Public District School Board Writing Partnership

Science

Course Profile

Earth and Space Science

Grade 12
University Preparation
SES4U

• *for teachers by teachers*

Course Profiles are professional development materials designed to help teachers implement the new Grade 12 secondary school curriculum. These materials were created by writing partnerships of school boards and subject associations. The development of these resources was funded by the Ontario Ministry of Education. This document reflects the views of the developers and not necessarily those of the Ministry. Permission is given to reproduce these materials for any purpose except profit. Teachers are also encouraged to amend, revise, edit, cut, paste, and otherwise adapt this material for educational purposes.

Any references in this document to particular commercial resources, learning materials, equipment, or technology reflect only the opinions of the writers of this sample Course Profile, and do not reflect any official endorsement by the Ministry of Education or by the Partnership of School Boards that supported the production of the document.

Acknowledgments

Public District School Board Writing Team – Grade 12, Earth and Space Science

Lead Board
- Peel District School Board
- Chuck Hammill, Project Manager

Partner Boards
- Simcoe County District School Board
- District School Board of Niagara

Course Profile Writing Team
- Tom Card, Lead Writer, Peel District School Board
- Josh Bhattacharya, Peel District School Board
- Robert Callcott, York Region District School Board (retired)
- Renaty Friedrich, Peel District School Board
- Elizabeth Jarman, Simcoe County District School Board
- Lee MacGregor, Peel District School Board
- David Miller, District School Board of Niagara
- Cheri Riddell, Peel District School Board
- Frank Sambells, Peel District School Board
- Carmen Tseng, Peel District School Board
- Poul von Bulow, Peel District School Board
- Rob Vucic, Peel District School Board

Reviewers
- Fred Michel, Carleton University
- Steve Bibla, Toronto District School Board
- Ted Sawicki, Peel District School Board

Course Overview
Earth and Space Science, SES4U, Grade 12, University Preparation

Policy Document: *The Ontario Curriculum, Grades 11 and 12, Science, 2000.*
Prerequisite: Grade 10 Science, Academic, SNC2DO

Course Description

This course focuses on the Earth as a planet, and on the basic concepts and theories of Earth science and their relevance to everyday life. Students will examine the Earth's place in the solar system and, after a general introduction to Earth science, will explore in more detail the materials of the Earth, its internal and surficial processes, and its history. The course draws on astronomy, biology, chemistry, mathematics, and physics in its consideration of geological processes that can be observed directly or inferred from other evidence.

Course Notes

The Goals of Grade 12 Earth and Space Science

As listed in *The Ontario Curriculum, Grades 11 and 12, Science, 2000*, (p. 6) SES4U is directed toward three goals:

- to relate science to technology, society, and the environment;
- to develop the skills, strategies, and habits of mind required for scientific inquiry;
- to understand the basic concepts of science.

The activities and assessment tasks in this profile reflect the importance of the three goals and have been developed around clusters of Specific Expectations. A design down approach was used in developing the overall course and individual units. The Final Assessment Tasks for the course were developed first, followed by the End-of-Unit Tasks. The Expectations in each unit were clustered into activities that connected together logically and provided the necessary background knowledge and skills to be applied in the completion of the End-of-Unit Tasks. However, this is not the only possible clustering. The unit activities were then expanded following each overview chart. The suggested activities are intended to be neither restrictive nor prescriptive; instead the intent is to provide teachers with suggestions for course development. Teachers should adapt the profile to suit their circumstances and to match the students' needs while ensuring that all Learning Expectations of the guideline are addressed fully.

Scientific Literacy for All Students and Preparation for Further Study

The paramount task of science education is to equip all students with scientific literacy – the combination of knowledge, skills, and habits of mind that enable them to think creatively, reason logically, evaluate information critically, and communicate effectively. This is an essential base for making productive and ethical decisions, not only about scientific and technological issues but in all areas of life.

The Ontario Curriculum, Grades 11 and 12, Science, 2000 (p. 4) notes that, "Achieving excellence in scientific literacy is not the same as becoming a science specialist." The focus in Grade 12 Earth and Space Science is scientific literacy for all students, with preparation for further studies in Earth and Space Science and related disciplines for some students. The policy document goes on to note, "The newer aspects of the science curriculum – especially those that focus on science, technology, society, and the environment (STSE) – call for students to deal with the impacts of science on society and the environment, which includes both the natural environment and the workplace environment. This requirement brings in issues that relate to human values. Science can therefore not be viewed as merely a matter of "facts;" rather, it is a subject in which students learn to weigh the complex combinations of fact and value that developments in science and technology have given rise to in modern society." (p. 4)

This perspective is consistent with the vision advanced in this profile. The challenge in delivering the course is to find ways to bring to the classroom an STSE focus from which the concepts and Earth and Space Science specific skills derive naturally.

At the same time, SES4U must adequately prepare those students who will opt for further study of the subject in university and similar postsecondary institutions. Knowledge, Inquiry, Communications, and Making Connections Expectations, along with the Learning Skills, including study skills and independent learning strategies, must be learned, practised, assessed, and evaluated at a standard that enables students to realistically assess their aptitude and chances for success in further studies in Earth and Space Science and possible employment in a related field.

Policy Requirements

The Ontario Curriculum, Grades 11 and 12, Science, 2000 contains recommendations regarding teaching approaches and curriculum expectations that are reflected in this profile and should be evident in courses developed using this profile as a template (pp. 8-10).

- "The expectations in science courses call for an active, experimental approach to learning, and require all students to participate regularly in laboratory activities;"
- "Where opportunity allows, students might be required, as part of their laboratory activities, to design and conduct research on a real scientific problem for which the results are unknown;"
- "Where possible, concepts should be introduced in the context of real-world problems and issues;"
- "In all courses, a list of expectations is given that precedes the strands. These expectations describe skills that are considered to be essential for scientific investigation, e.g., skills in research, in the use of materials, and in the use of units of measurement, and skills required for investigating possible careers in the subject area. These skills apply to all areas of course content and must be developed in all strands of the course. Assessment of students' mastery of these skills must be included in the evaluation of students' achievement of the expectations for the course." These expectations are called Science Investigative Skills (SIS). When developing detailed course plans, we recommend that teachers use these SIS Expectations as a primary guide. These skills serve as a lens through which all Expectations in the profile are interpreted.

Planning and Implementing Grade 12, Earth and Space Science

As teachers organize and plan the delivery of Expectations of SES4U, using, and/or adapting activities described in this profile, they should consider the following:

- SES4U requires a focus on inquiry skills. Through a variety of investigations, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations. Direct experience with technology, materials, and laboratory equipment is necessary to illuminate theoretical concepts and develop skills.
- Learning activities in this profile are set in a context that relates science to technology, society, and the environment.
- A number of activities in this profile have a research focus that requires accessing information beyond the laboratory or field trip. Students should be taught how to use all available sources of information – people, print, online sources, and other media, both within the school and in the community. They should also be given opportunities to use those skills, and to experience the challenges that invariably accompany the location and acquisition of valid information. However, care must be taken that student time is spent primarily on processing information rather than accessing information, so that the research does not become an end in itself.

- The Expectations are central to all aspects of this profile. The context in which each unit is delivered, the skills and concepts developed, and the assessment tasks used must be interconnected and linked to the Expectations. The assessment data accumulated throughout the course must be sufficient (in kind and number) to permit teachers to evaluate the consistent level of performance for each student in each of the four categories in the Achievement Chart for Science (*The Ontario Curriculum, Grades 11 and 12, Science, 2000* (pp. 174-175).
- Each student interprets new information in terms of what he or she already knows. The student tries to make sense of what is taught by trying to fit it with his or her experience. A key concept is understood when the student examines significant examples that represent the concept, then creates a generalization from those personal experiences. Teachers must be aware of the experiences that students have had prior to Grade 12 and use them as the base for new and more complex concepts. Students may also bring knowledge and skills from a variety of Geography courses. Students may also arrive with misconceptions from prior experience that will interfere with their ability to understand new concepts. Identifying misconceptions and revising them using concrete examples may be required at times. A number of diagnostic tools and activities are suggested throughout the Course Profile.
- Assessment and evaluation should focus on the application of terminology to explain concepts and phenomena, not on terms and definitions in isolation. It is essential that students understand the concept before acquiring the vocabulary.
- This Course Profile describes a science course in which students are encouraged to ask their own questions and, in many cases, find their own answers by inquiry (experiment or research). Fundamental to the skill set of a scientifically literate person/citizen is the ability to ask incisive questions, to interpret the answers critically, and to identify unstated assumptions.
- In this Course Profile, there is a reduced emphasis on traditional laboratory activities in which students are provided step-by-step instructions. Teacher demonstrations can be used in place of these activities and the time saved used for developing students' ability to devise and carry out true experimental inquiry. The teacher's role is to decide what knowledge and skills students must have to proceed safely and successfully in a laboratory setting. Many traditional laboratory exercises can be made more open ended by rewording statements into questions, and replacing detailed procedures with a teacher-led class discussion. This could be followed by a challenge, which requires students to devise a procedure and have its safety confirmed by the teacher prior to performance. By making decisions regarding what data to collect and which format to use for reporting both data and results, students develop skills of inquiry and communication essential in science.
- This Course Profile includes a large number of learning activities to be completed in the 110 hours available. Teachers may have to be selective in the choices they make for their classes.

Rationale for the Unit Sequences in the Course Profile

- This Course Profile clusters the expectations listed in *The Ontario Curriculum, Grades 11 and 12, Science, 2000* for teacher purposes. The curriculum strand Introduction to Earth Sciences has been distributed throughout the units of the profile where each expectation is more directly relevant. In addition, the strand Internal and Surficial Earth Processes has been used to establish two separate units for added emphasis.
- Unit 1 develops students understanding of the place of the Earth in the solar system, and the effects of cosmic and geological processes on it. Unit 2 examines the internal structure and processes of the earth, such as tectonic forces that drive the earth's heat engine and lithospheric plate movements. In Unit 3, students are introduced to the principles and techniques of determining geologic time through the study of geologic stratigraphy, correlation, and paleontology. Students also consider the insight these give about the history of the Earth.

- Unit 4 focuses on the Earth's surface and the natural processes and forces that shape it.
- In Unit 5, the materials that make up the Earth's lithosphere are explored. This includes the classification, identification, and formation of Earth materials as well as the economic and environmental importance of these resources.
- Unit 6, the Final Assessment Task, involves compilation and assessment of data charts, and written reports produced from each of the previous units. These charts and reports will be assessed and used to develop and present an Environmental Assessment of a potential Earth resource development project within the local region.

Units: Titles and Time

Unit 1	The Earth as a Planet	18 hours
Unit 2	Internal Structure and Processes of the Earth	19 hours
Unit 3	Earth History	16 hours
Unit 4	Surficial Earth Processes	22 hours
* Unit 5	Earth Materials	24 hours
Unit 6	Final Assessment Task: Environmental Assessment	11 hours

* This unit is fully developed in this Course Profile.

Unit Overviews

Unit 1: The Earth as a Planet

Time: 18 hours

Unit Description

This unit develops the students' understanding of the Earth's place in the solar system, and the effects of cosmic and geological processes on it. Students gain an understanding of the natural and human-made environments of the Earth through observations of the Earth itself, as well as other objects in the solar system.

Unit Overview Chart

Activity	Focus	Learning Expectations	Assessment Categories
1.1 4 h	Solar System	EPV.01, EPV.02, EPV.03, EP1.01, EP1.02, EP1.03, EP2.01, EP2.02, EP2.03, EP3.01 SIS.03, SIS.05, SIS.06, SIS.07	Knowledge/Understanding Inquiry Communication Making Connections
1.2 4 h	Sun, Earth, and Moon/ Impacts on the Earth	EPV.01, EPV.02, EPV.03, EP1.01, EP1.04, EP2.02, EP2.04, EP2.05, EP2.06, EP3.01 SIS.05, SIS.06, SIS.07	Knowledge/Understanding Inquiry Communication Making Connections
1.3 4 h	Exploring the Near-Earth Environment	EPV.01, EPV.02, EPV.03, EP1.05, EP2.04, EP3.02, EP3.04, EP3.05, EP3.06 SIS.05, SIS.06, SIS.07, SIS.10	Inquiry Communication Making Connections
1.4 6 h	End-of-Unit Task: Viewing the Earth	EPV.02, EPV.03, EP2.04, EP3.01, EP3.02, EP3.03, EP3.05 SIS.05, SIS.06, SIS.07, SIS.10	Knowledge/Understanding Making Connections Inquiry Communication

Suggested Activities

Solar System

1.1.1 Students are introduced to the Final Assessment Task, the assessment which concludes the course. The teacher first introduces and explains that the reports produced in the unit activities, especially the End-of-Unit Tasks, will all be used as resources for the Final Assessment Task (Unit 6). Students begin to keep a glossary of new terms as they are introduced throughout the course, and a file or log of reports and research completed during the activities for later reference. They investigate and explain, from text and/or case study readings, the fundamental forces and processes responsible for the formation of the solar system; (e.g., gravitational process of coalescence and implosion, nuclear reactions as they relate to the Nebular Hypothesis and Big Bang theories, and Newton's Universal Law as applied to the location and discovery of planets).

1.1.2 Students use the Internet to research, visualize, and describe the size, shape, and motions of the galaxy and solar system, and the place of the Earth within it. They explain how interplanetary studies in astronomy and geophysics have led to new understandings about the Earth's relationship with other objects in the solar system (e.g., the Goldilocks phenomena - significance and consequences of CO_2 in the atmosphere of Venus, Mars, and Earth).

1.1.3 Students view a data chart comparing the Earth with other solar system objects (e.g., mass, size, atmospheric composition, geologic composition, rotation, angle of axis of rotation, orbit paths, orbital revolution, distance, etc.). They use the information in the chart to hypothesize relationships among planets of the solar system as to distance, conjunction, gravity, and discuss their significance; to formulate scientific inquiry questions about the nature of the Earth in space (e.g., Is the Earth a perfect sphere? Is the rate of rotation, revolution changing?); and to formulate scientific questions about the origin, and evolution of the Earth and other objects in the solar system (e.g., What factors might have contributed to the arrangement and position of rocky and gaseous planets of the solar system?). The teacher then leads a classroom discussion on selected questions.

1.1.4 Students create a sequence of annotated diagrams to explain some of the external properties, processes, or phenomena that affect Earth, Moon, and Sun relationships (e.g., the earth's magnetic field, gravity and the effects on tides, orbital position and the effect on types of eclipses). They support their explanations by using quantitative data to demonstrate the causes and consequences of some aspect of these relationships (e.g., the effects of radiation from the Sun on the Earth's atmosphere; the force of gravity of the Moon and Sun on the tidal range on Earth; the effect of movement and position of the Moon and Sun on the frequency, duration, and type of eclipses; and effect of Earth motions such as obliquity, precession, eccentricity on variations in intensity of the Sun's energy). Direct observation of the Moon and Sun may be included and students must be informed of potential hazards and how to view the Sun safely.

Assessment Quiz on Earth motions (K/U); Formulation of Inquiry Questions (I, MC)
Annotated Diagrams: Earth, Moon, Sun Relationships (C)

Sun, Earth, and Moon/Impacts on the Earth

1.2.1 Students investigate the Internet and/or current periodicals for an article related to the near-Earth environment. They select an article that pertains to one of the following: the effects of planetary impacts on the near-Earth space environment (e.g., meteor showers and asteroidal impacts, their frequency, duration, periodicity, and consequences); the consequences of meteor impacts (e.g., mineralization of the Sudbury Basin, extinction of the dinosaurs); the phenomena of solar ultraviolet radiation; sunspot activity and variations in solar emissions as they relate to Aurora Borealis; and interruption to radio wave communication signals on earth. Students write a précis of the information presented including hypothesis, evidence, scientific methods of investigation used, and conclusions. Students may choose to present their findings using other methods, such as a poster, audio tape, webpage, or pamphlet.

