone. Stops at other buildings will show many other different, commonly exotic, rock types, and will demonstrate through their compositions, textures and structures how they formed (e.g. igneous, sedimentary, metamorphic.) This tour will also include a stop at the **BC Geological Survey** for an introduction to the role of this organization in mineral resource management, and a mid-day stop at the **Geological Survey of Canada** for a presentation on the southwest BC tectonic setting and related natural hazards.

This walking tour for teachers is intended to show how the city centre can be a great local field trip to take with your students who are learning about geosciences, mineral resources or mining 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 the GPS, and will, therefore support curriculum more broadly. It will also introduce activities you might like to repeat when doing this tour with your students.

The stops on this field 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:

- Igneous: plutonic, volcanic, granite/granodiorite (phenocryst, xenoliths), syenite, basalt (vesicles, columnar jointing), porphyry
- Sedimentary: sandstone (grain-size, cross-bedding) marine and non-marine fossils, coal, limestone depositional environments, susceptibility to weathering, burrowing
- Metamorphic: gneiss, schist (porphyroblast), slate, marble
- Weathering: rust (oxidation), root break-up (biological), sandstone disintegration, copper oxidation
- Man-made mineral products: bricks, concrete, steel, glass, aluminum
- SW BC geologic setting, earthquakes, volcanoes, other natural hazard risks

This guide book was will provide you with brief descriptions of some interesting and accessible stops in the heart of downtown Vancouver that can be visited along a circular route beginning at the Vancouver Trade and Convention Centre. To guide this field trip in the future, it also provides you with a location map, a simple summary diagram of the rock cycle, a map of SW BC showing the locations of historical and present day quarries referenced in the guide, and two schematic tectonic cross-sections through our area.

Acknowledgments

We are grateful to all our GSC partners who made this day possible: geologists Malaika Ulmi and Marianne Quat for guiding the day; Dr. Bert Struik for speaking to you about the BC tectonic setting and natural hazards; Louise Fox, Shashi Kapoor and Bev Vanlier for hosting our visit to the bookstore. Our thanks also go to Bruce Northcote, regional geologist with the BC Geological Survey for meeting you and introducing the role of that important provincial agency.

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References

The following are excellent sources of information on the local geology and the building materials for downtown buildings.

Armstrong, John E., 1990, *Vancouver Geology*: Geological Association of Canada, (Cordilleran Section), 128p.

Clague, J. and Turner, B., 2003, *Vancouver, City of the Edge*: Tricouri Press, Vancouver, 191p.

Mustard, Peter S., Hora, Z.D., and Hansen, Cindy D., 2003, Geology Tours of Vancouver's Buildings and Monuments: Geological Association of Canada and GAC Cordilleran Section, 142 p.

The following are links to other good sources for online information on topics related to this geotour.

BC Ministry of Energy and Mines: http://www.gov.bc.ca/empr/

BCMEM Mineral Exploration and Mining: http://www.em.gov.bc.ca/subwebs/mining/

BCMEM Map Place: http://www.em.gov.bc.ca/mining/Geolsurv/MapPlace/default.htm

BCMEM Minfile: http://www.em.gov.bc.ca/mining/Geolsurv/MINFILE/default.htm

Geological Survey of Canada: http://gsc.nrcan.gc.ca/index_e.php

GSC Geoscape Canada: http://geoscape.nrcan.gc.ca/index_e.php

Hardy Island Granite Quarries: http://www.hardygranite.com/

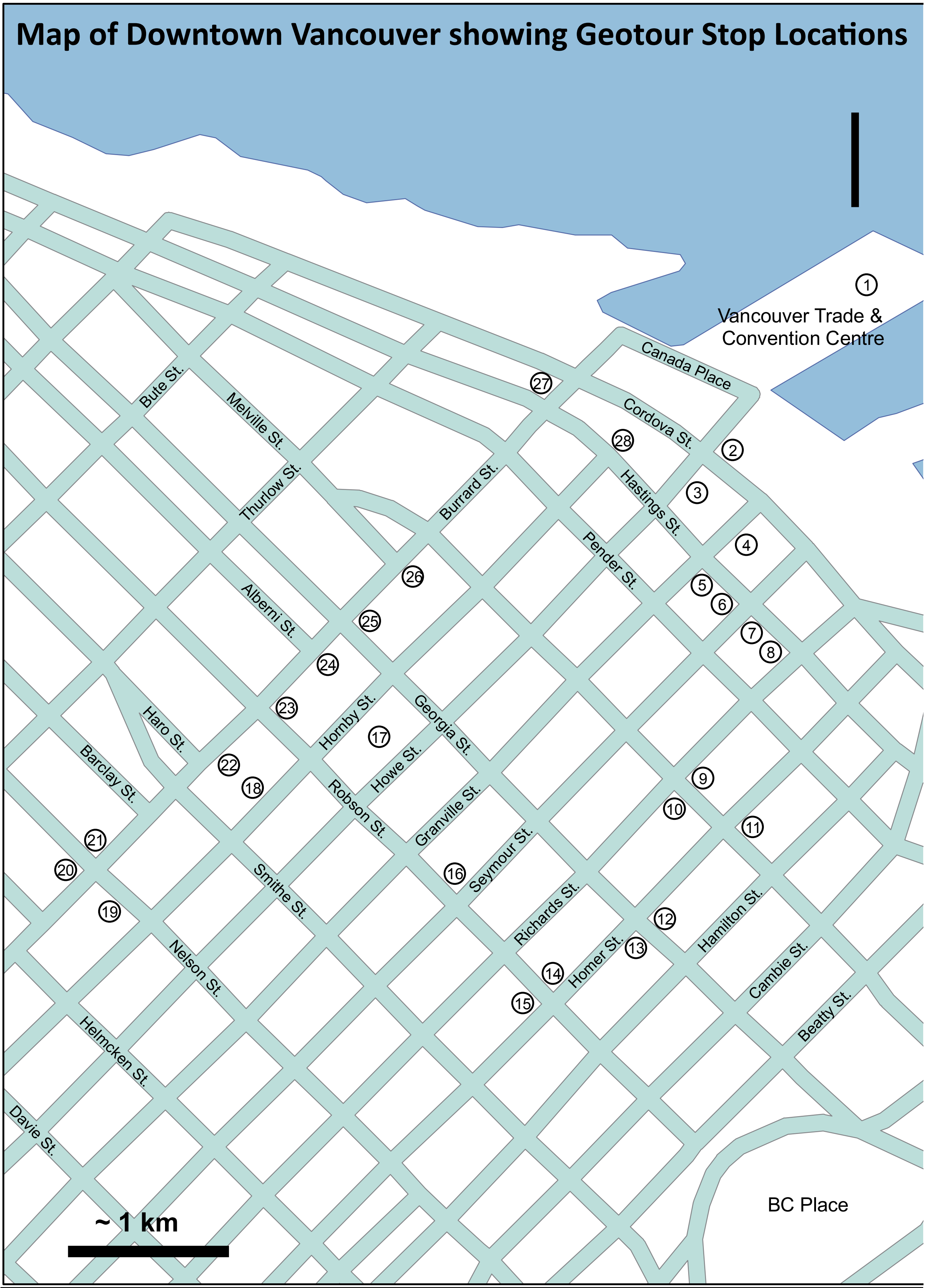
Indiana Limestone: http://igs.indiana.edu/geology/minRes/indianaLimestone/index.cfm

MineralsEd: www.MineralsEd.ca

Port of Vancouver Visitor Centre: http://www.portvancouver.com/community/interpretive.html

Tyndall Stone: http://www.gac.ca/PopularGeoscience/factsheets/TyndallStone_e.pdf

Map of Downtown Vancouver showing Geotour Stop Locations



1 A – Waterfront Canada Place – Viewpoint on second level in NW corner (N 49° 17' 21.6", W 123° 06' 35.9")

This is a great place to introduce or review many related topics: local geology, geographic features, landforms, commerce and resources shipped, tides, transportation. As well, the Port of Vancouver visitors centre, which welcomes school tours, is here.

Figure 1 – View of the North Shore Mountains with The Lions in the upper left and the sulphur piles at Vancouver Wharves in the centre.

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.

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 reveal **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.

