Geology 12

Guide

NOVA SCOTIA
NOUVELLE-ÉCOSSE

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Geology 12

Prepared by the Department of Education and Early Childhood Development

This is the most recent version of the current curriculum materials as used by teachers in Nova Scotia.

Geology 12
Implementation Draft
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Introduction

Background

The pan-Canadian *Common Framework of Science Learning Outcomes K to 12*, released in October 1997, provides a framework for standardizing science education across the country. This document includes a learning outcomes framework for earth science. F*oundation for the Atlantic Canada Science Curriculum* (1998) provides the basis for development of new programs in science, both provincially and regionally. General, key-stage, and specific curriculum outcomes for science have been adopted from the pan-Canadian framework.

Geology 12 (011211) has been developed to replace both Canadian Geology 12 (011023) and Earth Science 12 (011024). Canadian Geology 12 and Earth Science 12 will not be offered after 2002–03. Geology 12 comprises the following units: The Nature of Geology, Earth Materials, Internal Processes, Surface Processes, Historical Geology, and Environmental Geology. Geology 12 requires a minimum of 110 hours of instructional time.

This guide is intended to provide teachers with an overview of the outcomes framework for the course. It also includes some suggestions to assist teachers in designing learning experiences and assessment tasks.

Aim

The aim of science education in the Atlantic provinces is to develop scientific literacy.

Scientific literacy is an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities; to become lifelong learners; and to maintain a sense of wonder about the world around them. To develop scientific literacy, students require diverse learning experiences that provide opportunities to explore, analyse, evaluate, synthesize, appreciate, and understand the interrelationships among science, technology, society, and the environment.

Program Design and Components

Learning and Teaching Science

What students learn is fundamentally connected to how they learn it. The aim of scientific literacy for all has created a need for new forms of classroom organization, communication, and instructional strategies. The teacher is a facilitator of learning whose major tasks include

- creating a classroom environment to support the learning and teaching of science
- designing effective learning experiences that help students achieve designated outcomes
- stimulating and managing classroom discourse in support of student learning
- learning about and then using students' motivations, interests, abilities, and learning styles to improve learning and teaching
- assessing student learning, the scientific tasks and activities involved, and the learning environment to make ongoing instructional decisions
- selecting teaching strategies from a wide repertoire

Effective science learning and teaching take place in a variety of situations. Instructional settings and strategies should create an environment that reflects a constructive, active view of the learning process. Learning occurs through actively constructing one's own meaning and assimilating new information to develop a new understanding.

The development of scientific literacy in students is a function of the kinds of tasks they engage in, the discourse in which they participate, and the settings in which these activities occur. Students' disposition towards science is also shaped by these factors. Consequently, the aim of developing scientific literacy requires careful attention to all of these facets of curriculum.

Learning experiences in science education should vary and should include opportunities for group and individual work, discussion among students as well as between teacher and students, and hands-on/ minds-on activities that allow students to construct and evaluate explanations for the phenomena under investigation. Such investigations and the evaluation of the evidence accumulated provide opportunities for students to develop their understanding of the nature of science and the nature and status of scientific knowledge.

Writing in Science

Learning experiences should provide opportunities for students to use writing and other forms of representation as ways to learning. Students, at all grade levels, should be encouraged to use writing to speculate, theorize, summarize, discover connections, describe processes, express understandings, raise questions, and make sense of new information using their own language as a step to the language of science. Science logs are useful for such expressive and reflective writing. Purposeful note making is an intrinsic part of learning in science, helping students better record, organize, and understand information from a variety of sources. The process of creating webs, maps, charts, tables, graphs, drawing, and diagrams to represent data and results helps students learn and also provides them with useful study tools.

Learning experiences in science should also provide abundant opportunities for students to communicate their findings and understandings to others, both formally and informally, using a variety of forms for a range of purposes and audiences. Such experiences should encourage students to use effective ways of recording and conveying information and ideas and to use the vocabulary of science in expressing their understandings. It is through opportunities to talk and write about the concepts they need to learn that students come to better understand both the concepts and related vocabulary.

Learners will need explicit instruction in, and demonstration of, the strategies they need to develop and apply in reading, viewing, interpreting, and using a range of science texts for various purposes. It will be equally important for students to have demonstrations of the strategies they need to develop and apply in selecting, constructing, and using various forms for communicating in science.

The Three Processes of Scientific Literacy

An individual can be considered scientifically literate when he/she is familiar with, and able to engage in, three processes: inquiry, problem solving, and decision making.

Inquiry

Scientific inquiry involves posing questions and developing explanations for phenomena. While there is general agreement that there is no such thing as the scientific method, students require certain skills to participate in the activities of science. Skills such as questioning, observing, inferring, predicting, measuring, hypothesizing, classifying, designing experiments, collecting data, analysing data, and interpreting data are fundamental to engaging in science. These activities provide students with opportunities to understand and practise the process of theory development in science and the nature of science.

Problem Solving

The process of problem solving involves seeking solutions to human problems. It consists of proposing, creating, and testing prototypes, products, and techniques to determine the best solution to a given problem.

Decision Making

The process of decision making involves determining what we, as citizens, should do in a particular context or in response to a given situation. Decision-making situations are important in their own right, and they also provide a relevant context for engaging in scientific inquiry and/or problem solving.

Meeting the Needs of All Learners

Foundation for the Atlantic Canada Science Curriculum stresses the need to design and implement a science curriculum that provides equitable opportunities for all students according to their abilities, needs, and interests. Teachers must be aware of, and make adaptations to accommodate, the diverse range of learners in their classes. To adapt instructional strategies, assessment practices, and learning resources to the needs of all learners, teachers must create opportunities that will permit students to address their various learning styles.

As well, teachers must not only remain aware of and avoid gender and cultural biases in their teaching, they must also actively address cultural and gender stereotyping (e.g., about who is interested in and who can succeed in science and mathematics). Research supports the position that when science curriculum is made personally meaningful and socially and culturally relevant, it is more engaging for groups traditionally under-represented in science and indeed, for all students.

While this curriculum guide presents specific outcomes for each unit, it must be acknowledged that students will progress at different rates.

Teachers should provide materials and strategies that accommodate student diversity, and should validate students when they achieve the outcomes to the best of their abilities.

It is important that teachers articulate high expectations for all students and ensure that all students have equitable opportunities to experience success as they work toward achieving designated outcomes. Teachers should adapt classroom organization, teaching strategies, assessment practices, time, and learning resources to address students' needs and build on their strengths. The variety of learning experiences described in this guide provide access for a wide range of learners. Similarly, the suggestions for a variety of assessment practices provide multiple ways for learners to demonstrate their achievements.

Assessment and Evaluation

The terms *assessment* and *evaluation* are often used interchangeably, but they refer to quite different processes. Science curriculum documents developed in the Atlantic region use these terms for the processes described below.

Assessment is the systematic process of gathering information on student learning.

Evaluation is the process of analysing, reflecting upon, and summarizing assessment information, and making judgments or decisions based upon the information gathered.

The assessment process provides the data, and the evaluation process brings meaning to the data. Together, these processes improve teaching and learning. If we are to encourage enjoyment in learning for students now and throughout their lives, we must develop strategies to involve students in assessment and evaluation at all levels. When students are aware of the outcomes for which they are responsible and of the criteria by which their work will be assessed or evaluated, they can make informed decisions about the most effective ways to demonstrate their learning.

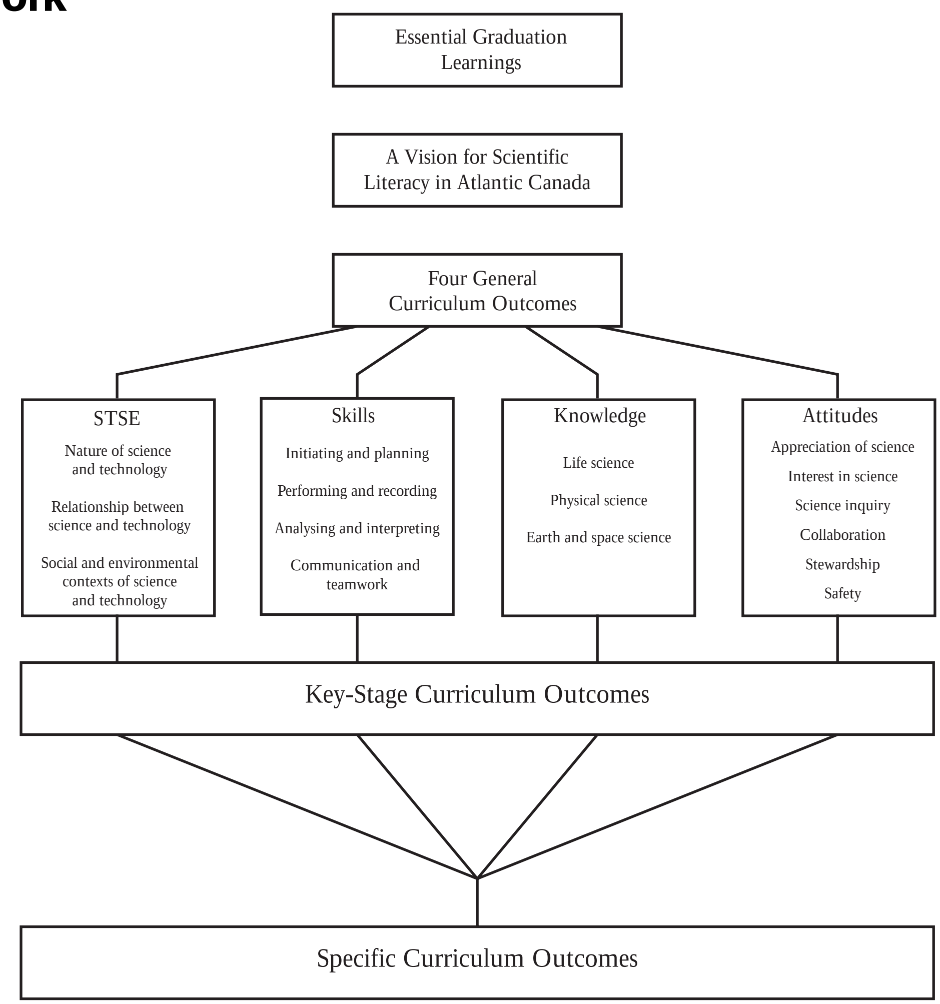
The Atlantic Canada science curriculum reflects the three major processes of science learning: inquiry, problem solving, and decision making. When a teacher assesses student progress, it is helpful to know some activities/skills/actions that are associated with each process of science learning. Student learning may be described in terms of ability to perform these tasks.

Curriculum Outcomes Framework

Overview

The science curriculum is based on an outcomes framework that includes statements of essential graduation learnings, general curriculum outcomes, key-stage curriculum outcomes, and specific curriculum outcomes. The general, key-stage, and specific curriculum outcomes reflect the pan-Canadian C*ommon Framework of Science Learning Outcomes K to 12*. The diagram below provides the blueprint of the outcomes framework.

Outcomes Framework



Essential Graduation Learnings

Essential graduation learnings are statements describing the knowledge, skills, and attitudes expected of all students who graduate from high school. Achievement of the essential graduation learnings will prepare students to continue to learn throughout their lives. These learnings describe expectations not in terms of individual school subjects but in terms of knowledge, skills, and attitudes developed throughout the curriculum. They confirm that students need to make connections and develop abilities across subject boundaries and to be ready to meet the shifting and ongoing opportunities, responsibilities, and demands of life after graduation. Provinces may add additional essential graduation learnings as appropriate. The essential graduation learnings are

Aesthetic Expression

Graduates will be able to respond with critical awareness to various forms of the arts and be able to express themselves through the arts.

Citizenship

Graduates will be able to assess social, cultural, economic, and environmental interdependence in a local and global context.

Communication

Graduates will be able to use the listening, viewing, speaking, reading, and writing modes of language(s) as well as mathematical and scientific concepts and symbols to think, learn, and communicate effectively.

Personal Development

Graduates will be able to continue to learn and to pursue an active, healthy lifestyle.

Problem Solving

Graduates will be able to use the strategies and processes needed to solve a wide variety of problems, including those requiring language, mathematical, and scientific concepts.

Technological Competence

Graduates will be able to use a variety of technologies, demonstrate an understanding of technological applications, and apply appropriate technologies for solving problems.

General Curriculum Outcomes

Four general curriculum outcomes form the basis of the outcomes framework. They also identify the key components of scientific literacy. Four general curriculum outcomes have been identified to delineate the four critical aspects of students' scientific literacy. They reflect the wholeness and interconnectedness of learning and should be considered interrelated and mutually supportive.

Science, Technology, Society, and the Environment

Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.

Skills

Students will develop the skills required for scientific and technological inquiry, for solving problems, for communicating scientific ideas and results, for working collaboratively, and for making informed decisions.

Knowledge

Students will construct knowledge and understandings of concepts in life science, physical science, and Earth and space science, and apply these understandings to interpret, integrate, and extend their knowledge.

Attitudes

Students will be encouraged to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment.

Key-Stage Curriculum Outcomes

Key-stage curriculum outcomes are statements that identify what students are expected to know, be able to do, and value by the end of grades 3, 6, 9, and 12 as a result of their cumulative learning experiences in science. The key-stage curriculum outcomes are from the *Common Framework for Science Learning Outcomes K to12*.

Specific Curriculum Outcomes

This curriculum guide outlines specific curriculum outcomes for Geology 12 and provides suggestions for learning, teaching, assessment, and resources to support students' achievement of these outcomes. Teachers should consult *Foundation for the Atlantic Canada Science Curriculum* for descriptions of the essential graduation learnings, vision for scientific literacy, general curriculum outcomes, and key-stage curriculum outcomes.

Specific curriculum outcome statements describe what students are expected to know and be able to do in each course or at each grade level. They are intended to help teachers design learning experiences and assessment tasks. Specific curriculum outcomes represent a framework for assisting students to achieve the key-stage curriculum outcomes, the general curriculum outcomes, and ultimately the essential graduation learnings.

Specific curriculum outcomes are organized in units. Each unit is organized by topic. Geology 12 units and topics follow.

The Nature of Geology

- You and Geology
- The Geologists
- Earth Systems

Earth Materials

- Crystallography
- Mineralogy
- Petrology

Internal Processes

- Earth's Interior
- Plate Tectonics
- Forces and Structures

Surface Processes

- Weathering
- Erosion
- Deposition

Historical Geology

- Geological Principles
- The Fossil Record
- Geological Time

Environmental Geology

- Geological Hazards
- Resource Issues
- Waste Management

The following pages outline Geology 12 specific curriculum outcomes grouped by units and topics.