Assessment Periodical Review/Précis (K/U, I, C, MC)

Exploring the Near-Earth Environment

1.3.1 Students discuss the challenges of developing human-made satellites: deployment size, thrust required, geosynchronous orbital path, life support systems required for manned flights and space station survival (e.g., first robotic spacecraft on the Moon, Mars).

1.3.2 Students develop a chronological timeline to demonstrate the contributions and significance of Canada to the study of our planet from near-Earth space (e.g., Radarsat, Canadarm).

1.3.3 From selected readings, textbook, or articles, students list the effects of human activity on near-Earth space (e.g., sources of human-made space debris, types, occurrences and their associated hazards such as the descent of MIR space station, pollution of upper stratosphere, affect on the electromagnetic spectrum).

Assessment Timeline Chart on Developing Technologies (I, C, MC)

End-of-Unit Task: Viewing the Earth

1.4.1 Students analyse a variety of image types of the Earth's surface from low and high altitudes, and describe the landform features, and natural agents of landscape development involved in their creation (e.g., fold mountains, volcanic landforms, canyons, river patterns, sand dune migration, glacial movement).

1.4.2 Students write an expository report identifying the changing perception of the Earth during the twentieth century from a visual perspective as a result of technological developments (e.g., first air photos of WWI trenches from a balloon; curvature of the Earth from a jet; Earth rise from Apollo moon voyage).

1.4.3 Students compare various technologies employed to view the Earth with the following headings: uses, applications, limitations, and societal impact of the development of technologies for viewing, recording, and interpreting information about Earth patterns and natural processes of change (e.g., the following examples could be assembled at workstations in class; oblique air photo, stereo air photo pairs, satellite photo-mosaics, infrared satellite images, Geographic Information System (GIS) mapping techniques).

1.4.4 Unit Test

Assessment Written Report (C, K/U); Comparison (I, MC); Unit Test (K/U, MC)

Resources

Internet Library – www.elibrary.com - a source of articles for Activity 1.1.2

Popular Science, Times Mirror Magazines – http://www.popsci.com

Discover Magazine, Disney Corp. – http:// www.discover.com

National Geographic – http://nationalgeographic.com

Scientific American – http://www.sciam.com

Note: Many of the above resources are also available in print form in school and community libraries.

Unit 2: Internal Structure and Processes of the Earth

Time: 19 hours

Unit Description

This unit examines the internal tectonic forces that drive the earth's heat engine. Students review the historic development of the concept of continental drift, and the current scientific evidence used to support the unifying theory of plate tectonics.

Unit Overview Chart

Activity	Focus	Learning Expectations	Assessment Categories
2.1 2 h	Internal Spheres and Processes of the Earth	ISV.02, ESV.01, EMV.01, IS2.01, IS2.05, ES1.02, ES1.03, EM1.05 SIS.05, SIS.08, SIS.09	Knowledge/Understanding Inquiry Communication Making Connections
2.2 5 h	Evidence of Internal Dynamics of the Earth	ISV.01, ISV.02, ISV.03, ESV.01, ESV.03, EHV.02, IS1.01, IS1.02, IS1.03, IS2.01, IS2.02, IS2.07, IS3.06, ES1.04, ES3.04, EH2.02 SIS.05, SIS.06, SIS.07, SIS.09	Inquiry Communication Making Connections
2.3 5 h	Seismology and Core Sampling	ISV.01, ISV.02, ISV.03, ESV.02, ESV.03, IS1.03, IS2.03, IS2.04, IS2.05, IS2.06, IS2.07, IS3.01, IS3.02, ES2.02, ES3.03, ES3.04 SIS.05, SIS.06, SIS.07, SIS.10	Knowledge/Understanding Making Connections Inquiry Communication
2.4 5 h	Earth Processes and Human Activity	ISV.03, ESV.02, IS3.01, IS3.02, IS3.04, IS3.05, ES2.02 SIS.05, SIS.06, SIS.07, SIS.09	Inquiry Communication Knowledge/Understanding Making Connections
2.5 2 h	End-of-Unit Task: Case Study Interpretation	ISV.01, ISV.02, ISV.03, IS1.01, IS1.03, IS2.01, IS2.02, IS2.07, IS3.01, IS3.04, IS3.05, IS3.06 SIS.05, SIS.06, SIS.07	Knowledge/Understanding Inquiry Communication Making Connections

Suggested Activities

Internal Spheres and Processes of the Earth

2.1.1 The teacher explains that the reports produced in the unit activities and especially the End-of-Unit Task will all be used as resources for the Final Assessment Task (Unit 6). Continue with the glossary throughout the unit. Students investigate the geophysical characteristics (e.g., composition, temperature, pressure, density, thickness) and interactions among the internal spheres of the Earth. They discuss and explain the forces and processes that account for the movement of crustal plates (e.g., explain how the Earth's internal heat engine works).

2.1.2 Students use a graphic computer program to create a scaled diagram to compare the geophysical characteristics of the Earth's internal spheres. The model should show the sources of heat, the transfer of that heat to the aesthenosphere, the formation of convection cells, and the conversion of the energy into forces that perform work to move the crustal plates.

2.1.3 Using a flow chart of the rock cycle, students explain how rocks and their constituent minerals are continuously being recycled as a result of the effects of the Earth's heat engine.

Assessment Written Quiz (K/U): Graphic Model of Earth's Heat Engine (I, C, MC)

Evidence of Internal Dynamics of the Earth

2.2.1 Students investigate the geophysical properties and uses of seismic waves, (i.e., P-waves, S-waves, L-waves) to calculate and identify the location of epicenters and variations in the density of subsurface Earth materials such as discontinuity boundaries.

2.2.2 Students design and construct a working model of a seismograph with annotated diagrams to demonstrate the significance of information gained from this instrument. They assess how developments in technology have contributed to our understanding of the Earth (e.g., the development and use of sonar to map the topography of the ocean floor, and of the magnetometer to identify magnetic signature of the ocean floor bedrock).

2.2.3 Through group research, students investigate and report on one of the national or international Earth Science endeavors that has increased our understanding of the Earth's crust, and assess the merits of funding such projects (e.g., Lithoprobe Ocean Drilling Program).

Assessment Model Seismograph (MC, I, C); Research (I, C)

Seismology and Core Sampling

2.3.1 Students participate in a lesson to describe and account for the types of landforms which occur along plate boundaries (e.g., distinguish between fissure eruptions along volcanic ridges of divergence; composite cones and fold mountains along zones of convergence; types of faults which occur along slip zones).

2.3.2 During a group mapping activity, students plot location, intensity, and frequency of earthquake activity along fault zones in order to identify relationships and establish precursor behaviour of tectonic events (e.g., Mt. St. Helens, or Iceland).

2.3.3 Students, individually, write a supported opinion essay (five-paragraph format) on the geophysical evidence which supports the concept of plate movement (e.g., paleomagnetism, jigsaw fit of continental slopes, geologic fit of shield and mountain zones, mesosaur fossil correlation, paleoglaciation, paleoclimatology evidence).

Assessment Mapping Activity (I, C, MC); Supported Opinion Essay (K/U, C, MC)

Earth Processes and Human Activity

2.4.1 Students participate in a teacher-led lesson to identify and describe the types and limitations of precursor information (e.g., frequency, intensity and duration of tremors, and occurrence intervals) used to predict earthquake activity and to develop warning systems and preparedness strategies.

2.4.2 Students investigate, assess, and prepare a report on the engineering and technological innovations which humans have used to deal with the impact that earthquakes have had on human activities (e.g., case study analysis of San Francisco, Japan, or Vancouver).

Assessment Report (I, C, K/U, MC)

End-of-Unit Task: Case Study Interpretation

2.5.1 Students participate in a group presentation to interpret historical scientific data about the nature of a tectonic disaster (e.g., duration, intensity, magnitude) and explain the involvement of natural physical processes in causing such events. They then explain the use of seismic data by scientists from various disciplines to predict future tectonic events (e.g., Vancouver Earthquake ~1700 AD).

2.5.2 Unit Test

Assessment Presentation (K/U, C, I, MC); Unit Test (K/U, MC)

Resources

Plate Tectonics This Dynamic Earth USGS (development of the theory of plate tectonics) – http://ppub.usgs.gov/publications/test/dynamic.html

Canadian Tectonics Group (website contains structural geology images and information on research projects) – http://craton.geol.brocku.ca/ctg.html

A story of Plate Tectonics – http://pubs.usgs.gov/publications/text/dynamic.htm

Sea Floor (world sea floor maps and information on ocean-drilling data and samples) – http://www.ngdc.noaa.gov/mgg/mggd.html

Convection Currents (Jet Propulsion Laboratory's Guide to Convection)
– http://bang.lanl.gov/solarsys/edu/convect.htm

Earthquakes and Volcanoes

New Scientist On-line Magazine (a source for articles on Earth Science topics including earthquakes and volcanoes. Institutional license is available for archival users.)
– http://www.newscientist.com

Seismology NEIC National Earthquake Information Center the world data center for seismology (current earthquake information and links) – http://www.neic.cr.usgs.gov/plate_tectonics/rift_man

Earthquakes (USGS information on quakes, hazards, preparedness, historical info, etc.)
– http://quake.wr.usgs.gov/

Volcanoes Volcano World (information on how a volcano works)
– http://volcano.und.edu/VolcanoWorld

Unit 3: Earth History

Time: 16 hours

Unit Description

Knowledge of Earth history is based on the study of fossils and the principles of stratigraphy. This unit introduces students to the techniques of determining geologic time and the insight gained about the evolutionary sequence of events that has shaped the Earth.

Unit Overview Chart

Activity	Focus	Learning Expectations	Assessment Categories
3.1 6 h	Geologic Time	EHV.01, EHV.02, EHV.03, ESV.01, EH1.01, EH1.02, EH1.03, EH2.01, EH2.04, EH2.05, EH2.06, EH2.07, EH3.01, EH3.02, EH3.04, ES1.03 SIS.05, SIS.06, SIS.07, SIS.10	Knowledge/ Understanding Inquiry Communication Making Connections
3.2 6 h	The Fossil Record	EHV.01, EHV.02, EHV.03, EH1.03, EH1.04, EH2.03, EH3.03 SIS.05, SIS.06, SIS.07	Knowledge/ Understanding Inquiry Making Connections Communication
3.3 4 h	End-of-Unit Task: Local Geology Project	EHV.02, EHV.03, EMV.02, EH2.01, EH2.04, EH2.05, EH2.07, EH3.01, EH3.03, EM2.06 SIS.05, SIS.06, SIS.07, SIS.10	Inquiry Communication

Suggested Activities

Geological Time

3.1.1 The teacher explains that the reports produced in the unit activities and especially the End-of-Unit Task will all be used as resources for the Final Assessment Task (Unit 6). Students continue building their glossary throughout the unit. Students investigate the concept of geologic time scale by contrasting the concept of catastrophism to the principles of uniformitarianism in the development of geologic thinking. Students compare a human time scale to a geologic time scale (e.g., events in the formation of North American continent to the events of early human activity to the present).

3.1.2 Students write an expository editorial, which James Hutton might have written to demonstrate an understanding of the significance of paradigm shifts in the development of geological thinking in his day. They then investigate relative geologic time by applying the principle of superposition, and fossil to stratigraphic correlation of bedrock sequences.

3.1.3 Students participate in an activity to graph stratigraphic data from different geologic drill core columns and correlate and interpret the chronology of geologic time. They explain the significance of an unconformity which interrupts the complete sequencing of geologic events in time (e.g., the Niagara Escarpment, Michigan Basin, Grand Canyon, or the boundary between Paleozoic and Precambrian rocks in southern Ontario).

3.1.4 Students participate in a lesson to investigate the technologies used to assess absolute geologic time (e.g., radiometric and radiocarbon dating techniques) along with an exercise to determine the rate of radioactive decay and the calculation of absolute time.

3.1.5 Students write a biographical sketch on the contributions of a Canadian to the development of techniques and technologies related to the enhancement of geologic time, geologic correlation, etc. (e.g., Tuzo Wilson).

Assessment Written quiz (K/U); Editorial Article (MC, C); Lab Stratigraphy Report (I, MC, C); Biographical Sketch (K/U, C)

The Fossil Record

3.2.1 Students examine, describe, and explain a variety of fossil samples which demonstrate different methods of natural preservation (e.g., petrification, carbonation, replacement, permineralization, desiccation, mould, and cast formations).

3.2.2 Students are provided a fossil sample representing one of the major life forms during one of the geologic time periods. They draw a hand sketch of the sample and label its external features. Students then research the order, genus, and species names of the specimen, describe the process of preservation, and environmental conditions during its lifetime. If possible, students include a labelled sketch of the organism's theoretical or possible internal structure. The information is presented in an interesting manner of the student's choosing (e.g., Bristol board, presentation software, story board).

3.2.3 From selected periodical articles and references provided by the teacher, students describe the environmental conditions of life on Earth during one of the geologic eras (e.g., Proterozoic, Paleozoic, Mesozoic, or Cenozoic). Students assess and discuss the information from the readings to identify issues and problems related to such research and interpretation. They debate the issues related to the apparent evolution and succession of life in the fossil record during these eras. They then research the use of index fossils as evidentiary data in support of plate movement or as economic indicators of oil and natural gas.

Assessment Fossil Lab Assignment (presentation/display) (I, C); Debate (C, K/U)

End-of-Unit Task: Local Geology Project

3.3.1 Students participate in a teacher-led lesson on how to use geologic maps, drill core data, etc., to interpret and describe the chronological sequence of major events which lead to the formation of the bedrock and surficial features of the Niagara Escarpment or a local region. They create a sequence of annotated diagrams and a timeline to represent the chronology of events that led to the formation of the geologic region in which the local area lies.

3.3.2 Students describe the uses, and socio-economic importance of the Earth's resources (e.g., quarrying, aggregate activities, metallic mineral extraction, dimensional stone production, petroleum extraction etc.) to the local economy by means of a visual display (e.g., graphs, maps, and pictures, etc.).

3.3.3 Unit Test

Assessment Diagrammatic Time Line (I, C, K/U); Graphic Pictorial Display (MC); Unit Test (K/U, MC)

Resources

Thompson I. *The Audubon Society: Field Guide to North American Fossils*. Alfred A. Knopf, Inc., 1982.

Geologic Dating Earth Net (dating rock) – http://www.inrs.uquebec.ca/cgq/eng/earth/datation.html

Isotopic Dating (information on the age of the earth)
– http//www.talkorigins.org/origins/faqs-youngearth.html

Paleontology (University of California Museum of Paleontology virtual exhibit)
– http://www.ucmp.berkeley.edu/exhibit/exhibits.html

A virtual field trip of the Jurassic Park Reef in Germany
– http://www.unisssstuttgart.de/geologie/Jurassic_Reef_Park/

Unit 4: Surficial Earth Processes

Time: 22 hours

Unit Description

This unit focuses on investigating many of the natural processes and forces that shape the Earth's surface. By making field observations, measuring, recording, and interpreting data, students quantify natural processes that influence the nature of human activities on the Earth's surface. A local stream or lake shoreline should be used as a means of acquiring field data and applying concepts in order to create representative models of the natural processes studied.

