Unit 3
Earth Materials
Suggested Time: 35 Hours

Unit Overview

Introduction

This unit is intended to provide the student with the fundamental knowledge of the solid materials of the Earth, of changes occurring in them, and of their value to humans in relation to career options. This will be done through identification of minerals and rocks, analysis of the rock cycle, and exploration of various career options.

Mineral and rock identification should be limited to the types indicated in the core laboratories and curriculum guide, and hand samples should be used for observation purposes when possible.

Focus and Context

The focus in this unit is to introduce students to a variety of minerals and rocks, and to have them identify and understand them based on their different properties and features. Core laboratories 3 and 4 will be completed by the students to aid with this learning.

The rock cycle will be used as a context for understanding the different rock types and their interrelationships. All rock types will be linked to the appropriate environments of formation.

Science Curriculum Links

Students will have explored minerals and rocks as well as the process of erosion in grade 4 Science. A study of Earth's crust would have been completed by students in grade 7 Science.

Curriculum Outcomes

STSE	Skills	Knowledge
Students will be expected to **Nature of Science and Technology** 114-6 relate personal activities and various scientific and technological endeavours to specific science disciplines and interdisciplinary studies **Relationships Between Science and Technology** 116-2 analyse and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology 116-5 describe the functioning of domestic and industrial technologies, using scientific principles 116-7 analyse natural and technological systems to interpret and explain their structure and dynamics **Social and Environmental Contexts of Science and Technology** 117-2 analyse society's influence on scientific and technological endeavours 117-4 debate the merits of funding specific scientific or technological endeavours and not others 117-7 identify and describe science- and technology-based careers related to the science they are studying	*Students will be expected to* **Performing and Recording** 213-3 use instruments effectively and accurately for collecting data **Analyzing and Interpreting** 214-2 identify limitations of a given classification system and identify alternative ways of classifying to accommodate anomalies 214-9 identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information 214-10 identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty **Communication and Teamwork** 215-1 communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others 215-7 evaluate individual and group processes used in planning, problem solving and decision making, and completing a task	*Students will be expected to* 330-2 classify rocks according to their structure, chemical composition, and method of formation 330-3 classify common minerals according to their physical and chemical characteristics

The Building Blocks -- Mineral Chemistry

Outcomes

Students will be expected to

- classify common minerals according to their physical and chemical characteristics (330-3)
  - define mineral chemistry terms. Include:
    - (i) atom
    - (ii) ion
    - (iii) element
    - (iii) compound
    - (iv) molecule
  - describe how atoms combine to form compounds. Include:
    - (i) ionic compounds
    - (ii) molecular compounds
    - (iii) metallic compounds
  - outline the abundance of the elements that comprise Earth's crust. Include:
    - (i) oxygen
    - (ii) silicon
    - (iii) aluminum
    - (iv) iron
    - (v) calcium
    - (vi) sodium
    - (vii) potassium
    - (viii)magnesium

Elaborations—Strategies for Learning and Teaching

Teachers could use the Edukit, supplied by the Johnson GEO CENTRE, as a supplementary reference/guide for this entire unit.

A brief review of mineral chemistry terms is all that is required as students would have been previously exposed to these terms in other science courses.

Students should be able to identify diagrams and/or graphics of each type of compound. Again, this would have been covered in previous courses. Teachers could use molecular model kits to complete this outcome.

It is important to note that the list typically goes from most abundant to least abundant.

Teachers could have students create unique mnemonics to remember the list of common elements by abundance by taking the first letter of each element and creating silly phrases. For example:

Ottawa
Senators
Are
Insane
Calgary
Should
Play
Montreal

The Building Blocks -- Mineral Chemistry

Suggested Assessment Strategies

Performance

- After teachers have introduced this topic, a quiz-quiz-trade activity or a mix and mingle party (Appendix C) could be used to review.
- Create a model of a molecular compound such as SiO_2 using a structural diagram as a guide.
- Create molecular models using a kit and trade them with other students in a modified quiz-quiz-trade activity.

Presentation

- Create a mnemonic device to remember the elements of the Earth's crust in order of abundance.

Paper and Pencil

- Create flip cards as review to match elemental symbols with names.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 35-38

Edukit

ST pp. 36-38

ST p. 44

Conventions used in Resources Column

ST = Student Text

The Building Blocks -- Mineral Groups

Outcomes

Students will be expected to

- classify common minerals according to their physical and chemical characteristics (330-3)

(continued)

- define a mineral

Elaborations—Strategies for Learning and Teaching

Students should know what criteria are used to denote a mineral. Criteria include: solid; naturally occurring; inorganic; definite chemical composition; and definite chemical structure.

- recognize the relationship between the abundance of the elements that comprise Earth's crust and the mineral groups. Include:
  - (i) silicates
  - (ii) carbonates
  - (iii) halides
  - (iv) sulfides
  - (v) sulfates
  - (vi) oxides
  - (vii) native elements

Students should recognize that oxygen and silicon are the two most abundant elements comprising Earth's crust. These two elements make up the silicates, thereby making it the most abundant mineral group.