The Nature of Geology

Students will be expected to

You and Geology

- demonstrate an understanding of the nature of geology and what makes it unique as a science (360-2)
- give examples of how geology is interconnected and integrated with other sciences (360-3)
- describe and give examples of the major themes that unite the study of geology (360-4)
- demonstrate an understanding of how geological processes and resources impact our daily lives (360-1)
- provide examples of the relevance of mining to everyday materials used in our lives (117-5)
- communicate questions, ideas, and intentions, and receive, interpret, understand, support and respond to the ideas of others (215-1)

The Geologists

- describe and give examples of how geologists study the earth (360-9)
- illustrate how science attempts to explain natural phenomena (115-2)

Earth Systems

- describe and give examples of interrelationships between Earth's spheres (360-6)
- explain how a knowledge of geology might influence our decisions about how we use Earth's resources (360-7)
- identify questions to investigate that arise from practical problems and issues (212-1)
- define and delimit problems to facilitate investigation (212-2)
- identify some sources and types of geological information needed to examine issues of a societal/environmental nature (360-8)
- synthesize information from multiple sources and make inferences based on this information (215-3)

Earth Materials

Students will be expected to

Crystallography

- construct a definition for a mineral and a rock and identify the features that characterize each (361-1)
- explain and give examples of basic chemical building blocks and atomic structures (atom, element, molecule, compound) (361-2)
- explain external crystal shape in terms of internal atomic arrangement (361-4)

- identify examples where scientific understanding was enhanced or revised as a result of the invention of a technology (116-1)
- identify examples where technologies were developed based on scientific understanding (116-3)

Mineralogy

- classify common minerals according to their chemical and physical characteristics (330-3)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5)

Petrology

- classify and identify rocks according to their structure, texture and mineral composition (361-11)
- relate the formation of igneous, sedimentary and metamorphic rocks to the rock cycle (361-13)
- apply and assess alternative theoretical models for interpreting knowledge in a given field (214-6)

Internal Processes

Students will be expected to

Earth's Interior

- describe theories and evaluate the limits of our understanding of earth's internal structure (330-1)
- identify questions to investigate that arise from practical problems and issues (212-1)
- select and integrate information from various print and electronic sources or from several parts of the same source (213-7)
- identify and describe science and technology-based careers related to the science they are studying (117-7)
- identify instances in which science and technology are limited in finding answers to questions or the solution to problems (118-7)

Plate Tectonics

- explain the roles of evidence, theories and paradigms in the development of scientific knowledge (114-2)
- explain how a major scientific milestone revolutionized thinking in the scientific communities (115-3)
- apply and assess alternative theoretical models for interpreting knowledge in a given field (214-6)
- explain how data support or refute the hypothesis of plate tectonics (214-12)
- describe examples of Canadian contributions to science and technology (117-10)
- explain the plate tectonic theory (362-6)

Forces and Structures

- illustrate how science attempts to explain natural phenomena (115-2)
- describe the various forces (compressional, tensional, shear) which operate in the Earth and how these forces create faults, folds and mountains (362-3)
- describe the geologic activity associated with plate boundaries and relate this to the rock cycle (362-7)

Surface Processes

Students will be expected to

Weathering

- demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposal of lab materials (213-9)
- communicate questions, ideas and intentions, and receive, interpret, understand, support and respond to the ideas of others (215-1)
- distinguish between weathering and erosion (363-1)
- describe the process of soil formation and identify the factors involved in the development of different soil types (363-4)

Erosion

- compare the risks and benefits to society and the environment of applying scientific knowledge or introducing a technology (118-1)
- work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise (215-6)
- describe and explain the processes by which running water, glaciers, wind and waves cause erosion (363-6)

Deposition

- propose a course of action on social issues related to science and technology, taking into account human and environmental needs (118-9)
- develop, present and defend a position or course of action based on findings (215-5)
- compare and contrast particle size, shape, and degree of sorting in fluvial, glacial and aeolian deposits (363-10)
- relate weathering, erosion and deposition of sediment to the rock cycle (363-5)

Historical Geology

Students will be expected to

Geological Principles

- explain how scientific knowledge evolves as new evidence comes to light (115-6)
- select and integrate information from various print and electronic sources or from several parts of the same source (213-7)

- synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information (215-3)
- determine the relative ages of different formations using the principles of uniformitarianism, superposition, original horizontality, original lateral continuity, cross-cutting relationships, and inclusions (364-2)

The Fossil Record

- explain and describe the process of fossil formation (364-5)
- identify and describe science and technology-based careers related to the science they are studying (117-7)
- describe examples of Canadian contributions to science and technology (117-10)

Geological Time

- define and differentiate between relative and absolute age dating (364-1)
- illustrate the geologic time scale and compare it to human time scales (332-4)
- communicate questions, ideas and intentions, and receive, interpret, understand, support and respond to the ideas of others (215-1)
- determine absolute age using the principles of radioactive decay (364-4)

Environmental Geology

Students will be expected to

Geological Hazards

- distinguish between scientific questions and technological problems (115-1)
- construct arguments to support a decision or judgement, using examples and evidence and recognizing various perspectives (118-6)
- identify questions to investigate that arise from practical problems and issues (212-1)
- propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan (214-15)
- identify multiple perspectives that influence a science-related decision or issue (215-4)
- identify examples of geological hazards that impact on human settlement and ways in which humans have attempted to minimize the impact of these hazards (365-1)
- identify factors which influence people to live in geologically hazardous areas (365-3)
- apply geological knowledge to the analysis of a local environmental issue or problem (365-9)
- compare the risks and benefits to society and the environment of applying scientific knowledge or introducing a technology (118-1)

- propose a course of action on social issues related to science and technology, taking into account human and environmental needs (118-9)
- provide examples of how science and technology are an integral part of their lives and their community (117-5)
- describe the functioning of domestic and industrial technologies, using scientific principles (116-5)

Resource Issues

- demonstrate an understanding that Earth's systems are complex and cyclic and that the Earth operates chiefly as a closed system (365-4)
- demonstrate an understanding of what is meant by a renewable and non-renewable resource and the concept of sustainable development (365-5)
- describe the functioning of domestic and industrial technologies, using scientific principles (116-5)
- identify and describe science and technology-based careers related to the science they are studying (117-7)
- select and use apparatus and materials safely (213-8)
- identify stratigraphy as a key element of environmental geology and describe some technologies used to acquire stratigraphic data (365-6)
- work cooperatively with team members to develop and carry out a plan and troubleshoot problems as they arise (215-6)
- apply geological knowledge to the analysis of a local environmental issue or problem (365-9)
- use library and electronic research tools to collect information on a given topic (213-6)
- propose a course of action on social issues related to science and technology, taking into account human and environmental needs (118-9)

Waste Management

- compare the risks and benefits to society and the environment of applying scientific knowledge or introducing a technology (118-1)
- evaluate a personally designed and constructed device on the basis of criteria they have developed themselves (214-16)
- identify and describe the environmental problems associated with waste disposal and management (365-8)
- apply geological knowledge to the analysis of a local environmental issue or problem (365-9)

Attitude Outcomes

It is expected that the Atlantic Canada science program will foster certain attitudes in students throughout their school years. The STSE, skills, and knowledge outcomes contribute to the development of attitudes, and opportunities for fostering these attitudes are highlighted in the Elaborations—Strategies for Learning and Teaching sections of each unit.

Attitudes refer to generalized aspects of behaviour that teachers model for students by example and by selective approval. Attitudes are not acquired in the same way as skills and knowledge. The development of positive attitudes plays an important role in students' growth by interacting with their intellectual development and by creating a readiness for responsible application of what students learn.

Since attitudes are not acquired in the same way as skills and knowledge, outcome statements for attitudes are written as key-stage curriculum outcomes for the end of grades 3, 6, 9, and 12. These outcome statements are meant to guide teachers in creating a learning environment that fosters positive attitudes.

The following pages present the attitude outcomes from the pan-Canadian *Common Framework of Science Learning Outcomes K to 12* for the end of grade 12.

Key-Stage Curriculum Outcomes: Attitudes

By the end of grade 12, students will be expected to

Appreciation of Science	Interest in Science	Scientific Inquiry
436 value the role and contribution of science and technology in our understanding of phenomena that are directly observable and those that are not 437 appreciate that the applications of science and technology can raise ethical dilemmas 438 value the contributions to scientific and technological development made by women and men from many societies and cultural backgrounds *Evident when students, for example,* • consider the social and cultural contexts in which a theory developed • use a multi-perspective approach, considering scientific, technological, economic, cultural, political, and environmental factors when formulating conclusions, solving problems, or making decisions on STSE issues • recognize the usefulness of being skilled in mathematics and problem solving • recognize how scientific problem solving and the development of new technologies are related • recognize the contribution of science and technology to the progress of civilizations • carefully research and openly discuss ethical dilemmas associated with the applications of science and technology • show support for the development of information technologies and science as they relate to human needs • recognize that western approaches to science are not the only ways of viewing the universe • consider the research of both men and women	439 show a continuing and more informed curiosity and interest in science and science-related issues 440 acquire, with interest and confidence, additional science knowledge and skills using a variety of resources and methods, including formal research 441 consider further studies and careers in science- and technology-related fields *Evident when students, for example,* • conduct research to answer their own questions • recognize that part-time jobs require science- and technology-related knowledge and skills • maintain interest in or pursue further studies in science • recognize the importance of making connections among various science disciplines • explore and use a variety of methods and resources to increase their own knowledge and skills • are interested in science and technology topics not directly related to their formal studies • explore where further science- and technology-related studies can be pursued • are critical and constructive when considering new theories and techniques • use scientific vocabulary and principles in everyday discussions • readily investigate STSE issues	442 confidently evaluate evidence and consider alternative perspectives, ideas, and explanations 443 use factual information and rational explanations when analysing and evaluating 444 value the processes for drawing conclusions *Evident when students, for example,* • insist on evidence before accepting a new idea or explanation • ask questions and conduct research to confirm and extend their understanding • criticize arguments based on the faulty, incomplete, or misleading use of numbers • recognize the importance of reviewing the basic assumptions from which a line of inquiry has arisen • expend the effort and time needed to make valid inferences • critically evaluate inferences and conclusions, cognizant of the many variables involved in experimentation • critically assess their opinions of the value of science and its applications • criticize arguments in which evidence, explanations, or positions do not reflect the diversity of perspectives that exist • insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position taken can be judged • seek new models, explanations, and theories when confronted with discrepant events or evidence

Key-Stage Curriculum Outcomes: Attitudes *(continued)*

By the end of grade 12, students will be expected to

Collaboration	Stewardship	Safety in Science
445 work collaboratively in planning and carrying out investigations, as well as in generating and evaluating ideas *Evident when students, for example,* • willingly work with any classmate or group of individuals regardless of their age, gender, or physical and cultural characteristics • assume a variety of roles within a group, as required • accept responsibility for any task that helps the group complete an activity • give the same attention and energy to the group's product as they would to a personal assignment • are attentive when others speak • are capable of suspending personal views when evaluating suggestions made by a group • seek the points of view of others and consider diverse perspectives • accept constructive criticism when sharing their ideas or points of view • criticize the ideas of their peers without criticizing the persons • evaluate the ideas of others objectively • encourage the use of procedures that enable everyone, regardless of gender or cultural background, to participate in decision making • contribute to peaceful conflict resolution • encourage the use of a variety of communication strategies during group work • share the responsibility for errors made or difficulties encountered by the group	446 have a sense of personal and shared responsibility for maintaining a sustainable environment 447 project the personal, social, and environmental consequences of proposed action 448 want to take action for maintaining a sustainable environment *Evident when students, for example,* • willingly evaluate the impact of their own choices or the choices scientists make when they carry out an investigation • assume part of the collective responsibility for the impact of humans on the environment • participate in civic activities related to the preservation and judicious use of the environment and its resources • encourage their peers or members of their community to participate in a project related to sustainability • consider all perspectives when addressing issues, weighing scientific, technological, and ecological factors • participate in social and political systems that influence environmental policy in their community • examine/recognize both the positive and negative effects on human beings and society of environmental changes caused by nature and by humans • willingly promote actions that are not injurious to the environment • make personal decisions based on a feeling of responsibility toward less privileged parts of the global community and toward future generations • are critical-minded regarding the short- and long-term consequences of sustainability	449 show concern for safety and accept the need for rules and regulations 450 be aware of the direct and indirect consequences of their actions *Evident when students, for example,* • read the label on materials before using them, interpret the WHMIS symbols, and consult a reference document if safety symbols are not understood • criticize a procedure, a design, or materials that are not safe or that could have a negative impact on the environment • consider safety a positive limiting factor in scientific and technological endeavours • carefully manipulate materials, cognizant of the risks and potential consequences of their actions • write into a laboratory procedure safety and waste-disposal concerns • evaluate the long-term impact of safety and waste disposal on the environment and the quality of life of living organisms • use safety and waste disposal as criteria for evaluating an experiment • assume responsibility for the safety of all those who share a common working environment by cleaning up after an activity and disposing of materials in a safe place • seek assistance immediately for any first aid concerns like cuts, burns, or unusual reactions • keep the work station uncluttered, with only appropriate lab materials present

Curriculum Guide Organization

Specific curriculum outcomes are organized in units for each grade level. Each unit is organized by topic. Suggestions for learning, teaching, assessment, and resources are provided to support student achievement of the outcomes.

The order in which the units of a grade appear in the guide is meant to suggest a sequence. In some cases, the rationale for the recommended sequence is related to the conceptual flow across the year. That is, one unit may introduce a concept that is then extended in a subsequent unit. Likewise, one unit may focus on a skill or context that will be built upon later in the year.

Some units or certain aspects of units may also be combined or integrated. This is one way of assisting students as they attempt to make connections across topics in science or between science and the real world. In some cases, a unit may require an extended time frame to collect data on weather patterns, plant growth, etc. These cases may warrant starting the activity early and overlapping it with the existing unit. In all cases, the intent is to provide opportunities for students to deal with science concepts and scientific issues in personally meaningful and socially and culturally relevant contexts.

Unit Organization

Each unit begins with a two-page synopsis. On the first page, introductory paragraphs provide a unit overview. These are followed by a section that specifies the focus (inquiry, problem solving, and/or decision making) and possible contexts for the unit. Finally, a curriculum links paragraph specifies how this unit relates to science concepts and skills addressed in other grades so teachers will understand how the unit fits with the students' progress through the complete science program.

The second page of the two-page overview provides a table of the outcomes from the *Common Framework of Science Learning Outcomes K to 12* that the unit will address. The numbering system used is the one in the pan-Canadian document as follows:

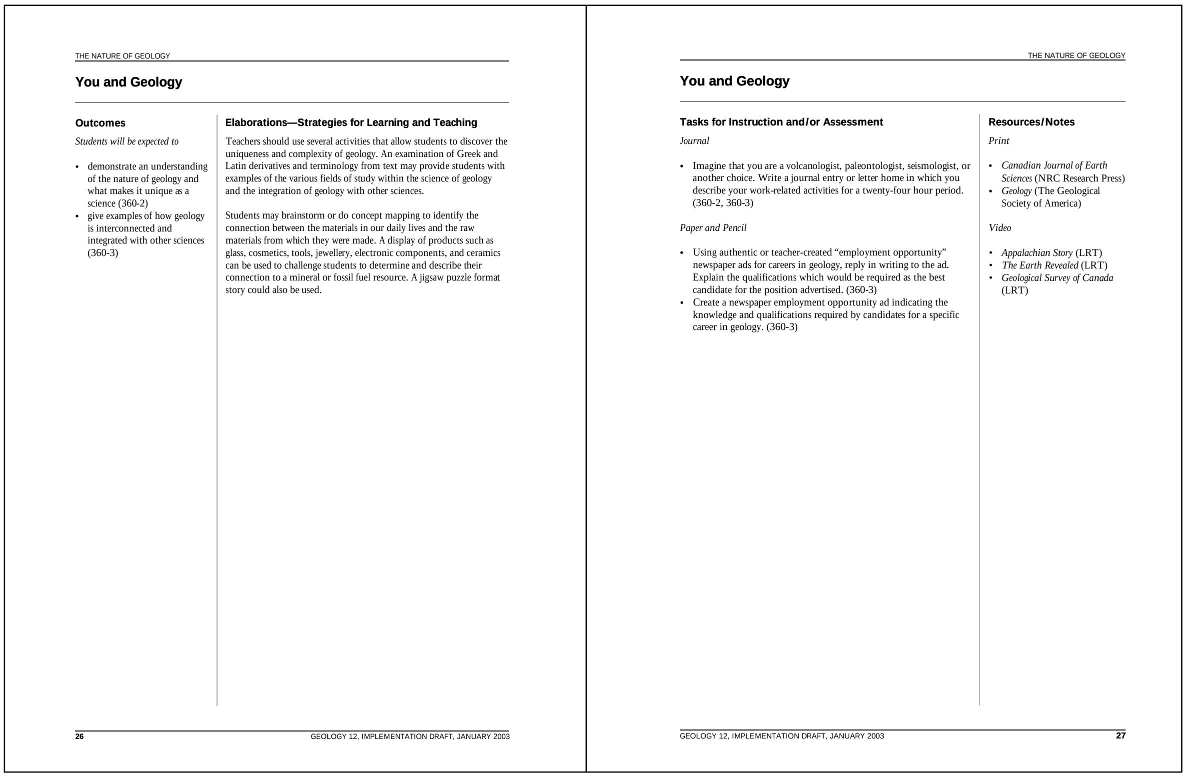
- 100s—Science-Technology-Society-Environment (STSE) outcomes
- 200s—Skills outcomes
- 300s—Knowledge outcomes
- 400s—Attitude outcomes (see pages 22–24)

These code numbers appear in brackets after each specific curriculum outcome (SCO).

The Four-Column Spread

All units have a two-page layout of four columns as illustrated below. In some cases, the four-column spread continues to the next two-page layout. Outcomes are grouped by a topic indicated at the top of the left page.

Two-Page, Four-Column Spread



THE NATURE OF GEOLOGY

You and Geology

Outcomes

Students will be expected to

- demonstrate an understanding of the nature of geology and what makes it unique as a science (360-2)
- give examples of how geology is interconnected and integrated with other sciences (360-3)

Elaborations—Strategies for Learning and Teaching

Teachers should use several activities that allow students to discover the uniqueness and complexity of geology. An examination of Greek and Latin derivatives and terminology from text may provide students with examples of the various fields of study within the science of geology and the integration of geology with other sciences.