Unit Overview Chart

Activity	Focus	Learning Expectations	Assessment Categories
4.1 3 h	Environmental Interactions With Water	ESV.02, ESV.03, ES2.03, ES3.01, ES3.02 SIS.06	Knowledge/Understanding Inquiry Communication Making Connections
4.2 6 h	Weathering/ Erosion/Fluvial/ Coastal Processes	ISV.01, ISV.02, ISV.03, EMV.03, IS1.04, IS1.05, IS1.06, IS1.07, IS2.08, IS2.09, IS3.07, EM2.06 SIS.05, SIS.06, SIS.07, SIS.08, SIS.09	Inquiry Making Connections Communication
4.3 5 h	Groundwater Processes	ISV.01, ISV.02, EMV.02, ESV.03, IS1.08, IS2.10, EM2.06, ES3.02 SIS.05, SIS.06, SIS.07	Knowledge/Understanding Inquiry Communication Making Connections
4.4 4 h	Glacial Processes	ISV.01, ISV.02, ISV.03, IS1.05, IS2.10, IS3.03, IS3.07 SIS.06, SIS.07, SIS.10	Knowledge/Understanding Communication Making Connections
4.5 4 h	End-of-Unit Task Glaciation and the Local Watershed	ISV.01, ISV.02, ISV.03, ESV.03, IS1.07, IS2.09, IS2.10, IS3.07, ES3.02 SIS.06, SIS.07, SIS.10	Knowledge/Understanding Making Connections Inquiry Communication

Suggested Activities

Environmental Actions With Water

4.1.1 The teacher explains that the reports produced in the unit activities and especially the End-of-Unit Task will all be used as resources for the Final Assessment Task (Unit 6). Continue with the glossary throughout the unit. Students participate in a lesson to explain the mineral/rock sources of macro and micro-nutrients essential for sustaining life on Earth (e.g., potash for potassium, apatite for phosphates). They construct a flow chart to represent the role of water as the mechanism that liberates essential nutrients from the lithosphere to be used by flora and fauna in the biosphere (e.g., nitrogen, phosphorus, carbon, and water cycles).

4.1.2 Students describe the adaptations of flora and fauna to the level of available nutrients in wetlands (e.g., carnivorous plants such as pitcher plant, sundew plant). They identify indicator species of flora and fauna that are representative of nutrient-deficient and nutrient-rich wetland environments (e.g., bog, marsh, swamp, fen) and account for their survival in these conditions.

4.1.3 Students add to their first flow chart to report on the ways and means by which humans are interdependent with natural cycles of materials (e.g., explain the affects of farming activities and practices on the use and release of phosphates and nitrates in the environment).

Assessment Written quiz (K/U, MC); Nutrient Cycle Flow Chart (I, C)

Weathering/Erosion/Fluvial/Coastal Processes

4.2.1 Students discuss and distinguish among agents of erosion (e.g., water, wind and ice) and classification of weathering processes (i.e., mechanical or chemical). Through researching a natural disaster (e.g., Frank slide in Alberta, Mt. St. Helens' debris flows, California or Venezuela mud slides), students investigate and prepare a report to describe the causes and effects of physical, chemical, and biological weathering, document the chronology of human events and environmental factors which led to a natural disaster, and suggest ways of preventing similar occurrences in the future. Students, working in small groups, design and construct models of mud slide (mass wasting) sites and demonstrate a method of controlling the problem.

4.2.2. Students identify the types of stream loads (i.e., solution, suspension, and bedload) and describe the factors affecting the movement of each in a stream. (Note: stream table experiments are possible here.). They describe and explain the consequences of erosion and deposition on the development of stream valley landforms, (e.g., slip-off-slope, undercut bank, natural levees, river terraces, meander scars, etc.). Students explain the relationships between stream flow and sediment load (e.g., stream velocity vs. particle size).

4.2.3 Students participate in a field trip to a local stream or the shore of a lake to conduct a field survey to measure some of the fluvial and hydrologic conditions (e.g., velocity, cross section depth profile, gradient, sediment composition, and human activities). Students complete an analysis of field data to relate the characteristics of erosion and deposition along a local stream or beach environment to the processes that have shaped the landform. They write a field report to present the data and explain the findings. The teacher needs to ensure that all board regulations are followed in planning such a field trip and that students (and parents) are informed of the potential hazards. Care must be taken in selecting a site so that students are not put at risk in any way. Deep water and fast moving water are primary concerns. Students should be informed about safety concerns and be given guidelines about safe practices at the field site.

Assessment Natural Disaster Report (I, C, MC); Fluvial Field Report (I, C, MC)

Accommodations See Accommodations following Activity 5.6.3 at the end of the developed unit.

Groundwater Processes

4.3.1 Through a teacher-led lesson, students describe and explain the position and significance of ground water regimes below the surface, (e.g., water table, zone of aeration and saturation, capillary fringe, rate of infiltration) and the factors affecting the natural systems (e.g., underground geology, aquifers, oasis, geysers, and springs).

4.3.2 Students identify the factors affecting the movement of water through the ground within a watershed and assess the factors affecting the quantity and quality of water within that area (e.g., precipitation, rate of infiltration, soil porosity and permeability, etc.). Students analyse sample data of hydrologic regimes related to a local watershed.

4.3.3 Students participate in a group investigation and oral presentation on important issues related to the movement of groundwater in aquifers, including their fragility in terms of how human activities alter them by contamination and depletion. Each group makes a short presentation to the class and then, on an individual basis, students produce an analysis of the role of humans in determining the quality and quantity of groundwater, integrating information from a number of presentations.

Assessment Oral Presentation (I, K/U, C); Data analysis (MC, I, C)

Glacial Processes

4.4.1 The students participate in a teacher-led lesson on the causes and consequences of climate changes in high latitudes which result in periods of glaciation (e.g., changes in Earth orbits linked to Unit 1). Students investigate and distinguish between glacial erosion and glacial depositional processes as they relate to alpine valley glaciers and continental ice sheets.

4.4.2 Through the use of geographic tools, such as stereo air photos and topographic maps of selected areas of Canada, students identify and describe landform types, processes of formation as a result of continental glacial advance and retreat, and the land uses associated with each type of landform.

4.4.3 Students describe and evaluate engineering and technological innovations and adaptations resulting from human activity in permafrost areas of northern Canada (e.g., house foundations; pipeline construction, road construction and limitations, diamond mine developments on permafrost).

4.4.4 Students use topographic map/air photos of the local region to identify and describe landform types and processes associated with the formation of local surficial features (e.g., drumlins, eskers, till plains, outwash plains, spillways, kames and kettles, moraines and abandoned glacial lake beds).

4.4.5. Students summarize the information presented in this activity in form of graphic organizer in preparation for the End-of-Unit Task

Assessment Written Quiz (K/U, MC); Graphic Organizer (C, MC)

End-of-Unit Task: Glaciation and the Local Watershed

4.5.1 Using air photo topographical maps, students investigate and write a report to explain how the erosional and/or depositional processes of glaciation have influenced the drainage features of the local watershed.

The report should include references to the fluvial and lacusterine features found in the local area, and how they have influenced the nature of human activities (e.g., how people have responded to the landscape on which they live as evidenced by the agricultural/urban land use patterns, road networks, and altered drainage patterns, etc.).

- or -

If a local environment is not suitable, the teacher could create a fictional landscape scenario to include the glacial, erosional, and depositional features on a watershed or coastal environment so that students could investigate and report on the influence that these features could have on human activities and how geomorphologists/engineers might respond to them.

4.5.2 Unit Test

Assessment Written Report (MC, K/U, I, C); Unit Test (K/U, MC)

Resources

A Digital Field Trip to the Wetlands. A virtual reality field trip – www.digitalfrog.com

Disasters

United States Geological Survey Home Page (a source in all areas of Earth science with many links available for specific research including worldwide disaster information) – http://www.usgs.gov/

Federal Emergency Management Agency (information on disasters, covering gradational forces of floods and storms) – http://www.fema.gov/

Natural Hazards Center (international information on natural hazards and human adjustments to hazards and disasters) – http://www.colorado.edu/hazards

Landslide hazards (Canadian source of landslide information)
– http://www.NRCan.gc.ca/gsc/cpdnew/Indsld_e.html

Information on the Red River Flood, Saquenay Flood with useful links
– http://www.ccrs.nrcan.gc.ca/ccrs/tekrd/rd/apps/disasterindese.html

Remote Sensing Canada Center for Remote Sensing (general information)
– http://www.ccrs.nrcan.gc.ca/ccrs/

National Environmental Satellite, Data, and Information Service
(provides access to global environmental data from satellites)
– http://ns.noaa.gov/NESDIS/NESDIS_Home.htm

Satellite Image Atlas (world glaciers)
– http://geochange.er.usgs.gov/pub/info/facts/atlas/indes.html

Stream Flow (contains information on surface water issues and specific data for stream flow throughout the U.S.) – http://h2o.usgs.gov/

Ground Water Atlas (information about aquifers in the U.S.)
– http://water.wr.usgs.gov/gwatlas/index.html

Water Pollution Environment Canada (information on clean air and water)
– http://www.ec.gc.ca/

Toxic Water (information about clean up of toxins in surface and ground water)
– http://toxics.usgs.gov/toxics/

Glaciations

Glacial Geology at University of Cincinnati (good reference link to all About Glaciers)
– http://tv11.geo.uc.edu/ice/Glacier.html

Glaciers and Climate Change (University of Illinois links to other related sites)
– http://Yahoo.com/Science/Earth_Sciences/Geology_and_Geoophysics/Glaciology

Unit 5: Earth Materials

Time: 24 hours

Unit Description

Humans depend upon a host of Earth materials from which they make a livelihood. Geology is the focus of this unit. Geology uses the scientific method to explain natural aspects of planet earth. Therefore, the formation, classification and identification of rocks and minerals in the earth's lithosphere are introduced. Students also investigate the economic importance of Earth resources and the consequences of environmental changes, which are created by mining activities. The knowledge acquired through these activities is applied in the End-of-Unit Task. A field excursion to a suitable site within the local region to observe and collect relevant samples and information in order to understand the importance that Earth materials play in the local economy is suggested.

Unit Overview Chart

Activity	Focus	Learning Expectations	Assessment Categories
5.1 2 h	Introduction to Earth Materials	EMV.01, EMV.02, EMV.03, EM1.01, EM1.05, EM2.02, EM3.03, EM3.04 SIS.05, SIS.06, SIS.07, SIS.10	Knowledge/Understanding Inquiry Making Connections
5.2 6 h	Mineralogy	EMV.01, EMV.02, EMV.03, ESV.01, EM1.01, EM2.01, EM2.02, EM3.01, ES1.01, ES1.03 SIS.01, SIS.02, SIS.04, SIS.05, SIS.06, SIS.07	Knowledge/Understanding Inquiry Communication Making Connections
5.3 4 h	Igneous and Sedimentary Rocks; Properties Identification and Formation	EMV.01, EMV.02, EMV.03, EM1.02, EM1.03, EM1.05, EM2.03, EM2.04, EM3.01 SIS.01, SIS.02, SIS.04, SIS.05, SIS.06, SIS.07	Knowledge/Understanding Inquiry Communication Making Connections
5.4 4 h	Metamorphic Rocks Properties Identification and Formation	EMV.01, EMV.02, EMV.03, EM1.04, EM1.05, EM2.05, EM3.01, EM3.03 SIS.01, SIS.02, SIS.04, SIS.05, SIS.06, SIS.07, SIS.10	Inquiry Communication Knowledge/Understanding Making Connections
5.5 4 h	Topical Reports	EMV.01, EMV.03, EM1.05, EM3.01, EM3.02, EM3.03, EM3.04, EM3.05 SIS.01, SIS.05, SIS.06, SIS.07, SIS.10	Inquiry Communication Knowledge/Understanding Making Connections
5.6 4 h	End-of-Unit Task: Field Excursion	EMV.02, EMV.03, EM2.06, E.M.3.03 EM3.05 SIS.01, SIS.02, SIS.05, SIS.06, SIS.07, SIS.08, SIS.09, SIS.10	Knowledge/Understanding Inquiry Making Connections Communication

Unit 6: Final Assessment Task: Environmental Assessment

Time: 11 hours

Unit Description

This culminating unit allows students to draw together the knowledge and skills gained from activities of the preceding units. Data gathered in previous reports on the local region is utilized to form the basis of an environmental assessment report. The report and presentation focus on the justification of a future Earth resource development project proposed for the local area. This unit could be presented as an authentic role-play scenario for the students as the local area can be used as a focus of studies.

Unit Overview Chart

Activity	Focus	Learning Expectations	Assessment Categories
6.1 1 h	Introduction	EPV.02, EMV.02, EMV.03, EP2.03, EM2.06, EM3.01, EM3.03, EM3.05 SIS.05, SIS.06	Knowledge/ Understanding

Activity	Focus	Learning Expectations	Assessment Categories
6.2 2 h	Environmental Assessment Research	EPV.02, ESV.01, ESV.02, ESV.03, EMV.02, EMV.03, ISV.01, ISV.02, ISV.03, EHV.02, EP2.03, EP2.04, EP3.03, ES1.02, ES2.02, ES2.03, ES3.04, EM2.06, EM3.02, EM3.03, EM3.05, IS1.08, IS2.09, IS2.10, IS3.03, EH2.01 SIS.05, SIS.06, SIS.08, SIS.09, SIS.10	Knowledge/ Understanding Inquiry Communication Making Connections
6.3 3 h	Environmental Report Writing	EPV.03, ESV.01, ESV.02, ESV.03, EMV.02, EMV.03, ISV.01, ISV.02, ISV.03, EHV.02, EP3.03, ES1.02, ES2.02, ES2.03, ES3.01, ES3.02, EM2.06, EM3.01, EM3.02, EM3.03, EM3.04, EM3.05, IS1.08, IS2.09, IS2.10, IS3.03, IS3.07, EH2.01 SIS.06, SIS.07, SIS.10	Knowledge/ Understanding Inquiry Communication Making Connections
6.4 3 h	Environmental Report Presentation	EPV.03, ESV.01, ESV.02, ESV.03, EMV.02, EMV.03, ISV.01, ISV.02, ISV.03, EHV.02, EP3.03, ES1.02, ES2.02, ES2.03, ES3.01, ES3.02, EM2.06, EM3.01, EM3.02, EM3.03, EM3.04, EM3.05, IS1.08, IS2.09, IS2.10, IS3.03, IS3.07, EH2.01 SIS.07, SIS.10	Knowledge/ Understanding Inquiry Communication Making Connections
6.5 2 h	Final Exam	EPV.01, EPV.03, ESV.01, ESV.03, EMV.01, EMV.03, ISV.01, ISV.03, EHV.01, EHV.03	Knowledge/ Understanding Making Connections

Suggested Activities

Introduction

6.1.1 The teacher introduces and describes the culminating task in relation to the End-of-Unit Tasks from the previous five units of study. Students need to assemble copies of previous unit reports to form a class library of resources. Reports that may be applicable could include the following: GIS Report, Activity 1.4.3; Socio-economic importance of a local Earth resource, Activity 3.3.2; Erosional/Depositional Glacial Surficial Report, Activity 4.5.1; Local Watershed Data report, Activity 4.3.3; Economic Geology, Resource Technology Reports, Activity 5.5.1; and Geologic Field Report, Activity 5.6.1. Students can utilize the information found in these reports to augment their research for the environmental assessment report.

6.1.2 Students brainstorm lists of potential development projects that make use of Earth resources that are available in the local region. Students should be well acquainted with the opportunities for development in their local area at this point in the course through the work completed in Units 4 and 5 (e.g., quarry, mineral/mining operation, landfill site, sustainable forestry, agriculture).

6.1.3 Students conduct research, including print and Internet sites, and explain the process of creating and writing an Environmental Impact Assessment (EIA) and Socio-economic Impact Assessment (SEIA) as they relate to the creation of formal Environmental Impact Statements (EIS). Students can draw on examples from Internet sites, city hall, local conservation authority, etc.

6.1.4 With direction from the teacher, students brainstorm and design a rubric which will be used to evaluate the Environmental Impact Statement report. The teacher is responsible for the evaluation criteria and final format of the rubric.

Assessment Informal assessment of student understanding of the environmental assessment process.

Environmental Assessment Research

6.2.1 The teacher divides the class into working groups of four students who will form an Environmental Engineering Consulting Firm that has been hired as an environmental assessment task force to develop, plan, and assess the environmental impact of the proposed resource-based development. Students are to select their roles within the task force to include a geologist, a hydrologist, a geomorphologist, and a geographic systems analyst (a GIS specialist).

