

## BIG IDEAS

### Earth Materials

Minerals and rocks are the foundation of the rock cycle and can be used as resources that drive industry and global economies.

### Geologic Time

Geologic time is preserved in Earth's rock record as fossils and reflects profound changes in the history of life on Earth.

### Plate Tectonic Theory

Tectonic plates are in constant motion and their interactions produce earthquakes, volcanoes, and characteristic landforms on the Earth's surface.

### Deformation and Mapping

Geological maps and models are tools used to represent surface features and subsurface structures.

### Surface Processes and the Hydrosphere

Weathering and erosion processes shape landscapes through the interaction of the geosphere and hydrosphere.

## Learning Standards

Curricular Competencies	Content
<p><i>Students are expected to be able to do the following:</i></p> <p><b>Questioning and predicting</b></p> <ul style="list-style-type: none"> <li>• Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal, local, or global interest</li> <li>• Make observations aimed at identifying their own questions, including increasingly abstract ones, about the natural world</li> <li>• Formulate multiple hypotheses and predict multiple outcomes</li> </ul> <p><b>Planning and conducting</b></p> <ul style="list-style-type: none"> <li>• Collaboratively and individually plan, select, and use appropriate investigation methods, including field work and lab experiments, to collect reliable data (qualitative and quantitative)</li> <li>• Assess risks and address ethical, cultural, and/or environmental issues associated with their proposed methods</li> <li>• Use appropriate SI units and appropriate equipment, including digital technologies, to systematically and accurately collect and record data</li> <li>• Apply the concepts of accuracy and precision to experimental procedures and data:               <ul style="list-style-type: none"> <li>– significant figures</li> <li>– uncertainty</li> <li>– scientific notation</li> </ul> </li> </ul>	<p><i>Students are expected to know the following:</i></p> <p><b>Earth Materials</b></p> <ul style="list-style-type: none"> <li>• minerals can be classified and <b>grouped</b> based on their <b>properties</b> and composition</li> <li>• rocks can be compared and classified based on their properties and processes of formation:               <ul style="list-style-type: none"> <li>– <b>igneous</b></li> <li>– <b>sedimentary</b></li> <li>– <b>metamorphic</b></li> </ul> </li> <li>• <b>resource deposits</b> within BC and globally:               <ul style="list-style-type: none"> <li>– origin and formation</li> <li>– <b>economic, environmental, and First Peoples considerations</b></li> </ul> </li> </ul>

Learning Standards (continued)

Curricular Competencies	Content
<p><b>Processing and analyzing data and information</b></p> <ul style="list-style-type: none"> <li>• Experience and interpret the local environment</li> <li>• Apply First Peoples perspectives and knowledge, other ways of knowing, and local knowledge as sources of information</li> <li>• Seek and analyze patterns, trends, and connections in data, including describing relationships between variables, performing calculations, and identifying inconsistencies</li> <li>• Construct, analyze, and interpret graphs, models, and/or diagrams</li> <li>• Use knowledge of scientific concepts to draw conclusions that are consistent with evidence</li> <li>• Analyze cause-and-effect relationships</li> </ul> <p><b>Evaluating</b></p> <ul style="list-style-type: none"> <li>• Evaluate their methods and experimental conditions, including identifying sources of error or uncertainty, confounding variables, and possible alternative explanations and conclusions</li> <li>• Describe specific ways to improve their investigation methods and the quality of the data</li> <li>• Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled</li> <li>• Demonstrate an awareness of assumptions, question information given, and identify bias in their own work and in primary and secondary sources</li> <li>• Consider the changes in knowledge over time as tools and technologies have developed</li> <li>• Connect scientific explorations to careers in science</li> <li>• Exercise a healthy, informed skepticism and use scientific knowledge and findings to form their own investigations to evaluate claims in primary and secondary sources</li> <li>• Consider social, ethical, and environmental implications of the findings from their own and others' investigations</li> <li>• Critically analyze the validity of information in primary and secondary sources and evaluate the approaches used to solve problems</li> <li>• Assess risks in the context of personal safety and social responsibility</li> </ul>	<p><b>Geologic Time</b></p> <ul style="list-style-type: none"> <li>• the geologic time scale sequences the <b>major events in Earth's history</b></li> <li>• <b>the fossil record:</b> <ul style="list-style-type: none"> <li>– <b>evidence of evolution</b></li> <li>– <b>methods of fossil formation</b></li> <li>– <b>fossil deposits in BC</b></li> <li>– First Peoples perspective on the fossil record</li> </ul> </li> <li>• dating methods of rocks and events: <ul style="list-style-type: none"> <li>– <b>relative dating</b></li> <li>– <b>absolute dating</b></li> </ul> </li> <li>• Earth's past can be reconstructed by correlating fossils and rock strata</li> </ul> <p><b>Plate Tectonic Theory</b></p> <ul style="list-style-type: none"> <li>• earthquakes are a result of plate motion: <ul style="list-style-type: none"> <li>– <b>properties</b></li> <li>– <b>measurement</b></li> <li>– <b>hazards</b></li> </ul> </li> <li>• the origins of magma and volcanism are related to plate tectonic theory: <ul style="list-style-type: none"> <li>– <b>within Earth</b></li> <li>– <b>at the Earth's surface</b></li> </ul> </li> <li>• First Peoples knowledge of geologic events</li> <li>• various <b>sources of evidence</b> support a layered model of Earth</li> </ul>