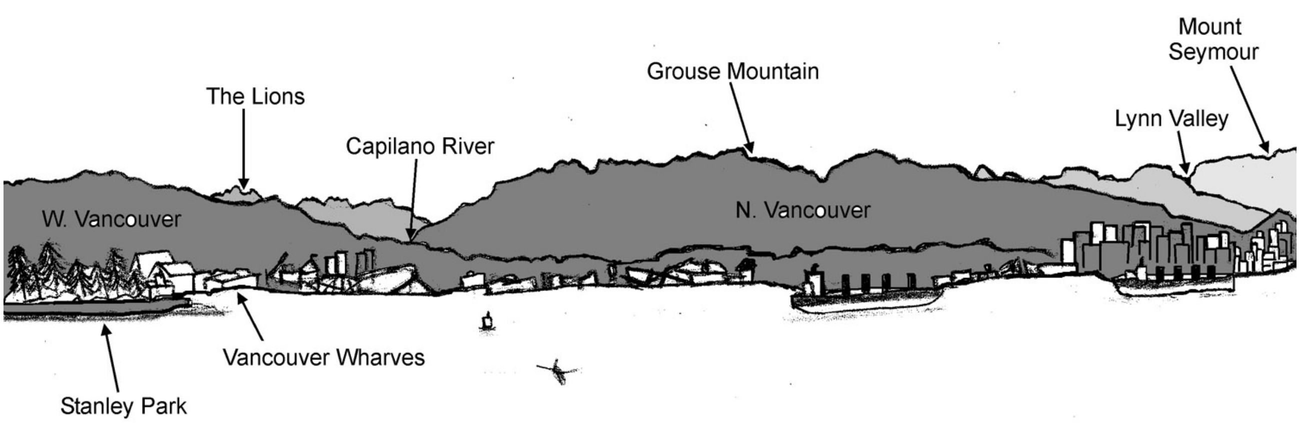


Figure 2 – Sketch of the North Shore Mountains from Canada Place.

Questions to ask:

How did granitic rocks that form kms below the surface come to make up high-elevation mountains?

How might you explain the sharp mountain front on the north shore?

What hazards does our local geology create?

1 B – Cross over to the east side of the pier: view to Second Narrows Bridge (N 49° 17' 20.0", W 123° 06' 34.6")

A more complete picture of commerce in the Harbour may be seen from this side of the pier: **Neptune Terminals** - near the east end of North Vancouver. Around 5 million tonnes of **metallurgical coal** mined in BC's Elk Valley pass through this terminal each year on its way to steel mills in Asia. Neptune also handles ~7 million tonnes of **potash** from Saskatchewan each year, a resource worth ~$4.2 billion. In general, the north shore operations are the major *export* terminals, while the south shore operations are the major *import* terminals (the exception being the grain elevators on the south side).

To the **east** you can see **Burnaby Mountain** with Simon Fraser University on top, rising much higher than the surrounding area. It is underlain by sedimentary rocks sitting on crystalline bedrock.

To the **east southeast** rises **Mount Baker,** an historically active volcano ~100 km from downtown Vancouver. Baker is part of the Cascade volcanic belt which includes Mount St. Helen's, Mount Ranier, etc., and which extends from here to northern California above an E-dipping **subduction zone**. North of Vancouver are young Canadian volcanoes including Mt. Garibaldi, Mt. Cayley, Silverthrone and Mt. Meager, which erupted only 2350 years ago.

Figure 3 – Vancouver from the east side of Canada Place. Sea Bus terminal centre left; CPR trains behind; Waterfront Station in centre right. Harbour Centre with revolving restaurant (disc), right, Sun Tower (arrow).

Turn around to the **south** you see **Vancouver's original waterfront** – which we know as **Gastown**. What is now Waterfront Skytrain and West Coast Express commuter train station was the original terminus of the Canadian Pacific Railway (CPR) (1887). The small brick buildings along the railway were located for convenient loading and warehousing of supplies.

The **Sun Tower (1912)** with the turquoise–coloured roof was once (for two years) the tallest building in the British Empire! Although it looks like weathered copper, the dome of this building was painted to look like weathered copper!

The **Dominion Building (1908-1910**), the brick-red capped building in foreground west of the Sun Tower, was once known as the most modern office building in Canada. It is made of brick and terra cotta tiles, the brick made from Sumas Mountain clays (Eocene, Huntington Formation).

Questions to Ask:

What are ships coming into the Port of Vancouver bringing? (A: manufactured goods)

What is being shipped out of Vancouver? (A: primary resources)

How many ships come and go each day? (A: check Port website)

Things to Do:

As you walk along, keep a running tab of all the things you see that come for rocks and minerals.

Look to south up Howe Street. Can you tell the difference between the old and new buildings in the city? (The old ones are short, made of brick or stone, have nice ornamentation and windows that open. The new ones are tall, made of steel, glass, and concrete, are unadorned and do not have windows that can be opened.)

Look down at the water's edge. Burrard Inlet is tidal. What is the physical evidence of tides? (The intertidal areas have a dark stain.) How are structures built in the water to accommodate the rise and fall of tides? (They float.)

2 – 250 Howe Street - PricewaterhouseCoopers Building (2006) (N 49° 17' 12.7", W 123° 06' 48.0")

This is a new glass and steel structure, with decorative stone veneers imported and supplied by Apex Granite and Tile in Surrey.

Gneiss (metamorphic) from India (swirly, wavy layers, grey, black and white, coarse-crystalline, and very hard) make up the 24" square tiles on the outside sidewalk and inside floor. Neither tile is polished, but the inside tiles have a protective coating.

Limestone (sedimentary) from Spain (pale yellow, very fine-grained with scattered, small (mm- to cm-sized) fossils (e.g. crinoids fragments, coral pieces, identifiable bivalves and snails in cross-section)) veneers the walls in the building foyer.

Diorite (igneous plutonic) (dark grey, very coarse-crystalline (5-6 cm) feldspars with small (1 cm) pale orange potassium (K) feldspar crystals, and 20% quartz) makes up decorative tiles on the inside foyer floor.

Figure 4 – Pale yellow limestone with scattered marine fossils, foyer walls at 250 Howe Street.

QUESTIONS TO ASK:

What would have happened if the gneiss had been subjected to even higher T and P?
How can we tell what kind of fossils are in the limestone? (Bring a few shells to show 3-dimension shape and how they would look in 2-dimensions.)

What do the fossils tell us about the place where the sediment was deposited?

THINGS TO DO:

Demonstrate metamorphism / deformation of non-brittle materials using clay and pennies.

Introduce the term foliation (like a leaf).

Trace or sketch the internal structure of the gneiss.

Walk inside and go stand by one of the many rocks used in the entrance.
Show a map of the world to show how far Spain and India are from BC. Make up a hypothetical math problem about the cost of shipping a certain volume that distance.

3 – Sinclair Centre (block of buildings bounded by Howe and Granville, Hastings and Cordova (N 49° 17' 10.0", W 123° 06' 53.7")

The northwest corner of this block (Cordova and Howe) is the old **Customs Building** (1911-1913). The base is *bossaged* **granodiorite**; the upper part of the building is **brick**. *Bossaged* refers to a rough split in which the centre of the dimension stone block is higher than the edges.

The southeast corner of this city block (Hastings and Granville) is the old **Winch Building** (1908-09).

Granodiorite (igneous plutonic) from Fox Island Quarry in Jervis Inlet (white, grey and black, coarsely-crystalline) makes up the blocks at the base of the building. Many show 5-10 cm, **xenoliths** - those black, rounded pebble- or cobble-size chunks floating in the otherwise even-textured granodiorite.

Imported **marble/limestone** (metamorphic) (jet black, finely-crystalline rock with white, calcite-filled fractures) is used as a decorative stone on the walls inside

Figure 5 – Light grey granodiorite from Fox Island, Sinclair Center.

the main entrance. A close look at the black rock reveals scattered fossils, especially clams and corals. The complex fractures show how rocks are brittly deformed. A close look at the fracture system reveals at least two generations of fractures.

Brass, a copper - zinc alloy, is used for ornamentation on the lobby doors, and for decorative brass plates on and above elevator doors. Copper and zinc are mined in BC (Cu - Myra Falls, Highland Valley, Mount Polley, Gibraltar and others; Zn - Myra Falls).

Questions to ask:

What features tell you the granodiorite is igneous and not metamorphic? (A: It lacks foliation.)

What features tell you that the limestone/marble is deformed? (A: cross-cutting fractures.)

Is there evidence of more than one episode of strain? (A: At least two; locally one set cross-cuts a previous set.)