Students may brainstorm or do concept mapping to identify the connection between the materials in our daily lives and the raw materials from which they were made. A display of products such as glass, cosmetics, tools, jewellery, electronic components, and ceramics can be used to challenge students to determine and describe their connection to a mineral or fossil fuel resource. A jigsaw puzzle format story could also be used.

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THE NATURE OF GEOLOGY

You and Geology

Tasks for Instruction and/or Assessment

Journal

- Imagine that you are a volcanologist, paleontologist, seismologist, or another choice. Write a journal entry or letter home in which you describe your work-related activities for a twenty-four hour period. (360-2, 360-3)

Paper and Pencil

- Using authentic or teacher-created “employment opportunity” newspaper ads for careers in geology, reply in writing to the ad. Explain the qualifications which would be required as the best candidate for the position advertised. (360-3)
- Create a newspaper employment opportunity ad indicating the knowledge and qualifications required by candidates for a specific career in geology. (360-3)

Resources/Notes

Print

- *Canadian Journal of Earth Sciences* (NRC Research Press)
- *Geology* (The Geological Society of America)

Video

- *Appalachian Story* (LRT)
- *The Earth Revealed* (LRT)
- *Geological Survey of Canada* (LRT)

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Column One: Outcomes

The first column provides the specific curriculum outcomes. These are based on the pan-Canadian *Common Framework of Science Learning Outcomes K to 12*. The statements involve the Science-Technology-Society-Environment (STSE), skills, and knowledge outcomes indicated by the outcome number(s) that appears in parentheses after the outcome. Some STSE and skills outcomes have been written in a context that shows how these outcomes should be addressed.

Specific curriculum outcomes have been grouped by topic. Other groupings of outcomes are possible and in some cases may be necessary to take advantage of local situations. The grouping of outcomes provides a suggested teaching sequence. Teachers may prefer to plan their own teaching sequence to meet the learning needs of their students.

Column One and Column Two define what students are expected to learn and be able to do.

Column Two: Elaborations—Strategies for Learning and Teaching

The second column may include elaborations of outcomes listed in Column One, and describes learning environments and experiences that will support students' learning.

The strategies in this column are intended to provide a holistic approach to instruction. In some cases, they address a single outcome; in other cases, they address a group of outcomes.

Column Three: Tasks for Instruction and/or Assessment

The third column provides suggestions for ways that students' achievement of the outcomes could be assessed. These suggestions reflect a variety of assessment techniques and materials that include, but are not limited to, informal/formal observation, performance, journal, interview, paper and pencil, presentation, and portfolio. Some assessment tasks may be used to assess student learning in relation to a single outcome, others to assess student learning in relation to several outcomes. The assessment item identifies the outcome(s) addressed by the outcome number in brackets after the item.

Column Four: Resources/Notes

This column provides an opportunity for teachers to make note of useful resources.

The Nature of Geology

Unit Overview

The problems of geology are complex, large in scale, and diverse. Careful observations, mapping, and extensive data collection allow geologists to make inferences in an attempt to explain what they have observed. By soliciting the input of fellow geologists and scientists from other fields, the geologists try to reach a reasonable conclusion. The hypothesis in geology is not always easy to prove as geological problems don't always lend themselves to laboratory study. It is often a case of further field observation and data collection in hopes the new evidence will support the hypothesis. In some instances, computer simulation allows for further investigation. If the hypothesis becomes generally accepted, a theory is developed.

Focus and Context

The focus in this unit is inquiry. As students explore print and other media to reveal the uniqueness and complexity of the geological sciences, the relevance of geology in their daily lives and the work of geologists. The students examine the importance of the Earth's resources and impact of geological processes. The unit then proceeds to investigate Earth's systems in the context of its four spheres. Students do research, construct models, carry out experiments, and report their findings in a variety of formats.

Science Curriculum Links

Students have already explored Earth materials and processes in the elementary and junior high curriculum. In grade 7 science, Earth's Crust is a unit. In this unit, they explore the relevance of geology to humanity and the Earth's resources and processes to which civilization is inextricably linked.

Curriculum Outcomes

STSE	Skills	Knowledge
Nature of Science and Technology • illustrate how science attempts to explain natural phenomena (115-2) **Social and Environmental Contexts of Science** • provide examples of the relevance of mining to everyday materials in our lives (117-5)	**Initiating and Planning** • identify questions to investigate that arise from practical problems and issues (212-1) • define and delimit problems to facilitate investigation (212-2) **Communication and Teamwork** • communicate questions, ideas and intentions, and receive, interpret, understand , support and respond to the ideas of others (215-1) • synthesize information from multiple sources and make inferences based on this information (215-3)	• demonstrate an understanding of the nature of geology and what makes it unique as a science (360-2) • give examples of how geology is interconnected and integrated with other sciences (360-3) • describe and give examples of major themes which unite the study of geology (360-4) • describe and give examples of the interrelationships between earth's spheres (360-6) • explain how a knowledge of geology might influence our decisions about how we use earth resources (360-7) • identify sources and types of geological information needed to examine issues of a societal/environmental nature (360-8) • describe and give examples of how geologists study the earth (360-9)

You and Geology

Outcomes

Students will be expected to

- demonstrate an understanding of the nature of geology and what makes it unique as a science (360-2)
- give examples of how geology is interconnected and integrated with other sciences (360-3)

Elaborations—Strategies for Learning and Teaching

Teachers should use several activities that allow students to discover the uniqueness and complexity of geology. An examination of Greek and Latin derivatives and terminology from text may provide students with examples of the various fields of study within the science of geology and the integration of geology with other sciences.

Students may brainstorm or do concept mapping to identify the connection between the materials in our daily lives and the raw materials from which they were made. A display of products such as glass, cosmetics, tools, jewellery, electronic components, and ceramics can be used to challenge students to determine and describe their connection to a mineral or fossil fuel resource. A jigsaw puzzle format story could also be used.

You and Geology

Tasks for Instruction and/or Assessment

Journal

- Imagine that you are a volcanologist, paleontologist, seismologist, or another choice. Write a journal entry or letter home in which you describe your work-related activities for a twenty-four hour period. (360-2, 360-3)

Paper and Pencil

- Using authentic or teacher-created "employment opportunity" newspaper ads for careers in geology, reply in writing to the ad. Explain the qualifications which would be required as the best candidate for the position advertised. (360-3)
- Create a newspaper employment opportunity ad indicating the knowledge and qualifications required by candidates for a specific career in geology. (360-3)

Resources/Notes

Print

- *Canadian Journal of Earth Sciences* (NRC Research Press)
- *Geology* (The Geological Society of America)

Video

- *Appalachian Story* (LRT)
- *The Earth Revealed* (LRT)
- *Geological Survey of Canada* (LRT)

You and Geology *(continued)*

Outcomes

Students will be expected to

- describe and give examples of the major themes that unite the study of geology (360-4)
- demonstrate an understanding of how geological processes and resources impact our daily lives (360-1)
- provide examples of the relevance of mining to everyday materials used in our lives (117-5)
- communicate questions, ideas, and intentions, and receive, interpret, understand, support and respond to the ideas of others (215-1)

Elaborations—Strategies for Learning and Teaching

After collecting media headlines and clippings and assembling them in poster format, students can present their findings, identifying current issues of a geological nature. Teams of students may also create a web which explores the theme "Geology is ... " using articles of geological interest.

Through discussion students may indicate their understanding of the importance of mining activities in a global context and the contribution of mining to local, provincial, and national economies. This activity may lead to an exploration of the decision making process of whether or not a mining activity should proceed with an examination of the economic, environmental, and social factors.

At this time students should begin their participation in a concurrent, extended inquiry. Understanding and doing this inquiry are contingent on knowing principles, laws, concepts, and theories of geology. It will serve as an assessment tool, and more importantly, as a capstone experience for the geology program. It involves students working in small groups or individually, investigating a question of their own choosing.

At this stage each student prepares a draft statement of a question related to geology they propose to investigate and why they feel it is a reasonable one. These drafts are circulated to all the students in the class. Students prepare written reviews of their classmates' proposals with comments regarding the quality of the research question and the reasons for the investigation. Based on peer feedback, the students revise their proposals and then present and defend the revised question.

Subsequent units include

- Planning the Investigation
- Executing the Research
- Drafting the Report
- Assessment

You and Geology *(continued)*

Tasks for Instruction and/or Assessment

Interview

- Working individually or as a team, arrange an interview with a professional working in a geology-related position to discuss their career. Conduct the interview in the classroom or record the interview for a classroom presentation. (117-5, 215-1)

Project

- Working individually or in teams, plan, design, and construct a model which illustrates natural phenomena that provide evidence in support of the theory of plate tectonics. (360-1, 215-1, 360-4)

Resources/Notes

World Wide Web Key Words

- planet earth
- earth resources
- geology
- geology in the classroom

Suggested Manipulatives

- Various products of mineral or fossil fuel origin

The Geologists

Outcomes

Students will be expected to

- describe and give examples of how geologists study the earth (360-9)
- illustrate how science attempts to explain natural phenomena (115-2)

Elaborations—Strategies for Learning and Teaching

Using vignettes, students should be able to describe how different careers in the field of geology would have unique ways of looking at the earth.

Students, working individually or in teams, may research a particular branch of geology and make an oral presentation to report their findings. Such a presentation should include

- a description of the scope of the chosen branch
- an identification of issues of particular relevance and/or current interest
- a description of some applicable technologies
- a description of a research method employed in the chosen branch
- a discussion of related careers
- an identification of connections to other scientific fields

This presentation could also be made as a poster display or multi-media presentation.

Students should develop an understanding that scientific theories are tentative explanations which are used to explain natural phenomena. The theories evolve as scientific data bases evolve, especially with regard to the advent of technology.

Students can explore the evolution of the Theory of Plate Tectonics, the great unifying theory of geology. Examining the contributions of J. Tuzo Wilson, Harry Hess, and Robert Dietz, Arthur Holmes, Alfred Wegener, and Francis Bacon, students can trace the observations, data collection, inferences, and arguments that led to the Theory of Continental Drift and the synthesis of additional data which produced today's Theory of Plate Tectonics.

The Geologists

Tasks for Instruction and/or Assessment

Journal

- Imagine that you are a volcanologist, paleontologist, or seismologist. Write a journal entry or letter home in which you describe your work-related activities for a twenty-four hour period. (360-9, 115-2)

Interview

- Working individually or as a team, arrange an interview with a professional working in a geology-related position to discuss their career. Conduct the interview in the classroom or record the interview for a classroom presentation. (360-9)

Paper and Pencil

- Using authentic or teacher-created "employment opportunity" newspaper ads for careers in geology. Reply in writing to the ad. Explain their qualifications which would identify them as the best candidate for the position advertised. (360-9)
- Create a newspaper employment opportunity ad indicating the knowledge and qualifications required by candidates for a specific career in geology. (360-9)

Project

- Working individually or in teams, plan, design, and construct a model which illustrates natural phenomena that provide evidence in support of the theory of plate tectonics. (115-2)

Resources/Notes

Print

- Information Series—Promotional booklets published by the Nova Scotia Department of Natural Resources, Minerals and Energy Branch

Software

- An Introduction to Topographic Maps (LRT)
- Science Discovery—Science Sleuths (LRT)

Video

- *The Earth Scientists* (LRT)
- *Geological Survey of Canada* (LRT)
- *Living Machine: Plate Tectonics* (LRT)
- *Born of Fire* (National Geographic Society)
- *Geoscience Mapping*

World Wide Web Key Words

- continental drift
- plate tectonics
- J. Tuzo Wilson
- Alfred Wegener
- Francis Bacon
- Geology careers

Suggested Manipulatives

- Plate Tectonics Models

Earth Systems

Outcomes

Students will be expected to

- describe and give examples of interrelationships between Earth's spheres (360-6)
- explain how a knowledge of geology might influence our decisions about how we use Earth's resources (360-7)
- identify questions to investigate that arise from practical problems and issues (212-1)
- define and delimit problems to facilitate investigation (212-2)

Elaborations—Strategies for Learning and Teaching

Earth possesses a variety of complex, interconnected systems. The major systems are usually referred to as Earth's spheres. They are the lithosphere, hydrosphere, atmosphere, and biosphere. Within each of these exist subsystems. The rock cycle is an example of a subsystem of the lithosphere.

Students can investigate each of Earth's systems to identify their general characteristics. Such investigations may include monitoring weather systems, analysing oceanographic data, and studying local erosional activity.

Students can make a poster presentation in which they provide illustrative examples of how the lithosphere, hydrosphere, and atmosphere provide the physical setting for the biosphere.

Students can describe the physical processes of evaporation, condensation, and precipitation, including the energy transfers which occur in these processes, as a way of illustrating the inextricable link between the hydrosphere and atmosphere.

Earth Systems

Tasks for Instruction and/or Assessment

Performance

- Conduct an experiment to simulate the impact of climatic change on plant growth. One or more species of plant is germinated/grown under the existing local climate conditions and simultaneously under artificial climate conditions to determine the affects of such factors as light, temperature, and moisture. Report on your findings in oral, written, or multi-media formats. (212-1, 212-2, 360-7)

Presentation

- Construct a model which illustrates and explains a current social/environmental issue which is the result of natural changes in an Earth system. Topics might include volcanic eruptions, severe weather, earthquake damage, drought, flooding, or landslides. (360-7)
- Create a poster or collage that illustrates several examples of how Earth's spheres are interconnected. (360-6)

Resources/Notes

Print

- *The Practical Geologist* (Dixon & Bernor)

Video

- *Lake That Fell to Earth, The* (LRT)
- *Blue Planet: Circulation of the Oceans* (LRT)
- *Climate Puzzle: The Atmosphere* (LRT)
- *Gifts from the Earth: Energy Resources* (LRT)

Earth Systems *(continued)*

Outcomes

Students will be expected to

- identify some sources and types of geological information needed to examine issues of a societal/ environmental nature (360-8)
- synthesize information from multiple sources and make inferences based on this information (215-3)

Elaborations—Strategies for Learning and Teaching

Students can be given a list of statements such as "Coal-fired generating stations contribute to acid rain," "Mineral deposits may form as a result of chemical precipitation from seawater," "Weathering contributes to soil formation," to be placed within the correct sphere(s). Students should notice that statements will overlap spheres, hence the connections.

Students can select a current geological issue, such as groundwater contamination, natural gas recovery, surface mining, siting landfills, exploration moratoriums, or soil erosion and identify the types of geological information presented in the associated arguments, after reviewing media releases and other information pertinent to the issue. Case studies could also be provided.

Students can identify sources of geological information and resources and prepare a class directory of current information sources. These might include government departments such as Minerals and Energy, Mines, Map Library, and the Environment, private industry and mining offices, provincial museums and sites found on the World Wide Web.

The directory mentioned above can provide students with information sources relevant to their extended inquiry and may assist them in identifying a researchable question. It will most certainly be of benefit in the next two stages which are Planning the Investigation and Executing the Research.

Earth Systems *(continued)*

Tasks for Instruction and/or Assessment

Performance

- In a group, desktop and publish a directory listing sources of geological information, specimens, data and maps. (360-8)

Paper and Pencil

- Identify the kinds of information that might be used to support the statement "Glaciers crossed the Sahara," or "Antarctica enjoyed a hot and humid climate," or "Tropical seas covered portions of Nova Scotia." (360-8)

Presentation

- Prepare an extended response in defence of conservation of non-renewable resources and recycling, based on geological information. (360-8, 215-3)

Portfolio

- Complete an illustrated article for possible inclusion in their portfolios that elaborates on an issue or problem affecting an Earth system resulting from the impact of human activity. Topics might include changes in soil chemistry as a result of irrigation, use of chemical fertilizers, burning of fossil fuels, deforestation and erosion, changes in runoff patterns as a result of development, dam building, or surface mining. (360-8)

Resources/Notes

World Wide Web Key Words

- lithosphere
- hydrosphere
- atmosphere
- biosphere

Suggested Manipulatives

- seeds, soils, plant trays
- thermometers
- light metres
- weather monitors

Earth Materials

Unit Overview

Rocks contain most of the minerals of the Earth. The variation in the appearance of rocks is due to the relative amounts and varieties of minerals they contain. Geologists classify rocks based on their origin, identifying each according to its mineral composition, texture, and structure. The close examination of a rock can reveal clues as to the environment in which it formed and this is the principle reason for studying them. After becoming familiar with the rock-forming minerals, students should examine a wide variety of rock specimens and infer their origins, following a careful study of their composition, texture and structure.