Learning Standards (continued)

Curricular Competencies	Content
<p><b>Applying and innovating</b></p> <ul style="list-style-type: none"> <li>• Contribute to care for self, others, community, and world through individual or collaborative approaches</li> <li>• Co-operatively design projects with local and/or global connections and applications</li> <li>• Contribute to finding solutions to problems at a local and/or global level through inquiry</li> <li>• Implement multiple strategies to solve problems in real-life, applied, and conceptual situations</li> <li>• Consider the role of scientists in innovation</li> </ul> <p><b>Communicating</b></p> <ul style="list-style-type: none"> <li>• Formulate physical or mental theoretical models to describe a phenomenon</li> <li>• Communicate scientific ideas, information, and perhaps a suggested course of action, for a specific purpose and audience, constructing evidence-based arguments and using appropriate scientific language, conventions, and representations</li> <li>• Express and reflect on a variety of experiences, perspectives, and worldviews through place</li> </ul>	<p><b>Deformation and Mapping</b></p> <ul style="list-style-type: none"> <li>• rock strata can behave in a plastic or brittle manner, depending on <b>internal and external influences</b></li> <li>• <b>faulting and folding</b> are characteristic of specific tectonic environments and forces: <ul style="list-style-type: none"> <li>– compressional</li> <li>– tensional</li> <li>– shear</li> </ul> </li> <li>• <b>geologic maps</b>, cross-sections, and block diagrams can be used to represent surface and subsurface structures: <ul style="list-style-type: none"> <li>– geologic history</li> <li>– resource exploration</li> </ul> </li> </ul> <p><b>Surface Processes and the Hydrosphere</b></p> <ul style="list-style-type: none"> <li>• <b>weathering and erosional processes</b> modify the Earth's surface and produce characteristic features</li> <li>• periods of glaciation produce characteristic <b>erosional and depositional</b> features and landforms: <ul style="list-style-type: none"> <li>– causes of glaciation</li> <li>– local landscapes within BC</li> <li>– First Peoples knowledge of landforms over time</li> </ul> </li> <li>• running water (streams and rivers) produces characteristic erosional and depositional <b>features and landforms</b></li> <li>• <b>groundwater</b> is a renewable resource whose quality and quantity are <b>affected by human activities</b> locally and globally</li> <li>• causes and controls of mass wasting</li> </ul>

**Big Ideas – Elaborations**

**Earth Materials**

*Sample opportunities to support student inquiry:*

- What is the difference between rocks and minerals?
- How does the rock cycle change rocks and minerals?
- Which resources are important in the local area?