- name and differentiate between the major mineral groups. Include:
  - (i) silicates
  - (ii) carbonates
  - (iii) halides
  - (iv) sulfides
  - (v) sulfates
  - (vi) oxides
  - (vii) native elements

Students should know that there are two sub-groups of the silicates mineral group (i.e. sialic and simatic). Sialic is richer in the element aluminum, thereby making the minerals lighter in colour; whereas, simatic is richer in magnesium and iron, thereby making the minerals darker in colour.

- identify mineral groups based on mineral formulas

Students should be able to make connections between the mineral groups and the elements that are contained within them. As examples, carbonates have the basic CO_3 unit, and silicates have the basic SiO_2 unit.

The Building Blocks -- Mineral Groups

Suggested Assessment Strategies

Presentation

- Research the chemical makeup of fool's gold (or other common mineral). Create a poster that explains the difference between fool's gold and real gold.

Performance

- Create a poster of a mineral group that contains mineral examples, chemical formula, and economic uses.
- Develop a "Who am I" activity for a specific mineral group and have the class guess which group they belong to.

Paper and Pencil

- Create a fill in the blank worksheet using Table 2.4 on page 54 of the course textbook.
- Create flip cards to match formulas with mineral groups.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 44-55

ST pp. 44-55

ST p. 54

The Building Blocks -- Mineral Properties

Outcomes

Students will be expected to

- classify common minerals according to their physical and chemical characteristics (330-3)

(continued)

- describe the arrangement of silicon and oxygen within a tetrahedron

Elaborations—Strategies for Learning and Teaching

Students should be able to recognize the silicon-oxygen tetrahedron as the structure that is common to all minerals in the silicate group. Students could build silicon-oxygen tetrahedrons using molecular model kits

- use instruments effectively and accurately for collecting data (213-3)
- identify and explain sources of error and uncertainty in measurement and express results in a form that acknowledges the degree of uncertainty (214-10)
- classify common minerals according to their physical and chemical characteristics (330-3)
  - describe the mineral properties that are used for identifying minerals. Include:
    - (i) crystal shape (form)
    - (ii) cleavage
    - (iii) fracture
    - (iv) hardness
    - (v) specific gravity
    - (vi) colour
    - (vii) streak
    - (viii) lustre
    - (ix) acid test
    - (x) taste
    - (xi) magnetism
    - (xii) double refraction
    - (xiii) fluorescence

Core Laboratory Activity: Mineral Identification and Specific Gravity

The laboratory outcomes 213-3, 214-10, and 330-3 are addressed, in whole or in part, by completing **CORE LAB #3:** “Mineral Identification and Specific Gravity”.

The Building Blocks -- Mineral Properties

Suggested Assessment Strategies

Performance

- Create a mineral properties matching game using cue cards. Have students compete using the cards as review.
- Create quiz-quiz-trade cards for mineral properties and participate in a class review (Appendix C).
- Demonstrate the shape of a tetrahedron using basket balls and a tennis ball, or molecular model kits.
- Following the core lab, provide students with a sample of a common mineral and assess their ability to classify the mineral according to its physical and chemical characteristics.

Paper and Pencil

- Following the core lab, teachers could develop a lab exam which includes stations with specific questions on the properties of the minerals at each station.
- Identify any sources of error in your determination of the hardness of unknown minerals.

Presentation

- Create a presentation that shows similar looking minerals and a property that can be used to easily distinguish between them. For example, barite and quartz (specific gravity), or white quartz and smokey quartz.

Observation

- Using a teacher or peer assessment rubic, observe whether students use Moh's hardness minerals, or equivalent common objects, effectively and accurately when determining mineral hardness.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 44-45

Core Lab #3: "Mineral Identification and Specific Gravity", Appendix B

ST pp. 40-44

The Building Blocks -- Mineral Properties (continued)

Outcomes

Students will be expected to

- classify common minerals according to their physical and chemical characteristics (330-3)

(continued)

- explain why minerals exhibit different mineral properties. Include:
  - (i) type of bonding involved
  - (ii) elemental composition
  - (iii) internal atomic structure
- identify minerals based on their mineral properties

- identify careers that relate to mineral chemistry. Include: (117-7)
  - (i) mineralogist
  - (ii) crystallographer
  - (iii) geochemist
  - (iv) gemologist

Elaborations—Strategies for Learning and Teaching

Students should understand that there are different types of bonding, which include covalent (molecular), ionic and metallic.