6.2.2 In their roles, students research and assemble data from a variety of sources including the previous class reports, text references, the Internet, and local sources (e.g., community newspapers, community associations, local municipal offices, local watershed conservation authority, regional government offices). Data and information gathered should be relevant to the role the student assumes within the task force:

- Geologist: Investigate the stratigraphic history and nature of the location and potential extent of the resource and the appropriate extractive technology used to map and assess the potential resource for future development.
- Hydrologist: Investigate the characteristics of water flow above and below ground and account for possible contamination and interruption in the natural nutrient cycles as they impact on human and ecological activities
- Geomorphologist: Investigate and interpret surficial landscape and drainage features and analyse the impact that the exploitation of the resource may have on the natural processes of the local watershed (e.g., erosion\deposition nodes, storm water management, tailings ponds, etc.).
- Geographic Systems Analyst: Map and account for the relationships among different data sets, e.g., drainage and resource location, land use patterns, transportation alignments etc.

Assessment Research Notes (I, C, MC, K/U) These may be peer assessed by being vetted by other task force members.

Environmental Report Writing

6.3.1 Students write an Environmental Impact Report on the proposed development project that should include details on the following criteria:

- specific location of the development
- site characteristics
- type of development and detailed description of the project
- land use description of the local area
- description of the local watercourses and related hydrology
- description of the local geology as it applies to the Earth resource development
- description of the local environment and the potential environmental effects as a result of the development project
- advantages and disadvantages to the environment
- assessment of the overall impact of the project.

6.3.2 Students prepare for a public open house/information meeting based on their findings in Activity 6.3.1. Students then plan and assemble the display materials required for the oral presentation of the Environmental Assessment Report to the public open house. Display materials may include land use maps, transportation alignments, project development plans, site maps, summary charts, fluvial and hydrologic characteristics, glacial and geologic characteristics, natural features, environmentally sensitive areas, etc.

Assessment Environmental Impact Report (I, C, MC, K/U). Although each group submits a single report, the defined roles of the different group members allows for individual evaluation.

Environmental Report Presentation

6.4.1 Students present their Environmental Impact Assessment Report to the Public Open House/Information Meeting. The class can act as the general public for each of the presenting groups. Roles can be given to individual members of the class audience to add authenticity to the process. Care should be taken to set up an environment that is in keeping with a public forum within the classroom or other suitable location in the school to make this as "real" an experience as possible for the students.

Assessment Report Presentation (K/U, I, C, MC) The defined roles of the different group members allows for individual evaluation.

Final Exam

6.4.1 Final Examination will focus on Relating Science to Technology, Society, and the Environment expectations.

Assessment Final Exam (K/U, MC)

Resources

Ministry of the Environment website – http://www.ene.gov.on.ca

Natural ResourcesStatistics Canada (information on Canada's resources) – http://www.statcan.ca/engllish/Pgdb/Land/geogra.htm

Reid, I. *Land In Demand: The Niagara Escarpment*. Book Society of Canada Ltd., 1977.

Miller, G. Tyler Jr. *Living in the Environment*, 7th ed. Wadsworth Publishing Co., 1992.

Teaching/Learning Strategies

Need for Variety and Balance

Since the over-riding aims of this course are to develop scientific literacy in all students and to prepare students for Earth and Space Science or related courses at university, a wide variety of instructional strategies is needed to provide learning opportunities that accommodate an equally wide variety of learning styles and interest. In planning activities for an Earth and Space Science class, make sure that students have:

- opportunities to work individually, in pairs and small groups, and in large groups;
- direct-instruction as well as open-ended exploration;
- opportunities to develop concepts themselves from observed data;
- tasks in which they define some of the parameters (such as scope or procedure);
- opportunities to acquire knowledge and apply that knowledge in a variety of contexts;
- opportunities to communicate using standard formats (such as lab reports) as well as opportunities to choose and develop the format;
- opportunities to develop skills that would assist them in being successful at university: note taking during a lecture, examination preparation, multiple-choice test taking, in-depth, independent research, report writing, and time management;
- opportunities to make connection between this course and senior level geography courses in which some students may also be enrolled.

Students need to be informed in advance of methods of assessment and evaluation. From the beginning, students should understand the nature and scope of the course's Final Assessment Tasks and how the completion of the End-of-Unit Tasks assists them in gaining the skills and knowledge necessary for its successful completion. Expectations are presented in such a way as to prepare students for the End-of-Unit Tasks. Assessment and evaluation then become an integral part of the teaching/learning strategies.

Skills are Developed through Experience and Refined with Practice

Many of the Learning Expectations describe Inquiry Skills. Students should be given repeated opportunities to carry out genuine inquiries in which they are responsible for defining one or more of the components of the inquiry: the topic or question, the methodology, the mode of presentation, the criteria of success. Within this course, students should have multiple opportunities to practise a variety of inquiry styles, including:

- **Research:** accessing information that has already been previously gathered, selecting the relevant details, analysing that information for patterns and meaning, and communicating the findings or conclusion. This will require instruction and practice in techniques for effective use of library/resource centre resources, searching the Internet, and interviewing experts.
- **Experimentation:** developing questions, identifying controls and variables, designing the experimental procedure, observing and measuring, analysing the data for patterns and meaning, and communicating conclusions. This may occur in laboratories or the field. Laboratory techniques and safety procedures must be taught and assessed.

Every inquiry should be driven by a clear question that is manageable and has relevance to the students. Students must be given instruction and repeated practice in: identifying and refining good inquiry questions; developing testable hypotheses; setting the parameters of the solutions to be sought; assessing results.

All forms of inquiry as well as other activities throughout the course develop **Communications Skills**. Although the traditional written report is one form of communication, students need to describe what they do and what they learn in other formats as well – poster presentations; computer presentations, video, music. Through various formats of cooperative learning, they discuss, debate, and reflect on their own thinking and learning.

In addition to key concepts, every learning activity should identify a technique or skill that will be taught or reinforced and assessed. Over the length of the course, all skills required to meet the Overall Expectations and the Science Investigative Skills should be practised repeatedly in a variety of contexts.

Initially, the teacher may assign specific review exercises from a textbook or other resource. Later, students could simply be told to complete what questions they feel are necessary to ensure their own understanding of the concepts.

Use of Computer Technology

Computer applications should be included in activities whenever they enhance student learning by enabling them to complete work more efficiently or to complete work that otherwise could not be done. A wide variety of software tools should be used to record and display information. Examples include word-processing (e.g., reports), spreadsheets (e.g., class data from measurements taken in the laboratory), graphics (e.g., flow charts, concept maps, diagrams in place of written reports of investigations), databases (e.g., to gather observations taken by small groups or individuals into a class set; collections of data from replicated experiments), and presentation programs (e.g., an alternative for reporting on investigations, particularly by groups). Probeware should be used to collect data (e.g., to permit replications of experiments where complex procedures would limit students to single experiments). Simulations may substitute for experiences but should not be used to replace direct experiences that are safe, ethical, and available. The portability of calculator-based laboratory systems makes them useful for work outside the classroom.

On-line communication between teacher and students could occur throughout the course. Homework assignments and answers could be posted, along with reminders about upcoming assignment deadlines and evaluation dates. Sample exam questions could be included and links made to pertinent sites, covering a variety of STSE topics. Online tutorials could be arranged and one of the later units in the course could be presented online.

Learning Skills

While not evaluated for marks, learning skills - Works Independently, Teamwork, Organization, Work Habits/Homework, Initiative – are keys to success in school and beyond. As with other skills, they should be taught, practised, and assessed in the science classroom. Variety is essential: individual assignments foster independence; small-group cooperative learning experiences (including laboratory work done in pairs) provides opportunities to develop teamwork.

Making Connections

The knowledge expectations of this course have intrinsic worth as useful information, but they also serve as vehicles for developing other expectations:

- acquisition of knowledge through inquiry develops inquiry skills;
- connecting chemical concepts to social and environmental issues develops the necessary habits of mind for making connections;
- applying scientific knowledge to practical problems makes connections to technology; considering how scientific knowledge is acquired brings understanding of the role that technology plays in scientific discovery.

During the study of Earth and Space Science, students should be encouraged to develop awareness of the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment

Assessment & Evaluation of Student Achievement

Seventy per cent of the grade will be based on assessments and evaluations conducted throughout the course. Thirty per cent of the grade will be based on a final evaluation in the form of an examination, performance, essay, and/or other methods of evaluation.

Assessment is a process of gathering information and providing descriptive feedback about student learning. Evaluation is the process of judging work and assigning a value, based on established criteria.

The purpose of assessment is to improve student learning. This means that judgements of student performance must be criterion-referenced so that feedback can be given that includes clearly expressed next steps for improvement. Tools of varying complexity can facilitate this.

- For assessing/evaluating a test or quiz, a marking scheme is used.
- Where completion or non-completion is the issue, a checklist is sufficient.
- Where quality of performance is easily identifiable, a rating scale can be used.
- For more complex tasks, the criteria may be incorporated into a rubric where levels of performance for each criterion are stated in language that can be understood by students. Rubrics describe performance of a generalized skill (such as Inquiry) or can be task-specific.

Marking schemes, checklists, rating scales and rubrics become powerful tools for improving learning when students understand the criteria and levels of performance before they undertake the task. Discussion of the criteria for success should be part of every learning task. Wherever possible, involve your students in the development of the rating scale or rubric (identifying criteria and setting levels of achievement in terms they understand).

Assessment must be embedded within the instructional process throughout each unit rather than being an isolated event at the end. Often, the learning and assessment tasks are the same, with formative assessment provided throughout the activity. In every case, the desired demonstration of learning is articulated at the beginning and the learning activity is planned to make that demonstration possible. When planning learning activities for Earth and Space Science, this process of beginning with the end in mind helps to keep focus on the Expectations and to reduce the inclination to expand what is taught beyond what is required by the guideline.

Assessment, Evaluation, and Reporting are tied to the Learning Expectations and Achievement Chart for Science, pp. 172-175 in *The Ontario Curriculum, Grades 11 and 12, Science, 2000*. Every learning activity and its assessment should collect data for making judgements about performance in one or more of the Achievement Categories: Knowledge/Understanding, Inquiry, Communications and Making Connections. Within each unit and across the course, teachers must collect sufficient data (in kind and number) to make valid judgements about each student's performance in all categories.

In the end, the evaluation of the assessment data is expressed as a percentage based on Achievement Chart levels. That evaluation must be based on each student's performance based on the criteria, not relative to other students' performances. Final evaluations should reflect the teacher's informed, professional judgement of each student's most consistent level of performance in each category of the Achievement Chart. Added weight should be given to more recent performances.

A wide and balanced range of assessment strategies is needed to accommodate the varied learning styles of all students, and to encompass a broadened range of knowledge and skills expectations. There must be opportunities for students to demonstrate learning at all levels of the Achievement Chart.

Diagnostic Activities

Students enrolled in SES4U come to this course with a wide variety of learning experiences. The number and kind of science and geography courses in the student's background vary, and part-time jobs and hobbies also provide these students with various sets of knowledge and skills. Diagnostic activities, at the start of all units, are important for providing a context for the unit design (based on student interest and background), for planning lessons to meet student needs, for filling in gaps and correcting misconceptions, and for tapping into student strengths. Diagnostic activities should consider Knowledge/Understanding, Inquiry and Communication Skills, and Making Connections. A range of activities should be considered including:

- pencil-and-paper quiz (marks are not recorded)
- class discussion suggested by one or more focus questions
- brainstorming activities
- carousel of laboratory activities for assessment of skills
- KWL charts (**K**now, **W**ant to know, and then later, what was **L**earned)
- carousel of different applications
- student survey
- responding to a short reading passage (fiction or non-fiction) or a video clip (fiction, documentary, or news broadcast) on a connected societal issue.

A diagnostic activity suggested within the profile can be substituted by any of the above or one of the teacher's own design. By varying the diagnostic activity from unit to unit, different learning styles of students will be addressed.

Group Work Considerations

A number of group activities are described that allow students to practise and be assessed and evaluated for Teamwork, one of the five Learning Skills. Teamwork is often identified as a key employability skill. Initiative, Organization, and Work Habits/Homework, three other Learning Skills, can be practised, assessed, and evaluated to some extent. However, when group assignments are used to evaluate course Expectations, the teacher must ensure that this is done on an individual basis. This can be accomplished in a number of ways:

- Individual teacher/student conferences could be arranged. Student responses to a series of questions can be used to evaluate Knowledge/Understanding, Communication Skills, and Making Connections most easily, but can also be used for Inquiry.

- Work journals or log books, where students describe their role and responsibility in completion of an activity, could be collected on a regular basis and evaluated.
- Reflection journals could be used by students to describe their learnings from a certain activity, and then evaluated for knowledge and making connections.
- Work logs and reflection journals can be in formats other than pencil-and-paper. Some students might produce more complete and detailed answers if they were using a tape recorder or a concept map. This would allow different learning styles to be addressed.
- Students could pool their experimental or research results, and produce an independent, individual final product that would be evaluated.
- Students could contract for different aspects of research or communication for a group project. This is another opportunity to address individual learning styles. When evaluating the group presentation, the teacher is aware of individual responsibilities.
  A quiz could be used to evaluate specific knowledge or making connection expectations gained through a group activity.
- Teacher observation, using a checklist, and on the spot questioning can be used to assess and evaluate meeting of expectations on an individual basis.
- Acquisition of technical skills could be evaluated in another, individual situation such as a summative, practical skills test.

Self- and peer assessment of individual performances within a group setting are appropriate and useful to assist students in becoming self-monitoring. However, such assessments are not to be the basis for evaluation; evaluation is the responsibility of the teacher.

Accommodations

Students with special needs, whether identified formally or not, may need additional supports to reach their full potential in Grade 12 Earth and Space Science. Teachers should consult individual student IEPs for specific direction on accommodation for individuals. The following are examples of accommodations and aids that may be helpful in a general way. Where there are specific accommodations required in an activity, the suggestions are noted within the activity.

- Ensure that peer helpers are available when students are working in small groups.
- Provide handout sheets with sample calculations and specific skill instructions.
- Help students create data charts into which they record information.
- Advise special education staff in advance when students are working on major assignments.
- Record key words on the board when students are expected to make their own notes.
- Allow students to report verbally to a scribe (teacher or student) who can then help in note making.
- Utilize student strengths by permitting them a wide range of options for recording and reporting their work (e.g., drawings, diagrams, flow charts, concept maps).
- Extend timelines to give students more time to process language and put their thoughts into words.
- Give readings in advance to students or provide a selection of materials at different reading levels.
- Provide extended timelines in situations where students have limited access to computers.
- Check the IEPs of all identified students for specific modifications in teaching methodologies and evaluation.
- Advise ESL/ELD staff in advance when significant written work is required.
- Have students keep a science dictionary of terms using pictures and first language words.
- Permit the use of a translation dictionary on assessments.
- Provide additional time on assessments for dictionary use and processing language.
- Have the library staff identify resources with appropriate reading level when research is required.
- Post formulas necessary for solving numerical problems on posters around the classroom.

Resources

The URLs for the websites were verified by the writers prior to publication. Given the frequency with which these designations change, teachers should always verify the website prior to assigning them for student use.

Units in the Course Profile make reference to the use of specific texts, magazines, films, videos, and websites. Teachers need to consult their board policies regarding use of any copyrighted materials. Before reproducing materials for student use from printed publications, teachers need to ensure that their board has a Cancopy license and that this license covers the resources they wish to use. Before screening videos/films with their students, teachers need to ensure that their board/school has obtained the appropriate public performance videocassette license from an authorized distributor (e.g., Audio Cine Films Inc.). Teachers are reminded that much of the material on the Internet is protected by copyright. The copyright is usually owned by the person or organization that created the work. Reproduction of any work or substantial part of any work on the Internet is not allowed without the permission of the owner.

Resources are found throughout the profile, wherever the writers felt it would be most useful for teachers. The following are general resources which are useful in all units:

Text Resources

Bennet, Barrie and Carol Rolheiser. *Beyond Monet - The Artful Science of Instructional Integration*. Toronto: Bookation, Inc., 2001. ISBN 0-9695388-3-9

Chapman, L.J. and D.F. Putnam. *The Physiography of Southern Ontario*, 3rd ed. Ministry of Natural Resources, 1984.

Judson, Kauffman, Leet. *Physical Geology*, 7th ed. Prentice-Hall, Inc., 1987.

Roberts, J. L. *The Macmillan Field Guide to Geologic Structures*. The MacMillan Press Ltd., 1989.