Would you classify the grade of metamorphism of the limestone low or high? (A: Low - organic structures still visible.)

Are copper and zinc mined in BC? If yes, where?

Things to do:

Find a smooth surface on the granodiorite and take a rubbing with a crayon on paper to record the texture.

Demonstrate how fractures form in brittle material – pre-cut en echelon fractures in paper and pull to open.

Bring a black pebble with a vein running through it to show what a small striped rock really represents.

Examine the inside walls for fossils in the limestone. Sketch the fossil shapes and interpret the organism.

4 – Royal Bank (1929-1931), NE corner of Hastings and Granville (N 49° 17' 06.1", W 123° 06' 49.0")

Haddington Island Andesite (igneous volcanic) (beige, finely-crystalline rock with very small (1mm) brownish "pits" that are weathered-out crystals of **biotite** (mica) is used for the outside building blocks. The andesite is light-coloured like the granite, but its fine texture indicates that it is a **volcanic rock**, one that has cooled quickly at or very near Earth`s surface. Use of this crystalline dimension stone in the relatively younger historic buildings in the downtown core was a deliberate change from 'crumbly sandstone' to more durable materials.

Figure 6 – Royal Bank building stone and pillars made from Haddington Island Andesite.

Indiana Limestone (sedimentary) from Indiana (beige, medium-grained **calcarenite** (calcareous sandstone) with fine layering and no visible fossils) is the main stone used on the inside walls. This building stone has been quarried in Manitoba since 1827; the same rock was used to clad the Empire State Building in New York City.

Questions to ask:

How is andesite similar to the granodiorite? (A: They are both light-coloured.)

What key feature of this fine-grained andesite tells you it is igneous and not sedimentary? (A: sparkly texture and geometric (crystal-shaped) pits.)

What physical characteristics would tell you the rock inside the bank is limestone? (A: It is soft, easily scratched and it would react with HCl.)

Inside this fancy building how many different rock materials do you see being used? (A: At least six.)

Things to do:

Introduce volcanic rocks and their distinctive fine-grained texture with small, but visible crystals..

Figure 7 – Close-up of Haddington Island Andesite at the Royal Bank.

Stand in the foyer and look inside the bank to tally the number of different stone materials used on the walls, stairs, railings, pillars and counters.

5 – Birks (1906-1908) , SE corner of Hastings and Granville

Outer walls of this former CIBC bank building are also made from blocks of **granodiorite** (flamed and honed), these quarried from **Kelly Island** in Jervis Inlet.

6 – 688 West Hastings Street (middle of Birks block) (N 49° 17' 06.3", W 123° 06' 47.5")

This newer building is faced in light-coloured (white) **granite** (igneous plutonic) and another very coarsely- crystalline, dark grey (igneous plutonic) rock with eye-catching, 1.5-2.5 cm, *opalescent* feldspar crystals. The rock is classified as a **syenite**. It is mined in Norway. The same rock is used as the facing stone on the old Vancouver Public Library (Stop 23) at Robson and Burrard.

7 – SFU Harbour Centre – (1919-20), SE corner of Hastings and Seymour (N 49° 17' 03.1", W 123° 06' 43.9")

The base of this former Union Bank building is BC coastal **granodiorite**, while the columns and ornamental pieces around the entry way are **Haddington Island Andesite.**

Figure 8 – Marble-ornamented lobby of the Standard Building.

8 – Standard Building (1913) - 510 West Hastings, SW corner of Hastings and Richards (N 49° 17' 04.1", W 123° 06' 42.3")

Local coastal **granodiorite** and **brick** make up the exterior of this grand old building.

Step inside the foyer to see how a variety of imported **marbles** (metamorphic) and **brass** (copper-zinc alloy) fixtures were used to ornament the entrance and give it great style.

Figure 9 – Imported blue-cheese marble, Standard Building lobby.

Five types of **imported marble**: 1- beige-coloured marble 2- black marble with fossil snails; 3- blue cheese marble; 4- swirly, white-light grey marble; 5 - beige, grainy with stylolites (See Stop 12). In general, these rocks feature irregular, swirly internal structure which records deformation of the original limestone. The lack of distinct layers, commonly diagnostic of metamorphism, is due to a lack of platey minerals in the parent limestone.

THINGS TO DO:

Find a fossil.

Identify the different rocks used to ornament the foyer. Look for evidence of whether they are soft or hard. (Marbles are made of calcite and they are relatively soft so easily scratched.)

Figure 10 – Ceramic tile mosaic with images of Canada and Vancouver, Cathedral Square.

9 – Cathedral Square (NE corner of Dunsmuir and Richards)

This is an open, safe place to gather and look around at the many things made of mineral resources that make up the city. Brick used in old downtown buildings came from local sources. **Haney Brick and Tile Company** in present-day Maple Ridge manufactured bricks from glacial clays mined from the banks of the Fraser River. This company operated from the early 1900s until 1977 producing bricks for the local construction market. **Clayburn Industries**, now based in present day Abbotsford, has been making bricks for over 100 years, and continues to today from clay mined on Sumas Mountain.

THINGS TO DO:

Make a list in 1-2 minutes of all the things you see that come from rocks and minerals? (1 minute) –church building stone, concrete pavers, parking metre poles and tops, cars, light pole, bikes, steel sculpture, window glass, brick, sidewalk, etc.

Visit the mosaic mural on the retaining wall running along Dunsmuir Street. What do the images represent?

Math activity: look at one of the modern highrises and count the number of floors to the top, including the first floor. If each floor is 4 metres high, calculate the total height of the building.

Figure 11 – Restored Holy Rosary Cathedral.

10 – Holy Rosary Cathedral (1899-1900), SE corner of Dunsmuir and Richards (N 49° 16' 55.8", W 123° 06' 50.8")

Gabriola Island Sandstone (sedimentary) was used to construct this beautiful church; coastal **granodiorite** (igneous plutonic) forms the very base. Look closely to see the medium sand grains and feel the sandy texture. Restoration of the church was completed in 2008. Severe weathering and degradation of the sandstone blocks was inevitable as the rock is not extremely well cemented, and the blocks were cut and placed with the depositional layers parallel (not perpendicular) to the walls.

When it comes to sedimentary rocks, geologists look at the grain size to interpret how energetic the depositional environment was. They look at the structures (laminations) to determine how the sediment was deposited (flat beds or ripples/ dunes). They look for fossils to determine if the environment was fresh, brackish or marine, and to determine the age of the rock.

Figure 12 – Gabriola Sandstone blocks make up the wall around and foundation of Holy Rosary Cathedral.

THINGS TO DO:

Review how sedimentary rocks form.

Look at the sandstone with a hand lens to identify the mineral grains that make up the sand. Determine if any of the black minerals are magnetite.

Feel and describe the sandstone.

Make a rubbing of the sandstone to record the texture using tracing paper and crayons. Look for fossils (plant or shells) in the sandstone.

Discuss lithification and limited strength and durability of cemented sedimentary rocks.

QUESTIONS TO ASK:

Where does this fit in the rock cycle? How can you tell?

Considering the size of the grains, what agent most likely deposited this sediment? (A: Water. Ice moves coarse grains and doesn't sort them, so big and small are deposited together; wind has limited lifting power and is a superb sorter.)

How can we tell what mineral is cementing the grains together? (A: Look closely, if there is a rusty rim, it could be iron oxide; if it reacts with HCl it is calcite; otherwise likely quartz.)

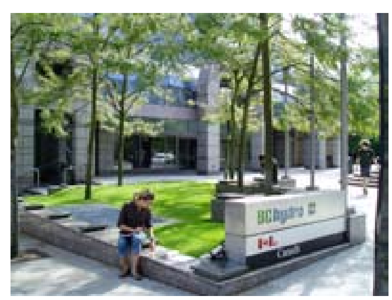


Figure 13 – BC Hydro Plaza and building uses megacrystic granite.

11 – BC Hydro Building (1991-92), 333 Dunsmuir Street (N 49° 16' 54.1", W 123° 06' 47.5")

Megacrystic Granite (**Texas Pink**) (igneous plutonic) is used for both the facing stone and outside plaza retaining wall and benches. Polished stone is used on plaza wall and benches; unpolished stone is used as facing stone on the lower part of the building and sidewalk at the entrance.