Students should understand that diamond and graphite are polymorphs of the element carbon; however, they differ in terms of the mineral properties hardness and cleavage due to arrangement of the carbon atoms. Diamond is hard and has no cleavage since the carbon atoms are arranged in a network covalent structure. This does not allow for any weak planes of bonding. Graphite is soft and has perfect basal cleavage since the carbon atoms are arranged in planes of strong bonding with planes of weak bonding in between. Quartz and mica could also be compared and contrasted. They compare in that both are comprised of the silicon-oxygen tetrahedron. They contrast in that quartz exhibits fracture and mica exhibits basal cleavage. The brittle nature of halite is due to the ionic binding between the sodium and chloride ions.

The Building Blocks -- Mineral Properties (continued)

Suggested Assessment Strategies

Presentation

- Research and create a presentation on possible career choices involving minerals.
- Create a poster to show the bonding structures of diamond and graphite to compare them as polymorphs.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 39-40, 45-46

Introduction to Rocks and the Rock Cycle

Outcomes

Students will be expected to

- classify rocks according to their structure, chemical composition, and method of formation (330-2)
  - define rock
  - distinguish between rocks and minerals
  - recognize that minerals are the building blocks of rocks
- analyse the rock cycle as a natural system and explain its structure and dynamics (116-7)
  - describe the pathways comprising the rock cycle

Elaborations—Strategies for Learning and Teaching

Students, at this point, will already know the definition of a mineral

For example, the rock granite is comprised of the minerals quartz, orthoclase feldspar, mica, and amphibole in varying percentages.

Students should understand the pathways and associated processes that link igneous, sedimentary, and metamorphic rocks. Students should also be able to diagram in detail the rock cycle. Students could refer to the diagram of the rock cycle (Figure 1.12) on page 16 of the student text.

Students should understand that all three types of rocks could be weathered and eroded. The resulting sediment, once deposited, could be lithified (compacted and cemented) into sedimentary layers. Students should understand that all three types of rocks could be metamorphosed if subjected to appropriate conditions of metamorphism (e.g., heat, pressure, chemically-active fluids). Students should understand that the process of melting is not involved in metamorphism. They should also understand that the grade of metamorphism could be increased (e.g., low-grade metamorphic rocks to high-grade metamorphic rocks) as the conditions of metamorphism are increased. Students should understand that all three types of rocks could be melted if the temperatures become high enough. Once melting to a molten has occurred, students should realize that igneous activity has begun. The resulting igneous rocks will depend on the composition of the molten as well as whether it cools slowly inside the Earth (magma) or cools quickly on the Earth's surface (lava).

Introduction to Rocks and the Rock Cycle

Suggested Assessment Strategies

Presentation

- Create a visual presentation representing how one rock type changes into another.

Pencil and Paper

- Create a diagram of the rock cycle with household items inserted to represent the processes involved as rocks develop and/or change. Items could include a vice, sandpaper or an oven.
- Create a concept map (mind map) referencing rocks, minerals, mineral groups, and mineral properties.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 32-33

ST pp. 15-17

Igneous Rocks

Outcomes

Students will be expected to

- classify rocks according to their structure, chemical composition, and method of formation (330-2)
  - recognize that igneous rocks are classified according to their mineral composition and texture
  - describe how mafic igneous rocks differ from felsic igneous rocks based on chemical composition
  - identify igneous rocks that have similar chemical compositions. Include:
    - (i) rhyolite and granite
    - (ii) andesite and diorite
    - (iii) basalt and gabbro

Elaborations—Strategies for Learning and Teaching

Teachers should note that there is an inclination to use colour as an identifier for igneous rocks. This can be somewhat misleading. Composition and texture are the correct identifiers.

Students should know that mafic igneous rocks are in general dark in colour since they are comprised of mostly dark-coloured minerals. Examples of dark-coloured minerals include: olivine; hornblende; and pyroxene. Students should know that felsic igneous rocks are in general light in colour since they are comprised of mostly light-coloured minerals. Examples of light-coloured minerals include: quartz; orthoclase feldspar; and muscovite mica. Students should know that intermediate igneous rocks are dark to light (mixed) in colour and are comprised of a mixture of dark-coloured minerals and light-coloured minerals.

Students should be familiar with the igneous rock composition chart. Students should refer to Bowen's reaction Series (Figure 3.23) in the student text. This will help with understanding which minerals comprise ultra-mafic, mafic, intermediate, and felsic igneous rock.

Students should know that elements such as iron and magnesium make minerals dark-coloured, thereby making rocks dark. Elements such as aluminum, calcium, copper, sodium and silicon make minerals light-coloured, thereby making rocks light.

As an example, students should know that the rocks basalt and gabbro are comprised of the same mafic (dark-coloured) minerals, which include olivine, hornblende, and pyroxene.

Igneous Rocks

Suggested Assessment Strategies

Presentation

- Cookie Challenge - create a cookie to represent an igneous rock. Present your cookies with an explanation to the class. **(Caution: Allergy Awareness)**
- Create a presentation highlighting the major minerals in igneous rocks.
- Develop a presentation illustrating the textures and colours of the rocks listed in Figure 3.8 on p. 69 of the student text.