Focus and Context

This unit provides students with the opportunity to examine Earth materials in "hands-on, minds-on" investigations. Students should make many first-hand observations of prepared specimens as they identify the physical and chemical characteristics of common minerals and classify them. It is imperative that the students become familiar with the rock-forming minerals and the various rock textures before they attempt to identify and classify rock specimens. The investigations in this unit will lead to an awareness of how the characteristics of a rock specimen allow geologists to infer its origin. Good quality, prepared, laboratory specimens of common minerals and specimens of rocks that clearly display the classic textures are essential resources for this unit.

Science Curriculum Links

Students are involved with mineral and rock examination at the junior high level. The detailed observation of physical and chemical characteristics of minerals carried out in this unit will build upon that knowledge base and lead to classification of minerals and interpretation of rock textures from which they can infer the origin of a rock specimen.

Curriculum Outcomes

STSE	Skills	Knowledge
Relationships between Science and Technology • identify examples where scientific understanding was enhanced or revised as a result of the invention of a technology (116-1) • identify examples where technologies were developed based on scientific understanding (116-3)	**Performing and Recording** • compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5) **Analysing and Interpreting** • apply and assess alternative theoretical models for interpreting knowledge in a given field (214-6)	• construct a definition for a mineral and a rock and identify the features that characterize each (361-1) • explain and give examples of basic chemical building blocks and atomic structures (atom, element, molecule, compound) (361-2) • explain external crystal shape in terms of internal atomic arrangement (361-4) • classify common minerals according to their chemical and physical characteristics (330-3) • classify and identify rocks according to their structure, texture and mineral composition (361-11) • relate the formation of igneous, sedimentary and metamorphic rocks to the rock cycle (361-13)

Crystallography

Outcomes

Students will be expected to

- construct a definition for a mineral and a rock and identify the features that characterize each (361-1)
- explain and give examples of basic chemical building blocks and atomic structures (atom, element, molecule, compound) (361-2)
- explain external crystal shape in terms of internal atomic arrangement (361-4)
- identify examples where scientific understanding was enhanced or revised as a result of the invention of a technology (116-1)
- identify examples where technologies were developed based on scientific understanding (116-3)

Elaborations—Strategies for Learning and Teaching

Students should construct their own definition of a mineral and a rock through "hands-on, minds-on" activities. One method of accomplishing this is by using a deductive investigation. Representative specimens of minerals and rocks are arranged in two labelled groups for students to examine. After observing similarities within each collection, the students identify the unique characteristics of each group which allows them to determine what makes a mineral a mineral and a rock a rock. Careful selection of classic specimens is of utmost importance. The minerals should display a variety of uniform colours and crystal forms. The rocks should be chosen for their texture and heterogeneous composition.

Having established a definition for a mineral and a rock students can then be presented with a collection of both types of specimens and asked to sort them based on their definitions and defend their reasoning. At this point specimens of broken concrete, brick, and glass may be included to initiate discussion regarding manufactured materials and whether they should be included in either group. (They should not be, as they are items that are not naturally occurring.)

Students should construct molecular and ionic models of some common minerals, using materials such as styrene balls and skewers or crystal lattice modelling kits. Students should grow crystals from super-saturated solutions. Potassium alum, chrome alum, cupric sulfate and sodium chloride are good choices for growth on nylon thread. Microscopic examination of the crystals grown should be encouraged. Rapid crystal growth may be observed by cooling a super-saturated solution of sodium thiosulphate in a petri dish on an overhead projector. A "seed crystal" may be added to the solution in the dish to speed the crystallization process. The petri dishes can be photocopied or scanned to record the experiment visually.

Crystallography

Tasks for Instruction and/or Assessment

Performance

- Classify a collection of earth materials as minerals or rocks and justify their decisions. Teachers could note the degree to which students are able to make observations regarding the similarities and differences in the specimens, their ability to recognize the crystal form and homogeneous composition of minerals and distinguish this from the textured, heterogeneous composition of most rocks. (361-1, 361-2, 361-4)
- Conduct an experiment in crystal growth with an emphasis on purity and crystal form and present your results in an illustrated report. Such a report could include a section on the research in crystal growth being carried out as part of the space program. (361-2, 361-4, 116-1, 116-3)
- Build three-dimensional models representing various crystal systems. (361-2, 361-4)
- Construct ionic or molecular models of minerals which illustrate how external crystal form is dependant upon the internal structure. (361-2, 361-4)

Journal

- Complete an illustrated journal entry which elaborates on the statement “The silicon tetrahedron is the most important building block in the earth’s crust.” (116-3, 116-1, 361-4, 361-2)

Paper and Pencil

- Create a poster that distinguishes between the terms mineral and rock. (361-1, 361-2, 361-4)
- Working individually or collectively, conduct research into the discovery of polarized light and the subsequent development of the petrographic microscope and its contributions to the field of mineralogy and submit reports. (116-3, 116-1, 361-4)

Resources/Notes

Print

- Field Guides to Rocks and Minerals

Software

- Geology Explorer (LRT)

Video

- *Minerals: The Materials of Earth* (LRT)
- *The Rock Cycle* (LRT)

Crystallography *(continued)*

Outcomes

Students will be expected to

- identify examples where scientific understanding was enhanced or revised as a result of the invention of a technology (116-1)
- identify examples where technologies were developed based on scientific understanding (116-3)

Elaborations—Strategies for Learning and Teaching

Students should construct diagrams or models of the six crystal systems, those being the isometric (cubic), tetragonal, hexagonal, orthorhombic, monoclinic, and triclinic systems. Emphasis should be placed on the accuracy of depicting the number and length of axes and their angles of intersection. Students can identify representative minerals crystallizing in each system.

Students should explore the crystal structure and physical and chemical properties of the minerals graphite and diamond. These two minerals clearly illustrate that the fundamental difference between minerals lies in their internal structure and not their composition.

Students should explore the evolution of the x-ray analysis of crystals by investigating the work of John Dalton, Max von Laue, and Friedrich and Knipping. The development of x-ray techniques confirmed the earlier inferences made by mineralogists that the constant angles displayed by crystals is a factor of a regular, internal packing of submicroscopic particles, the atoms and ions.

Crystallography *(continued)*

Tasks for Instruction and/or Assessment

Journal

- Having presented various research questions to class, during this unit students may form research groups and come to agreement on a question they will research as a team. As they plan the investigation, the question may undergo further modification until their plans are ready to be presented to the class. Each team distributes a written copy of their research plan to every member of the class. Once again all students are required to provide a written critique of each team's plan with suggestions for modification. Groups revise their proposals on the basis of the feedback they receive. The teacher should require every member in the groups to maintain journal entries documenting the development of their research question. Development of a rubric could assist in assessing this work. (116-1, 116-3)

Resources/Notes

World Wide Web Key Words

- atomic theory
- ionic bonds
- covalent bonds
- crystals
- crystallography
- Max von Laue
- silicon tetrahedron
- solid solutions

Suggested Manipulatives

- crystal lattice models
- microcrystal study kits
- macrocrystal growth kits
- stereoscopic microscopes
- hand lenses
- crystal growth supplies
- overhead projector
- selected crystal specimens
- selected mineral specimens
- selected rock specimens

Video

- *Chemistry of the Earth* (LRT)

Mineralogy

Outcomes

Students will be expected to

- classify common minerals according to their chemical and physical characteristics (330-3)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5)

Elaborations—Strategies for Learning and Teaching

The accurate identification of minerals in hand specimen requires a knowledge of the physical properties of minerals. While other laboratory techniques, such as petrographic, x-ray and chemical analysis are frequently employed, the common rock-forming minerals and many minerals of economic importance can be identified by careful observation of their physical properties. Pre-laboratory discussion to familiarize students with the observable physical properties and how to test for those requiring a laboratory procedure is essential.

Cleavage, fracture, form, colour, and luster are readily observable although occasionally a stereo-microscope or hand lense may prove helpful. The streak is easily observed by rubbing the mineral on unglazed porcelain or a streak-plate. Specific gravity is easily determined for larger specimens but a more sensitive balance will be required for smaller specimens. You may prefer to use a density calculation if you have access to overflow cans for the volume measurement. A knowledge of Mohs Scale of Hardness and how to test for "scratch resistance" using common items must precede any laboratory assignment. Testing for hardness should be treated as a pre-requisite lab procedure and practised "hands-on." As specimens tested repeatedly for hardness tend to be pretty much destroyed during the procedure, you may not want to assign classic crystal specimens for use in this activity.

Students may also test for magnetic attraction, reaction with dilute hydrochloric acid, fluorescence under ultraviolet light and observe striations on cleavage surfaces and crystal faces.

Mineralogy

Tasks for Instruction and/or Assessment

Performance

- Conduct laboratory examinations of selected minerals to determine properties such as hardness, specific gravity or density, streak, reaction with dilute hydrochloric acid and report your findings. (330-3, 213-5)
- Given a selected collection of minerals, observe and describe specified physical properties for each specimen. Create your own format for reporting. (213-5)
- Individually or collectively, given a collection of mineral specimens, develop a classification key for the collection. The key should be accompanied with an explanation of its limitations. (330-3, 213-5)

Journal

- Select a metalliferous or non-metallic mineral resource of importance to Nova Scotia and complete a journal entry elaborating on its role in the economy of our province. (330-3)

Paper and Pencil

- Design a travel brochure that advertises mineral collecting as a tourist attraction in Nova Scotia, or in a particular region of the province. (330-3)

Presentation

- Prepare a collection of minerals from a specific location. The collection should be labelled, specimens identified and be presented with an accompanying map that identifies the collecting locations. (330-3, 213-5)
- Conduct research and prepare an illustrated magazine article highlighting a particular mineral of importance to humanity. Include a description and illustration of the mineral, a map showing locations where it is found or mined and historical notes. (330-3, 213-5)

Resources/Notes

Print

- Promotional booklets published by the Nova Scotia Department of Natural Resources, Minerals and Energy Branch
- Geological Highway Map of Nova Scotia (Nova Scotia Department of Natural Resources, Minerals and Energy Branch)
- Elsevier's Minerals of the World Poster

Video

- *Mineral Vignettes* (LRT)
- *Mineral Wealth of Atlantic Canada* (LRT)
- *Gifts From the Earth: Mineral Resources* (LRT)
- *The Rock Cycle* (LRT)

Mineralogy *(continued)*

Outcomes

Students will be expected to

- classify common minerals according to their chemical and physical characteristics (330-3)
- compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data (213-5)

Elaborations—Strategies for Learning and Teaching

After a thorough overview of the physical properties of minerals, students should be assigned a carefully selected collection of labelled mineral specimens to examine. They should report on the observable physical properties of each in a suitable format. Students should examine a variety of mineral identification keys and charts, noting the importance of accurate observation of physical properties. They should then be assigned selected collections of minerals and asked to create their own keys. Ideally, each team or group should have their own collection to work with. The initial specimens assigned should lend themselves to simple dichotomous classification, but subsequent lab activities should include more challenging mineral specimens. Following this, students should be required to identify unknown specimens by using appropriate references and keys.

The responsibility of managing the mineral collection should be shared by the students who may serve as both collectors and curators. Compartmented and numbered collection boxes make inventory easier to manage. Collections may be grouped according to chemical composition, by association, in suites, or by use. Some suggested starter collections follow:

- Industrial Minerals: Gypsum, Anhydrite, Garnet, Halite
- Rock-forming Silicates: Orthoclase, Plagioclase, Muscovite, Biotite, Augite, Hornblende, Olivine, Garnet, Staurolite, Epidote, Serpentine, Quartz, Talc
- Ore minerals: Galena, Sphalerite, Pyrite, Chalcopyrite, Gold, Cassiterite, Hematite
- Gem minerals: Agate, Amethyst, Jasper, Smoky Quartz
- Unique minerals: Iceland Spar Calcite, Willemite, Sulfur, Magnetite, Graphite, Silver, Halite
- Zeolite minerals: Heulandite, Stilbite, Chabazite, Natrolite, Analcime

Students should be encouraged to collect, identify and catalogue their own specimens. Local collectors and prospectors should be invited to discuss the recreational and economic aspects of mineralogy with the students and areas of special interest should be identified on the Geological Highway Map of Nova Scotia.

Mineralogy *(continued)*

Tasks for Instruction and/or Assessment

Interview

- Prepare questions for inquiry and interview a mineral collector, lapidary specialist, jeweller, gemologist or prospector, either live in the classroom or as a taped, video presentation (213-5, 330-3)

Performance

- Construct models of mineral crystals and use the various faces of the crystals to display information about the physical and chemical properties, uses, sources, and other information of the chosen mineral. (330-3, 213-5)

Paper and Pencil

- Conduct a Web or library research assignment which investigates the minerals coesite and/or cristobalite, two polymorphs of quartz. These minerals have the same chemical composition as quartz, but a different internal structure. Coesite forms under extreme pressures such as meteorite impact and cristobalite is found in volcanic rocks. (330-3, 213-5)
- Assemble a report on Nova Scotia's famed zeolite minerals, a family of late-forming minerals found in pockets in the North Mountain lava flows. These minerals are quite rare and much sought after by collectors. (330-3, 213-5)

Resources/Notes

World Wide Web Key Words

- minerals
- mineralogy
- mining
- mineral collecting
- gemstones
- gemology
- lapidary

Suggested Manipulatives

- selected mineral specimens
- streak plates
- glass plates
- hardness points
- laboratory balances
- overflow cans
- graduated cylinders
- compartmented collection boxes
- ultraviolet lamp
- dilute hydrochloric acid
- magnifiers
- stereoscopic microscope
- contact goniometers

Petrology

Outcomes

Students will be expected to

- classify and identify rocks according to their structure, texture and mineral composition (361-11)
- relate the formation of igneous, sedimentary and metamorphic rocks to the rock cycle (361-13)
- apply and assess alternative theoretical models for interpreting knowledge in a given field (214-6)

Elaborations—Strategies for Learning and Teaching

A geologist's primary interest in studying rocks is the record of earth's history they can reveal. The science of petrology goes beyond the mere chemistry and physics of the specimen and becomes an investigation into the origin of the rock and what it can tell us about its past.

The rocks found in the crust of the Earth are classified into three main categories based on their origin. The igneous rocks form from magma or lava. Metamorphic rocks are rocks that have been altered by high temperatures and pressures deep within the earth. Sedimentary rocks form from sediment deposited on or near the earth's surface by water, wind, or ice. The first two groups are formed by internal processes and therefore provide us with information about conditions within the Earth's crust. The latter group provides a record of processes that were at work on the Earth's surface at the time of their formation

The science of petrology is also the study of change. The crust of the Earth is forever being altered by forces at work on the surface and deep within. The rocks that make up the crust are slowly and constantly undergoing changes and are part of a massive recycling process. Rock on the surface may undergo weathering and erode to form sediment which eventually forms sedimentary rock. Rock that lies deep within the Earth might be altered to become a metamorphic rock or melt and re-crystallize to form new igneous rock. Within this rock cycle any class of rock can be changed into another depending upon its location in the Earth's crust.

Students should begin their work in petrology by examining and recording their observations of carefully selected examples of the three classes of rock, presented as labelled collections. Emphasis should be placed on the students noting the composition (minerals or particles), texture (grain size) and structure (crystalline, banded, layered, glassy) and illustrating their report with a hand-draw and coloured likeness of the specimen being examined. Some students will begin to infer origins and this should be encouraged.

