BIG IDEAS

Minerals, rocks, and earth materials form in response to conditions within and on the Earth's surface and are the foundation of many resource-based industries.	**Earth's geological and biological history** is interpreted and inferred from information stored in rock strata and fossil evidence.	The **plate tectonic theory** explains the changes that occur within Earth and to Earth's crust throughout geological time.	The **form, arrangement, and structure of rocks** are affected by three-dimensional forces over time.	**Weathering and erosion processes** continually reshape landscapes through the interaction of the geosphere with the hydrosphere and atmosphere.

Learning Standards

Curricular Competencies

Students are expected to be able to do the following:

Questioning and predicting

- Demonstrate a sustained intellectual curiosity about a scientific topic or problem of personal, local, or global interest
- Make observations aimed at identifying their own questions, including increasingly abstract ones, about the natural world
- Formulate multiple hypotheses and predict multiple outcomes

Planning and conducting

- Collaboratively and individually plan, select, and use appropriate investigation methods, including field work and lab experiments, to collect reliable data (qualitative and quantitative)
- Assess risks and address ethical, cultural, and/or environmental issues associated with their proposed methods
- Use appropriate SI units and appropriate equipment, including digital technologies, to systematically and accurately collect and record data
- Apply the concepts of accuracy and precision to experimental procedures and data:
  - significant figures
  - uncertainty
  - scientific notation

Content

Students are expected to know the following:

- classification of **minerals**
- processes of rock formation:
  - **igneous**
  - **sedimentary**
  - **metamorphic**
- B.C. **resource deposits** and others:
  - origin and formation
  - **economic, environmental, and First Peoples considerations**
- the geologic time scale and **major events in Earth's history**
- the local and global **fossil record**:
  - **evidence of evolution**
  - methods of fossil formation
  - First Peoples perspectives
- methods for **relative and absolute dating** of rocks, fossils, and geologic events
- reconstruction of Earth's past through correlation of fossil data and rock strata

Learning Standards (continued)

Curricular Competencies	Content
Processing and analyzing data and information • Experience and interpret the local environment • Apply First Peoples perspectives and knowledge, other ways of knowing, and local knowledge as sources of information • Seek and analyze patterns, trends, and connections in data, including describing relationships between variables, performing calculations, and identifying inconsistencies • Construct, analyze, and interpret graphs, models, and/or diagrams • Use knowledge of scientific concepts to draw conclusions that are consistent with evidence • Analyze cause-and-effect relationships **Evaluating** • Evaluate their methods and experimental conditions, including identifying sources of error or uncertainty, confounding variables, and possible alternative explanations and conclusions • Describe specific ways to improve their investigation methods and the quality of their data • Evaluate the validity and limitations of a model or analogy in relation to the phenomenon modelled • Demonstrate an awareness of assumptions, question information given, and identify bias in their own work and in primary and secondary sources • Consider the changes in knowledge over time as tools and technologies have developed • Connect scientific explorations to careers in science • Exercise a healthy, informed skepticism and use scientific knowledge and findings to form their own investigations to evaluate claims in primary and secondary sources • Consider social, ethical, and environmental implications of the findings from their own and others' investigations • Critically analyze the validity of information in primary and secondary sources and evaluate the approaches used to solve problems • Assess risks in the context of personal safety and social responsibility	• the formation of **volcanic and deformational features** through plate movement • **evidence** that supports a layered model of Earth • **earthquakes** and analysis of seismic waves • First Peoples knowledge of geologic events • **internal and external factors** that affect the plasticity of rock strata • **faulting and folding** • **geologic maps, cross-sections, and block diagrams** • **weathering and erosion processes** • First Peoples knowledge of landforms over time • **periods of glaciation** • **groundwater and aquifers** • causes and **controls of mass wasting**

Learning Standards (continued)

Curricular Competencies	Content
Applying and innovating • Contribute to care for self, others, community, and world through individual or collaborative approaches • Co-operatively design projects with local and/or global connections and applications • Contribute to finding solutions to problems at a local and/or global level through inquiry • Implement multiple strategies to solve problems in real-life, applied, and conceptual situations • Consider the role of scientists in innovation **Communicating** • Formulate physical or mental theoretical models to describe a phenomenon • Communicate scientific ideas and 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 • Express and reflect on a variety of experiences, perspectives, and worldviews through **place**	