**Geologic Time**

*Sample opportunities to support student inquiry:*

- How is geologic time different from standard time?
- Why is geologic time broken into eons, eras, and epochs?
- Do all living things become fossils?
- Why is the fossil record considered to be “incomplete”?

**Plate Tectonic Theory**

*Sample opportunities to support student inquiry:*

- What evidence suggests that a supercontinent will form again?

**Deformation and Mapping**

*Sample opportunities to support student inquiry:*

- Who would have a use for geologic maps?
- What information would be found on a geologic map?

**Surface Processes and the Hydrosphere**

*Sample opportunities to support student inquiry:*

- How do wind, water, and ice shape our landscape?
- How do scientists know what paleo-environments looked like?

Curricular Competencies – Elaborations

**Questioning and predicting:**

*Sample opportunities to support student inquiry:*

- Classify fossils using student-created criteria.
- Collect data to establish where most earthquakes tend to occur and the risks associated with living in earthquake-prone areas.
- Predict the geologic history of an area given the types of structures evident in map or model form.
- Where does the water in our homes come from? Where does it go?

**Planning and conducting:**

*Sample opportunities to support student inquiry:*

- Observe and test for physical and chemical properties of minerals (e.g., colour, crystal form, cleavage, fracture, specific gravity, acid reaction, magnetism, hardness).
- Observe and compare physical properties of igneous rocks (e.g., texture, composition, density).
- Compare and contrast different fossilization methods.
- Classify fossils based on their taxonomy, habitats, and lifestyles.
- Collect and map local seismic data.
- Investigate the local area for evidence of tectonic plate motion.
- Survey a local geologic structure and create a block diagram.
- Explore local coastlines, parks, watersheds, lakes, and other areas to collect evidence of weathering and erosion.

**Processing and analyzing data and information:**

*Sample opportunities to support student inquiry:*

- Determine the most likely environment of deposition for sedimentary rock samples, based on their properties and composition (e.g., texture, layering, fossils, chemical, clastic).
- Solve stratigraphy problems, including:
  - dating rocks, faults, and deformation events
  - using fossils to correlate rock strata that extend across large distances
  - using fossils to determine the geologic history of an area
  - using fossils, along with other relative dating methods (e.g., superposition, cross-cutting relationships), to determine the age of rocks and approximate dates of geologic events
  - using fossils to establish whether and when an unconformity has occurred in a given sequence of rock strata
- Apply relative dating principles to establish the geologic history and the sequence of events in a given sequence of rock strata. Relative dating principles may include:
  - law of superposition
  - law of cross-cutting relationships
  - law of Inclusions
  - law of unconformities

Curricular Competencies – Elaborations

- Explore different tectonic settings in various parts of the world and classify different plate boundaries based on types of features (e.g., types of volcanoes, trenches, location of earthquake foci), landforms (e.g., mountain ranges), ages of rock, and other characteristics.
- Identify heat and convection in the upper mantle as being the primary cause for the distribution of plates on the Earth's surface.
- Use multiple seismographs and triangulation to locate an earthquake's epicentre on a map.
- Examine geologic maps from the local area and make observations and connections to:
  - rock types
  - mineral resource (e.g., mines, sand and gravel sources)
  - faults
  - topographic information
- Explore and classify geological structures:
  - various folds that may be produced in rock strata
  - various sources of evidence (e.g., rock types, ages of rocks, fossil data)
  - various fault structures (normal, reverse, thrust, strike-slip)
- Identify and interpret patterns in rock strata (e.g., ages of rocks, strike and dip patterns in rock strata, fossil information) that can be applied to identify a geological structure (e.g., anticline, syncline).
- Differentiate erosional and depositional glacial features as observed through illustrations and photographs.
- Visit areas that have a history of landslides, soil creep, slumping, and other forms of mass movement to observe the causes and effects of mass movements.