Petrology

Tasks for Instruction and/or Assessment

Performance

- Given a collection of selected rock specimens, describe the composition, texture and structure of each. Classify each rock based on your observations and infer its origin. (361-11, 361-13)
- Given three related rock specimens, (igneous, sedimentary and metamorphic) elaborate on the processes which were responsible for the formation with reference to the rock cycle. Examples of related specimens might include arkose-gneiss-granite or diorite-quartz sandstone-quartzite. (361-13, 361-11)

Paper and Pencil

- Give illustrative examples of the processes that turn a sedimentary rock into an igneous rock, and a metamorphic rock into an igneous rock. (361-13)

Presentation

- Conduct a field study of an area of your choosing and assemble a suite of rocks representative of that area. The collection should be properly prepared with each specimen identified and labelled. A map could be included. (361-11, 214-6)

Resources/Notes

Print

- Field Guides to Rocks and Minerals
- Promotional booklets published by the Nova Scotia Department of Natural Resources, Minerals and Energy Branch
- Geological Highway Map of Nova Scotia (Nova Scotia Department of Natural Resources, Minerals and Energy Branch)
- Elsevier's Mineral and Rock Table

Video

- *The Rock Cycle* (LRT)
- *The Rock Cycle* (Marlin) (LRT)

Petrology *(continued)*

Outcomes

Students will be expected to

- classify and identify rocks according to their structure, texture and mineral composition (361-11)
- relate the formation of igneous, sedimentary and metamorphic rocks to the rock cycle (361-13)
- apply and assess alternative theoretical models for interpreting knowledge in a given field (214-6)

Elaborations—Strategies for Learning and Teaching

Once students are familiar with the characteristics of the three groups they should be challenged to create a classification key for all rock types. Following these activities the students should be formally introduced to a selection of rock classification keys.

Discussion regarding the processes responsible for the formation of the various rock types is a necessary component of this introduction. Students need extensive, hands-on opportunities to identify and classify selected specimens and an essential component of this work is to infer the origin of each specimen based on its observable characteristics. Some suggested specimens for starter collections follow. Label-edge trays for individual specimens simplifies lab set-up and maintenance of such a collection.

- Igneous Rocks: Andesite, Basalt, Diorite, Gabbro, Granite, Obsidian, Peridotite, Pumice, Rhyolite, Tuff, Volcanic Breccia
- Metamorphic Rocks: Amphibolite, Gneiss, Hornfels, Marble, Migmatite, Phyllite, Quartzite, Schist, Slate
- Sedimentary Rocks: Anhydrite, Breccia, Coal, Conglomerate, Chert, Dolomite, Gypsum, Limestone, Salt, Sandstone, Shale

Students can create their own version of the rock cycle, either graphically or pictorially and should be encouraged to refer to the rock cycle when inferring the origins of laboratory specimens.

A geologic scavenger hunt which utilizes the Geologic Highway Map of Nova Scotia can introduce students to the tectonic settings of rocks they are examining.

Students should be encouraged to prepare a collection of rocks from their geographic area which they then identify and label. Collecting locations should be noted. A mapping exercise could be introduced as a component of this activity.

Students can research the historical discussions surrounding the origin of granite. The arguments put forth by Abraham Werner and evidence collected by James Hutton rebutting them clearly illustrate opposing theoretical models and the evolution of modern theory.

Petrology *(continued)*

Tasks for Instruction and/or Assessment

Performance

- Build a model or prepare a map of your county which illustrates the rock types present and supplement the model with actual specimens they collect and identify. (361-11)
- Individually or collaboratively, create a game with a geology theme in which a knowledge of petrology is the key to success. The game might be modelled after a favourite television game show, board game, or be of an original design. (214-6, 361-13)

Journal

- Write a journal entry in which you identify the rock which underlies your home property and elaborate on its origin including the sequence of events that may have happened in its geologic history. The Geologic Highway Map of Nova Scotia might be used as a reference. (361-11, 361-13)

Presentation

- Prepare a poster presentation based on research conducted on the World Wide Web or in libraries which illustrates the development of a modern theory in petrology. (214-6)
- Individually or collaboratively, create a multi-media presentation in which you explain the process of collecting, identifying and inferring the origin of a rock specimen. (214-6, 361-13, 361-11)

Resources/Notes

World Wide Web Key Words

- petrology
- rocks
- igneous rock
- sedimentary rock
- metamorphic rock
- rock cycle

Suggested Manipulatives

- selected rock specimens
- magnifiers
- stereoscopic microscope
- rock cycle model
- rock hammers
- safety goggles

Video

- *Fossil Story* (LRT)
- *Volcanism* (LRT)

Internal Processes

Unit Overview

In this unit the students begin their study of the Earth's interior with an investigation of how science has determined the internal structure of our planet and how technology has helped in revealing the layered structure of the interior. The cause of earthquakes is explored and the interpretation of seismic data examined.

Focus and Context

The focus in this unit is decision making as students explore print and other media to understand the origins of the Earth's structures. The students begin their study of the Earth's interior with an investigation of how science has determined the internal structure of our planet. The unit then proceeds to investigate how technology has helped in revealing the layered structure of the interior. Students do research, construct models and diagrams, and report their findings in a variety of formats.

Science Curriculum Links

Students have already explored Earth materials and processes in the elementary and junior high curriculum. In this unit, they explore the relevance of geology to explaining the connection between our planet's internal processes and the structures of its crust.

Curriculum Outcomes

<table>
<tr><th>STSE</th><th>Skills</th><th>Knowledge</th></tr>
<tr>
<td>Nature of Science and Technology

• explain the roles of evidence, theories and paradigms in the development of scientific knowledge (114-2)

• illustrate how science attempts to explain natural phenomena (115-2)

• explain how a major scientific milestone revolutionized thinking in the scientific communities (115-3)

Social and Environmental Contexts of Science and Technology

• identify and describe science and technology-based careers related to the science they are studying (117-7)

• describe examples of Canadian contributions to science and technology (117-10)

• identify instances in which science and technology are limited in finding answers to questions or the solution to problems (118-7)</td>
<td>Initiating and Planning

• identify questions to investigate that arise from practical problems and issues (212-1)

Performing and Recording

• select and integrate information from various print and electronic sources or from several parts of the same source (213-7)

Analysing and Interpreting

• apply and assess alternative theoretical models for interpreting knowledge in a given field (214-6)

• explain how data support or refute the hypothesis of plate tectonics (214-12)</td>
<td>• describe theories and evaluate the limits of our understanding of earth's internal structure (330-1)

• describe the various forces (compressional, tensional, shear) which operate in the Earth and how these forces create faults, folds and mountains (362-3)

• explain the plate tectonic theory (362-6)

• describe the geologic activity associated with plate boundaries and relate this to the rock cycle (362-7)</td>
</tr>
</table>

Earth's Interior

Outcomes

Students will be expected to

- describe theories and evaluate the limits of our understanding of earth's internal structure (330-1)
- identify questions to investigate that arise from practical problems and issues (212-1)
- select and integrate information from various print and electronic sources or from several parts of the same source (213-7)
- identify and describe science and technology-based careers related to the science they are studying (117-7)
- identify instances in which science and technology are limited in finding answers to questions or the solution to problems (118-7)

Elaborations—Strategies for Learning and Teaching

Some of the earliest studies of the Earth were observations made by the ancient Greeks who inferred the shape of the Earth by noting the shadow it cast during eclipses of the moon. About 235 BC Eratosthenes measured the diameter of the Earth with a simple method that involved just two assumptions, that the earth is a sphere and that the sun's rays are all parallel. The work of Aristotle, Galileo, and Newton lead to the determination of the Earth's mass, and studies of the planet's motion in space revealed that most of its mass is located deep within the sphere.

To introduce this unit, students can conduct a case study or jigsaw activity to facilitate a chronological review of the theories leading to our present understanding of the Earth's internal structure.

At this time students could be given a research assignment to gather information on a selection of famous earthquakes and prepare their reports for presentation in class at the close of this unit.

Students should brainstorm to identify methods used to examine the Earth's interior. In review, drill cores, mining activity, volcanic eruption, tectonics, earthquakes, and meteorite composition should be discussed.

Travel times of earthquake waves through the Earth have distinguished three main layers. Knowledge that P-waves will travel through both solids and liquids (although slower through liquids) and that S-waves only travel through solids has provided the data that has allowed geologists to infer the Earth's inner structure. The changes in wave velocity allow scientists to locate the divisions between the layers, known as discontinuities.

Earth's Interior

Tasks for Instruction and/or Assessment

Performance

- Make a physical model or diagrammatic representation of the Earth's interior. (213-7)
- Build or conceptualize an instrument used to detect earth tremors and explain its operation. (212-1, 213-7)
- Using a map, predict which locations are more likely to experience an earthquake and state their reasoning. (212-1, 213-7, 330-1)

Paper and Pencil

- Given statements of a historical nature regarding the evolution of our understanding of Earth's internal structure, place these in chronological order. (330-1)
- Analyse seismographic data and locate the epicenter of an earthquake. Why a knowledge of S- and P-wave velocities is necessary for locating an epicentre. While three arcs can locate an epicenter and a fourth will serve as a check, is it ever possible to locate an epicenter with data from just two recording stations. (212-1, 213-7, 118-7)
- Elaborate how architecture influences the impact of earth tremors on civilizations. (118-7, 117-7, 213-7, 212-1)
- Compare the earthquake risks in Halifax and Mexico City, with consideration of such factors as geography, geology, topography, and architecture. (212-1, 213-7)

Presentation

- Create a multimedia presentation that challenges the validity of the term "solid earth." (330-1, 212-1, 213-7, 117-7, 118-7)

Portfolio

- Complete an illustrated article, for possible inclusion in your portfolios, in which you devise a set of construction recommendations for housing construction in a geologically active area. (212-1, 118-7, 117-7)

Resources/Notes

Video

- *Earth's Interior* (LRT)
- *Earth's Structure* (LRT)
- *Volcanism* (LRT)

Earth's Interior *(continued)*

Outcomes

Students will be expected to

- identify questions to investigate that arise from practical problems and issues (212-1)
- select and integrate information from various print and electronic sources or from several parts of the same source (213-7)
- identify instances in which science and technology are limited in finding answers to questions or the solution to problems (118-7)

Elaborations—Strategies for Learning and Teaching

Through class discussion, students may indicate their understanding of earthquakes and seismology. Students may explore elastic rebound by applying shear force to a block of Jell-O until it breaks. Using two-by-four lumber which they can cut and paint to create models representing rock layers, the students may then manipulate these block models to investigate and diagram various types of fault movement. Students can investigate the nature of S- and P-waves using a Slinky. After acquiring data from earthquake information centres, students can practice plotting the epicentres of earthquakes using the wave arrival time data. Students may enjoy investigating the virtual earthquake sites on the Internet. At this time worldwide earthquake zones should be examined. These include the Circum-Pacific belt, Mediterranean zone, Trans-Himalayan zone, Mid-Atlantic Ridge, Mid-Indian Ridge, Hawaiian Islands, and African Rift Valley zones.

Students can be challenged to research the development of the seismograph and construct a model of the instrument which illustrates the principles involved in recording earthquake data.

Using library and Internet resources students may conduct their own research and then construct models or posters which illustrate and explain the Earth's inner structure and the techniques used to define the crust, mantle and core. They could also elaborate on the divisions of the crust based on rigidity, those being the lithosphere, asthenosphere and mesosphere.

Students can be asked to imagine they are a seismologist and create a journal entry in which they reminisce about their education, training and various job assignments they or their colleagues have had. An alternate journal assignment might be to take on the role of a local news reporter and write a feature article in which they report on a severe earthquake hitting their hometown.

Working individually or collectively, students might produce illustrated magazine articles which elaborate on recent earthquake activity and geologic risk. Topics could also include the Modified Mercalli intensity scale, the Richter Scale of magnitude, the many catastrophic earthquakes which have been recorded in human history, tsunamis and the attempts made to predict such devastation. The articles could be desktop published in the classroom.

Earth's Interior *(continued)*

Tasks for Instruction and/or Assessment

Project, Presentation

- Using information gathered from reports of past earthquake experiences, prepare a poster presentation illustrating an earthquake preparedness plan or emergency response plan that you have created for a community in a geologically active area. (213-7, 212-1, 118-7)

Journal

- Now that each team has an established research plan that has been revised after being reviewed by their peers, design and test different forms of data collection. Develop a data collection schedule and then proceed to collect, organize, and interpret their data. This period of data collection will extend over this unit and Unit 4 in the curriculum. Encourage students to explore technologies that might assist them in their research and data handling. Appropriate use of the Internet, science probes for data acquisition, data bases, and spreadsheets for data management, and graphing software might be considered. Throughout this period in the inquiry, maintain a log of all activities associated with the research in your journal. (213-7, 118-7)

Resources/Notes

World Wide Web Key Words

- Eratosthenes
- Aristotle
- Galileo
- Newton
- Mohorovicic
- sial and sima
- seismology
- earth structure
- earthquake
- earthquake prediction
- Mercalli
- Richter
- lithosphere
- asthenosphere
- mesosphere
- rift valleys
- virtual earthquakes

Suggested Manipulatives

- Earthquake watch kits
- Seismograph model
- Mid-Atlantic ridge maps
- Relief globes

Videos

- *New World Below* (LRT)
- *Lithoprobe: Probing the Earth* (LRT)

Plate Tectonics

Outcomes

Students will be expected to

- explain the roles of evidence, theories and paradigms in the development of scientific knowledge (114-2)
- explain how a major scientific milestone revolutionized thinking in the scientific communities (115-3)
- apply and assess alternative theoretical models for interpreting knowledge in a given field (214-6)
- explain how data support or refute the hypothesis of plate tectonics (214-12)
- describe examples of Canadian contributions to science and technology (117-10)
- explain the plate tectonic theory (362-6)

Elaborations—Strategies for Learning and Teaching

The Theory of Continental Drift has had a turbulent history since it was introduced by Alfred Wegener in 1910. It was both criticized and ignored and for many years it languished due to lack of a reasonable mechanism to support continental drift. With the discovery of sea-floor spreading in the mid-1900s, the idea was revisited and became known as the Theory of Plate Tectonics. While the Theory of Plate Tectonics is now well accepted, the details of some of its mechanisms still require further research.

To introduce this unit student teams can be presented with a collection of terms relevant to plate tectonics and asked to construct and present concept maps.

Following a discussion of the work of J. Tuzo Wilson, students, individually or as teams, may be asked to research different scientists whose work contributed to the evolution of the Theory of Plate Tectonics and prepare a report for class presentation.

According to this theory the plates of the crust are rigid and moving very slowly and where they meet each other three events may occur. They may grow larger by addition of molten material along fault zones, they may collide and form mountains or one plate may move past another with a shearing motion which forces one plate margin down into the asthenosphere. Following a discussion of the paleomagnetic evidence associated with the rocks adjacent to mid-ocean ridges, students should model sea-floor spreading by pulling two adding machine tapes up and in opposite directions, at about the same rate, from between two desks that have been pushed together. By using felt markers of different colours (one for normal polarity, another for reversed polarity) and alternately marking the tapes just as they emerge from the crack, a model of a “paleomagnetic record” can be formed.

Plate Tectonics

Tasks for Instruction and/or Assessment

Performance

- Demonstrate plate tectonics as one of the great, unifying theories of geology and has relevance to most geologic disciplines. (114-2, 115-3, 214-6, 214-12, 362-6)

Project

- Continue to select pieces of your research and writing for inclusion in your portfolios. (114-2)
- Having now revisited the topic of plate tectonics, self-evaluate your progress. (362-6, 117-10, 214-12, 214-6, 115-3, 114-2)

Resources/Notes

Print

- *Investigations in Earth Science* (Beckway and Young)
- *Dictionary of Geological Terms* (Prinz, Harlow and Peters)
- *The Restless Earth* (Calder)
- Mid-Atlantic Ridge Map
- Geologic Highway Map of Nova Scotia

Software

- The Theory of Plate Tectonics (LRT)

Video

- *Plate Dynamics* (LRT)
- *Mountain Building and Growth of Continents* (LRT)
- *Living Machine: Plate Tectonics* (LRT)
- *Living Machine: Continental Tectonics and the Earth's Interior*
- *Plate Tectonics: The Puzzle of the Continents* (LRT)

Plate Tectonics *(continued)*

Outcomes

Students will be expected to

- explain the roles of evidence, theories and paradigms in the development of scientific knowledge (114-2)
- explain how a major scientific milestone revolutionized thinking in the scientific communities (115-3)
- apply and assess alternative theoretical models for interpreting knowledge in a given field (214-6)
- explain how data support or refute the hypothesis of plate tectonics (214-12)
- describe examples of Canadian contributions to science and technology (117-10)
- explain the plate tectonic theory (362-6)

Elaborations—Strategies for Learning and Teaching

To model the collision of plates the students can construct a “sandbox” about 50 cm square, which allows for a sheet of Mylar (or similar) film to be pulled across the base of the box and under the end-boards. About 3 cm of sorted fine sand is placed in the box on top of the film and the upper surface is evenly dampened with water from a spray bottle. As the film is very slowly pulled through the box, the upper surface acts brittlely, underlain by the weaker, dry layer, as together they collide with the side of the box. Students can sketch, photograph or videotape the various structures which develop and then identify them along with the forces responsible. The results could be presented in multimedia format. Such a report would lend itself well to using software such as Hyperstudio as a presentation format.