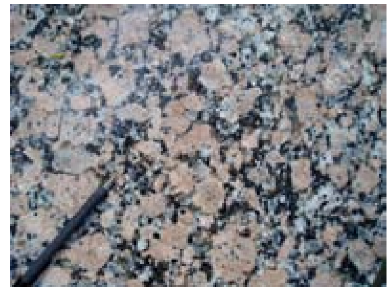


Figure 14 – Polished ***Texas Pink*** granite at BC Hydro Plaza with very coarse potassium-feldspar crystals (orange).

It is overall pinky-orange in colour and outstanding by its very coarsely-crystalline texture and huge (5cm+), pinky-orange, potassium (K) feldspar crystals. Also easy to recognize are clear quartz and black biotite.

THINGS TO DO:

Review how igneous rocks form.

Review the texture and internal structure that characterize igneous plutonic rocks. Bring a sample of obsidian to contrast very rapid cooling glass without crystalline texture.

Using tracing paper, draw the outlines of the mineral crystals on a polished bench tile.

Using tracing paper and crayon, do a rubbing of the granite on an unpolished tile surface to record the very coarse texture.

QUESTIONS TO ASK:

How many colours do you see? (A: At least 4.) What are they? (A: Minerals.)

How many minerals are in this rock?

Are the black mineral grains magnetic?

What is the shape of the biggest mineral crystals? (A: rectangular)

What does their size tell you about how this rock formed? (A: the magma cooled slowly underground.)

What does the size of the crystals indicate about the rate of cooling? (A: It cooled very slowly.)

Why don't you find fossils in this rock? (A: Organic materials do not survive melting.)

12 – Vancouver Main Post Office (1953-58), NE corner of Georgia and Homer (N 49° 16' 50.7", W 123° 06' 54.0")

Figure 15 – Inverse bas relief letter carrier in foliated granite, Vancouver Main Post Office.

This mid-century government building is clad and decorated inside with several different exotic **granitic** rocks (igneous plutonic) and a unique **fossiliferous limestone** (sedimentary). Interestingly, this Post Office is linked to the CPR Station (Waterfront Centre) by a tunnel along which originally ran a mail train!

Look on the outside and inside of the PO to find:

Granite 1 – orange/red, coarsely-crystalline with .5-1mm black biotite crystals, homogeneous internal structure.

Granite 2 – orange/red, very coarsely-crystalline with 3-4 cm potassium (K) feldspar crystals, foliated internal structure indicating an intermediate stage between metamorphic gneiss and igneous granite.

Granite 3 – light grey, coarsely-crystalline with 1-2 mm feldspar crystals (white) and other minerals, homogeneous internal structure.

Figure 16 – Coarsely-crystalline granite, Vancouver Main Post Office.

Limestone – beige, very fossiliferous; very distinctive, 1-2 cm **foramenifera,** bivalves, stromatolites, and a variety of other skeletal debris. (Foramenifera are omnivorous marine organisms related to amoebae and enclosed in a tiny shell riddled with pores.) Note cobble-size areas of slightly different composition and texture suggest that the limestone is made of re-deposited, semi-lithified limestone 'clasts'. Possible bedding also visible in the tiles defined by **stylolites** (pressure-dissolution surfaces) that form during burial. These rocks are most likely from Spain and are around ~50 million years old (Eocene).

Black marble is used on the counter tops in the lobby. They are soft and are pretty scratched up. The postal boxes and much of the ornamentation in the lobby are made of **polished aluminium.**

Figure 17 – Fossiliferous limestone with large football-shaped forams and other fossil debris; Vancouver Main Post Office. The dark grey zig zag surfaces are stylolites.

THINGS TO DO:

Look inside and out and take a tally of all the different rock types used here.

Note the difference between the appearance of polished and unpolished granite.

Review/ introduce sediments and sedimentary rocks made from skeletal debris.

*Sketch a cross-section of a fossil foramenifera (**foram** for short). Label the fossils you can identify; include a bar scale.*

Search the limestone for a stylolite along which a fossil is clearly partly dissolved.

Mapping / math exercise: using the scale on the field trip stop location map, carefully estimate the length of the train line between the PO and CPR train station. If the train travelled 10km/hr, how long did it take to bring the mail from the train station to the PO?

13 – Vancouver Public Library (VPL) (1995), SE corner of West Georgia and Homer Street

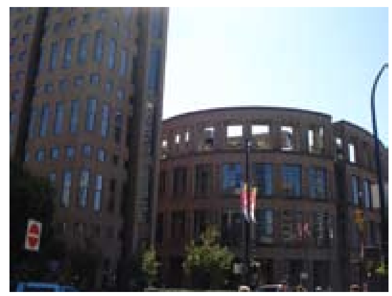


Figure 18 – Vancouver Public Library is made of concrete (and steel and glass).

Before you leave the Post Office, look across the street at the **Vancouver Public Library**. What does that building *appear* to be made of?

The VPL is made of **man-made** fine grained "conglomerate" with pink, very fine-grained volcanic (?) rocks plus small granitic fragments and scattered chips of wood. This structure was built by Lehigh Northwest Cement, a company operating out of Delta, BC. The surface material is **concrete** with the red stone aggregate quarried from the Kamloops area; special order and pretty expensive!

THINGS TO DO:

Look around inside and outside of the VPL and find ten things that this library is made of that come from rocks and minerals.

Use the lobby of the library for a lunch stop on a rainy day.

14 – The Centre for the Performing Arts, 777 Homer Street

Figure 19 – Panels of banded gneiss at the base of The Centre. (Umbrella handle for scale.)

The facade of this new theatre (1995) and adjoining hotel is an excellent example of a crystalline **metamorphic** rock with a foliated internal structure.

Gneiss – orange and black, coarsely-crystalline and prominently foliated with mm-wide to several tens of cm wide bands of light (orange) and dark minerals.

THINGS TO DO:

Demonstrate metamorphism / deformation of non-brittle materials using clay and pennies.

Introduce the term foliation (like a leaf).

Trace or sketch the internal structure of the gneiss. Add arrows to the figure to show the direction of pressure which created the foliation.

QUESTIONS TO ASK:

What kind of parent rock did this gneiss develop from? (A: granite.)

What would happen if this rock were to subjected to even higher T and P?

What rock have we seen en route that is that kind of 'parent'? (A: orange granites were seen at the Post Office just *down the street.)*

What other uses are there for this hard, decorative rock? (A: countertops, lobby floors, tombstones, etc.)

Figure 20 – Tiles of grey schist with garnet porphyroblasts, 850 Robson Street.

15 – 850 Robson Street (various store front facades)

The facade of this commercial and residential building is an excellent example of a prominently foliated, micaceous **metamorphic rock, schist**. The surfaces of the tiles on the vertical walls are the natural parting surfaces of the schist. They show other prominent linear structures, outlines of tabular "ghost crystals" and randomly scattered, outsized **garnet** crystals.

Schist – dark grey, fine- to medium-crystalline, with a **micaceous sheen**, prominent sub-horizontal partings and .5-3mm red garnet **porphyroblasts** which, like the micas, grew in the rock by the recombination of elements during metamorphism.

THINGS TO DO:

Review metamorphic rock formation and origin of foliation.

Closely examine the schist surface; observe garnet crystal shape.

QUESTIONS TO ASK:

What kind of parent rock might this schist have develop from? (A: likely from a shale or muddy siltstone.)

What rock have we seen en route that is that kind of 'parent'? (A: Nothing really; poorly lithified shales do not make good building stone.)

What other practical uses are there for this "flat" rock? (A: Floor tiles, walking paths)

16 – Geological Survey of Canada (GSC), 625 Robson Street (N 49° 16' 51.8", W 123° 07' 09.3")

The Geological Survey of Canada, established in 1842, is part of the Earth Sciences sector of Natural Resources Canada (NRCan). The GSC is Canada's national geoscience agency, with offices across Canada. The GSC provides Canada with a comprehensive geoscience knowledge base which contributes to economic growth, sustainable development, public health and safety and environmental protection.

The GSC is our country's premier agency for geoscience research. It pre-dates confederation, and was established to formally map the dominion and all its vital mineral resources.

The GSC office in Vancouver has a store front bookstore with an enormous selection of geoscience publications and resources for educators and the general public. The GSC staff offices are in the high rise above the bookstore, along with the GSC research library which is open to the public.

17 – Vancouver Art Gallery (VAG) (1906-12) 750 Hornby Street (N 49° 16' 59.3", W 123° 07' 12.6")

Figure 21 – Vancouver Art Gallery (West Georgia Street entrance).