Pencil and Paper

- Create a table similar to Figure 3.8 on p. 69 of student text showing dominant minerals, colours, and texture of intrusive and extrusive equivalent rock types using felsic (granitic), intermediate (andesitic), mafic (basaltic) and ultramafic headings.

Performance

- Identify the various minerals that comprise a sample of crushed granite.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 62-69

ST pp. 66-67, 80

ST pp. 67, 69, 70-74

Igneous Rocks (continued)

Outcomes

Students will be expected to

- classify rocks according to their structure, chemical composition, and method of formation (330-2)

(continued)

- identify igneous rocks based on texture. Include:
  - (i) rhyolite and granite
  - (ii) andesite and diorite
  - (iii) basalt and gabbro

- describe igneous rock textures. Include:
  - (i) coarse-grained (phaneritic)
  - (ii) fine-grained (aphanitic)
  - (iii) glassy (compact and frothy)
  - (iv) vesicular
  - (v) porphyritic

Elaborations—Strategies for Learning and Teaching

Students should understand that texture is controlled by cooling rate, which is determined by the environment in which the rock formed. A fine-grained rock originates from lava that cools quickly on or near Earth's surface. Note that rocks formed from lava are also referred to as either volcanic or extrusive. Basalt, andesite, and rhyolite are examples of extrusive or volcanic igneous rocks. A coarse-grained rock originates from a magma that cools slowly under Earth's surface. Note that rocks formed from magma are also referred to as either plutonic or intrusive. Gabbro, diorite, and granite are examples of intrusive or plutonic igneous rocks. Students should also know that the word molten is used to describe both lava and magma; however, lava is molten on or near Earth's surface, whereas, magma is molten under Earth's surface.

Students should be able to relate the texture to the rate of cooling as well as the content and/or escape of gases.

Course grained: peridoitite, gabbro, diorite, granite,

Fine grained: komatiite, basalt, andesite, rhyolite

Glassy: obsidian, pumice, scoria

Vesicular: pumice, scoria

Porphyritic: andesitic porphyry

Students should know that a porphyritic texture originates from two-stage cooling. Slow cooling from a magma results in pherocrysts (large crystals) and fast cooling from a lava results in groundmass (a matrix of small crystals).

Igneous Rocks (continued)

Suggested Assessment Strategies

Performance

- Create "Who am I?" cards for Igneous Rock Types. For example, I am an aphanitic igneous rock with pyroxene and biotite as accessory minerals. Who am I?

Presentation

- Create an interactive "Bowen's reaction series" similar to a jigsaw puzzle.

Journal

- Write a short narrative to chronicle the life story of an igneous rock like granite. Include a timeline to sequence the events of their life story.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 70-74

ST pp. 62-65, 69-74

Igneous Rocks (continued)

Outcomes

Students will be expected to

- classify rocks according to their structure, chemical composition, and method of formation (330-2)

(continued)

- describe how cooling rate and mineral composition determine rock types based on Bowen's reaction series

Elaborations—Strategies for Learning and Teaching

Students should understand that different minerals crystallize from magma at different temperatures. Students should also understand that as minerals crystallize from magma the remaining composition of the magma is forever changed. Therefore, it is possible for more than one igneous rock to form from the same magma depending on the cooling environment.

Bowen's reaction series represents the organizing philosophy of crystallization sequence of igneous rock minerals. The diagramatic sequence illustrates the separation of mafic minerals by cooling temperatures and the progression of felsic mineral enrichment possible in some magmas.

Teachers could use thawed and frozen orange juice concentrate to demonstrate fractional crystallization. Show students thawed orange juice concentrate then partially freeze concentrate and slice container in half. The water in the mixture will have frozen leaving a more concentrated liquid within the container.

Igneous Rocks (continued)

Suggested Assessment Strategies

Performance

- Grow crystals from a saturated solution of salt and H_20. Demonstrate the affect of elapsed time of crystal growth? (increased time allows for increased crystal growth).

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 78-80

Igneous Rocks (continued)

Outcomes

Students will be expected to

- identify limitations of a given classification system and identify alternative ways of classifying to accommodate anomalies (214-2)
- identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information (214-9)
- communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others (215-1)
- evaluate individual and group processes used in planning, problem solving and decision making, and completing a task (215-7)
- classify rocks according to their structure, chemical composition, and method of formation (330-2)
  - identify igneous rocks based on mineral composition and texture

Elaborations—Strategies for Learning and Teaching

Core Laboratory Activity: Igneous, Sedimentary and Metamorphic Rocks - Part I: Igneous Rocks

The laboratory outcomes 214-2, 214-9, 215-1, 215-7, and 330-2 are addressed, in whole or in part, by completing **CORE LAB #4:** "Igneous, Sedimentary and Metamorphic Rocks - Part I: Igneous Rocks".

Rock types that should be addressed for Part I of this lab include: basalt, gabbro, andesite, diorite, rhyolite, granite, perdoitite, pumice, scoria, and obsidian.