Students can prepare posters illustrating cross-sections of the convergent, divergent and transform types of plate boundaries with labels indicating their unique geologic activity and rock types.

In 1931 the English geologist Arthur Holmes speculated that convection currents within the Earth could be the force responsible for moving the continents. To model convection cells within the Earth students can observe convection currents using kalliroscope rheoscope fluid, a nonflammable, water-based suspension of microscopic crystals. (The results are more dramatic when a few drops of red food colouring are added.) Sawdust in boiling water also works.

Students may plot earthquake epicentres and volcanic eruptions on world-map overhead transparency masters to create a series of overlays which illustrate geologic evidence for plate boundaries.

With reference to the Geologic Highway Map of Nova Scotia, students can explore the geologic features of their home province that can be related to plate tectonics. Topics to investigate might include the Avalonian Orogeny that created mineral deposits at Stirling and Coxheath, the origin of Maguma sediments adjacent to ancient Africa, the Acadian Orogeny which formed the South Mountain batholith along with the East Kemptville tin deposit and various gold veins, or the Glooscap Fault System.

Plate Tectonics *(continued)*

Tasks for Instruction and/or Assessment

Performance

- Trace a world map, cut it out, and reassemble it as they believe it might appear 100 million years from now. (362-6)
- Debate among a group of early scientists as some present arguments in support of continental drift while others take on the role of historical figures. (114-2, 115-3, 214-6, 214-12, 117-10, 362-6)

Paper and Pencil

- Prepare a summary of the evolution of plate tectonic theory in flow chart format. (114-2, 115-3, 214-6, 214-12, 117-10, 362-6)
- Create labelled diagrams or models of convergent, divergent and transform plate boundaries and identify where each might be located on a world map. (362-6)
- Choose a region of Nova Scotia and prepare a list of its geologic features which they describe in terms of tectonic history. (362-6)

Resources/Notes

World Wide Web Key Words

- Plate Tectonics
- Structural Geology
- Sea-floor spreading
- J. Tuzo Wilson

Suggested Manipulatives

- Ocean floor models
- Terrestrial globe
- Hydrographic relief globe
- Plate tectonics models
- Two-by-four lumber, paint
- Sea-floor spreading kits
- Adding machine tape
- Kalliroscope rheoscope fluid
- Materials for “sandbox” lab
- Earthquake Watch kit

Forces and Structures

Outcomes

Students will be expected to

- illustrate how science attempts to explain natural phenomena (115-2)
- describe the various forces (compressional, tensional, shear) which operate in the Earth and how these forces create faults, folds and mountains (362-3)
- describe the geologic activity associated with plate boundaries and relate this to the rock cycle (362-7)

Elaborations—Strategies for Learning and Teaching

The discipline which studies the deformation (faulting and folding) of rocks is known as structural geology and its origins can be traced back to the late eighteenth century and the work of the Swiss geologist and mountaineer H. B. de Saussure. This field of the geologic sciences looks a folds and faults from a microscopic scale of a few millimetres to mountain ranges that are hundreds of kilometres long.

About one hundred years before de Saussure's work in Switzerland, Nicolaus Steno had proposed the Law of Original Horizontality—that strata are usually deposited in nearly horizontal layers, parallel or nearly so to the surface on which they are accumulating. He also first stated the Law of Superposition—simply put, that in any undisturbed pile of sedimentary strata, the youngest stratum is at the top and the oldest at the bottom, just like an accumulating the stack of daily newspapers. A discussion of these principles should proceed any interpretive work in this unit.

Instruction in this section should be "hands-on, minds-on" and utilize concrete models to facilitate a clearer understanding of the sometimes abstract concepts of Earth's inner structure. If wood is being stressed, it is imperative that the observers have proper shielding from the experimental process. To easily cut clay during the model building process, fine wire wrapped around pieces of dowelling for handles and stretched taught makes an efficient cutting tool.

To permit observation of what happens to rock layers when stress is applied, strips of carpet underpad or clay models may be used to model folding. Stacked-layer clay block models built by the students or the wooden block models described earlier in this unit will serve to model faulting. Stacked-layer clay models should be used for the study of unconformities as these can be easily "eroded" by slicing off the tops.

As an introduction to this topic, students may collect images of landforms that are vivid examples of faulted or folded structures and assemble a collection of study cards which they then add explanatory captions to as this unit of study progresses.

Forces and Structures

Tasks for Instruction and/or Assessment

Performance

- Using a geologic block model or cross-section, interpret its geologic history with reference to structures and age relationships. (115-2, 362-3, 362-7)
- Identify faults and folds from outcrop patterns or map views. (362-3)

Presentation

- Given a series of geologic occurrences, prepare a cross-section diagram or block model that illustrates the sequence of events. (115-2, 362-3, 362-7)

Resources/Notes

Print

- The Geological Highway Map of Nova Scotia

Video

- *Faulting and Folding* (LRT)
- *The Rock Cycle* (LRT)

Forces and Structures *(continued)*

Outcomes

Students will be expected to

- illustrate how science attempts to explain natural phenomena (115-2)
- describe the various forces (compressional, tensional, shear) which operate in the Earth and how these forces create faults, folds and mountains (362-3)
- describe the geologic activity associated with plate boundaries and relate this to the rock cycle (362-7)

Elaborations—Strategies for Learning and Teaching

Using a thin slab of rock set in plaster or concrete, introduce the terms strike and dip and discuss the possible methods of describing its orientation with the students. The students can then practice measuring strike and dip with a collection of prepared slabs. (Standing the rock slab in sand can work, but setting the slabs in a bit of plaster or concrete will prevent dislocation during use and make these a permanent teaching resource) Students should examine the use of dip and strike symbols on maps to explain subsurface structure.

Fractures in rocks are classified as joints or faults. It is important to point out to the students that a joint is simply a fracture that has opened without any offset occurring while a fault shows definite offset. Classic examples of joints appear in areas of the basalts of Nova Scotia's North Mountain.

Using clay or wooden block models the students can illustrate and distinguish between the dip-slip faults (normal, thrust and reverse), strike-slip faults (left and right laterals) and transform faults and relate these to compression, tension and shear forces. Students should then complete diagrams which clearly depict their observations of forces and deformation. This process of modelling and diagramming will allow for an easier transition to interpreting the same structures in map format.

Using stacked-layer clay models students can model and then diagram cross-sections of monoclines, synclines, anticlines and overturned folds and relate these structures to the forces responsible for their formation. Compression is the primary force responsible for folding. The formation and structure of domes and basins may also be introduced.

Using clay as a medium for modelling, students may build block models of various unconformities after researching classic examples using the World Wide Web.

Forces and Structures *(continued)*

Tasks for Instruction and/or Assessment

Performance

- Prepare a display consisting of geologic block models you have created. The models should illustrate a group of geologic structures and identify the forces responsible for their formation. (115-2, 362-3, 362-7)
- In teams, interpret the geologic history of classic settings in Nova Scotia after examining geologic block diagrams featured in the Geological Highway Map of Nova Scotia and other sources. Prepare illustrated articles based on their interpretation. (362-3, 115-2)

Paper and Pencil

- Prepare a report in which you identify and describe landforms that result from folding and faulting. (362-3)

Resources/Notes

World Wide Web Key Words

- structural geology
- diastrophism
- folding
- faults
- slickensides
- geologic maps

Forces and Structures *(continued)*

Outcomes

Students will be expected to

- illustrate how science attempts to explain natural phenomena (115-2)
- describe the various forces (compressional, tensional, shear) which operate in the Earth and how these forces create faults, folds and mountains (362-3)
- describe the geologic activity associated with plate boundaries and relate this to the rock cycle (362-7)

Elaborations—Strategies for Learning and Teaching

Students may be challenged to interpret prepared block diagrams or models of geologic structures, identifying relative ages of strata and inferring the sequence of events in the geologic history of the area depicted.

When and where feasible, actual field experience and observations would greatly assist students in developing a greater appreciation for, and understanding of, structural geology.
Students should review the video materials dealing with the rock cycle (see The Rock Cycle) and discuss the relationship between plate boundary activity and the rock cycle.

Forces and Structures *(continued)*

Tasks for Instruction and/or Assessment

Performance

- Create a geologic block model, accompanying cross-sections and map view to demonstrate the relationships among these formats. (115-2, 362-3, 362-7)

Project/Journal

- Research structural features and associated mineral occurrences in Nova Scotia, such as the Meguma Group and its associated gold occurrences. Complete an illustrated journal entry or an article for your portfolio. (115-2, 362-3)

Resources/Notes

Suggested Manipulatives

- Geologic block model materials
- Plasticine and cutting tools
- Landform models
- Geology demonstration kit
- Geologic maps
- Compasses and clinometers

Surface Processes

Unit Overview

The Earth's surface is constantly changing. As tectonic and volcanic activities build crustal features, the processes of weathering, transportation and deposition wear down and rearrange the landscape. Unlike internal processes, which we often infer based on indirect observation, the surface processes are observable. The beds of sedimentary rock formed by these processes comprise only about 5 percent of the crust, but cover 75 percent of the planet's surface.

In this unit students begin their study of the surficial processes with an examination of the weathering process. Utilizing laboratories, Internet and library resources they explore the disintegration of bedrock and the development of soil as a result of action by atmospheric agents. Physical, chemical and biological processes of weathering are identified, modeled and explained. They identify the origin, structure and economic importance of soils and the factors which affect their rate of formation.

Focus and Context

Through inquiry, students should make many first-hand observations of land forms and surfaces as they identify the characteristics of landscapes and classify them. In this unit students begin to identify surficial processes by examining the weathering process by designing and carrying out experiments on soil erosion.

Science Curriculum Links

Students are involved with erosion and weathering at the junior high level. The detailed observation of surface formations carried out in this unit will build upon that knowledge base and lead to an understanding of how landscapes are formed and from which they can develop methods for controlling erosion and deposition of sediments and the environmental impact.

Curriculum Outcomes

STSE	Skills	Knowledge
Social and Environmental Contexts of Science and Technology • compare the risks and benefits to society and the environment of applying scientific knowledge or introducing a technology (118-1) • propose a course of action on social issues related to science and technology, taking into account human and environmental needs (118-9)	**Performing and Recording** • demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposal of lab materials (213-9) **Communication and Teamwork** • develop, present, and defend a position or course of action based on findings (215-5) • communicate questions, ideas and intentions, and receive, interpret, understand, support and respond to the ideas of others (215-1) • work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise (215-6)	• distinguish between weathering and erosion (363-1) • describe the process of soil formation and identify the factors involved in the development of different soil types (363-4) • relate weathering, erosion and deposition of sediment to the rock cycle (363-5) • describe and explain the processes by which running water, glaciers, wind and waves cause erosion (363-6) • compare and contrast particle size, shape, and degree of sorting in fluvial, glacial and eolian deposits (363-10)

Weathering

Outcomes

Students will be expected to

- demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposal of lab materials (213-9)
- communicate questions, ideas and intentions, and receive, interpret, understand, support and respond to the ideas of others (215-1)
- distinguish between weathering and erosion (363-1)

Elaborations—Strategies for Learning and Teaching

Weathering is the process by which bedrock disintegrates into sediment. Climate determines the processes involved and the particles produced. Dry areas where mechanical weathering dominates tend to have bold, angular topography while enhanced chemical weathering in humid climates results in rounded uplands.

Mechanical weathering breaks existing rock into smaller fragments. Frost wedging is caused by the expansion of water upon freezing. Exfoliation occurs when rock surfaces give way as rock expands when overlying rock, and pressure, is removed. Biological weathering may occur when plant roots physically break rock. Other plants dissolve minerals with acid. Chemical weathering, acting on the fragments produced by mechanical weathering, reorganizes the chemical elements creating new minerals. For chemical processes to occur water must be present as the reactions occur in solution. The three principle reactions that occur are oxidation, hydrolysis and carbonation. After discussing the types of weathering, students may begin this unit of study by brainstorming to list a variety of ways rock is broken into smaller fragments, then classifying them as mechanical, chemical and biological. They may then elaborate on the three classifications.

Students may model biological weathering by mixing water-soaked bean seeds in plaster of Paris and pouring the mixture into ice cube trays. Once the plaster is set, remove the cubes and place them in water-filled petri dishes. Gemination will soon crack the plaster.

The mineral composition of a rock affects the rate of weathering. Students may model the effects of chemical weathering on different rock types by placing similar masses of a variety of crushed, washed rock chips in dilute hydrochloric acid. (Before handling acids, students must be instructed as to the proper safety procedures, handling techniques and disposal protocols, and demonstrate a knowledge of applicable WHMIS standards).

Weathering

Tasks for Instruction and/or Assessment

Performance

- In teams, examine your local area for rock exposures which could serve as field-examples of weathering. Prepare an illustrated, geological highway map which locates the various sites and provides commentary on each. (215-1)
- Plan a field trip during which each group leads a tour and discussion at their sites. (215-1)

Paper and Pencil

- Presented with a selection of illustrations depicting various examples of weathering, classify the examples as mechanical, chemical or biological. The illustrations might be collected and contributed by the students, mounted on cards and maintained as a teaching or assessment resource. It is often difficult to separate chemical and physical weathering, and therefore some examples will undoubtedly fit more than one category. (215-1)
- Design and conduct an experiment which explores some facet of weathering. Compile your data and prepare a detailed report which illustrates and explains procedures, lists observations and presents conclusions. (213-9, 215-1, 363-1)

Project

- Complete a photo-essay which illustrates the weathering processes at work in the vicinity of your home. Such a project would lend itself well to a multimedia presentation format. (215-1)

Resources/Notes

Print

- *Laboratory Manual for Physical Geology* (Zumberge & Rutford)
- Regional Soil Maps (Department of Agriculture)

Video

- *Weathering the Soils* (LRT)

Weathering *(continued)*

Outcomes

Students will be expected to

- demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposal of lab materials (213-9)
- communicate questions, ideas and intentions, and receive, interpret, understand, support and respond to the ideas of others (215-1)
- distinguish between weathering and erosion (363-1)
- describe the process of soil formation and identify the factors involved in the development of different soil types (363-4)

Elaborations—Strategies for Learning and Teaching

Rinsing, drying and weighing the samples the following day will allow the students to determine the changes in mass as a result of weathering. Be sure to include some carbonate rocks. To model the effects of climate on rates of weathering, a similar experiment may be repeated at different temperatures. A field trip to an older cemetery will provide an opportunity for students to compare and record rates of weathering on different rock types.

Discoloration of rock is an indicator of chemical weathering, commonly seen as the rusty stain observed on the surface of an iron-rich rock. A container of moist sand and steel wool will allow students to monitor the process of oxidation over a period of days. Students should be encouraged to collect specimens of rock that display evidence of chemical weathering.

Chemical weathering and mechanical weathering often occur concurrently. Chemical weathering is most intense on grain surfaces and acids play an important role in weathering reactions in nature. To observe the role of mechanical weathering in determining the rate of chemical weathering, the students may precisely record the masses of small but equal amounts of ground, granular and broken limestone, then place these in equal volumes of dilute hydrochloric acid. The reaction is monitored and after a period of time the samples are rinsed, dried and weighed to determine the changes in mass, which are related to particle size.

Soils are considered to be the interfaces between the living and nonliving world. After researching the formation and classification of soils on the Internet and in libraries, student teams can prepare illustrated reports addressing the origin, structure and importance of soils. The students should examine a variety of soils and discuss the terminology used to describe them. Each student should then examine the soil profile near their home, completing a scale drawing of the profile and collecting samples from each zone. The specimens should be examined in the lab with regard to composition and origin and the characteristics may then be plotted on a map of the region.

Students may investigate the global classification of soil types using the Internet and searching the key words pedalfer, pedocal and laterite. They can complete a journal entry in which they elaborate on the importance of soils to civilization. An alternate topic might focus on agricultural practices which are beneficial to soils and those which are detrimental.