Plummer, C., D. McGeary, and D. Carlson. *Physical Geology*, 8th ed. McGraw Hill, 1999.

Miller. G. Tyler Jr. *Living in the Environment*, 7th ed. Wadsworth Publishing Co., 1992.

Websites

Structural Geology (Kuxtown University with related links to the topic)
– http://home.earthlink.net/~schimmrich/structure/structure.html

Natural Resources Statistics Canada (information on Canada's resources)
– http://www.statcan.ca/englllish/Pgdb/Land/geogra.htm

OSS Policy Considerations

Students can apply and refine the skills, knowledge, and habits of mind they acquire in SES4U through Cooperative Education, work experience and service placements within the community.

A work site placement must be directly connected to the Expectations of SES4U if it is to contribute to a student's perspective of future careers or educational opportunities. The wording in the document *Cooperative Education and Other Forms of Experiential Learning* (Ontario Ministry of Education, 2000) provides clear direction, and should be the focus of the personalized learning plans for students. "The personalized learning plan must include the following: "the curriculum expectations of the related course that describe the knowledge and skills the student will extend and refine through application and practice at the workplace" (p. 23, emphasis added). The placement is not intended to introduce the student to the expectations, but should connect closely enough that significant Expectations are clearly extended and refined in a workplace setting. Both workplace and community experiences may offer unique opportunities for students to achieve aspects of the goal of SES4U "To relate science to technology, society, and the environment" and to gain experience in the Science Investigative Skills defined at the beginning of the course description in the guideline. The personalized placement-learning plan of a student who has an Individual Education Plan (IEP) must be developed with direct reference to the IEP.

Coded Expectations, Earth and Space Science, Grade 12, University Preparation, SES4U

Scientific Investigation Skills

SIS.01 - demonstrate an understanding of Workplace Hazardous Materials Information System (WHMIS) legislation by selecting and applying appropriate techniques for handling, storing, and disposing of laboratory materials (e.g., following safety procedures when sampling rocks; using materials safely when identifying minerals and rocks), and by using appropriate personal protection (e.g., wearing safety glasses when sampling, and hard hats when visiting outcrops and quarries);

SIS.02 - select appropriate instruments and use them safely, effectively, and accurately in collecting observations and data (e.g., hand lens, polarizing microscope);

SIS.03 - use safe procedures to protect the eyes when observing the sky by day, and choose safe, secure locations when observing the sky at night;

SIS.04 - demonstrate an understanding of emergency laboratory procedures;

SIS.05 - select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate scientific ideas, plans, and experimental results (e.g., use an appropriate time scale when representing geological time, or appropriate units to represent astronomical distances);

SIS.06 - select, integrate, and analyse information from print and electronic sources, including Internet sites, and, either in writing or using a computer, compile and display the information in various forms, including flow charts, tables, and graphs (e.g., use the Internet to compile information on areas of major earthquake activity, and compare the frequency and intensity of the activity in graphical form);

SIS.07 - communicate the procedures and results of investigations and research for specific purposes using data tables and laboratory reports (e.g., prepare a table of known and unknown minerals sorted in groups according to physical properties such as hardness, colour, and streak);

SIS.08 - express the result of any calculation involving experimental data to the appropriate number of decimal places or significant figures;

SIS.09 - select and use appropriate SI units (units of measurement of the *Système international d'unités*, or International System of Units);

SIS.10 - identify and describe careers related to Earth and space science (e.g., careers related to hydrology, meteorology, geology, mineralogy, astronomy, and remote sensing).

The Earth As a Planet

Overall Expectations

EPV.01 · demonstrate an understanding of the properties of the Earth and of the internal (geological) and external (cosmic) processes operating on it, and draw comparisons with other objects in the solar system;

EPV.02 · investigate and analyse the Earth's place in the solar system and the effects of cosmic and geological processes on it and on other objects in the solar system;

EPV.03 · describe and explain how observations of the Earth and other objects in the solar system, made both from Earth and from space, are used to study and better understand the natural and the human-made environments of the Earth.

Specific Expectations

Understanding Basic Concepts

EP1.01 – visualize and describe the size, shape, and motions of the solar system, and the place of the Earth within it;

EP1.02 – describe the origin and evolution of the Earth and other objects in the solar system, and identify the fundamental forces and processes involved;

EP1.03 – compare the Earth with other objects in the solar system with respect to such properties as mass, size, composition, rotation, and magnetic field;

EP1.04 – describe and explain the following external processes and phenomena that affect the Earth: radiation and particles from the "quiet" and "active" sun; gravity and tides of the sun and moon; and the impacts of asteroidal and cometary material;

EP1.05 – describe the properties of the near-Earth space environment.

Developing Skills of Inquiry and Communication

EP2.01 – formulate scientific questions about the nature, origin, and evolution of the Earth and other objects in the solar system;

EP2.02 – visualize and describe the size, shape, and motions of the solar system, and compare the Earth with other planets and objects within it, on the basis of information gathered through research;

EP2.03 – assess critically the scientific questions they have formulated and the information they have gathered in order to identify the fundamental forces and processes that shape the interior, surface, and atmosphere of the Earth and other objects in the solar system;

EP2.04 – identify surface features of the Earth and other objects in the solar system (e.g., craters, faults, volcanoes), using light, infrared, and radio/radar images;

EP2.05 – investigate, either through laboratory activities or research, the interaction of radiation and impacting particles with Earth materials such as air, water, and rock;

EP2.06 – assess the risks associated with solar ultraviolet radiation, and with the collision of asteroidal and cometary material with the Earth.

Relating Science to Technology, Society, and the Environment

EP3.01 – explain how the study of other planets and objects in the solar system has led to a better understanding of the Earth (e.g., explain how studying the greenhouse effect on Venus has increased understanding of the same effect on Earth);

EP3.02 – demonstrate an understanding of some of the historical, cultural, and aesthetic consequences of changes in the perception and understanding of the Earth's place in space (e.g., evaluate the impact of images of the whole Earth taken from space);

EP3.03 – describe how observations and measurements of the Earth made from space are used to study and better understand natural physical elements of the Earth's environment (e.g., its crust, water, air) as well as human-made elements (e.g., crops, cities, air and water pollution);

EP3.04 – describe the challenges of designing piloted and robotic spacecraft, and of operating them in near-Earth space;

EP3.05 – investigate Canada's contributions to the study of our planet from near-Earth space (e.g., Radarsat, International Space Station), using information from various print and electronic sources;

EP3.06 – evaluate the negative effects of human activity on near-Earth space (e.g., space debris, pollution of the electromagnetic spectrum).

Introduction to Earth Sciences

Overall Expectations

ESV.01 · identify and describe the elements and dynamic interactions of the Earth's natural systems;

ESV.02 · investigate the basic structure of the planet and the geological processes associated with it, and use the knowledge gained to explain the major interactions among the hydrosphere, lithosphere, biosphere, and atmosphere;

ESV.03 · assess the impact of natural forces and systems on the Earth's physical and human environments, as well as the impact of human activities on natural systems.

Specific Expectations

Understanding Basic Concepts

ES1.01 – demonstrate an understanding of the range of physical scales that apply in the Earth sciences (e.g., from those that apply to the planet as a whole to those used at the atomic level);

ES1.02 – describe the major interactions among the four spheres of the Earth – the atmosphere, hydrosphere, lithosphere, and biosphere;

ES1.03 – demonstrate an understanding of the continuous recycling of major rock types throughout Earth history, of the evidence that this process provides with respect to the length and complexity of Earth history, and of the very late appearance of human beings in the geological record;

ES1.04 – describe various kinds of evidence that suggests that life forms, climate, continental positions, and the Earth's crust have changed over time (e.g., the extinction of the dinosaurs, evidence of past glaciations, evidence of the existence of Pangaea and Gondwanaland).

Developing Skills of Inquiry and Communication

ES2.01 – interpret data about the nature of natural disasters, and explain the involvement of physical processes and the role of Earth science in connection with such events;

ES2.02 – demonstrate an understanding of the major tools and techniques (e.g., seismograph, magnetic signature of the ocean floor) that various Earth scientists (e.g., seismologists, geophysicists) use to conduct research on the basic structure and processes of the planet;

ES2.03 – document and explain, through investigation, examples of the complex interconnectedness of physical, chemical, and biological processes as they apply to the Earth (e.g., plants live in the biosphere by taking nutrients and other crucial substances from the other three spheres of the Earth, to which they also contribute important substances).

Relating Science to Technology, Society, and the Environment

ES3.01 – explain the interactions of the atmosphere and hydrosphere in the water cycle, and the impact of these interactions on humans;

ES3.02 – describe and explain the effects of natural systems on the Earth's physical and human environments, and the increasing alteration of certain natural systems that has resulted from human activities;

ES3.03 – analyse, through cooperative research, national and international Earth science endeavours (e.g., Lithoprobe, Ocean Drilling Program) that have increased our understanding of the Earth's crust, and assess the merits of funding such projects;

ES3.04 – assess how developments in technology have contributed to our understanding of the Earth (e.g., the development of sonar to map the ocean floor).

Earth Materials

Overall Expectations

EMV.01 · distinguish between minerals and rocks, and describe the formation and characteristics of both;

EMV.02 · apply a series of specific tests to identify minerals and rocks, including those in the local area, and to determine their physical properties;

EMV.03 · demonstrate an understanding of society's dependence on Earth materials, of the effects of developments in technology on the exploration and mining of Earth materials, and of the ways in which the use and extraction of Earth materials have affected natural and human-made environments.

Specific Expectations

Understanding Basic Concepts

EM1.01 – identify different minerals by their physical and chemical properties, and demonstrate understanding that minerals are the constituents of rocks;

EM1.02 – describe the formation of igneous rocks (plutonic and volcanic), and identify their distinguishing characteristics (e.g., composition and flow behaviour; characteristics of volcanic rocks that indicate the type of volcano in which they were formed);

EM1.03 – describe the formation of clastic and chemical sediments, and of the corresponding sedimentary rocks;

EM1.04 – describe the different ways in which metamorphic rocks are formed (i.e., through changes in temperature, pressure, and chemical conditions) and the factors that contribute to their variety (e.g., variation in parent rock);

EM1.05 – explain (e.g., by interpreting a rock cycle diagram) how rocks and their constituent minerals are continuously being recycled.

Developing Skills of Inquiry and Communication

EM2.01 – apply a series of tests (e.g., tests evaluating hardness, streak, and density) to identify common minerals (e.g., quartz, calcite, potassium feldspar, plagioclase feldspar, muscovite, biotite, talc, graphite, gold, silver);

EM2.02 – identify and classify selected hand samples of unknown minerals on the basis of their physical properties (e.g., sort the groups by hardness, colour, streak);

EM2.03 – apply a series of tests to identify common igneous rocks (e.g., granite, obsidian, andesite, basalt, gabbro, peridotite), and classify each according to its origin (e.g., volcanic, plutonic), texture (e.g., coarse- or fine-grained, vesicular, glassy), and composition (e.g., mafic, felsic, intermediate);

EM2.04 – apply a series of tests to identify sedimentary rocks (e.g., conglomerate, breccia, sandstone, shale, limestone, chert, gypsum, rock salt, coal), and classify each according to its origin (e.g., clastic, chemical), texture (e.g., coarse- or fine-grained, detrital), and composition;

EM2.05 – apply a series of tests to identify and classify metamorphic rocks (e.g., slate, phyllite, schist, gneiss, quartzite, marble) and, on the basis of the characteristics of each type, identify its parent rock and the temperature, pressure, and chemical conditions at its formation;

EM2.06 – investigate and describe the geological setting of the local area (e.g., examine the geological setting of a local river/stream bed or lakeshore, and identify and classify rock types on the basis of representative samples collected at the site).

Relating Science to Technology, Society, and the Environment

EM3.01 – explain the importance of minerals and other Earth resources (e.g., sand, gravel, dimension stone, oil and gas), and of exploration for these resources, for the local, provincial, and national economies;

EM3.02 – describe and assess the role of Earth materials in the safe disposal of industrial and urban waste and toxic materials;

EM3.03 – describe the uses and evaluate the economic importance of minerals, rocks, and metallic resources (e.g., gold, silver, nickel, copper) and non-metallic resources (e.g., sand and gravel, aggregates, oil and gas, lime, gypsum, industrial minerals, gems);

EM3.04 – describe the use of dimension stone (e.g., in buildings and cemeteries) and explain how the development of new technologies has influenced the type of stone used in the local area (e.g., relate advances in the technology for quarrying and cutting stone to changes in the type of stone used);

EM3.05 – describe some of the technologies used to recover natural resources from the Earth, and evaluate economic, social, and environmental ramifications of their use (e.g., the need for fewer workers and the practice of site rehabilitation resulting from the use of improved technologies in the mining of nickel).

Internal and Surficial Earth Processes

Overall Expectations

ISV.01 · identify the processes at work within the Earth (e.g., plate tectonics, earthquakes, volcanism) and on its surface (e.g., running water, weathering and erosion, mass wasting, glaciation), and describe the role of both types of processes in shaping the Earth's surface;

ISV.02 · investigate, through the use of models and analysis of information gathered from various sources, the nature of internal and surficial Earth processes, and the ways in which these processes can be measured;

ISV.03 · demonstrate an understanding of the interrelationships between internal and surficial Earth processes (e.g., earthquake activity, volcanic eruptions, floods, erosion) and the ways in which they affect human activity.

Specific Expectations

Understanding Basic Concepts

IS1.01 – demonstrate an understanding of the kinds of evidence that Earth scientists use to document lithospheric plate motion (e.g., the corresponding shapes of the coastlines of Africa and South America; fossil evidence);

IS1.02 – distinguish between faults and joints;

IS1.03 – describe the characteristics of the three main types of seismic waves, P-, S-, and L-waves, and explain the different modes of travel, travel times, and types of motion associated with each;

IS1.04 – distinguish between erosion and weathering, and describe the processes and effects of physical, chemical, and biological weathering;

IS1.05 – demonstrate an understanding of the importance of different erosional processes, and describe the types and causes of mass wasting (e.g., landslides) and its critical role in changing the Canadian landscape;

IS1.06 – identify types of sediment transport (e.g., wind, water, glacial), and compare the particle size and shape, degree of sorting, and sedimentary structures resulting from each;

IS1.07 – identify the types of stream load (i.e., solution, suspension, and bedload) and describe how each moves in a stream;

IS1.08 – demonstrate an understanding of the importance of aquifers and of their fragility in terms of contamination and depletion.

Developing Skills of Inquiry and Communication

IS2.01 – describe, on the basis of information gathered from print and electronic sources, the various types of possible margins between lithospheric plates (e.g., convergent, divergent, transform, and intraplate activity) and the types of internal Earth processes occurring at each;

IS2.02 – produce diagrams of the following structures, and identify examples of them in maps and photographs: normal, reverse, thrust, and strike-slip (transform) faults; domes and basins; anticlines and synclines;
IS2.03 – investigate and produce a model of each type of seismic wave, using springs and ropes, and describe for each the nature of its propagation and the resulting movement within the rocks through which it is travelling;
IS2.04 – compare qualitative and quantitative methods (e.g., the Mercalli Scale and the Richter Scale) used to measure earthquake intensity and magnitude;
IS2.05 – produce a diagram or model, to scale, of the interior of the Earth in order to differentiate among the layers of the Earth and their characteristics (e.g., use cross-sections to provide the dimensions of crust, mantle, and inner and outer core, and travel-time curves for various seismic waves to provide data on the characteristics of the individual layers);
IS2.06 – design and construct a working model of a seismograph, and explain its use in recording earthquake activity;
IS2.07 – locate the epicentre of an earthquake, given the appropriate seismographic data (e.g., the travel-time curves to three recording stations for a single event);
IS2.08 – design and test methods to control mass wasting;
IS2.09 – relate the characteristics of sediment (e.g., grain size, shape, composition) to the velocity and direction of currents in a beach or stream environment (e.g., examine where sediment is being eroded and deposited in a local beach or river/stream environment);
IS2.10 – investigate and explain the interrelationship among geological maps, cross-sections, and block diagrams, and the ways in which they represent the subsurface structure and/or the geological history of an area.