Big Ideas – Elaborations

- **Minerals, rocks, and earth materials:**
  Sample questions to support inquiry with students:
  - What are the differences between various types of rocks, minerals, and earth materials?
  - How does the rock cycle change rocks and minerals?
  - What information can rock formations and mineral deposits provide on past environments and conditions?
- **Earth's geological and biological history:**
  Sample questions to support inquiry with students:
  - How do geoscientists establish the age of geological events and materials?
  - How do fossils contribute to an understanding of past geological conditions and environments?
  - How was the geologic time scale developed and what are its applications?
  - How does the fossil record suggest that Earth has experienced significant periods of change?
- **plate tectonic theory:**
  Sample questions to support inquiry with students:
  - What evidence suggests that a supercontinent will form again?
  - What drives the motion of tectonic plates?
  - What evidence do scientists have to support the idea that Earth is composed of layers?
  - How can seismic data be used by scientists?
  - What is the significance of the global distribution of volcanoes, mountain ranges, and earthquake epicentres?
- **form, arrangement, and structure of rocks:**
  Sample questions to support inquiry with students:
  - How are geologic maps and 3D block models used by different interest groups?
  - What types of information do geoscientists use to reconstruct past landscapes, environments, and geological conditions?
  - What factors contribute to the folding and faulting of strata?
  - What patterns exist in rock strata that identify various geological structures?
- **Weathering and erosion processes:**
  Sample questions to support inquiry with students:
  - How have wind, water, ice, and mass movements shaped our landscape over time?
  - What are the causes and effects of Earth's glaciation events?
  - How does First Peoples knowledge further our understanding of weathering and erosional processes?
  - What impacts do human activities have on local and global groundwater resources?

Curricular Competencies – Elaborations

- **Questioning and predicting:**
  Sample opportunities to support student inquiry:
  - Predict the geologic history of an area, given the types of structures evident in maps or models.
  - What knowledge do First Peoples have of tectonic events in the local area?
  - Predict how the local landscape would change if a major faulting or folding event were to occur.
  - How could current use of groundwater affect future land uses?
- **Planning and conducting:**
  Sample opportunities to support student inquiry:
  - Classify minerals by observing and testing physical and chemical properties (e.g., colour, crystal form, cleavage, fracture, specific gravity, acid reaction, magnetism, hardness).
  - Create molds and casts of local plants and animal artifacts.
  - Collect data to establish where most earthquakes tend to occur.
  - Assess the risks associated with geological field work.
  - How is a geological compass used to record accurate and precise strike-and-dip data?
  - What evidence is needed to measure and determine slope stability?
  - 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:
  - Classify fossils based on their modes of formation, taxonomy, and environments.
  - Reconstruct and interpret past environments, applying the principles of absolute and relative dating and using stratigraphy diagrams.
  - Use multiple seismographs and triangulation to locate an earthquake's epicentre on a map.
  - Create and interpret time-distance graphs for P and S waves.
  - Survey a local geologic structure and create a block diagram.
  - Model geologic events in your local area, using shared First Peoples knowledge and personal observations.
  - Apply information from index fossils to solve problems that require correlation among various rock units.
  - Show the interrelationships among a geologic map, a cross-section, and a block diagram for a specific feature (e.g., fold, fault, dome).
  - Differentiate erosional and depositional glacial features as observed through illustrations and photographs.
  - Analyze the properties of subsurface rock layers that are capable of storing water or fossil fuels.
- **Evaluating:**
  Sample opportunities to support student inquiry:
  - Debate the economic, environmental, and social impacts of oil and gas pipelines in B.C.
  - Consider the impacts of resource development on First Peoples communities and traditional territories.

- Measure various properties of rocks, sediments, and minerals, and analyze error within data samples collected.
- Analyze the evidence and approaches used to develop the various models explaining K-T boundary extinction (i.e., end of the dinosaurs).
- How can the fossil record be used as a source of evidence to support models of evolution?
- What are the limits of technology on absolute dating methods?
- Evaluate the development of various models of Earth's internal structure and composition as tools and technologies have developed.
- Debate possible locations for landfills based on porosity and permeability of the surrounding rock layers and the implications for groundwater.

- **Applying and innovating:**
  Sample opportunities to support student inquiry:
  - Describe and evaluate the many ways in which technology and innovation have been applied in the discovery of new ore and fossil fuel deposits and in bringing these resources to markets.
  - Co-operatively design a display or exhibit to educate the community on the geologic history of the local area, including plants, animals, landforms, and environmental conditions.
  - Design and build structures that are resistant to surface wave ground shaking (e.g., sugar cubes or toothpicks and marshmallows on a shake table).
  - Produce a plate tectonic map of a fictional terrestrial planet, showing evidence to support the types of plate boundaries.
  - Create a model of a well in an aquifer with a working pump.
- **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 use digital media to model the processes of the rock cycle.
  - Create a diorama consisting of plants, animals, and landscapes that depicts a past geological era (e.g., Devonian, Carboniferous, Cambrian).
  - Create a timeline, using a variety of methods (e.g., paper and string, digital media), that relates the expanse of geologic time to the evolution of Earth and life from its formation to the present day.
  - How does tectonic setting affect the perspectives and experiences of a local community?
  - Create a cross-sectional model of B.C. that illustrates the interaction of tectonic plates through the subduction zone.
  - How does the geology of an area influence First Peoples sense of place?
  - Create a public service advertisement explaining the causes of mass wasting and how they can be mitigated.
- **place:** Place is any environment, locality, or context with which people interact to learn, create memory, reflect on history, connect with culture, and establish identity. The connection between people and place is foundational to First Peoples perspectives.