Igneous Rocks (continued)

Suggested Assessment Strategies

Pencil and Paper

- Create a mind map of the igneous rocks including formation, naming, and composition.
- Which rock samples were difficult to classify. Explain why?

Observation

- Using a checklist, assess students ability to sort rock samples by colour and texture.

Performance

- Following the lab, assess students ability to identify samples of igneous rocks based on mineral composition and texture.
- Using a teacher, peer or self assessment rubric, assess group processes used in decision making and completing the assigned tasks.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

Core Lab #4: "Igneous, Sedimentary and Metamorphic Rocks", Part I: Igneous Rocks, Appendix B

ST pp. 598-600

Igneous Rocks (continued)

Outcomes

Students will be expected to

- relate personal activities and various scientific and technological endeavours to specific science disciplines and interdisciplinary studies (114-6)
- analyse and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology (116-2)
- describe the functioning of domestic and industrial technologies, using scientific principles (116-5)
- analyse society's influence on scientific and technological endeavours (117-2)
- debate the merits of funding specific scientific or technological endeavours and not others (117-4)
- classify rocks according to their structure, chemical composition, and method of formation (330-2)
  - describe the formation of kimberlite and its relationship with diamond deposits

Elaborations—Strategies for Learning and Teaching

The CORE STSE component of this unit incorporates a broad range of outcomes. More specifically, it addresses, in whole or in part, outcomes 114-6, 116-2, 116-5, 117-2, and 117-4. The STSE component "Diamonds - Their Formation and Properties", can be found in Appendix A.

Igneous Rocks (continued)

Suggested Assessment Strategies

Presentation

- Research and create a presentation on diamond mining in Labrador.
- Research and create a presentation on the diamond jewelry industry.

Paper and Pencil

- Describe how geophysical exploration methods work.
- Explain how society's need for diamonds has influenced scientific or technological endeavours.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

Core STSE #3: Diamonds - Their Formation and Properties", Appendix A

Discovering Diamonds: a Canadian Earth Science Curriculum Resource for Senior High School, a Prospectors and Developers Association of Canada Mining Matters Project

Sedimentary Rocks

Outcomes	Elaborations—Strategies for Learning and Teaching
Students will be expected to	
• classify rocks according to their structure, chemical composition, and method of formation (330-2) **(continued)** - describe the origin and process of formation of sedimentary rocks	Students should know that sedimentary rocks form from sediments, which are created by the processes of weathering (i.e. the breaking up of existing rocks) and erosion (i.e. the movement of Earth material). Such sediments are deposited in various environments and are then subject to the process of lithification. Note that lithification is the process by which sediments are converted in sedimentary rocks. It is important that students recognize that compaction and cementation are two sub-processes of the process of lithification. Compaction involves pressure being exerted on the sediments due to increased burial. This results in reduced porosity and permeability. Cementation involves the crystallization of minerals from water in the pore spaces, thereby cementing the sediments together. Example of cements in sedimentary rocks include calcite, silica, and iron oxide.
- describe the classes of sedimentary rocks. Include: (i) clastic (detrital) (ii) chemical (iii) biochemical	Students should know that clastic detrital sedimentary rocks are made of fragments of pre-existing rocks that were weathered, eroded, and deposited. Chemical sedimentary rocks are due to the chemical processes of evaporation and precipitation. Biochemical sedimentary rocks originate from organic remains.
- identify clastic sedimentary rocks. Include: (i) shale (ii) siltstone (iii) sandstone (iv) conglomerate (v) breccia	Students should recognize that clastic detrial sedimentary rocks differ based on particle size. Students should also recognize that conglomerate and breccia are different not based on particle size, but rather particle shape. Conglomerate consists of rounded particles and breccia consists of angular particles. Rounded versus angular is determined by distance from the source of weathering.
- relate sediment sorting to clastic sedimentary rocks	Students should know that clastic sedimentary rocks can be well-sorted or poorly-sorted; however, sorting does not apply to chemical rocks.
- relate particle size to current velocity	Students should know that the greater the current velocity the greater the size of particles transported. Therefore, students should know that as current velocity decreases, the particle size transported decreases. This correlates with the types of clastic sedimentary rocks that result in a horizontal segment. <u>High Velocity → Low Velocity</u> Breccia, Conglomerate → Sandstone → Siltstone → Shale

Sedimentary Rocks

Suggested Assessment Strategies

Performance

- Create a sample of concrete using a mixture of gravel sized particles, water, and cement. After several days of hardening, break it apart with a rock hammer and compare to an actual conglomerate. Note the similarities and emphasize the time factor in the comparison.
- Demonstrate the sediment sorting process by using a sifting tower or a water tower. Pour in unsorted sediment and observe how it is sorted by particle size.
- Demonstrate the formation of a chemical sediment using a mixture of water and calcium hydroxide and a straw. Blowing air into the mixture will form a calcium carbonate precipitate ($CaCO_3$).