Relating Science to Technology, Society, and the Environment
IS3.01 – describe methods of monitoring and predicting earthquakes, tsunamis, and volcanic eruptions;
IS3.02 – describe and explain how the development of the seismograph has contributed to a better understanding of the internal structure of the Earth;
IS3.03 – identify and describe engineering and technological innovations and adaptations resulting from human activity in areas of permafrost (e.g., pipeline construction, oil and natural gas exploration, residential construction and urbanization);
IS3.04 – identify and describe engineering and technological innovations and adaptations (e.g., in building design, highway construction, emergency services) resulting from the impact of earthquake activity on human populations;
IS3.05 – describe the underlying assumptions and the limitations of predictions of earthquake activity, and assess the implications of such predictions for populations in Canada and around the world;
IS3.06 – identify major areas of tectonic activity in the world (e.g., Japan – convergent margin; Iceland – divergent margin; California – transform fault), drawing on information about the relationship between earthquakes, volcanoes, and plate boundaries (e.g., plot on a world map, for a given time period, the locations of recorded earthquakes and active volcanoes);
IS3.07 – demonstrate an understanding of how erosion and deposition by streams are affected by load, gradient, channel shape, sediment composition, and human activities.

Earth History

Overall Expectations

EHV.01 · demonstrate an understanding of the concept of geological time;
EHV.02 · analyse and assess geological evidence that suggests that life forms, climate, continental positions, and the Earth's crust have changed over time;

EHV.03 · explain the importance of the geological and fossil records for our understanding of the Earth's history, and describe their use in related economic activities.

Specific Expectations

Understanding Basic Concepts

EH1.01 – demonstrate an understanding of the differences between relative and absolute dating techniques as they apply to natural systems;

EH1.02 – describe and explain the various methods of isotopic age determination, giving for each the name of the isotope, its half-life, its effective dating range, and some of the materials (e.g., minerals and rocks) that it can be used to date;

EH1.03 – describe some processes by which fossils are produced and/or preserved (e.g., original preservation, carbonization, replacement, permineralization, and mould and cast formations), and sketch a representative fossil of a foraminifer, mollusc, brachiopod, echinoderm, arthropod, coelenterate, vertebrate, graptolite, and plant;

EH1.04 – describe the diversity of life in the Proterozoic, Paleozoic, Mesozoic, and Cenozoic eras and the ranges of important groups of fossils that date from each.

Developing Skills of Inquiry and Communication

EH2.01 – use and interpret information from appropriate sources (e.g., a sequence diagram, geological maps showing major geological regions and associated rock types) in describing the geological history of an area (e.g., Ontario);

EH2.02 – investigate and analyse various types of preserved geological evidence of changes that have taken place in Earth history (e.g., past glaciations, tectonic activity, plate movement);

EH2.03 – demonstrate an understanding of the evolution of life, as revealed through fossil analysis;

EH2.04 – demonstrate the ability to use the geological time scale as an aid in interpreting the history of a sequence of strata;

EH2.05 – investigate and interpret the significance of an unconformity preserved in a sequence of strata (e.g., the boundary between Paleozoic and Precambrian rocks in southern Ontario);

EH2.06 – investigate radioactive decay and the concept of half-life determination (e.g., design a simple, safe experiment that provides a model of half-life decay of radioactive elements);

EH2.07 – analyse the evidence used to determine the age of the Earth (e.g., radiometric dating of geological materials), and outline the historical evolution of attempts to establish the Earth's chronology.

Relating Science to Technology, Society, and the Environment

EH3.01 – illustrate the geological time scale and compare it to human time scales (e.g., develop a series of timelines to represent their life, their family tree or history, the history of Canada, the history of civilization, the geological history of the local area, and the major events in Earth history, and compare the scales necessary to present this data on a 1m strip);

EH3.02 – demonstrate an understanding of the significance of paradigm shifts in the development of geological thinking (e.g., contrast the principles of uniformitarianism and catastrophism);

EH3.03 – demonstrate an understanding of the importance of fossils in the petroleum and mining industries as tools for biostratigraphic correlation and as indicators of depositional environments;

EH3.04 – describe Canadian contributions to our knowledge about absolute age dating and to technological applications based on this knowledge.

Unit 5: Earth Materials

Time: 24 hours

Unit Description

Humans depend upon a host of Earth materials from which they make a livelihood. Geology is the focus of this unit. Geology uses the scientific method to explain natural aspects of planet earth. Therefore, the formation, classification and identification of rocks and minerals in the Earth's lithosphere are introduced. Students also investigate the economic importance of Earth resources and the consequences of environmental changes, which are created by mining activities. The knowledge acquired through these activities is applied in the End-of-Unit Task. A field excursion to a suitable site within the local region to observe and collect relevant samples and information in order to understand the importance that Earth materials play in the local economy is suggested.

Unit Synopsis Chart

Activity	Learning Expectations	Assessment Categories	Tasks
5.1 Introduction to Earth Materials 2 h	EMV.01, EMV.02, EMV.03, EM1.01, EM1.05, EM2.02, EM3.03, EM3.04 SIS.05, SIS.06, SIS.07, SIS.10	Knowledge/ Understanding Inquiry Making Connections	Introduction to end-of-unit and final assessment tasks Lab: activity to classify selected samples of Earth materials Discussion: Purpose and techniques of geological field work, and a Geological Report Earth Science Career summary chart
5.2 Mineralogy 6 h	EMV.01, EMV.02, EMV.03, ESV.01, EM1.01, EM2.01, EM2.02, EM3.01, ES1.01, ES1.03 SIS.01, SIS.02, SIS.04, SIS.05, SIS.06, SIS.07	Knowledge/ Understanding Inquiry Communication Making Connections	Classification of selected minerals by observation and standardized tests Research: contributions of N. L. Bowen to understanding the formation of silicates from a melt and the use of silicates as a natural resource
5.3 Igneous and Sedimentary Rocks: Properties, Identification, and Formation 4 h	EMV.01, EMV.02, EMV.03, EM1.02, EM1.03, EM1.05, EM2.04, EM3.01 SIS.01, SIS.02, SIS.04, SIS.05, SIS.06, SIS.07	Knowledge/ Understanding Inquiry Communication Making Connections	Properties and formation of intrusive and extrusive igneous rocks Properties and formation of sedimentary rocks Lab: identification and classification of sedimentary and igneous rocks using chart organizers
5.4 Metamorphic Rocks: Properties, Identification, and Formation 4 h	EMV.01, EMV.02, EMV.03, EM1.04, EM1.05, EM2.05, EM3.01 SIS.01, SIS.02, SIS.04, SIS.05, SIS.06, SIS.07	Knowledge/ Understanding Inquiry Communication Making Connections	Demo/lecture: processes of formation of metamorphic rocks Lab: Metamorphic rock identification chart Jigsaw group activity: research different types of metamorphism

Activity	Learning Expectations	Assessment Categories	Tasks
5.5 Topical Report 4 h	EMV.01, EMV.03, EM1.05, EM3.01, EM3.02, EM3.03, EM3.04, EM3.05 SIS.01, SIS.05, SIS.06, SIS.07, SIS.10	Knowledge/ Understanding Inquiry Communication Making Connections	Investigative reports and oral presentation on fundamental geologic concepts
5.6 End-of-Unit Task: Geologic Field Report 4 h	EMV.02, EMV.03, EM2.06, EM3.03, EM3.05 SIS.01, SIS.02, SIS.05, SIS.06, SIS.07, SIS.08, SIS.09, SIS.10	Knowledge/ Understanding Inquiry Communication Making Connections	Planning a Geologic Field Trip – Conducting a Geologic Field Excursion to local site Written report on location, distribution, formation, and economic importance of a rock/mineral resource of local area/region

Activity 5.1: Introduction to Earth Materials

Time: 2 hours

Description

In these activities, students are introduced to the requirements of the End-of-Unit Task and also how the unit relates to the Final Assessment Task. Students are also introduced to the purpose and techniques of geologic field work; Geographic Information Systems; field mapping and sketching; collecting and preparing and testing samples of Earth materials for identification and interpretation of the processes that led to their creation. Students continue their glossary of working terminology related to the classification of Earth materials and then apply them to a set of unknown samples.

Strand(s) & Learning Expectations

Strand(s): Earth Materials

Learning Expectations

EMV.01 - distinguish between minerals and rocks, and describe the formation and characteristics of both;
EMV.02 - apply a series of specific tests to identify minerals and rocks, including those in the local area, and to determine their physical properties;
EMV.03 - demonstrate an understanding of societies dependence on Earth materials, of the effects of developments in technology on the exploration and mining of Earth materials, and of the ways in which the use and extraction of Earth materials have affected natural and human-made environments;
EM1.01 - identify different minerals by their physical and chemical properties, and demonstrate understanding that minerals are the constituents of rocks;
EM1.05 - explain how rocks and their constituent minerals are continuously being recycled;
EM2.02 - identify and classify selected hand samples of unknown minerals on the basis of their physical properties;
EM3.03 - describe the uses and evaluate the economic importance of minerals, rocks, and metallic resources and non-metallic resources;
EM3.04 - describe the use of dimension stone and explain how the development of new technologies has influenced the type of stone used in the local area;

SIS.05 - select and use appropriate and linguistic modes (geologic terminology) of representation to communicate scientific ideas, plans;
SIS.06 - select, integrate, and analyse information from print and electronic sources, including Internet sites, and, either in writing or using a computer, compile and display the information in various forms, including flow charts, tables, and graphs (e.g., use the Internet to compile information on the nature of Environmental Assessment and Geologic Reports as well as GIS);
SIS.07 - communicate the procedures and results of investigations and research for specific purposes using data tables and laboratory reports (e.g., prepare a table of known and unknown Earth materials sorted in groups according to physical properties);
SIS.10 - identify and describe careers related to Earth and Space Science (e.g., careers related to hydrology, meteorology, geology, mineralogy, astronomy, and remote sensing).

Prior Knowledge & Skills

- Internet research skills developed in previous courses and previously in this course
- Knowledge of different chemical properties from Grade 9 and 10 Science

Planning Notes

- Gather and organize required hand samples of rocks and minerals as suggested in the teacher notes.
- Secure access to computer lab for Internet search on careers in the Earth sciences and to investigate the use of GIS as a tool of Earth science research.
- Prepare a set of current reference materials (e.g., newspaper classifieds, for careers in the Earth sciences).
- Arrange for a guest speaker.

Teaching/Learning Strategies

5.1.1 **Student Activity:** A teacher-directed lesson introduces students to the activities of this unit, and how information gathered throughout the activities and reports produced are used in the culminating activity (Unit 6). This includes identification and classification of rock and mineral samples; creation of a visual presentation to represent the economic geology of a province; and reporting on the recovery and disposal technologies for a selected Earth resource. Students read a copy of a geologic report and identify the type of information included and the purpose/audience for which the report was written. Students investigate and compile information to create a career chart which summarizes the job skills, educational requirements, job expectations and responsibilities, and opportunities for advancement in careers related to the Earth sciences (e.g., engineer, geologist, survey technician, hydrologist, seismologist, etc.).

Teacher Facilitation: The teacher introduces and discusses the culminating activities of this unit as they relate to the End-of-Unit Task (the geologic report) and the Final Assessment Task (the environmental assessment report). The teacher then describes the methods of collecting information about the type and distribution of Earth materials, the purpose of, and analysis of field data, and the use of this information in writing geologic field reports for Environmental Assessment Statements. Website investigation offers the opportunity to review the expectations of Environmental Assessment Statements and the dependence of such reports on interdisciplinary studies. A guest speaker from a local engineering firm, a survey company, or environmental/ geologic consultant could make a presentation about the nature of his/her work as it applies to environmental assessments. This, along with newspaper classifieds, also provides an opportunity to identify careers dependent upon the Earth science disciplines.

5.1.2 **Student Activity:** Students recall and apply previous knowledge about classification systems used in other courses, in order to understand the need for, and purpose of the classification of Earth materials. Students continue to develop their glossary of terminology related to the classification of Earth materials.

Teacher Facilitation: The teacher leads the students in a discussion that requires them to recall examples of classification systems from the other science and non-science courses (e.g., periodic table of elements, optical properties of matter, biological classification of life, flora, fauna, classification of streams). Teachers should undertake diagnostic assessment or classification systems to determine what review or teaching of new material may be required. Samples and photographs from various references could be displayed for the students to consider. The information is tabulated as to the specific purpose of the classification systems and the parameters used to group items within the systems. To address misconceptions about the naming of Earth materials, the teacher should be sure to clarify definitions for the following terms: surficial and subsurface Earth materials, native element, fossil fuels, metallic minerals, non-metallic mineral, ores, aggregates, dimensional stone, rock and minerals, soil, till, consolidated, and unconsolidated material. It would also be appropriate here to present a simplified model (as used in the Grade 9 Geography course) of the rock cycle, in order for students to recognize the source and uses of Earth materials, and some of the interrelationships which occur among these resources. However, it should be recognized that this topic will be explored in greater depth through later activities in this unit.

5.1.3 **Student Activity:** Students observe and group a variety of samples of Earth materials. They use the glossary of new terminology from the previous activity, and apply this knowledge in order to make connections and identify the samples and categories.

Teacher Facilitation: The teacher creates approximately eight activity stations with appropriate samples. Depending on the size of the class, multiple stations might be necessary to allow all students to actively engage in the activity. At each station, provide students with several different samples to represent the same group of Earth materials, or mix the samples at each station depending upon the level of difficulty desired. Students move in small groups from station to station at about 10-minute intervals to complete the task. Direct students to develop an organizational matrix to chart and identify the criteria that they used to make an assessment for each group of Earth materials. With the assistance of a teacher-directed lecture and demonstration, the characteristics in the matrix to be used might include the following physical characteristics:

- texture – size and arrangement of mineral grains, feel
- lustre – metallic or non-metallic appearance, shininess
- hardness – Moh's hardness scale
- fracture – the way a substance breaks
- cleavage – mineral's tendency to split apart along certain preferred directions
- porosity – ability of the substance to hold liquids
- permeability – ability of the substance to allow liquids to pass through
- colour – as seen in natural light
- streak – colour of powdered substance scraped against unglazed porcelain
- type of Earth material

The native elements group could include samples of sulfur, copper, graphite, silver, gold. Fossil fuels could include peat, bitumen, bituminous coal, anthracite coal, oil shale, crude oil. Metallic minerals could include samples of galena, pyrite, calchopyrite, copper and nickel. Non-metallic minerals could include samples of calcite, talc, gypsum, apatite, and feldspar. Aggregates could include samples of river gravel, till deposits, esker gravel, sand, marl, conglomerate, and crushed limestone screenings. Dimensional stone could include samples of dolomite, limestone,

sandstone, granite, marble, and travertine. The rock and mineral station could include samples of rocks such as fossiliferous limestone, shale, granite, marble, and common rock forming minerals such a calcite, hornblende, quartz, feldspar, biotite. The soil samples could include samples of clay, sand, loam, and humus.

Assessment & Evaluation of Student Achievement

- A written quiz could be used to assess student achievement of Knowledge/Understanding expectations related to new terminology (e.g., multiple choice, matching items). A checklist applied to the Career Summary Chart could assess the thoroughness of Inquiry, while the Earth Materials Classification Chart allows for assessment of student's ability to Make Connections.
- Quiz (K/U, MC); Career Chart (K/U, I, MC); Classification Chart (K/U, I, MC)

Accommodations

- As an additional challenge, students could extend their investigations into a further study of the processes of formation of other essential life-giving Earth materials such as fossil fuels and/or soils.

Resources

Samples are available from rock, mineral kits listed in scientific supply catalogues (e.g., Wards, Boreal)

Judson, Kauffman, Leet. *Physical Geology*, 7th ed. Prentice-Hall, Inc., 1987.

Plummer, C., D. McGeary, and D. Carlson. *Physical Geology,* 8th ed. McGraw Hill, 1999.