**Evaluating:**

*Sample opportunities to support student inquiry:*

- Evaluate ore-forming processes (hydrothermal ore genesis) and the role of heat and fluids in the formation of ore deposits.
- Debate the economic, environmental, and social impacts of oil and gas pipelines in BC.
- Consider the social impacts of resources development on First Peoples communities.
- Explain how a variety of factors (e.g., price, concentration, accessibility, size, environmental considerations) determine whether it is economically feasible to extract a given occurrence of a mineral, rock, or other resource.
- Consider the fossil record as a source of evidence to support the theory of evolution, and explore wider concepts, including some of the following:
  - punctuated equilibrium
  - gradualism
  - convergent evolution
  - adaptive radiation
  - extinction
- Discuss the limits of technology (e.g., effect of metamorphism, half-life adequate sample size) on absolute dating methods.
- Consider how the role of seismic waves (their velocities and their interaction with internal boundaries) supports the idea of a layered model of Earth.

Curricular Competencies – Elaborations

- Relate fossil evidence (*Glossopteris*), paleo-glacial evidence, coastline fit, offset mountain ranges, and other evidence to support the theory of plate tectonics. Evaluate the evidence and offer contrarian views that may contradict the theory.
- Show the interrelationships among a geologic map, a cross-section, and a block diagram for a specific feature (e.g., fold, fault, dome).
- Evaluate geological maps and 3D models, with the aid of geological symbols (e.g., strike and dip symbols, syn-form and anti-form symbols), to identify and classify various types of folds and faults and subsurface structures.
- Assess and evaluate subsurface geology as having porous and permeable geologic strata capable of storing water (aquifers), or fossil fuels (oil, natural gas).
- Investigate groundwater use and abuse by visiting the local landfill. Debate suitable locations for landfills.
- Evaluate maps of depositional features (moraines, eskers, outwash plains, and glacial erratics) in an effort to establish the direction of ice transport and the maximum extent of ice in a given study area.

**Applying and innovating:**

*Sample opportunities to support student inquiry:*

- Create fossils (molds and casts) of local plants.
- Investigate structural designs, using toothpicks and marshmallows that are resistant to surface wave ground shaking (model with shake table or pan of jello that can be manually shaken).
- Create a model of a subsurface structure and in a shoebox and (in groups) investigate different survey techniques to generate a geologic map and block diagram.
- Develop a local action plan to educate residents on the importance of water conservation.

**Communicating:**

*Sample opportunities to support student inquiry:*

- Create an illustrated guide to the Mohs scale of mineral hardness, using common substances found around the home.
- Make an illustration or animated video that models the components of the rock cycle.
- Create an infographic or timeline detailing the major events of the geologic time scale.
- Create a model of Earth and its interior that represents the various layers, with particular emphasis on:
  - thickness of layers
  - composition of layers
  - temperature and state of matter within layers
- Produce a map of a fictional planet with plate boundaries similar to Earth's. Identify various types of boundaries, and provide evidence for others to determine the types of boundaries illustrated in your map.
- Construct a geological map using appropriate data.
- Create a model of a working aquifer, with an active, pumping well.