The present day Vancouver Art Gallery occupies a majestic building originally constructed to house the BC Provincial Courts (which are now housed in a new building located in the block just South of the VAG).

VAG base is made of familiar-looking **granodiorite** (igneous plutonic) from Nelson Island; the structure above the base is made from **Haddington Island Andesite** (igneous volcanic)**.**

The **Lions** are made of coarsely-crystalline, light grey **granodiorite** from Hardy Island. These enormous sculptures would have been barged to Vancouver; they were hauled by oxen and carts from the waterfront to this building (D. Inglis, pers. comm., 2000).

Pillars on the original main entrance are made of beige, finely-crystalline Haddington Island **Andesite** (igneous volcanic) with very small brownish "pits" formed by weathered-out **biotite** crystals (red=rust=remnants of iron in the biotite).

The **portico floor** at the top of the main entrance staircase is imported **marble** (metamorphic). It is smooth, but not polished, light-coloured tiles with swirly, light and dark, irregular and discontinuous bands that record deformation during **metamorphism.** The parent rock is limestone, made mostly of calcite, though all organic structures have been obliterated by metamorphism. Calcite is soft, so it is easily scratched.

Figure 23 – Lions sculpted in granodiorite, VAG.

THINGS TO DO:

Review igneous textures: plutonic vs. volcanic.

Sketch the front of the VAG and label the rocks used in the base, main floors, Lions and pillars at the entrance.

Show the location of the Lions' granodiorite quarry on a BC map and discuss the route to Vancouver.

Discuss durability of the granitic sculptures to weathering compared to concrete used to hold the pieces of the sculpture together.

QUESTIONS TO ASK:

Based on the rock materials used, what other buildings seen on this tour would have been part of the downtown Vancouver landscape when this 'courthouse' was built? (A: Sinclair Centre, Royal Bank, Birks, SFU Wosk Centre, Standard Building.)

18 – BC Geological Survey, 865 Chancery (N 49° 16' 53.7", W 123° 07' 22.3")

The BC Geological Survey (BCGS) is part of the BC Ministry of Energy Mines and Petroleum Resources which manages the province's mineral resources (oil, gas, coal, metals, and industrial minerals). The BCGS is responsible for detailed geological mapping , first order assessment of mineral potential, compilation of all geoscience data, issuing Free Miner's licences, managing mineral claims, and inspecting BC mineral operations - among other things. They have regional offices scattered around the province, and offer full access to their entire mineral resources and geological databases online through Minfile and the Map Place (see References, page 1).

19 – Sheraton Vancouver Wall Centre, 1055 Burrard Street (Nelson Street side) (N 49° 16' 50.7", W 123° 07' 32.9")

When the Wall Centre was completed (2001) it became the tallest skyscraper in the city, only surpassed this year by Living Shangri La at Thurlow and Alberni. The outside courtyard design includes two special BC rocks: **basalt** from the Garibaldi volcanic and **marble** from a Vancouver Island quarry.

Figure 24 – Basalt columns in the Nelson Street garden at Wall Centre.

Basalt – elongate, vertically standing "boulders" in a garden display; dark grey-black, finely-crystalline (mossy covered) with irregular holes (vesicles=trapped gas bubbles); 6-sided **columns** ~30-60cm across produced by jointing as the basaltic lava quickly cooled at Earth's surface.

Marble – small sidewalk tiles, white with wispy dark bands (cloud-like)

THINGS TO DO:

Review volcanic igneous textures; introduce the phenomenon of cooling joints and column formation.

*View in the sidewalk and then sketch a basalt column in cross-section showing the **vesicles** and their preferred* *orientation. Add an arrow to indicate stretching in the lava flow direction.*

Show the location of the Garibaldi volcanic field on a BC map and discuss the origin of the Cascade chain of volcanoes.

Questions to Ask:

What key features identify this rock as volcanic? (A: small crystals, vesicles, columnar jointing.)

If this basaltic magma would have cooled slowly deep underground, what would the plutonic igneous rock look like? (A: coarsely-crystalline, black granite-like rock called gabbro.)

Why do all the cooling columns form a similar shape? (A: The lava is homogenous, the same material, therefore same % size reduction as it cools.)

Have you seen this rock in your travels (to Whistler)? (A: many excellent outcrops on the highway above Squamish, near the entrance to Garibaldi Provincial Park, Daisy Lake and Brandywine Falls.)

What gases escape during a volcanic eruption? (A: water vapour, CO_2, H_2S, etc.)

Figure 25 – Cross-section through a basalt column showing flow-aligned vesicles, Wall Centre.

20 – Andrew's Wesley United Church (1931-32), 1012 Nelson St. (N 49° 16' 51.0", W 123° 07' 33.7")

Granodiorite (igneous plutonic) from **Nelson Island;** light grey with white, potassium (K) feldspar, transluscent quartz, biotite and some magnetite. Note: different colours of feldspar.

Questions to Ask:

Why does the same rock show a change in colour and mineral composition? (A: magma differentiation.)

21 – First Baptist Church (1910-11), 969 Burrard Street (N 49° 16' 52.3", W 123° 07' 32.6")

Coastal granodiorite (**Fox Island or Nelson Island**) – granitic rock (igneous plutonic) with pale orange feldspars, large (1mm) biotite crystals, used to construct the church and outside walls.

Sandstone (sedimentary) – pale brown, fine-grained, lacking internal, structure used to make the window frames.

22 – Transport Canada Building, 800 Burrard (1981) (N 49° 16' 59.2", W 123° 07' 23.4")

Travertine (sedimentary) is used for the 2' by 3' floor and wall tiles. It is white and grey, fine-grained, with irregular **vugs** (1m to >1 cm), and uneven wavy lamination. This unique-looking and commonly used ornamental rock is made of **calcite** and formed by **precipitation from a mineral hotspring,** such as are seen in Yellowstone National Park and Mt. Meager west of Pemberton, BC. This is an **inorganic mineral precipitate**, likely with high temperature tolerant micro-biotic control.

Questions to Ask:

How can we easily tell that travertine is made of calcite? (A: scratch it with a nail (calcite is soft); check for a positive reaction with HCl.)

Now that we know that sedimentary rocks have holes in them too, what kinds of things might you look for to tell whether a holey rock is igneous or sedimentary? (A: fossils will identify the rock as sedimentary; a sparkly texture and mineral phenocrysts will identify it as volcanic, hardness.)

Figure 26 – Travertine wall panels showing irregular lamination and scattered to sub-parallel vugs; Transport Canada building.

If this rock was metamorphosed, what would it become? (A: marble.)

Things to do:

*Stop mid-block **(N 49° 16' 59.2", W 123° 07' 23.4")** with a view to the top of the copper roofed Hotel Vancouver. Look for all around for evidence of **weathering**.*

*Things look pretty good around here. The elements have not taken their toll. **Light standard:** what is it made of? Steel is iron and iron oxidizes to produce rust. Heavy duty paint is the protector. **Parking meter pole:** What is it made of? Coated with zinc (the great protector) to prevent rust. **Hotel Vancouver roof:** oxidized copper (bring a green copper penny).*

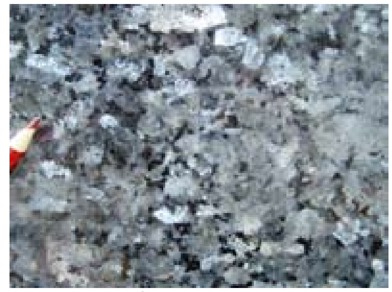


Figure 27 – Syenite wall panels with cm-sized, iridescent sodium-rich feldspar, HMV Megastore.

23 – HMV Megastore (1957)
(N 49° 17' 01.0", W 123° 07' 20.8")

The facade of this mid-20th century building, formerly the Vancouver Public Library is a very coarsely-crystalline, igneous plutonic rock, a **syenite**, from Norway, made up mostly of cm-size, rectangular crystals of a blue-grey sodium-rich feldspar.

Syenite – dark-grey, blue-black, very coarsely-crystalline (several mm – to 2.5cm) with opalescent feldspar crystals.

Questions to Ask:

How do we know this is an igneous plutonic rock? (A: very coarse, crystalline texture, no internal structure.)

What do the crystal sizes tell you about cooling rate? (A: very slowly.)