Content – Elaborations

- **minerals:** composition, properties, structure
- **igneous:**
  - Bowen's reaction series
  - relationships between texture and rate of crystallization in extrusive (volcanic) and intrusive (plutonic) igneous rocks (e.g., cooling rate, flow behaviour)
  - classification of igneous rocks according to texture (e.g., vesicular, glassy) and composition (e.g., felsic, intermediate, mafic)
  - properties of common igneous rocks (e.g., granite, andesite, tuff, rhyolite, basalt, obsidian, pumice, porphyry)
  - volcanic and intrusive features (e.g., lava, pyroclastic flow, batholiths, sills, dikes)
- **sedimentary:**
  - clastic sediments and chemical (precipitate or biochemical) sediments, and the rocks they become
  - relationships between depositional environments and particle size, shape, sorting, fossils, and organic structures
  - properties of common sedimentary rocks (e.g., conglomerate, breccia, sandstone, chert, coal)
  - sedimentary features (e.g., stratification, cross bedding, ripple marks, graded bedding, varves)
  - sedimentary features that affect porosity and permeability
- **metamorphic:**
  - relationships between the types and characteristics of metamorphic rocks and parent rock, temperature, pressure, and chemical conditions
  - properties of common metamorphic rocks (e.g., slate, phyllite, schist, gneiss, marble)
  - foliated and non-foliated rocks
  - contact versus regional metamorphism
  - metamorphic grade (e.g., with reference to coal)
- **resource deposits:** resources in the local area:
  - hydrothermal and volcanogenic ore deposits
  - placer and surficial deposits
  - oil, liquid natural gas (LNG), coal, and other fossil fuels
- **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, environmental impacts)
  - uses of geologic resources in B.C.
  - current resource conflicts (e.g., pipelines, oil sands, open-pit mines)
- **major events in Earth's history:** for example, formation of oldest rocks, earliest recorded life, domination of invertebrates, first land plants, domination of reptiles, appearance of flowering plants, Rocky Mountain orogeny, mass extinctions

Content – Elaborations

- **fossil record:** for example, Foraminifera, Mollusca, Brachiopoda, Echinodermata, Arthropoda (trilobites), Coelenterata (corals), Vertebrata, Graptolithina, Conodonta, algae, plants, reptiles
- **evidence of evolution:** changes found in the fossil record over time as evidence for natural selection, adaptive radiation, and punctuated equilibrium
- **relative and absolute dating:**
  - absolute dating using radioactive isotopes
  - principles of relative dating (e.g., superposition, unconformities, cross-cutting, index fossils, law of faunal succession)
- **volcanic and deformational features:**
  - volcanic features (e.g., contact metamorphism, sills, dykes, volcano types, flow behaviours, extrusive materials, columnar jointing)
  - deformational features (e.g., folds, faults, mountains)
- **evidence:** for example, seismic wave velocities and paths, shadow zones, state of material, density, composition
- **earthquakes:**
  - origin (e.g., shallow, medium, deep focus, location of the epicentre)
  - properties (e.g., Richter or Mercalli scale, amount of energy released)
  - potential hazards (e.g., tsunamis, city infrastructures, liquefaction of soils)
- **internal and external factors:** for example, temperature, pressure, chemical composition
- **faulting and folding:** results of specific tectonic environments and forces:
  - faulting (e.g., normal, reverse, thrust, strike-slip)
  - folding (e.g., symmetrical, asymmetrical, plunging folds, domes, basin)
- **geologic maps, cross-sections, and block diagrams:**
  - representation of surface and subsurface structures using past or present data
  - geologic mapping symbols (e.g., strike and dip)
  - symbols for different rock types and fossils
  - age of strata
  - methods of data collection (e.g., surveying, GIS)
- **weathering and erosion processes:**
  - modifications of the Earth's surface and production of characteristic features
  - mass movements (slide, soil creep)
  - chemical, physical, and biological weathering
  - weathering potential of minerals in Bowen's reaction series (e.g., stability of quartz)
  - erosion by wind, water, gravity, and ice
  - erosion and deposition by rivers

Content – Elaborations

- **periods of glaciation:**
  - characteristic erosional and depositional features and landforms
  - causes and frequency
- **groundwater and aquifers:**
  - quality and quantity
  - water table, zone of saturation
  - effect of porosity and permeability on aquifer characteristics
  - artesian wells and springs
  - use of groundwater (e.g., urbanization, agriculture, sea-water contamination of groundwater, over-pumping)
- **controls of mass wasting:** for example, drainage, installation of perforated pipe