Presentation

- Using the information on particle size contained in Table 6.1 on page 160 of the student text, create circular manipulatives to represent the various sizes. Provide a mixture of manipulatives to classmates and have them separate them based on grain size, glue glue them to paper, and label them with the appropriate name.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp 158-159

ST pp. 159-173

ST pp. 160-165, 179-180

Sedimentary Rocks (continued)

Outcomes

Students will be expected to

- classify rocks according to their structure, chemical composition, and method of formation (330-2)

(continued)

- describe the environments and rock types that relate to clastic sedimentary rocks. Include:
  - (i) fluvial (rivers, streams)
  - (ii) lagoonal
  - (iii) beaches
  - (iv) deep marine/ocean
  - (v) shallow marine

- identify chemical sedimentary rocks. Include:
  evaporites
  - (i) halite
  - (ii) gypsum
  - (iii) sylvite

  precipitates
  - (i) limestone
  - (ii) dolomite
  - (iii) travertine

Elaborations—Strategies for Learning and Teaching

The clastic sedimentary rocks that could form in the environments as listed in column 1 depend on the agent(s) of erosion as well as the depositional environments. They are as follows:

fluvial - breccia, conglomerate, sandstone, siltstone, shale, and mudstone

lagoonal - siltstone, shale, and mudstone

beaches - conglomerate, sandstone

deep ocean/marine - includes turbidites (conglomerate, sandstone, siltstone, shale), but is dominated by chemical sedimentary rocks

shallow marine - various types of clastic sedimentary rocks

Students should realize that evaporite rocks are the result of the evaporation of water, usually leaving the rock behind. Students should also realize that precipitate rocks are the result of the changes in environmental conditions (e.g. temperature change, concentration change, chemical change).

Sedimentary Rocks (continued)

Suggested Assessment Strategies

Performance

- Create or use a stream table (fluvial) to demonstrate how how sorting can occur in a stream environment. Demonstrate how sediments might form breccia, conglomerate, sandstone, siltstone, shale, and mudstone.
- Using a supersaturated solution of alum, demonstrate how evaporating water creates crystals in the same way halite and gypsum deposits form from an evaporating sea.

Presentation

- Create a poster illustrating the different clastic sedimentary rock environments.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 174-176

ST pp. 165-171, 173

Sedimentary Rocks (continued)

Outcomes

Students will be expected to

- classify rocks according to their structure, chemical composition, and method of formation (330-2)

(continued)

- describe the environments and rock types that relate to chemical sedimentary rocks. Include:
  - (i) shallow marine
  - (ii) deep marine/ocean
  - (iii) cave

- identify biochemical sedimentary rocks. Include:
  - (i) coquina
  - (ii) chaulk
  - (iii) chert
  - (iv) limestone (coral)
  - (v) coal

- describe the sequence of formation of coal. Include:
  - (i) peat
  - (ii) lignite
  - (iii) bituminous
  - (iv) anthracite

Elaborations—Strategies for Learning and Teaching

The chemical sedimentary rocks that are associated with the environments in column 1 are as follows:

Shallow marine - gypsum, halite, sylvite, limestone, dolomite
Deep marine/ocean - limestone, dolomite, chert
Cave – travertine (stalactites and stalagmites).

Students should know that stalactites are icicle-like pendants that hang from the ceilings of caverns and form where water seeps through cracks above. Stalagmites form on the floors of caverns and reach upwards towards the ceilings. Both are composed of precipitated travertine (i.e. a type of limestone).

Students should know that coquina results from the build-up, compaction, and cementation of the shells of dead organisms. Chaulk results from the build-up, compaction, and cementation of microscopic marine organisms (e.g. foraminifera). Chert is a name used for a number of very compact and hard rocks made of microcrystalline silica (e.g., flint, jasper, agate). Corals are examples of organisms that are capable of creating large quantities of marine limestone from their shells and external skeletons which are composed of calcium carbonate. Coal is the end product of large amounts of plant material that has been buried and chemically altered over millions of years.

Students should know that peat is not a rock, but a stage of coal. It is the accumulation of plant material containing large amounts of volatiles (i.e. gases). Students should also know that lignite and bituminous are sedimentary rocks and are also stages of coal containing lesser amounts of volatiles. Remember that the grade of coal increases from lignite to anthracite. Students should know that anthracite is a metamorphic rock and is also the stage of coal containing the least amount of volatiles due to the metamorphic processes and related agents (e.g. heat and pressure). Note that due to the small amount of volatiles in anthracite, it burns much cleaner than the other stages of coal; however, there is a smaller amount of anthracite world-wide than the other stages of coal.

Sedimentary Rocks (continued)

Suggested Assessment Strategies

Paper and Pencil

- Outline the formation of coal from peat to anthracite.
- Based on the definition of a mineral, is coal a rock?
- Create quiz-quiz-trade cards to review the sequence of coal formation (Appendix C)

Performance

- Participate in a "write around" activity (Appendix C) for each type of biochemical sediment, or have all five headings on the same page.