In what ways is it different from the granitic rocks seen in downtown buildings? (A: It is much darker, due to a very different mineral composition; it is much coarser than the local granitic rocks, and a little finer than the BC Hydro granite.)

Things to Do:

Determine if any of the black minerals are magnetite.

Look at the VPL dedication plaque on Burrard Street. Spot the geological error.

Figure 28 – Clayburn bricks made from Sumas Mountain clays (plus sand), Hotel Vancouver.

24 – Hotel Vancouver (1928-1939), 900 West Georgia St.
(N 49° 17' 02.8", W 123° 07' 18.5")

This CNR hotel replaced a very grand hotel that sits on the site of the present-day Sears store (Granville and Robson). Construction was halted during the Depression, so it took 11 years to complete. The outside is local building stone; exotic varieties are found inside.

Hotel Backside (south of drive through): Yellow **brick** here is made from Eocene clays mined on Sumas Mountain near Abbotsford. Clayburn Industries brick-making operation in Abbotsford continues to operate today (102 years in 2008). Bricks are made of clay minerals, with minor amounts of other silicate minerals (e.g. quartz, feldspar, mica), calcite, and iron oxides. The clay is mixed with water, then extruded and cut or moulded to form familiar bricks, then air dried, and finally fired in a kiln to produce a clay-silica fused, very durable building material.

Note: *Clayburn fireclay has very unique thermal properties. Fireclay bricks are used to form the walls of kilns (and other heat holding vessels) rather than to construct buildings.*

VAG hotel base is made of grey and white, speckled **granodiorite** (igneous plutonic) from **Nelson Island** and beige, pitted, finely-crystalline, **Haddington Island Andesite** (igneous volcanic)**.**

25 – Christ Church Cathedral (1889-1905), 690 Burrard Street (N 49° 17' 05.1", W 123° 07' 15.9")

Figure 29 – Century plus-old Christ Church Cathedral constructed from sandstone.

Christ Church Cathedral is one of the oldest buildings in the city, built after the Great Fire in 1886.

Foundation and steps are coastal **granodiorite** with scattered pebble-to cobble-size **xenoliths**. Xenoliths (*foreign stone*) are the remnants of the country rock that the magma intruded.

Church walls are constructed of brown, medium-grained **sandstone** with fine, horizontal and inclined laminations; black laminae are organic/coal material. Recognized as a local stone, but uncertain whether it was quarried from **Saturna Island** or **Gabriola Island**.

Figure 30 – Sandstone block from the Cathedral showing inclined laminations, some with black organic debris.

Note: Geologists look at the grain size to interpret how energetic the depositional environment was. They look at the internal structures (laminations) to determine how the sediment was deposited (flat beds or ripples/dunes). They look for fossils to determine if the environment was fresh, brackish or marine, and to determine the age of the rock.

Cobble "Creek": a mixture of cobbles and boulders set in concrete along the sidewalk on west side of church display the range of rock types found in nearby mountain streams. They sample the geology of mountains to the North eroded during Pleistocene glaciation and deposited here.

QUESTIONS TO ASK:

What is the most abundant mineral grain in the sandstone? (A: quartz or feldspar.)

What internal structures help identify this rock as sedimentary? (A: parallel and inclined laminations.)

If the black laminae is coal, what does that tell you about where this sand was deposited? (A: deltaic environment, freshwater-marine interface, land plants in swamps perhaps tolerant of marine incursions.)

Compared to the granitic rocks used to construct many of the other buildings, how does this sandstone rate for durability and resistance to weathering? Why? (A: Not so good - crystalline rocks are more coherent.)

Figure 31 – "Cobble Creek".

THINGS TO DO:

Review the formation of sedimentary rocks.

Feel and describe the sandstone.

Make a rubbing of the sandstone to record the texture using tracing paper and crayons.

Determine if any of the black minerals are magnetite.

Cobble Creek: Divide into groups and assign each to find examples of plutonic, volcanic, sedimentary and metamorphic rocks. Discuss how they became so rounded.

26 – 666 Park Place (1984) (N 49° 17' 06.0", W 123° 07' 11.6")

Granite - orange (feldspar), very coarsely-crystalline (4-5 mm), used everywhere as a polished facing stone on the building and garden walls and benches.

Questions to Ask:

If this rock was subjected to high temperature and pressure, what would it become? (A: gneiss)

27 – Marine Building (1929-30) NW corner of Burrard and W. Hastings St. (N 49° 17' 12.7", W 123° 07' 00.4")

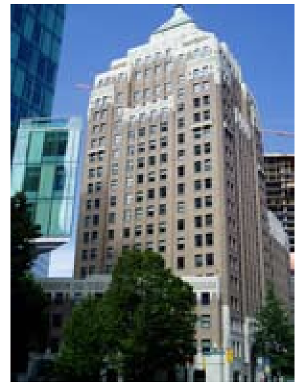


Figure 32 – The Marine Building from Burrard Street.

The stately Marine Building was inspired by the notion of "a giant rock rising from the sea, clinging with sea life"; it is capped by a pyramidal copper roof. It was built to house BC firms engaged in shipping, logging, mining and insurance and import/export; some the original tenants are still in place. The outside base is polished **granodiorite** from **Kelly Island;** glazed **terra cotta** panels are used around the entrance way**; marble** and **travertine** are used to create intricate scenes and graphic designs on the interior floors; **brass** fixtures ornament the foyer.

Things to Do:

Look at the roof top from afar and interpret what the roof is made of.

Visit the lobby to examine the stone materials and see if the decorative floor and walls indicate who resides in the building.

Look at the Directory to see if mining companies still have offices here.

Math activity: If every story is ~ 5m high, estimate how tall the Marine Building is. (A: ~110m)

28 – Terminal City Club (1998), 837 W. Hastings Street (N 49° 17' 10.8", W 123° 06' 55.4")

This new highrise is clad in two unique sedimentary building stones that are not found locally.

Fossiliferous limestone (sedimentary) panels veneer the building front at sidewalk level on Hastings. It is a beige-coloured, large-scale cross-bedded **grainstone**, a type of limestone made of sand-size fragments of shells made of calcite; imported from Bruni Oggi Quarry, Italy.

Tyndall Stone panels veneer all the outer walls of the upper parts of the entire building and are readily seen on the west-side facing the plaza. This rock is tan and grey, **burrow-mottled limestone** (sedimentary), fine-grained, with out-sized fossils (15 cm diametre coral-like *stromatoporoid* (calcareous sponge), 5 -10 cm bivalves, snails, cephalopods, etc.). This rock comes from near Winnipeg, MB where it has been quarried since 1832.

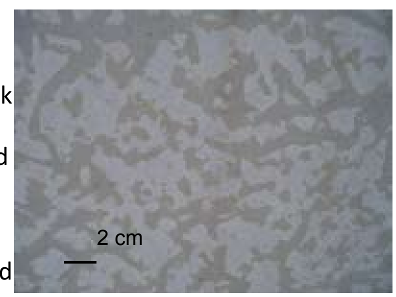


Figure 33 - Unique borrow-mottled limestone/dolostone from Manitoba, in the trade referred to as Tyndall Stone, on the new Terminal City Club.

Things to Do:

Trace and shade the burrow-mottled pattern on paper.