Content – Elaborations

**Earth Materials**

- **grouped:** silicates, oxides, sulphides, carbonates, phosphates
- **properties:** cleavage, fracture, hardness, colour, streak, lustre
- **igneous:**
  - Bowen’s reaction series
  - Relate texture to rate of crystallization for extrusive (volcanic) and intrusive (plutonic) igneous rocks (e.g., cooling rate, flow behaviour).
  - Classify igneous rocks according to texture (e.g., vesicular, glassy) and composition (e.g., felsic, intermediate, mafic).
  - Describe the features of the specific igneous rocks (e.g., granite, andesite, tuff, rhyolite, basalt, obsidian, pumice, porphyry).
  - Identify and describe volcanic and intrusive features (e.g., lava, nuee ardent, batholiths, sills, dikes).
- **sedimentary:**
  - Contrast clastic sediments and chemical (precipitate or biochemical) sediments and the rocks they become.
  - Relate particle size, shape, sorting, fossils, and organic structures to particular depositional environments.
  - Classify sedimentary rocks according to properties (e.g., conglomerate, breccia, sandstone, chert, coal).
  - Identify sedimentary features (e.g., stratification, crossbedding, ripple marks, graded bedding, varves).
  - Describe sedimentary features that affect porosity and permeability.
- **metamorphic:**
  - Relate the types and characteristics of metamorphic rocks to parent rock, temperature, pressure, and chemical conditions.
  - Describe the features of metamorphic rocks (e.g., slate, phyllite, schist, gneiss, marble).
  - foliated and non-foliated rocks
  - contact and regional metamorphism
  - Explain the significance of metamorphic grade (e.g., with reference to coal).
- **resource deposits:** Consider the resources in the local area:
  - hydrothermal and volcanogenic ore deposits
  - placer and surficial deposits
  - oil, gas, coal, and fossil fuel deposits
- **economic, environmental, and First Peoples considerations:**
  - role of geochemical or geophysical data in locating geological resources
  - factors used to determine economic feasibility of extracting a geologic resource (e.g., price, concentration, accessibility, size, and environmental)
  - uses of geologic resources in BC
  - current resource conflicts (e.g., pipelines, oil sands)
  - current resource conflicts with First Peoples communities

**Geologic Time**

- **major events in Earth’s history:** formation of oldest rocks, earliest recorded life, invertebrates dominated, first land plants, reptiles dominated, appearance of flowering plants, Rocky Mountain orogeny, mass extinctions

Content – Elaborations

- **the fossil record:** *Foraminifera, Mollusca, Brachiopoda, Echinodermata, Arthropoda* (trilobites), *Coelenterata* (corals), *Vertebrata, Graptolithina, Conodonts*, algae, plants
- **evidence of evolution:** natural selection, adaptive radiation, punctuated equilibrium
- **methods of fossil formation:** cast and mold, permineralization, carbonization
- **fossil deposits in BC:** Burgess Shale, Marble Canyon fossil beds
- **relative dating:** superposition, unconformities, cross-cutting, index fossils, law of faunal succession
- **absolute dating:** radioactive dating

Plate Tectonic Theory

- **properties:** shallow, medium, deep focus and primary, secondary and surface waves
- **measurement:** seismographs, Richter, Mercalli
- **hazards:** tsunamis, city infrastructures, liquefaction
- **within Earth:** contact metamorphism, plutonic activity, sills, dykes
- **at the Earth's surface:** composition, flow behaviours, volcano types, extrusive materials, columnar jointing
- **sources of evidence:** seismic wave velocities and paths, shadow zones, state of material, density, composition

Deformation and Mapping

- **internal and external influences:** temperature, pressure, chemical composition
- **faulting:** normal, reverse, thrust, strike-slip
- **folding:** symmetrical, asymmetrical, plunging folds, domes, basins
- **geologic maps:**
  - geologic mapping symbols (e.g., strike and dip)
  - age of strata
  - methods (e.g., surveying, GIS)

Surface Processes and the Hydrosphere

- **weathering:**
  - chemical, physical, and biological weathering
  - weathering potential of minerals in Bowen's reaction series (e.g., stability of quartz)
- **erosional processes:** wind, water, gravity, ice
- **erosional:** cirques, arêtes, glacial striae, horns, U-shaped valleys
- **depositional:** moraines, drumlins, outwash plains, eskers, glacial till

## Content – Elaborations

- **features and landforms:**
  - Describe various methods by which materials move in streams and rivers (e.g., bedload, solution, saltation, traction).
  - Describe the processes by which materials are deposited by running water, with an emphasis on particle size and sorting, river discharge, and formation of meanders and oxbow lakes.
- **groundwater:**
  - water table, zone of saturation, aquifers
  - effect of porosity and permeability on aquifer characteristics
- **affected by human activities:** urbanization, agriculture, sea-water contamination of groundwater, over-pumping of the resource
- **controls of mass wasting:** drainage, installation of perforated pipes

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