Presentation

- Create a visual presentation which represents each type of coal.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 174-177

ST pp. 167-173

ST pp. 170-172

Sedimentary Rocks (continued)

Outcomes

Students will be expected to

- classify rocks according to their structure, chemical composition, and method of formation (330-2)

(continued)

- describe the environments and rock types that relate to biochemical sedimentary rocks. Include:
  - (i) swamp
  - (ii) shallow marine
  - (iii) beach
  - (iv) deep marine
- identify sedimentary rocks

- identify limitations of a given classification system and identify alternative ways of classifying to accommodate anomalies (214-2)
- identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information (214-9)
- communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others (215-1)
- evaluate individual and group processes used in planning, problem solving and decision making, and completing a task (215-7)

Elaborations—Strategies for Learning and Teaching

The biochemical sedimentary rocks that are associated with the environments in column 1 are as follows:

Swamp – coal

Shallow marine – coquina, limestone (coral)

Beach – coquina

Deep marine – chaulk, chert

Teachers could at this time reiterate the concept of systems as related to Earth processes. Biochemical rocks and coal represent a dynamic interaction of the spheres. Students could be asked to show how this is true.

Core laboratory Activity: Igneous, Sedimentary and Metamorphic Rocks - Part II: Sedimentary Rocks

The laboratory outcomes 214-2, 214-9, 215-1, 215-7, and 330-2 are addressed, in whole or in part, by completing **CORE LAB #4:** "Igneous, Sedimentary and Metamorphic Rocks - Part II: Sedimentary Rocks".

Sedimentary Rocks (continued)

Suggested Assessment Strategies

Paper and Pencil

- Create a mind map of sedimentary rock highlighting environments of formation, types, and names.

Presentation

- Create a poster of sedimentary rocks, formation environments, classification, and naming.
- As a description of biochemical sedimentary rocks, research the formation of England's white cliffs of Dover or Australia's Great Barrier Reef and create a presentation of your findings.

Performance

- Create a "shoebox model" of a shallow marine environment graduating into a deep ocean environment or an "enclosed shoebox model" of a cave with stalactites and stalagmites.
- Using a teacher, peer or self assessment rubric, assess group processes used in decision making and completing the assigned tasks.
- Following the lab, assess students ability to identify samples of sedimentary rocks.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 174-182

Core Lab #4: "Igneous, Sedimentary and Metamorphic Rocks", Part II: Sedimentary Rocks, Appendix B

Metamorphic Rocks

Outcomes

Students will be expected to

- classify rocks according to their structure, chemical composition, and method of formation (330-2)
  - describe the process of metamorphism
  - describe possible changes that result from metamorphism. Include:
    - (i) texture
    - (ii) volume change
    - (iii) chemical change
  - describe the result of selected rocks being metamorphosed. Include:
    - (i) limestone to marble
    - (ii) sandstone to quartzite
    - (iii) shale to slate (to phyllite to schist to gneiss)
    - (iv) granite to gneiss
  - contrast the two types of metamorphism. Include:
    - (i) contact
    - (ii) regional

Elaborations—Strategies for Learning and Teaching

Students must know that heat, pressure, and chemically active fluids (water) are the three agents that are necessary to cause rocks to change. Students must also know that all three rock types (i.e. igneous, sedimentary, and metamorphic) can be metamorphosed.

Students must understand that metamorphism does not involve a melt and that there is no recrystallization of minerals from such melt. It is usually the chemically active fluids that serve to dissolve minerals and serve as the medium for the crystallization of new minerals.

Students should know that the process of metamorphism can result in two types of textures, which include foliated and non-foliated. Note that the texture of a metamorphic rock is usually coarser than the parent rock. Students should know that volume is often reduced as increased pressure is often the result of metamorphism. Students should know that with metamorphism new minerals are often the result (i.e. minerals that differ from the minerals that were present in the parent rock). Students should realize that chemically-active fluids (e.g. water) are often essential as a transport medium for the movement of ions and the formation of new minerals.

Note that limestone, sandstone, and shale are sedimentary rocks. Note that granite is an igneous rock. Students should know examples of foliated and non-foliated metamorphic rocks, which include:
Foliated – slate, phyllite, schist, and gneiss
Non-foliated – quartzite, and marble.

Students should understand the metamorphic agents that dominate in relation to each type of metamorphism. Contact metamorphism is dominated by heat and chemically active fluids, whereas, regional metamorphism is dominated by pressure and chemically active fluids. It is essential; however, for students to recognize that all three agents are present in relation to both types of metamorphism.

Metamorphic Rocks

Suggested Assessment Strategies

Performance

- Create a poster to represent the transformational changes from shale to gneiss.
- Create a mind map for metamorphic rocks that includes factors of formation, changes, etc.
- Create a collage of rock types.
- Demonstrate how pressure causes changes in rock form by compressing and/or twisting colour layered plasticine.