Weathering *(continued)*

Tasks for Instruction and/or Assessment

Performance

- Presented with a collection of different kinds of soil from your local area, examine the samples, describing and explaining any differences you observe in colour, texture, composition, and so on. Laboratory testing of the samples for nitrogen, phosphorus, potassium and pH might be included in this examination. (363-4, 363-1, 215-1, 213-9)
- Conduct field studies of biological weathering. Mosses and lichens may be examined along with the rock they occur on. The condition of the rock, sediment particle sizes and their condition and pH of the flora might form the basis of a report. (213-9, 215-1, 363-1)

Journal

- Complete a journal entry in which they comment on the effect of increased atmospheric pollution in industrial areas on the weathering of stone structures. (363-1, 215-1)

Paper and Pencil

- Given a particular set of climatic conditions, including mean temperature and precipitation, contrast the effectiveness of chemical and mechanical weathering in that climate. (213-9)
- Explore the process of leaching and describe its effects on soil horizons. (363-4, 363-1)
- Prepare an illustrated report in which you relate climate and type of bedrock to soil formation after researching the topic on the Internet and in libraries. (363-4, 215-1)

Resources/Notes

World Wide Web Key Words

- weathering
- soils
- soil profiles
- soil testing
- pedalfer
- pedocal
- laterite
- oxidation
- hydrolysis
- carbonation
- soil conservation

Suggested Manipulatives

- bean seeds
- plaster of Paris
- soil sampling tubes
- screen sieves
- soil analysis materials
- powdered limestone
- granular limestone
- broken limestone
- a variety of rocks chips
- carbonate rock chips
- dilute hydrochloric acid
- soil samples (local)
- local topographic maps
- magnifiers

Erosion

Outcomes

Students will be expected to

- compare the risks and benefits to society and the environment of applying scientific knowledge or introducing a technology (118-1)
- work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise (215-6)
- describe and explain the processes by which running water, glaciers, wind and waves cause erosion (363-6)

Elaborations—Strategies for Learning and Teaching

Weathering produces sediment and the transportation of this material from one place to another is referred to as erosion. The principle agent of erosion is running water. Glaciers, waves and wind also rearrange sediments creating new landscapes. Gravity is the force that powers all of these processes. Early in this section the students should be encouraged to identify erosional processes in their local area and record their observations through photography or sketching. Topographic maps should be made available for students so they may relate the location of the erosional features to local topography. Students may also collect illustrations of erosional features from other sources and present these as a collage or bulletin board display, having classified each according to the agent responsible for its formation. Classification may also be done on the basis of climate.

To facilitate modelling of stream erosion, student teams should be challenged to create a stream table on which they may conduct studies in stream mechanics. The tables need not be elaborate to work. A wallpaper tray with a board for bottom support, a few plastic pails and a metre of vinyl tubing will get the project started. A simple siphon arrangement looks after water flow. Loading the table with ungraded sediment will allow students to model how the three types of stream loads (solution, suspension and beetled) move downstream and the factors that affect stream load. Loading a fairly wide stream table with a very fine, graded sand will permit modelling the formation of a river valley. Students may wish to set up one table with kalliroscope-rheoscope fluid so they may observe fluid flow in various stream channels.

A record of the experimental process and results may best be achieved using a video camera or time-lapse still-photography. Where students have access to a digital camera, the time-lapse photographs may be inserted into a word-processing document which in turn may be presented as a slide show, with quite dramatic results. The students should be given the opportunity to compare the features which develop on the stream tables to those in photos, slides, videos, aerial photos, etc. Students relate the processes observed on stream tables to the processes occurring in nature and to those which they identified in the local region. They should then be given the opportunity to identify similar features on maps and aerial photographs.

With reference to aerial photos, maps or stream table model, identify classic erosional features in a river valley. These might include meanders, cutoffs, oxbow lakes and levees. Describe how a river changes over time, including commentary on gradient, velocity, course and channel complexity. The Annapolis and Shubenacadie are excellent examples of well-developed river systems.

Erosion

Tasks for Instruction and/or Assessment

Performance

- Investigate fluvial erosion using a stream table. Use of terminology and the accuracy of your observations should be noted. (363-6)
- Using various samples of sediment, infer the relative lengths of time each was transported (based on the degree of rounding.) (215-6)

Paper and Pencil

- Prepare a series of sketches that illustrate the erosion of a river valley. (363-6)
- Assemble an illustrated glossary of the terms used in this unit. (363-6)
- Given the waves along Nova Scotia's shorelines as the example, elaborate on how other agents of erosion work concurrently with the waves in the overall erosional process. (363-6, 119-1)

Resources/Notes

Print

- *Dictionary of Geologic Terms* (Prinz, Harlow and Peters)
- Geologic Highway Map of Nova Scotia
- selected topographic maps

Video

- *All You Ever Wanted to Know About Dirt*
- *Geoscience Mapping* (LRT)
- *Climate Puzzle: Climates—Past, Present and Future* (LRT)
- *Secrets of Ice* (LRT)

Erosion *(continued)*

Outcomes

Students will be expected to

- compare the risks and benefits to society and the environment of applying scientific knowledge or introducing a technology (118-1)
- work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise (215-6)
- describe and explain the processes by which running water, glaciers, wind and waves cause erosion (363-6)

Elaborations—Strategies for Learning and Teaching

Students can examine the formation and influence of alpine and continental glaciers by viewing and discussing video material, imagery found on the Internet and diagrams from texts. The loading of valley glaciers by frost weathering and avalanching can be discussed with reference to lateral and medial moraines. As Nova Scotia lacks such geologic features, students may create a model of an alpine landscape which illustrates the modification of topography by glaciation (a classic example is the Mount Assiniboine area near Banff, Alberta) and identifies cirques, horns, tarns, aretes, cols, U-shaped valleys and hanging valleys.

Nova Scotia does display clear evidence of continental glaciation. During the last of four major stages of glaciation to affect our area, the Wisconsinan ice sheet was responsible for the erosional features we see today. With reference to the Geological Highway Map of Nova Scotia, students may trace glacial history of our province and relate its topography to glacial activity. When possible, students should examine field evidence of glaciation such as smoothed and grooved rock surfaces and erratic boulders. Students may use screen sieves to examine the particle size of sediment carried by glaciers and compare this to sediment carried by running water.

Using library and Internet references, students may research some of the theories of glacier origin that have been proposed. It is estimated that sea-levels were about 150 m lower during glacial advances and that if today's glaciers were to melt, sea-level would rise 50 m. With reference to current topographic information, students can generate a post-glacial map of Nova Scotia which illustrates the consequences of a 50 m increase in sea-level.

Waves breaking on the shore are agents of erosion. Waves are caused by the wind and may transmit the energy of even a distant storm onto our shores. In deep water it is the form and not the water that moves, but in shallow environments the water itself begins to move and this is the cause of erosion. Should students have access to an overhead flow table, they can model wave action on shorelines using this device. Waves erode mainly by hydraulic action and abrasion. Students may gather information on shorelines in their area and then classify them as neutral, emergent or submergent.

Erosion *(continued)*

Tasks for Instruction and/or Assessment

Interview

- Conduct a live or videotaped interview with a representative from the farming, forestry or mining industry. Describe the operational practices relative to preventing erosion and preserving topsoil. (118-1, 363-6)

Paper and Pencil

- Describe the erosional processes that would affect an upland area, given the climatic conditions. (363-6)
- Using the Internet, take part in a virtual field trip to view glacial erosion. Submit a report of your observations, identifying and explaining the various glacial features they saw. The continental glaciers of Antarctica are well documented, as are the alpine glaciers of North America. (215-6)

Resources/Notes

World Wide Web Key Words

- erosion
- fluvial erosion
- river formation
- meandering
- glacial erosion
- glaciers
- waves
- sandbars
- Sable Island
- aeolian erosion
- Pleistocene

Erosion *(continued)*

Outcomes

Students will be expected to

- compare the risks and benefits to society and the environment of applying scientific knowledge or introducing a technology (118-1)
- describe and explain the processes by which running water, glaciers, wind and waves cause erosion (363-6)

Elaborations—Strategies for Learning and Teaching

The students should examine maps of their area and plan a field trip to observe the effects of waves on shorelines. A photo-essay, which elaborates on the trip objectives and observations made, could be completed.

They may research the process known as long-shore drift and relate this to coastal features. An interesting field study can be carried out to gather evidence for this process by placing marked pebbles made from brick in the surf on a gravel shoreline and monitoring their movement (usually in a sawtooth pattern) down the beach. Student teams may conduct case studies of related topics, such as the formation of Sable Island, the spit at Advocate Harbour and placer gold deposits along the south shore of Nova Scotia.

Illustrated articles may be prepared which elaborate on artificial interference with shoreline processes. The uses of breakwaters, armoured shorelines and dune protection are some topics that might be considered. While wind erosion is usually associated with strong, desert winds that develop from rapid heating and cooling of the desert, students may discuss the formation of sand dunes between Kingston and Aylesford, which are a result of sand being blown from glacial deposits farther to the west.

Mass wasting, the downslope movement of surface materials, is the result of a number of factors, including slope, precipitation and in certain instances, human activity. The influence of water on the stability of sediment may be modeled in the lab by molding damp sand in a one liter, plastic ice cream tub, then slowly adding more water to the shape until it slumps. The students can carry out a case study into a mass wasting event, such as a rock slide, landslide or mudflow, in which they describe the topography of the area, the factors influencing the slide and its effects.

Erosion *(continued)*

Tasks for Instruction and/or Assessment

Performance

- Removal of vegetation as a result of farming, forestry and construction activity promotes erosion and the sediment load in streams increases. In teams, design a laboratory experiment or field study which examines the role of vegetation in preventing erosion. (118-1, 363-6)

Resources/Notes

Suggested Manipulatives

- stream table, or materials for constructing one
- stream table sand
- kalliroscope-rheoscope fluid
- sediment samples
- overhead flow table
- selected aerial photographs

Deposition

Outcomes

Students will be expected to

- develop, present and defend a position or course of action based on findings (215-5)
- compare and contrast particle size, shape, and degree of sorting in fluvial, glacial and aeolian deposits (363-10)
- relate weathering, erosion and deposition of sediment to the rock cycle (363-5)

Elaborations—Strategies for Learning and Teaching

Early in this section the students should select an issue which involves artificial interference in the natural cycles of weathering, erosion and deposition. Working as individuals or teams, they conduct research into the issue that will later be debated in class, or written reports may be submitted in which the students propose a course of action with respect to their issue. An example follows.

The giant sand bars in Cobequid Bay provide evidence of erosion and deposition by the powerful tidal currents of the Bay of Fundy. These same tides affect nutrient distribution in the bay and the development of estuaries rich in wildlife. They also have the potential to generate enormous quantities of electricity on which society depends. Students may collect information on tidal power development and the environmental impact such projects might have on the ecosystem, which include the possible destruction of wildlife habitats as a result of changes in the pattern of erosion and deposition. They can compare the environmental costs of tidal power to nuclear power and fossil fuel generation. In their report they propose a course of action and defend it.

The concept of sediment sorting should be discussed with the students, with reference to selected specimens. A uniform grain size indicates a slow accumulation of sediment under relatively stable conditions whereas poorly sorted sediments may indicate more rapid accumulation. The sediments deposited by running water are unique. As the water velocity slows, the heaviest particles settle out first, the lightest last. Over time this process will result in layers of graded sediment. Using a stream table, students can model sediments being deposited in a delta by allowing the water depth to build up at the lower end of the table. Students should compare their model to illustrations of delta structure.

Deposition

Tasks for Instruction and/or Assessment

Performance

- Given samples of sediment, identify the corresponding sedimentary rock from a collection of specimens or visuals. (363-5)
- Provided with a variety of selected sedimentary rocks, infer the environment of deposition with reference to the composition of the sediment, grain size(s) and degree of sorting. Carefully examine the characteristics of a rock that result from its being produced in a particular environment and based on these observations the geologic history may be revealed. (363-5, 363-10, 215-5)
- Given a geologic cross-sectional diagram that depicts an accumulation of sediment, describe the sequence of events leading to its formation. (363-5, 215-5)
- Given a sample of sand of various grain sizes and a set of sieves, determine the mass of the sample, assemble the sieves, and determine the percentages of each grain size by sieving and weighing the portions. Express the results numerically, graphically or statistically. Discuss your results. (363-10, 215-5)

Presentation

- Defend your proposed course of action with respect to the issue of artificial interference in natures cycles. (215-5)
- Prepare a display of sediments that you have collected and identified, representing various depositional environments. Consult the Geological Highway Map of Nova Scotia and other publications for locations of specific deposits. (363-5)

Resources/Notes

Print

- *Laboratory Manual for Physical Geology* (Zumberge & Rutford)
- *Dictionary of Geologic Terms* (Prinz, Harlow & Peters)
- Geological Highway Map of Nova Scotia
- selected topographic maps

Video

- *Waves, Beaches and Coasts* (LRT)
- *Ocean Mapping* (LRT)
- *The Rock Cycle* (LRT)

Deposition *(continued)*

Outcomes

Students will be expected to

- propose a course of action on social issues related to science and technology, taking into account human and environmental needs (118-9)
- develop, present and defend a position or course of action based on findings (215-5)
- compare and contrast particle size, shape, and degree of sorting in fluvial, glacial and aeolian deposits (363-10)
- relate weathering, erosion and deposition of sediment to the rock cycle (363-5)

Elaborations—Strategies for Learning and Teaching

The size of sediment particles is often measured by visual estimation by geologists, or in the case of silt and clay, whether it feels crunchy or like plastic between the teeth. For students, sand sieve analysis using grain size classification is a way of introducing this concept. After discussing grain size classification, students can shake a sample of sediment of known mass through a set of sieves arranged in descending mesh diameters. The percentage of each grain size can be shown using bar graphs or histograms. Students may express sorting using statistical methods as well (median, mode, mean). The results for various samples may be compared and degrees of sorting discussed.

Sediment deposition environments may be classified as continental (alluvial, river, desert, lake, swamp, glacial, cave), coastal (beach, estuary, delta, lagoon, dune) and marine (reef, shelf, slope, canyon, basin). Students should have the opportunity to examine and discuss samples of sediment, selected specimens of sedimentary rock and visuals that are representative of these environments. Grain size and shape, degree of sorting and composition of the sediment should be emphasized. Students may then demonstrate their understanding of how each deposition environment is unique through poster presentations.

After reviewing the role of weathering, erosion and deposition in the rock cycle, students may be introduced to sedimentary structures, the features preserved in sedimentary rock that reflect a physical, chemical or biological process. As these structures (such as beds, ripple marks, cross-bedding, mud cracks, raindrop impressions, worm burrows, salt crystal casts, etc.) are common in modern environments, their preserved replicas are useful in inferring environmental conditions in the past. Students should have the opportunity to examine either specimens or visuals displaying classic sedimentary structures, relate these to modern events, and infer the ecological and/or environmental conditions at the time of deposition.

The soil that forms from eroded material is transported soil. Students should research the importance of flood plains and deltas to agriculture and the roles that such soils played in influencing the location of early civilizations. Students may complete a journal entry in which they elaborate on this topic.

Deposition *(continued)*

Tasks for Instruction and/or Assessment

Performance

- Using a stream table, model and identify landforms associated with deposition by running water such as meanders, flood plains and deltas. Demonstrate the stages of valley development by photographing each stage as it evolves and prepare a photo-essay. Construct models that illustrate valley development. (363-10)
- With reference to appropriate aerial photos and maps, identify landforms that have resulted form the processes of erosion and deposition. (363-5, 363-10, 215-5)

Paper and Pencil

- Create flow charts/posters to show the processes relevant to chemical precipitates (dissolution/ion exchange—transportation—precipitation). (363-5)
- Conduct research and compile an illustrated report that explores the formation of estuaries and explains the process of flocculation, a depositional process dependant on salinity levels. (363-10, 215-5)
- List specific characteristics that could be used to distinguish between sedimentary deposits that form in different depositional environments. (363-5, 363-10)

Presentation

- Make a poster to illustrate the landforms that result from the action of glaciers. Differentiate between those formed by erosion and those that result from deposition. (215-5, 118-9)
- With reference to topographic maps, aerial photos and field observations, produce a map that identifies examples of depositional landforms in your area. The map may focus on a particular depositional environment or agent of deposition. (363-5, 363-10)

Resource/Notes

World Wide Web Key Words

- sediment deposition
- landforms
- depositional sedimentary environments
- sedimentary structures
- sedimentary rocks
- soil
- river formation
- Canadian landscapes
- glaciers

Suggested Manipulatives

- stream table
- stream table sand
- sediment samples
- sedimentary rocks
- magnifiers
- sand sieves
- laboratory balances
- visuals of sedimentary structures
- selected aerial photographs
- landform models
- landform map kits

Deposition *(continued)*

Outcomes

Students will be expected to

- propose a course of action on social issues related to science and technology, taking into account human and environmental needs (118-9)
- develop, present and defend a position or course of action based on findings (215-5)
- relate weathering, erosion and deposition of sediment to the rock cycle (363-5)

Elaborations—Strategies for Learning and Teaching

Following a discussion regarding landforms resulting from deposition of sediment, with references to models and aerial photos, students may identify some of those associated with running water in their stream tables, such as meanders, point bars, flood plains and deltas. The precipitation of dissolved sediments can be illustrated by cooling a supersaturated saline solution and observing the salt crystals that form.