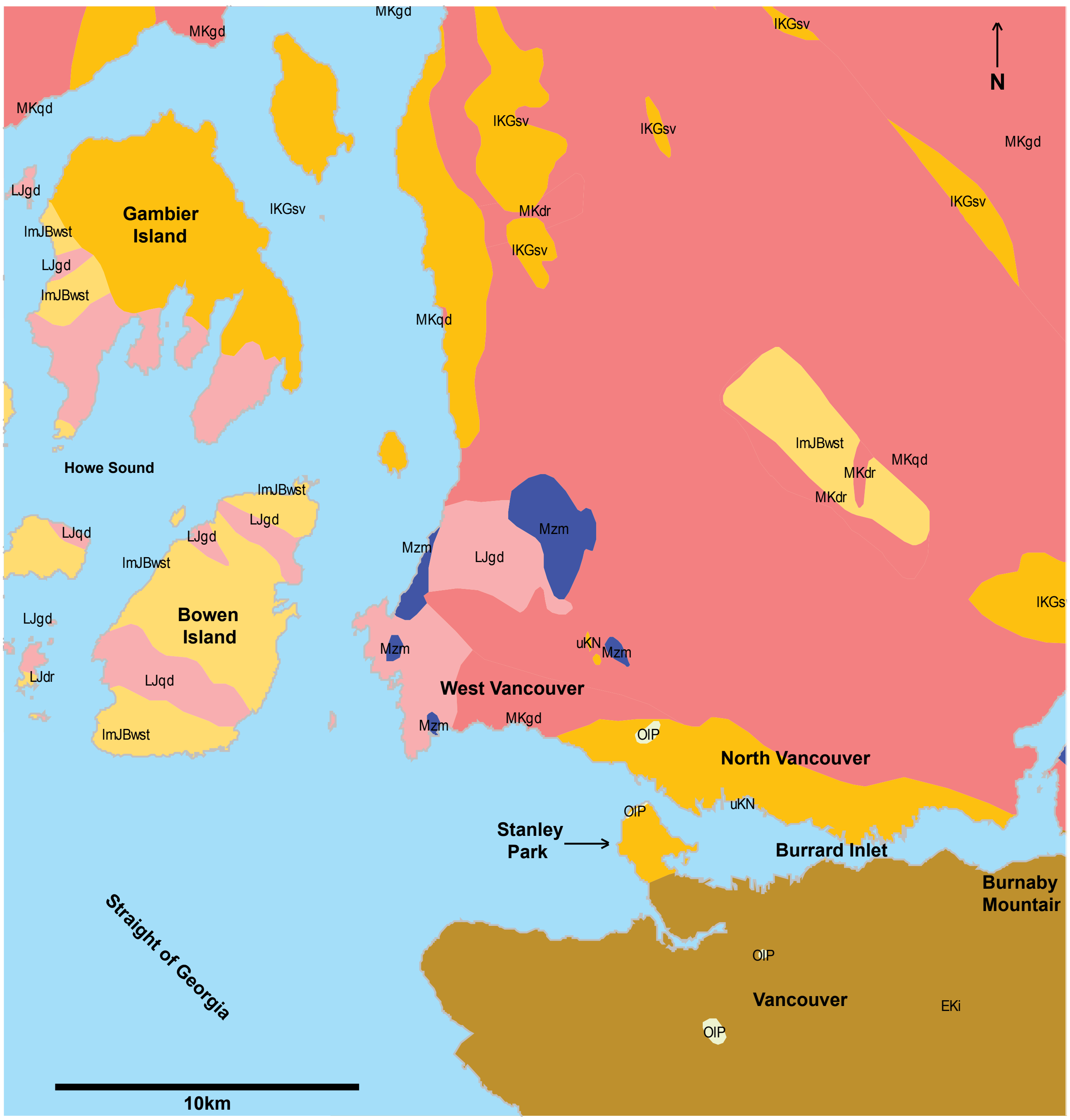
Questions to Ask:

Based on the size of the mottles, can you estimate the size of the creature that did the burrowing? (A: 1-2 cm)

If this sediment had not been burrowed, what sedimentary structures might we see? (A: laminations)

What will this rock become if it is metamorphosed? (A: marble.)

LOWER MAINLAND GEOLOGY MAP



Lower Mainland Geology Legend

Bounding Box: *North: 49.544 South: 49.225 West: -123.485 East: -122.553*
NTS Mapsheet: 092G

Oligocene

OIP	**Point Grey Eruptives:** basaltic volcanic rocks

Eocene

EKi	**Kitsilano Formation:** undivided sedimentary rocks

Mesozoic

Mzm	metamorphic rocks, undivided

Upper Cretaceous

Naniamo Group

uKN	**Extension - Protection Formation:** coarse clastic sedimentary rocks

Mid-Cretaceous

MKdr	dioritic intrusive rocks
MKgd	granodioritic intrusive rocks
MKqd	quartz dioritic intrusive rocks

Lower Cretaceous

Gambier Group

lKGsv	marine sedimentary and volcanic rocks

Late Jurassic to Early Cretaceous

LJKdr	dioritic intrusive rocks
LJKgd	granodioritic intrusive rocks
LJKqd	quartz dioritic intrusive rocks

Late Jurassic

LJdr	dioritic intrusive rocks
LJgd	granodioritic intrusive rocks
LJqd	quartz dioritic intrusive rocks

Middle Jurassic to Late Jurassic

MLJqd	quartz dioritic intrusive rocks

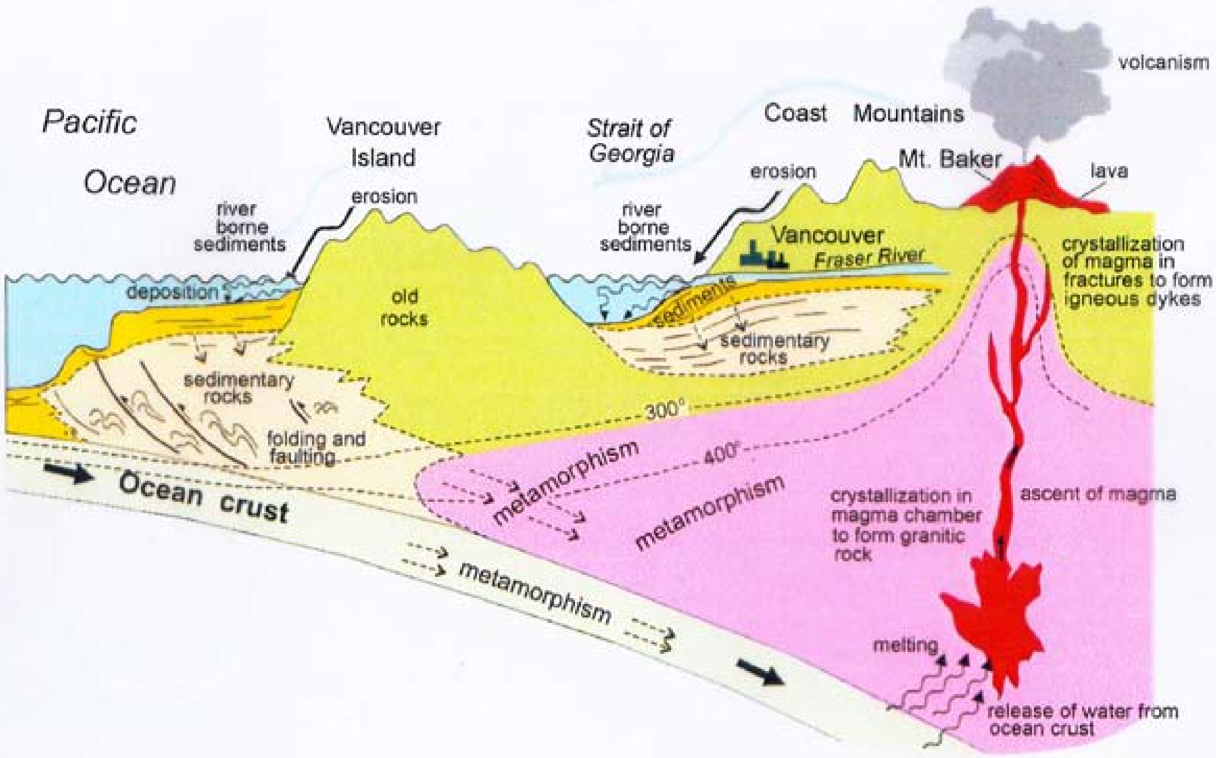
Lower Jurassic to Middle Jurassic

Bowen Island Group

lmJBwst	argillite, greywacke, wacke, conglomerate turbidites

British Columbia Ministry of Energy, Mines and Petroleum Resources
Geological Survey Branch

Geologic Processes in Coastal B.C.