Paper and Pencil

- How is regional metamorphism different from contact metamorphism?
- Given a diagram similar to Fig. 7.16 on p. 204 of the student text, label the metamorphic rocks found at each location and describe their characteristics.

Presentation

- Create a narrative pretending to be a piece of shale. Tell the life story of shale as it transforms into different metamorphic rock types (slate, phyllite, schist and gneiss).
- Cookie Challenge - create a cookie to represent a metamorphic rock (no melting). Present your cookies with an explanation to the class. **(Caution: Allergy Awareness)**

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 193-196

ST pp. 193-196

ST pp. 193, 201-205, 209

ST pp. 198-202

Metamorphic Rocks (continued)

Outcomes

Students will be expected to

- classify rocks according to their structure, chemical composition, and method of formation (330-2)

(continued)

- describe the locations where contact metamorphism occurs. Include:
  (i) beneath lava flows
  (ii) adjacent to magma intrusions
  (iii) dykes and sills

- describe how contact metamorphism can be used to distinguish between a buried lava flow and an intrusion of magma.

- describe the locations where regional metamorphism occurs. Include:
  (i) areas of mountain building
  (ii) subduction zones

Elaborations—Strategies for Learning and Teaching

Students should be able to identify locations where contact metamorphism occurs in diagrams.

Students should know that a buried lava flow will only exhibit contact metamorphism (i.e. baking) in the rock below the lava flow; whereas, an intrusion of magma will exhibit contact metamorphism in the rock below and above the intrusion. Teachers should review the concept of cooling rate and crystal size as well as inclusions. Students should know that crystals in the lava or magma will grow larger where cooling is slower (i.e. not near an edge); whereas, crystals in the lava or magma will grow smaller where cooling is faster (i.e. near an edge). Students should also know that inclusions within the rock formed from lava or magma are called rafts and belong to adjacent rock.

Students should understand that regional metamorphism in relation to subduction zones occurs where sediments accrete (build-up) at the edges of the crustal plates. There can be different grades of metamorphism depending on the amount of change due to the metamorphic agents. Using the sedimentary rock shale, which could be formed at the edges of crustal plates at subduction zones, students should be able to explain the sequence of metamorphic rocks that result from increasing grades of metamorphism. The sequence is as follows:

Shale → Slate → Phyllite → Schist → Gneiss

Metamorphic Rocks (continued)

Suggested Assessment Strategies

Performance

- In groups, model locations of metamorphism.
- Participate in a “Who am I” activity where students wear a word card that they can’t see (taped to back). Students can ask each other questions to find out what rock type they are. Only one question per student. Keep moving around the room until you find out who you are.
- Using a numbered heads strategy (Appendix C), have students review which rock type matches with which environment of formation.

Paper and Pencil

- Draw and label sketches to demonstrate understanding of the difference between an intrusion and a buried lava flow.
- Given a diagram of a subduction zone, similar to Fig. 7.23 on p. 209 of the student text, which includes a volcanic chain. Have students label areas where contact and regional metamorphism might occur.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

ST pp. 198-201, 207, 209-210

ST p. 114

ST pp. 202-205, 207-209

Metamorphic Rocks (continued)

Outcomes

Students will be expected to

- identify limitations of a given classification system and identify alternative ways of classifying to accommodate anomalies (214-2)
- identify and apply criteria, including the presence of bias, for evaluating evidence and sources of information (214-9)
- communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others (215-1)
- evaluate individual and group processes used in planning, problem solving and decision making, and completing a task (215-7)
- classify rocks according to their structure, chemical composition, and method of formation (330-2)

  - identify metamorphic rocks
- identify careers that relate to the study of rocks. (117-7) Include:
  (i) petrology
  (ii) volcanology
  (iii) geochemistry
  (iv) sedimentologist
  (v) hydrology

Elaborations—Strategies for Learning and Teaching

Core laboratory Activity: Igneous, Sedimentary and Metamorphic Rocks - Part III: Metamorphic Rocks

The laboratory outcomes 214-2, 214-9, 215-1, 215-7, and 330-2 are addressed, in whole or in part, by completing **CORE LAB #4:** "Igneous, Sedimentary and Metamorphic Rocks - Part III: Metamorphic Rocks".

Metamorphic Rocks (continued)

Suggested Assessment Strategies

Performance

- Following the lab, assess students ability to identify samples of metamorphic rocks.
- Using a teacher, peer or self assessment rubric, assess group processes used in decision making and completing the assigned tasks.

Interview

- Research a career. Students can develop questions that they would like answered related to that career. Students could take on the role of the expert and answer questions.

Resources

http://www.ed.gov.nl.ca/edu/k12/curriculum/documents/science/highschool.html

Core Lab #4: "Igneous, Sedimentary and Metamorphic Rocks", Part III: Metamorphic Rocks, Appendix B