Activity 5.2: Mineralogy

Time: 4 hours

Description

Students identify different minerals using the classification methods practised in Activity 5.1.They also investigate the role of different minerals as constituents of rocks. They add classification terms to their glossaries and apply a series of standardized tests to verify classification. A flow chart to represent the crystallization of silicate minerals according to the discoveries of N. L. Bowen is prepared.

Strand(s) & Learning Expectations

Strand(s): Earth Materials; Introduction to Earth Sciences

Learning Expectations

EMV.01 - distinguish between minerals and rocks, and describe the formation and characteristics of both;
EMV.02 - apply a series of specific tests to identify minerals and rocks, including those in the local area, and to determine their physical properties;
EMV.03 - demonstrate an understanding of societies dependence on Earth materials, of the effects of developments in technology on the exploration and mining of Earth materials, and of the ways in which the use and extraction of Earth materials have affected natural and human-made environments;
ESV.01 - identify and describe the elements and dynamic interactions of the earth's natural systems;
EM1.01 - identify different minerals by their physical and chemical properties, and demonstrate understanding that minerals are the constituents of rocks;
EM2.01 - apply a series of tests to identify common minerals;
EM2.02 - identify and classify selected hand samples of unknown minerals on the basis of their physical properties;

EM3.01 - explain the importance of minerals and other Earth resources and of exploration for these resources, for the local, provincial, and national economies;
ES1.01 - demonstrate an understanding of the range of physical scales that apply in the Earth sciences (e.g., the atomic level of chemical bonding of elements);
ES1.03 - demonstrate an understanding of the continuous recycling of minerals throughout Earth history;
SIS.01 - demonstrate an understanding of Workplace Hazardous Materials Information System (WHMIS) legislation by selecting and applying appropriate techniques for handling, storing, and disposing of laboratory materials (e.g., following safety procedures when identifying minerals), and by using appropriate personal protection;
SIS.02 - select appropriate instruments and use them safely, effectively, and accurately in collecting observations and data (e.g., hand lens, polarizing microscope);
SIS.04 - demonstrate an understanding of emergency laboratory procedures;
SIS.05 - select and use appropriate linguistic modes of representation to communicate scientific ideas about the classification of minerals;
SIS.06 - select, integrate, and analyse information from print and electronic sources, including Internet sites, and, either in writing or using a computer, compile and display the information in various forms, including flow charts, tables, and graphs;
SIS.07 - communicate the procedures and results of investigations and research for specific purposes using data tables and laboratory reports (e.g., prepare a table of known and unknown minerals sorted in groups according to physical properties such as hardness, colour, and streak);

Prior Knowledge & Skills

- Laboratory investigative skills previously developed
- Research skills developed in previous courses and earlier in this course
- Knowledge of chemical bonding from Grade 10 Science

Planning Notes

- Prepare samples to show mineral characteristics.
- Prepare Internet URLs for research into N.L. Bowen's contributions.

Teaching/Learning Strategies

5.2.1 **Student Activity:** From textbook readings, a review of Activity 5.1.3, or a teacher- directed lesson, the students add the terminology used to classify minerals to their glossary. The terms including colour and streak, fracture and cleavage, crystal structure and crystal form are listed in Activity 5.1.3.

Teacher Facilitation: The teacher reviews with students the difference between a rock and mineral along with a lesson explaining the standardized mineral classification system. The teacher demonstrates the application of this system with a few suitable samples (e.g., sulfur, galena, calcite).

5.2.2 **Student Activity:** Students apply a series of standardized tests (e.g., streak, hardness) and make observations in order to identify and classify common rock forming minerals by their physical and chemical properties.

Teacher Facilitation: The teacher assembles sets of suitable samples that best represent the characteristics of minerals to be identified (e.g., quartz, hornblende, augite, biotite, muscovite, potassium feldspar, plagioclase feldspar, calcite, pyrite, talc, apatite, fluorite, sulfur, graphite, copper, gold, silver). Mineral identification reference books should be made available to assist students with this activity. This lab activity could be completed in small groups or by a bell ringer process whereby students are given a few minutes to examine a sample and record their findings before passing on the sample to another student.

5.2.3 **Student Activity:** Students conduct an Internet search to identify the contributions that N. L. Bowen made to the understanding of the crystallization of rock forming silicates from a melt. Students write a biographical review of Bowen's life and scientific contributions to the development of geological understanding.

Teacher Facilitation: The teacher introduces the topic of silicates by presenting a brief overview of the chemical composition and characteristics of the major mineral families. The emphasis of this student activity will be on the most common rock forming minerals of the silicate family. The explanation should provide an explanation of chemical bonding as it applies to the silicate family only, i.e., the silica oxygen tetrahedra. Reference materials and appropriate URLs should be prepared ahead of time. Present the expectations of the biographical review as to content and length. Students should be expected to present Bowen's discoveries about the formation of silicate minerals by means of a fully annotated flow chart. The report should also highlight the importance of the silicate family of minerals as natural resources (e.g., clays of feldspar minerals used in the production of ceramics).

Assessment & Evaluation of Student Achievement

- The Mineral Identification Chart could be evaluated for evidence of the students' ability to Make Connections between hand samples of minerals and the glossary of terms previously created. The biographical review of N.L. Bowen could be used to assess Inquiry and Communication skills. A bell-ringer quiz could be used to assess Knowledge/Understanding of different mineral properties.
- Mineral Identification Chart (K/U, MC, I); Biography (I, C) Quiz (K/U, MC)

Accommodations

- As an extension, students could research into the principles of chemical bonding and thereby explain why silicate minerals are so common.

Resources

Rock and mineral samples are available from kits listed in scientific supply catalogues (e.g., Wards, Boreal)

Bob's Rock Shop (contains a great deal of information for mineral collectors)
– http://www.rockhounds.com/

Smithsonian Museum (website for mineral and gem collection)
– http://galaxy.einet.net/images/gems/gems-icons.html

Chesterman, C.W. *The Audubon Society: Field Guide to North American Rocks & Minerals*. Alfred A. Knopf. 1997.

Mottana A., R, Crespi, and G. Libori. *Simon & Schuster's Guide to Rocks & Minerals*. Simon & Schuster Inc., 1977.

O'Donoghue, M. *Rocks and Minerals*. Gallery Books, 1990.

Activity 5.3: Igneous and Sedimentary Rocks: Properties, Identification, and Formation

Time: 6 hours

Description

Through careful laboratory examination, students identify the physical properties of a range of igneous and sedimentary rocks. Based on these observations, they deduce the mode of formation of these rock types.

Strand(s) & Learning Expectations

Strand(s): Earth Materials

Learning Expectations

EMV.01 - distinguish between minerals and rocks, and describe the formation and characteristics of both;
EMV.02 - apply a series of specific tests to identify minerals and rocks, including those in the local area, and to determine their physical properties;
EMV.03 - demonstrate an understanding of societies dependence on Earth Materials,
EM1.02 - describe the formation of igneous rocks (plutonic and volcanic), and identify their distinguishing characteristics;
EM1.03 - describe the formation of clastic and chemical sediments, and of the corresponding sedimentary rocks;
EM1.05 - explain (e.g., by interpreting a rock cycle diagram) how rocks and their constituent minerals are continuously being recycled;
EM2.03 - apply a series of tests to identify common igneous rocks (e.g., granite, obsidian, andesite, basalt, gabbro, peridotite), and classify each according to its origin (e.g., volcanic, plutonic), texture (e.g., coarse- or fine-grained, vesicular, glassy), and composition (e.g., mafic, felsic, intermediate);
EM2.04 - apply a series of tests to identify sedimentary rocks (e.g., conglomerate, breccia, sandstone, shale, limestone, chert, gypsum, rock salt, coal), and classify each according to its origin (e.g., clastic, chemical), texture (e.g., coarse- or fine-grained, detrital), and composition;
EM2.05 – apply a series of tests to identify and classify metamorphic rocks (e.g., slate, phyllite, schist, gneiss, quartzite, marble) and, on the basis of the characteristics of each type, identify its parent rock and the temperature, pressure, and chemical conditions at its formation;
EM3.01 - explain the importance of minerals and other Earth resources (e.g., sand, gravel, dimensional stone) and of exploration for these resources;
SIS.01 - demonstrate an understanding of Workplace Hazardous Materials Information System (WHMIS) legislation by selecting and applying appropriate techniques for handling, storing, and disposing of laboratory materials (e.g., following safety procedures when sampling rocks; using materials safely when identifying minerals and rocks), and by using appropriate personal protection (e.g., wearing safety glasses when sampling, and hard hats when visiting outcrops and quarries);
SIS.02 - select appropriate instruments and use them safely, effectively, and accurately in collecting observations and data (e.g., hand lens, polarizing microscope);
SIS.04 - demonstrate an understanding of emergency laboratory procedures;
SIS.05 - select and use appropriate linguistic modes of representation to communicate scientific ideas, plans, (e.g., use standardized classification terminology);
SIS.06 - select, integrate, and analyse information from print and electronic sources, including Internet sites, and, either in writing or using a computer, compile and display the information in various forms, including flow charts, tables, and graphs (e.g., use the Internet to reference classification systems for sedimentary and igneous rocks);
SIS.07 - communicate the procedures and results of investigations and research for specific purposes using data tables and laboratory reports (e.g., prepare a table of known and unknown rocks sorted in groups according to physical properties).

Prior Knowledge & Skills

- Laboratory investigative skills previously developed
- Research skills developed in previous courses and earlier in this course
- Knowledge of chemical bonding from Grade 10 Science
- Knowledge of use of microscope from Grade 9 Science

Planning Notes

- Prepare samples of igneous and sedimentary rocks.
- Prepare research material or book student access on the Internet.

Teaching/Learning Strategies

5.3.1 **Student Activity:** After a teacher-directed lesson, students observe and record physical features of selected igneous rock samples (of unknown name and origin) and by deduction, hypothesize as to their processes of formation. Using an organizing chart, students record these physical characteristics (e.g., relative heft, texture, size of grains, presence or absence of pores, colour, hardness etc.). Students explain the evidence upon which their hypotheses are based (e.g., a light weight porous rock such as pumice or scoria suggests cooling from a gaseous lava; a dense non-porous igneous rock such as granite, gabbro, or diotite suggests slower cooling below the surface; an igneous rock with large crystals such as pegmatite, suggests very slow cooling over an extremely long period of time; a glassy textures igneous rock such as obsidian suggests rapid cooling of lava possibly by quenching in water; angular fragments imbedded in a matrix of finer grained material such as volcanic breccia suggests a pyroclastic material ejected from a volcano).
Teacher Facilitation: Prior to the lab activity, the teacher presents a lesson on the classification and formation processes associated with intrusive and extrusive igneous rocks. The subsequent activity provides the teacher with an opportunity to stress the importance of careful observation of hand samples of rock (by eye, hand lens, and binocular microscope) in order to identify clues and suggest factors affecting the processes of formation. After the lab activity, a follow-up discussion might involve a short oral presentation in which the student states the hypothesis and explains the characteristics that he/she used to make the deduction. The responses can be tabulated and the factors affecting the formation of these samples discussed (e.g., the rate of cooling/solidification of molten material, mineral composition of the parent lava and magma, crystallizing of magma from a subsurface melt or from surficial volatile lavas).

5.3.2 **Student Activity:** Students investigate and write a report on the factors affecting the formation of intrusive and extrusive igneous rocks. With reference to composition of the molten material, viscosity, volatile gasses, water, rate of cooling, etc., explain how igneous rocks can be grouped by texture (e.g., aphanetic, phaneritic, pyroclastic, vesicular, glassy) and the relation that these textures have to the mode of formation.
Teacher Facilitation: The teacher provides students with hand samples of common igneous rocks which may be used as examples to illustrate variations in rock texture and mode of formation. Examples could include pumice, scoria, rhyolite, obsidian, granite, diorite, gabbro, basalt, tuff, volcanic breccia, andesite.

5.3.3 **Student Activity:** Students investigate and explain the processes of formation of sedimentary rocks by means of an annotated flow chart.
Teacher Facilitation: The teacher organizes reference texts and/or an opportunity to use the Internet. From this the students should be able to identify the major subgroupings of sedimentary rocks (e.g., detrital and chemical) as well the natural processes involved. The teacher stresses the importance of explaining the complete stages in the processes of formation of the detrital group (e.g., lithification by weathering erosion deposition, accumulation and cementation and the type of geologic environments in which the final stage occurs) and chemical subgroups (e.g., evaporates, precipitates). A teacher-led demonstration, or student lab activity could be used to demonstrate the natural processes in the formation of chemical precipitates and evaporates which lead to the formation of non-clastic sedimentary rocks (e.g., limestone, travertine, salt, potash, gypsum).

5.3.4 **Student Activity:** Students identify and classify samples of sedimentary rocks using a chart organizer: heft, porosity, relative hardness, colour, size of mineral grains, presence of fossils, mode of formation etc.

Teacher Facilitation: The teacher prepares sets of the following rocks for students to examine and classify: shale, mudstone, siltstone, sandstone, conglomerate, limestone, rock salt, gypsum, travertine, coquina, and coal.

Assessment & Evaluation of Student Achievement

- A written quiz could be used to assess student's Knowledge of important terminology and Understanding of formation processes. A bellringer identification test of rock samples could test student's skills of recognizing new samples and applying the system of classification to them. Checklists could be used to assess both the Igneous and Sedimentary Rock Identification Charts and the Sedimentary Rock Formation Flow Chart. The Igneous processes report could be used to assess Communication skills (of logical and sequential explanations) as well as demonstrating the ability of students to Make Connections between physical features of rock samples and their mode of formation.
- Quiz (K/U, MC); Bell Ringer (K/U); Report (I, C); Identification Chart (K/U, I); Flow Chart (K/U, C, MC)

Resources

Rock and mineral samples are available from kits listed in scientific supply catalogues (e.g., Wards, Boreal).

Bob's Rock Shop (contains a great deal of information for mineral collectors)
– http://www.rockhounds.com/

Smithsonian Museum (website for mineral and gem collection)
– http://galaxy.einet.net/images/gems/gems-icons.html

Bob's Granite Page (information related to granite and igneous activity with many links to other sites)
– http://uts.cc.utexas.edu/~rmr/

Activity 5.4: Metamorphic Rocks: Properties, Identification, and Formation

Time: 4 hours

Description

Through research, students determine the factors that contribute to the different ways in which metamorphic rocks are formed. A laboratory exercise requires that students prepare a chart to identify and compare the physical characteristics of various metamorphic rocks. A group jigsaw activity provides opportunity for students to investigate the type of ancient geologic environments in which selected samples of metamorphic rocks form.

Strand(s) & Learning Expectations

Strand(s): Earth Materials

Learning Expectations

EMV.01 - distinguish between minerals and rocks, and describe the formation and characteristics of both;

EMV.02 - apply a series of specific tests to identify minerals and rocks, including those in the local area, and to determine their physical properties;

EMV.03 - demonstrate an understanding of societies dependence on Earth materials, of the effects of developments in technology on the exploration and mining of Earth materials, and of the ways in which the use and extraction of Earth materials have affected natural and human-made environments;
EM1.04 - describe the different ways in which metamorphic rocks are formed and the factors which contribute to their variety;
EM1.05 - explain how rocks and their constituent minerals are continuously being recycled;
EM2.05 - apply a series of tests to identify and classify metamorphic and, on the basis of the characteristics of each type, identify its parent rock and the temperature, pressure, and chemical conditions at its formation;
EM3.01 - explain the importance of minerals and other Earth resources (e.g., sand, gravel, dimension stone, oil and gas), and of exploration for these resources, for the local, provincial, and national economies;
SIS.01 - demonstrate appropriate techniques for handling, storing, and disposing of laboratory materials (e.g., following safety procedures when sampling rocks; using materials safely when identifying rocks);
SIS.02 - select appropriate instruments and use them safely, effectively, and accurately in collecting observations and data (e.g., hand lens, polarizing microscope);
SIS.04 - demonstrate an understanding of emergency laboratory procedures;
SIS.05 - select and use appropriate linguistic modes (terminology) to communicate scientific ideas;
SIS.06 - select, integrate, and analyse information from print and electronic sources, including Internet sites, and, either in writing or using a computer, compile and display the information in various forms, including flow charts, tables, and graphs;
SIS.07 - communicate the procedures and results of investigations and research for specific purposes using data tables and laboratory reports (e.g., prepare a table of known and unknown minerals sorted in groups according to physical properties).