Natural Resources Canada   Ressources naturelles Canada

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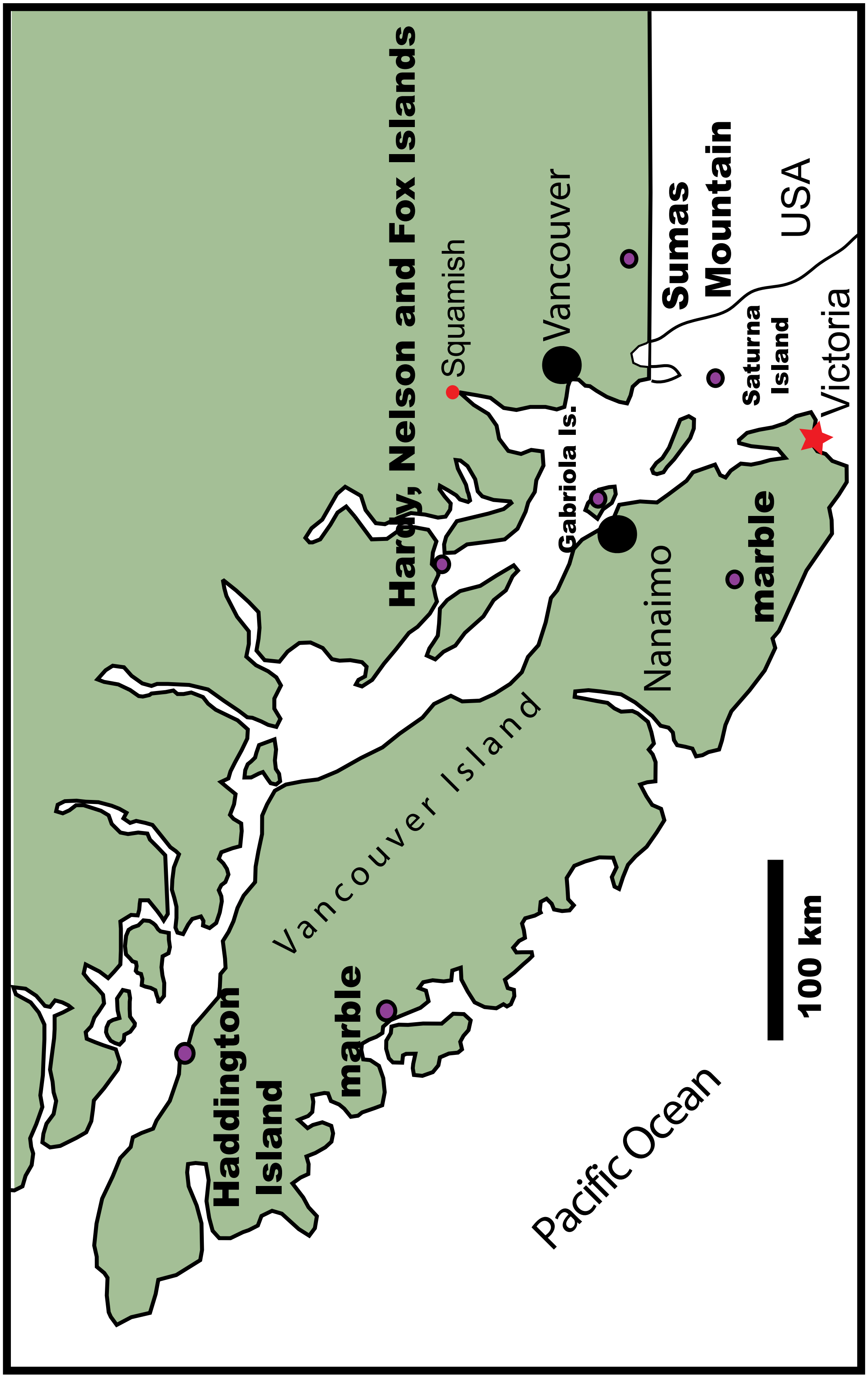
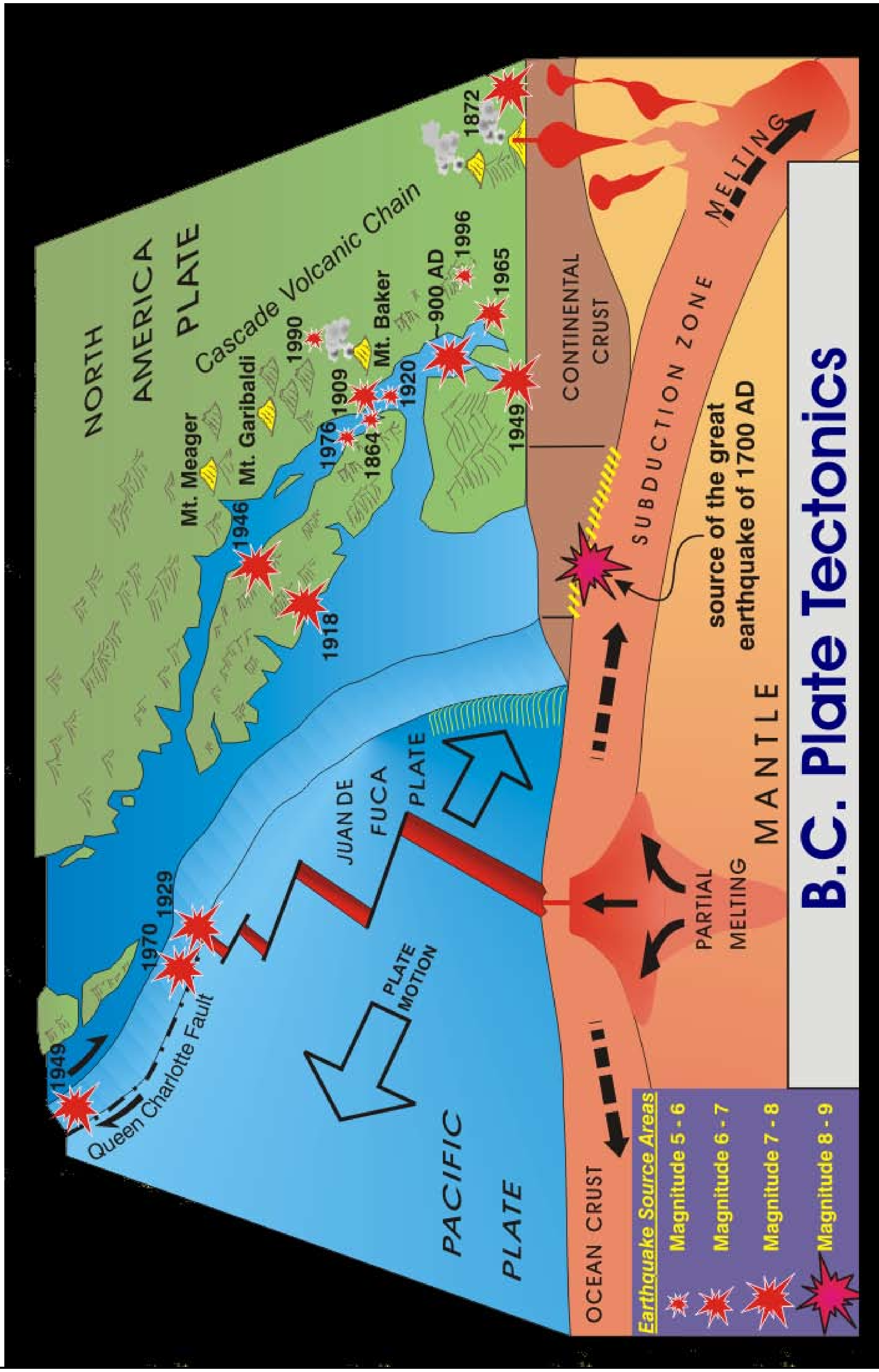

Hardy, Nelson and Fox Islands
Squamish
Vancouver
Sumas
Mountain
USA
Saturna
Island
Victoria
Gabriola Is.
Nanaimo
marble
Vancouver Island
Haddington
Island
marble
Pacific Ocean
100 km


B.C. Plate Tectonics
NORTH AMERICA PLATE
Cascade Volcanic Chain
Mt. Meager
Mt. Garibaldi
Mt. Baker
1990
1976
1909
1864
1920
~900 AD
1996
1965
1949
1872
1946
1918
1970
1929
1949
Queen Charlotte Fault
JUAN DE FUCA PLATE
PLATE MOTION
PACIFIC PLATE
CONTINENTAL CRUST
OCEAN CRUST
SUBDUCTION ZONE
MELTING
source of the great earthquake of 1700 AD
MANTLE
PARTIAL MELTING
Earthquake Source Areas
Magnitude 5 - 6
Magnitude 6 - 7
Magnitude 7 - 8
Magnitude 8 - 9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Ressources naturelles Canada
Mount Baker (volcano)
to Seattle
Canada-U.S. International Border
Strait of Georgia
Fraser River
Vancouver
Coast Mountains
to Whistler
Howe Sound
Vancouver, Canada: Where People Meet Mountains, River, and Sea
Canada

THE ROCK CYCLE - HOW ROCKS CHANGE