Prior Knowledge & Skills

- Research skills gained in previous courses and earlier in this course

Planning Notes

- Prepare class sets of samples of metamorphic rocks.
- Prepare geologic reference materials for the jigsaw activity.

Teaching/Learning Strategies

5.4.1 **Student Activity:** By means of textbook readings, students explain the agents, factors, and processes of formation that lead to the development of metamorphic rocks. By using a geologic map of Canada, they compare the distribution of metamorphic rocks to the distribution of current landform types and account for the similarities and differences in patterns by applying the knowledge of metamorphic processes. Students add to their glossary.

Teacher Facilitation: By means of text readings, teacher-directed lesson, and demonstrations, the teacher reviews the processes of formation of metamorphic rocks and the role that extreme heat, extreme pressure, and hydrothermal ionized solutions play as they contribute to the alteration and recycling of pre-existing rocks. The following concepts are included in order to provide students with some of the necessary background information to complete the jigsaw activity in 5.4.3:

- Distinguish between the geologic environments/conditions and processes involved in contact and regional metamorphism.
- Use some samples such as garnet, staurolite, kyanite, sillimanite, andalusite to explain and illustrate the importance of index minerals in interpreting the geologic conditions at the time of formation.

- Explain the location and formation of metamorphic aureoles which form as a result of proximity to sources of extreme heat such as a batholith, and/or skarns which form as a result of hydrothermal activity.

5.4.2 **Student Activity:** Students use a conventional metamorphic classification chart to identify and describe the physical characteristics of a selected set of metamorphic rocks.

Teacher Facilitation: The teacher demonstrates how to identify and classify metamorphic rocks. The metamorphic rock chart (and new terminology) should include a description of the texture (foliated, non-foliated), rock cleavage (platy, schistose, flaky, phyllitic), particle size, composition, the original parent rock, type of metamorphism, major metamorphic agents, type of metamorphic environment, original parent rock, possible uses. Samples to be studied could include slate, phyllite, schist, gneiss, quartzite, marble, amphibolite, and anthracite coal.

5.4.3. **Student Activity:** As a member of an expert group, each student researches a given topic (from resources provided by the teacher), and returns to their home team to present their findings. The home group collectively studies and reviews each member's oral presentation and prepares for a follow-up quiz on the five topics. The concepts presented to the expert groups are:

- Use of samples of shale, slate, phyllite, schist, to explain and illustrate the process of progressive metamorphism by load pressure in areas of regional metamorphism.
- Use of limestone and marble to explain and illustrate the process of recrystallization by extreme heat and chemically active solutions in zones of contact metamorphism.
- Use of samples of lignite, bituminous coal, anthracite to explain the progressive metamorphism by load.
- Use of samples of iron ore to explain the process of metasomatism (intrusion/replacement of rocks by crystallization of ionized solutions) by iron-rich hydrothermal solutions which form skarns.
- Use of examples of granite and gneiss, and basalt and amphibolite to explain the process of metamorphism which leads to foliation. Describe the characteristics of foliation and the geologic environments in which it takes place.

Each concept investigated should include a component that requires the students to explain the economic importance of the metamorphic rocks.

Teacher Facilitation: The teacher divides the members of the class into appropriate home teams and expert groups. Sets of relevant geologic reference materials from reference texts, scientific periodical reprints, and/or Internet sources are assembled. These reference sets are provided to each expert group in the class. Additional research by the students beyond the resources provided by the teacher is not an expectation of this activity.

Assessment & Evaluation of Student Achievement

- A written response to compare a geologic map of Canada to a landform regions map could in itself be used as an activity to assess Making Connections. The classification of samples of metamorphic rock also demonstrates the student's ability to make connections between appropriate terminology and the physical samples to which they apply. The multiple-choice quiz related to the jigsaw activity would be an appropriate means of assessing the students acquisition of Knowledge/Understanding.
- Written Response (C, MC); Classification (K/U, I); Quiz (K/U, MC)

Resources

Rock and mineral samples are available from kits listed in scientific supply catalogues (e.g., Wards, Boreal)

Bob's Rock Shop (contains a great deal of information for mineral collectors)
– http://www.rockhounds.com/

Smithsonian Museum (website for mineral and gem collection)
– http://galaxy.einet.net/images/gems/gems-icons.html
Metamorphic Rocks(information from University of British Columbia's Metamorphic Rocks Home Page) – http://www.science.ubc.ca/~geol1202/meta/metamorphic.html

Activity 5.5: Topical Investigations and Reports

Time: 4 hours

Description

Through a variety of research and reporting activities, students apply previous knowledge gained in this unit to explain basic geologic concepts such as rock cycles, formation and use of Earth resources, resource extraction technologies, and disposal technologies of by-product wastes.

Strand(s) & Learning Expectations

Strand(s): Earth Materials

Learning Expectations

EMV.01 - distinguish between minerals and rocks, and describe the formation and characteristics of both;
EMV.03 - demonstrate an understanding of society's dependence on Earth materials, of the effects of developments in technology on the exploration and mining of Earth materials, and of the ways in which the use and extraction of Earth materials have affected natural and human-made environments;
EM1.05 - explain how rocks and their constituent minerals are continuously being recycled;
EM3.01 - explain the importance of minerals and other Earth resources (rocks);
EM3.02 - describe and assess the role of Earth materials in the safe disposal of industrial and urban waste and toxic materials;
EM3.03 - describe the uses and evaluate the economic importance of minerals, rocks, and metallic resources and non-metallic resources;
EM3.04 - describe the use of dimension stone and explain how the development of new technologies has influenced the type of stone used in the local area;
EM3.05 - describe some of the technologies used to recover natural resources from the Earth, and evaluate economic, social, and environmental ramifications of their use;
SIS.01 - demonstrate an understanding of appropriate techniques for handling, storing, and disposing of laboratory materials (e.g., following safety procedures when sampling rocks; using materials safely when identifying minerals and rocks), and by using appropriate personal protection (e.g., wearing safety glasses when sampling, and hard hats when visiting outcrops and quarries);
SIS.05 - select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate scientific ideas, plans, and experimental results;
SIS.06 - select, integrate, and analyse information from print and electronic sources, including Internet sites, and, either in writing or using a computer, compile and display the information in various forms, including flow charts, tables, and graphs;
SIS.07 - communicate the procedures and results of investigations and research for specific purposes using data tables and laboratory reports;
SIS.10 - identify and describe careers related to Earth and Space Science (e.g., careers related to hydrology, meteorology, geology, mineralogy, astronomy, and remote sensing).

Prior Knowledge & Skills

- Research and investigative skills previously developed

Planning Notes

- Prepare topics for investigation.
- Plan for student access of computers, and provide a clear list of expectations and evaluation of the oral presentation.
- Design rubrics to be used.

Teaching/Learning Strategies

5.5.1 **Student Activity:** Students research, prepare, and deliver an oral/visual presentation on one of the following topics. A career component should be included where relevant.

Topics may include:

- The Rock Cycle: Develop and construct an annotated flow chart to represent the links among the processes of formation of the three major families of rocks. Include the sequence of steps in the processes of formation as well as the sub groups of each family supported with examples studied in previous activities.
- Earth Resources: Explain the economic classification and uses of Earth resources, e.g., mineral fuel, metallic ore, industrial minerals, non-metallic dimensional stone, aggregates, fossil fuels, mineral fuels, etc.
- Resource Technologies: Write a report on one of the technologies used to recover and to safely dispose of industrial by-product wastes. Select one rock or mineral resource and describe the extractive methods and technologies used (e.g., biochemical uranium extraction and disposal of uranium wastes in Elliot Lake, nickel ore extraction/refining and acid rain in Sudbury, etc.).
- Economic Geology: Create a visual display on the economic geology of a selected province of Canada to include:
    1. a provincial map to show the location and distribution of major geologic resources in relation to the regional bedrock geology;
    2. an explanation of the relationship between the bedrock geology and the particular mineral resource;
    3. a description of the uses of the mineral resources and the social and environmental consequences of their use (e.g., alteration of the landscape, drainage patterns, runoff effluent, waste disposal etc.);
    4. graphs to illustrate the economic importance of the resource to the provincial economy (e.g., the value of production as a percentage of provincial GDP).

Teacher Facilitation: In order to maintain relatively small groups with different topics, the teacher could provide a list of specific examples that could be used as a focus for each topic (e.g., different rock/mineral resources for topic 3, and different provinces could be selected for topic 4).

Assessment & Evaluation of Student Achievement

- The 10-minute oral presentation could be assessed for both Inquiry and Knowledge/Understanding and communications components. An evaluation checklist for oral presentations could be used to evaluate one or more of the components, (e.g., Inquiry, Communications, Knowledge/Understanding, or Making Connections).

Resources

See the list of resources in previous activities.

Activity 5.6: End-of-Unit Task: Geologic Field Report

Time: 2 hours

Description

In this activity, students participate in a field trip to a selected local site to gain insight into the geologic history and Earth resources produced within the local region. Students draw on the knowledge and skills gained throughout the unit, as well as the data recorded in the field trip, to prepare a report on the rock and/or mineral resources of the local area.

Strand(s) & Learning Expectations

Strand(s): Earth Materials

Learning Expectations

EMV.02 - apply a series of specific tests to identify minerals and rocks, including those in the local area, and to determine their physical properties;
EMV.03 - demonstrate an understanding of society's dependence on Earth materials, of the effects of developments in technology on the exploration and mining of Earth materials, and of the ways in which the use and extraction of Earth materials have affected natural and human-made environments;
EM2.06 - investigate and describe the geological setting of the local area;
EM3.03 - describe the uses and evaluate the economic importance of minerals, rocks, and metallic resources;
EM3.05 - describe some of the technologies used to recover natural resources from the Earth, and evaluate economic, social, and environmental ramifications of their use;
SIS.01 - demonstrate an understanding of Workplace Hazardous Materials Information System (WHMIS) legislation by selecting and applying appropriate techniques for handling, storing, and disposing of laboratory materials (e.g., following safety procedures when sampling rocks; using materials safely when identifying minerals and rocks), and by using appropriate personal protection (e.g., wearing safety glasses when sampling, and hard hats when visiting outcrops and quarries);
SIS.02 - select appropriate instruments and use them safely, effectively, and accurately in collecting observations and data (e.g., hand lens, polarizing microscope);
SIS.05 - select and use appropriate numeric, symbolic, graphical, and linguistic modes of representation to communicate scientific ideas, plans, and experimental results (e.g., use an appropriate time scale when representing geological time, or appropriate units to represent astronomical distances);
SIS.06 - select, integrate, and analyse information from print and electronic sources, including Internet sites, and, either in writing or using a computer, compile and display the information in various forms, including flow charts, tables, and graphs (e.g., use the Internet to compile information on areas of major mineral/rock extraction, and compare the location and distribution to other rock types of the area/region);
SIS.07 - communicate the procedures and results of investigations and research for specific purposes using data tables and laboratory reports;
SIS.08 - express the result of any calculation involving experimental data to the appropriate number of decimal places or significant figures (e.g., measuring the thickness of outcrop exposures and the angle of dip);
SIS.09 - select and use appropriate SI units (units of measurement of the Systéme international d'unités, or International System of Units);
SIS.10 - identify and describe careers related to Earth and Space Science (e.g., careers related to hydrology, meteorology, geology, mineralogy, astronomy, and remote sensing).

Prior Knowledge & Skills

Students use research and investigative skills previously developed

Planning Notes

- Access topographical maps.
- Prepare (with students) a rubric to be used to assess the report.
- Visit the site of the field trip along with making all other necessary arrangements, including permission forms.

Teaching/Learning Strategies

5.6.1 **Student Activity:** Students, with teacher input, brainstorm and select a local site where bedrock is exposed (e.g., river valley, escarpment, shoreline, quarry, brickyard, mine). As a class, a set of activities that provide opportunities to collect information in order to write a geologic field report, as identified in activity 5.1.1, is designed.

Teacher Facilitation: The teacher provides a set of topographic maps, land use maps, and air photos of the local region to serve as reference resources for students. The teacher guides students in the brainstorming activity by having them reflect upon the activities and products generated in this unit. During the field trip to the site(s), students should be expected to sketch bedrock exposures and label geologic structures, measure the thickness of exposed formations, measure the angle of dip of the bedding planes, collect representative samples of the rocks/minerals of the area. The teacher prepares necessary equipment for the excursion, rock hammer, chisels, protective eye glasses, hard hat, field collecting bag, note pad, recording work sheets, etc. The teacher reviews safety rules to be observed and checks with the board regarding field trip procedures and regulations. It is crucial to pre-visit the site to ensure it is accessible and safe. The teacher provides a letter to parents to explain the purpose and nature of the trip, as well as permission forms, including an itinerary of stops and activities to be completed.

5.6.2 **Student Activity:** Students participate in the field trip as described in Activity 5.6.1

Teacher Facilitation: The teacher is responsible for planning the field trip and ensuring student safety (see Teacher Facilitation Activity 5.6.1).

5.6.3 **Student Activity:** Students write a field report on the rock/mineral resources of the local area.. In their report, students:

- describe the geological setting of the local area from first hand field observation (e.g., site and situation of the location visited, drainage pattern, overburden type and thickness, thickness of exposure, etc.);
- classify the representative field samples of Earth resources collected and describe their economic uses (e.g., metallic or non-metallic mineral ore, dimensional stone, aggregate, mineral fuel, etc.);
- prepare a display of samples collected;
- describe the methods and technologies used in extraction of one of the local Earth resources by means of a pictorial flow chart.

Teacher Facilitation: The teacher organizes students into working groups of about three or four. Provide students with reference resources such as Physiographic regions map of Ontario, local topographic maps, Conservation Authority maps, air photos, road maps, outline base map of the local region, as well as public information brochures which may be available from local conservation parks, mines, quarries or pits.

Assessment & Evaluation of Student Achievement

- Evaluation would focus on inquiry, organizational, and communication skills. A rubric and/or checklist could be used as a tool to assess the final field report.
- Report (K/U, MC, I, C)

Accommodations

- For the excursion, wherever possible select sites that are accessible to all students; if necessary, arrange for additional assistance in transporting students. Consider sites with board walks or wide walking trails. By calling ahead, some field site areas will allow vehicle access (e.g., they will unlock gates to maintenance roads) to allow transporting students with physical challenges.
- Visually challenged students can often make use of visual descriptions provided by their classmates to supplement their own tactile observations.
- The teacher may decide to contract the group work ahead of time so that individual skills may be matched to suitable tasks within the group. To accommodate and assess individual contributions to this group activity, have students keep a log of their time and task activities started and completed.

Resources

Hewitt, D. F. *Geology and Scenery*: *Peterborough, Bancroft and Madoc Area*. Dept. Mines, Geological Guide Book No. 3, 1969.

Sabina, A.P. *Rocks & Minerals for the Collector: Bancroft - Parry Sound area and Southern Ontario*. Geologic Survey of Canada, Misc. Report #39, 1986.

Chapman, L.J. and D.F. Putnam. *The Physiography of Southern Ontario*, 3rd ed. Ministry of Natural Resources. 1984.

Chesterman, C.W. *The Audubon Society: Field Guide to North American Rocks & Minerals*. Alfred A. Knopf. 1997.

Mottana A., R. Crespi, and G. Libori. *Simon & Schuster's Guide to Rocks & Minerals*. Simon & Schuster Inc., 1977.

O'Donoghue, M. *Rocks and Minerals.* Gallery Books, 1990.

Roberts, J.L. *The Macmillan Field Guide to Geologic Structures*. The MacMillan Press Ltd., 1989.

Reid, I. *Land In Demand: The Niagara Escarpment*, Book Society of Canada Ltd. 1977.