Sediment deposited by glaciers (till) tends to be a mixture of anything and everything the glacier passed over, including bedrock, older sediments and organic remains. Students can view landforms that are created when till is deposited at a variety of sites on the Internet, such as the Natural Resources Canada-Terrain Sciences Division Web site, "Canadian Landscapes." With reference to aerial photos and topographic maps, the students should locate examples of glacial deposits in their region. Some Nova Scotia examples include the barrier beach and drumlins near Moose Point, hummocky kame moraine in the Parrsboro Valley, boulder landscape around Peggy's Cove, drumlin islands in Kejimkujik Lake and the esker near Corberrie.

The economic significance of glacial deposits may be examined.

Various means have been developed in our attempt to control erosion and deposition of sand along our shorelines. Student teams may brainstorm to create a list of reasons for such controls and then conduct library and Internet research to identify and evaluate some methods currently employed.

Deep beds of sediment near the edge of the continental slope are unstable and tend to be transported down the slope in rapid surges called turbidity currents. These surges commonly erode deep canyons in the continental shelf with the sediment deposited in the deep ocean basin. Students can explore the significance of The Gully off Nova Scotia's Atlantic coast and complete a journal entry in which they elaborate on this topic and the environmental issues surrounding this unique ecosystem.

Deposition *(continued)*

Tasks for Instruction and/or Assessment

Performance

- Identify examples in their communities of attempts to control erosion and deposition. After examining a site and identifying the problem, evaluate the procedure currently being employed and propose an alternative solution. (363-5, 215-5, 118-9)

Resources/Notes

Historical Geology

Unit Overview

In this unit of study the students begin their investigation of Earth's history with an examination of the fundamental principles of geology. They look at the development of the concept of geologic time, the different reasoning that has been used in estimating the Earth' age and the controversies involved. Most sedimentary rocks form as layers or strata during a depositional process. To acquire the skills necessary for interpreting the rock strata, the students examine Steno's Laws and other basic principles of geology, which they will use to determine the relative ages of rocks.

Focus and Context

The focus in this unit is decision making. Students explore print and other media to explore the historical development of geological theory and the work of early geologists to develop these theories. The students examine the importance of fossil layers in showing us the history of the Earth. The unit then proceeds to investigate Earth's history by exploring both relative time and absolute time in the development of our planet. Students do research, construct models, carry out experiments, and report their findings in a variety of formats.

Science Curriculum Links

Students have already explored Earth materials and planet development and processes in the elementary and junior high curriculum. In this unit, they explore the history of the Earth and the fundamental principles of geology.

Curriculum Outcomes

STSE	Skills	Knowledge
Nature of Science and Technology • explain how scientific knowledge evolves as new evidence comes to light (115-6) **Relationships between Science and Technology** • identify and describe science and technology-based careers related to the science they are studying (117-7) • describe examples of Canadian contributions to science and technology (117-10)	**Performing and Recording** • select and integrate information from various print and electronic sources or from several parts of the same source (213-7) **Communication and Teamwork** • communicate questions, ideas and intentions, and receive, interpret, understand, support and respond to the ideas of others (215-1) • synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information (215-3)	• compare and contrast the principles of uniformitarianism and of catastrophism in historical geology (332-5) • define and differentiate between relative and absolute age dating (364-1) • determine the relative ages of different formations using the principles of uniformitarianism, superposition, original horizontality, original lateral continuity, cross-cutting relationships, and inclusions (364-2) • determine absolute age using the principles of radioactive decay (364-4) • illustrate the geologic time scale and compare it to human time scales (332-4) • explain the process of fossil formation (364-5) • describe how fossils are used to deduce ages of rocks and evolutionary history using index fossils and the principles of fossil succession and correlation (364-8)

Geological Principles

Outcomes

Students will be expected to

- explain how scientific knowledge evolves as new evidence comes to light (115-6)
- select and integrate information from various print and electronic sources or from several parts of the same source (213-7)
- synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information (215-3)
- determine the relative ages of different formations using the principles of uniformitarianism, superposition, original horizontality, original lateral continuity, cross-cutting relationships, and inclusions (364-2)

Elaborations—Strategies for Learning and Teaching

Specimens of gneiss from Canada's far north have been dated at nearly four billion years of age, establishing it as some of the oldest rock on Earth. Throughout this expanse of time our planet has experienced the impact of meteorites, periods of mountain building, devastating volcanic explosions and destructive earthquakes. Oceans have formed and been deformed by plate tectonic activity and climatic change has both nurtured and annihilated its life forms. The record in our planet's rocks indicates that these events have occurred throughout its history just as we see them happening today, a concept in geology known as Uniformitarianism. Students should form groups and brainstorm to develop lists of processes that are occurring today and that have occurred throughout Earth's history.

Using library and Internet resources, teams of students should investigate the reasoning of Usher, Hutton, Kelvin, Lyell, Joly and others in their attempts to determine the extent of geologic time. The students may then complete poster presentations in which they illustrate the "evidence" and elaborate on the thinking of these individuals. The progression from hypothesis through theory to natural law should be discussed with reference to these early geologists.

The students may explore the controversy surrounding the opposing doctrines of Uniformitarianism and Catastrophism and complete journal entries. They could include discussion regarding the differing explanations for the "gaps" in the stratagraphic column.

The geologic record of Earth's history is preserved in its rocky crust and the extensive beds of sedimentary rock can be used to interpret the events of the past. The Danish physician Nicholaus Steno first stated the basic principles we use today to interpret the relative ages of rocks.

Steno's Laws

1. The Principle of Superposition states that in any series of layered rocks, the older rocks are on the bottom and they become younger as you move up though the beds. The students may relate this principle to an accumulation of daily newspapers where each day's paper is added to the top of the stack. Labeled models can be prepared using cylindrical jars and coloured sand or aquarium gravel.

Geological Principles

Tasks for Instruction and/or Assessment

Performance

- Demonstrate uniformitarianism and catastrophism by selecting a feature of Nova Scotia. Give two explanations for its formation, each in turn grounded in the ideas of the above doctrines. (364-2, 213-7)
- Provided with selected illustrations of geologic cross-sections, explain the order of the geological events based on the information present in the illustrations. (364-2)

Journal

- Compare and contrast the work of James Hutton and Charles Lyell with reference to their attempts to explain the geologic past. Recreate a diary entry of either gentleman in which they imagine how he might have recorded his musings as he reflects on his own reasoning. (115-6, 215-3, 364-2)

Paper and Pencil

- Prepare a written report in which you examine various ideas surrounding the origin of the Earth. Remember that discussing an idea does not equate with believing it. Library and Internet resources could be used. (115-6, 213-7, 215-3)

Presentation

- Prepare a poster that illustrates various geologic processes that relate to uniformitarianism. (364-2, 215-3)

Resources/Notes

Print

- *Laboratory Manual for Physical Geology* (James Zumberge)

Video

- *Faulting and Folding* (LRT)
- *The Rock Cycle* (LRT)
- *The Lake that Fell to Earth* (LRT)

World Wide Web Key Words

- historical geology
- geologic principles
- uniformitarianism
- Archbishop Usher
- Lord Kelvin
- John Joly
- Charles Lyell
- Nicholaus Steno
- James Huttton
- William Smith
- Charles Darwin
- Steno's Laws
- unconformities

Geological Principles *(continued)*

Outcomes

Students will be expected to

- synthesize information from multiple sources or from complex and lengthy texts and make inferences based on this information (215-3)
- determine the relative ages of different formations using the principles of uniformitarianism, superposition, original horizontality, original lateral continuity, cross-cutting relationships, and inclusions (364-2)

Elaborations—Strategies for Learning and Teaching

2. The Principle of Original Horizontality states that all sediments are originally deposited in flat layers. While generally true, the students should review the depositional environments discussed in the Surface Processes unit and identify exceptions to this statement, such as glacial moraines and sand dunes.

3. The Principle of Original Lateral Continuity states that sedimentary beds form over a large area in a continuous sheet, gradually thinning toward the edges. Using various colours of aquarium gravel and a large transparent container (aquarium or root-view containers), the students may create a model that illustrates this concept. Clay may also be used to model a cross-section of a sedimentary basin.

There are four other Basic Principles of Geology that are used to determine the relative ages of rocks. Students, working individually or with a partner, should demonstrate their understanding of these four geologic principles by creating stacked-layer clay models (with labelling attached) that clearly illustrate the concepts. Diagrams could also be used.

1. The Principle of Intrusive Relationships states that an igneous intrusion must be younger than the rock it cuts. To model this, a portion of the original block is cut away and replaced with clay representing the intruded material (such as a sill or dike.)

2. The Principle of Cross-cutting Relationships states that any fault is younger than the displaced rock. Models created in the Internal Processes unit illustrate this as well.

3. The Principle of Inclusions states that clasts in a sediment layer above the bed they were derived from must be younger than their source, but older than the layer that contains them. Students should discuss the concept and classification of unconformities at this point. It is very important that the student view an unconformity as a result of an erosional process that may produce a gap in the stratagraphic column, and thus, in the geologic record. Unconformities may also be illustrated using stacked-clay models.

Geological Principles *(continued)*

Tasks for Instruction and/or Assessment

Performance

- Identify and classify unconformities illustrated in selected models or diagrams. Distinguish among angular unconformities, nonconformities and disconformities.
  (215-3, 364-2)
- Provided with the appropriate materials, create models or illustrations which demonstrate their understanding of the Geologic Principles of
  - Superposition
  - Original Horizontality
  - Original Lateral Continuity
  - Intrusive Relationships
  - Cross-cutting Relationships
  - Inclusions
  - Fossil Succession (364-2)

Resources/Notes

Suggested Manipulatives

- Plasticine in various colours
- tectonics model
- geology models
- basic fossil replica kits
- small aquaria or root-view containers
- aquarium gravel or coloured sand

Geological Principles *(continued)*

Outcomes

Students will be expected to

- determine the relative ages of different formations using the principles of uniformitarianism, superposition, original horizontality, original lateral continuity, cross-cutting relationships, and inclusions (364-2)

Elaborations—Strategies for Learning and Teaching

4. The Principle of Fossil Succession states that fossils found worldwide in sedimentary strata are in a similar vertical order. Providing the students with inexpensive fossil replicas to embed in the clay or sand will allow them to create more dramatic models of this concept. Working with reference to an illustrated Geologic Time Scale the students can construct a collection of accurate geologic columns. These columns may also be used later in correlation activities. Coloured sand or aquarium gravel placed in tall glass jars or vials make vivid, easy-to-store columns.

Students may take part in virtual field trips via the internet to examine classic exposures that illustrate these geologic principles. If suitable exposures are present in the area, a field tour will allow students to apply their understanding of these principles. Should such field work be undertaken, the students should complete a photo-essay that highlights the application of these principles.

Using library and internet resources the students may conduct research and prepare illustrated articles in which they elaborate on the work of William Smith and Charles Darwin.

Concurrent Extended Inquiry

Having completed their research during the previous two units, the student teams should now compile their gathered data and information for analysis and draw their conclusions. Each draft report is circulated among, and reviewed by, classmates before the final draft is completed.

Geological Principles *(continued)*

Tasks for Instruction and/or Assessment

Interview

- During field studies, complete a checklist of the correct use of terminology and ability to determine the relative ages of rocks and geologic events as displayed in natural exposures. (364-2)

Resources/Notes

Video

- *Fossil Story* (LRT)

The Fossil Record

Outcomes

Students will be expected to

- explain and describe the process of fossil formation (364-5)

Elaborations—Strategies for Learning and Teaching

Only a very small fraction of the creatures and plants that have lived on Earth through its long history have been preserved as fossils. The remains of most organisms are completely destroyed, but occasionally conditions are favourable for fossilization. The students should begin their investigations in palaeontology with a discussion of the conditions necessary for preservation. To be preserved the organism needs to have hard parts such as wood, bones, teeth or shell and undergo quick burial in an environment relatively free of oxygen and bacteria. Given these criteria groups of students should compile a list of modern candidates for fossilization.

Teams of students may be presented with a number of scenarios leading to the possible formation of a fossil and asked to rank these from least likely to most likely. Entrapment in tar pits, tree resin, ash and quicksand, freezing, and burial in a variety of environments should be included in the situations presented.

Students may model the formation of fossils in a variety of ways. Plaster moulds may be prepared using leaves, shells, hand prints, etc. The hardened moulds may be lightly coated with vegetable oil and filled with plaster to produce casts. Portions of sea-sponge collected from beaches may be buried in a shallow tray of sand which is then soaked with a supersaturated saline solution. In a few days permineralization of the sponge occurs, with salt crystals filling the pores. Discuss the recent market in “counterfeit” amber which is produced by embedding modern insects (an entomologist can tell the difference) in amber-coloured resins.

The students should examine a collection of fossil specimens or visuals and identify those which are actual remains, those which are fossil imprints and those best described as trace fossils. The trace fossils are evidence of a creature’s existence such as footprints, nests, dung, stomach stones and burrows. The students may begin to infer the environments suggested by the fossils.

The Fossil Record

Tasks for Instruction and/or Assessment

Presentation

- Given a list of modern organisms, prepare study cards by illustrating the organisms in their habitat using a prescribed format. Cards can then be circulated in class so that students can rate each organism's likelihood of becoming fossilized, stating their reasoning. (364-5)

Resources/Notes

Print

- Illustrated field guides for fossil identification
- *The Geological Highway Map of Nova Scotia* (Atlantic Geoscience Society)
- *Sydney Mines: Fossil Interpretation Project* (ME 1998-3) (NS Natural Resources)
- *Brule Fossil Site Project. . .* (ME 1998-2) (NS Natural Resources])

Video

- *Fossil Story* (LRT)
- *Geoscience Mapping* (LRT)
- *Offshore Oil and Natural Gas* LRT)
- *Mineral Vignettes* (LRT)

The Fossil Record *(continued)*

Outcomes

Students will be expected to

- explain and describe the process of fossil formation (364-5)

Elaborations—Strategies for Learning and Teaching

Given a collection of selected fossil specimens and a variety of field guides and other references, the students (pairs or teams) should first identify the fossil and then complete a data table with such relevant information as its age, its environment, how it moved (if applicable), what it ate and the process by which it was preserved. The students may create a diorama for a fossil in which they illustrate its life-habitat and community.

Given a fossil assemblage, the students can recreate the life-environment based on information they gather from library and internet references.

One of the most important milestones in the science of geology was the discovery that fossils could be used to put different series of rock layers in sequence, even when separated by great distances. Certain fossils were identified as being more useful for this purpose than others—the index fossils. The characteristics of index fossils include easy identification, life in a short geologic time range while having a widespread occurrence and a good chance of preservation. Students should prepare data sheets on a selected collection of fossils with reference to library and internet resources. Working as teams the students then discuss the attributes of each fossil, identifying those that meet the criteria for index fossils.

The procedure of matching-up rocks of similar age in different regions is called correlation. The students may practice correlation using prepared "core-samples" consisting of coloured aquarium gravel or sand with fossil replicas embedded, arranged in tall jars or large vials. A colour code for rock types must be provided. By correlating the vials, a geologic column may be established, sketched and labelled, with the fossils identified using appropriate references. The ages of the rock layers can be deduced by referring to a fossil key to find the age of the embedded fossils. The geologic history may be inferred from the column and the relative ages of the fossils present determined. Students should also identify any "unconformities" you choose to build into the "core samples."

The Fossil Record *(continued)*

Tasks for Instruction and/or Assessment

Performance

- Working individually or in teams, design and construct a geologic model which illustrates the concept of correlation.
  (364-5)

Resources/Notes

World Wide Web Key Words

- palaeontology
- fossils
- trace fossils
- index fossils
- palaeoecology
- fossil correlation
- lithology
- Tyrrell
- Burgess

Suggested Manipulatives

- small plastic tubs
- plaster of Paris
- vegetable oil
- sea sponge
- salt
- tall jars or vials
- basic fossil replica kits
- aquarium gravel or coloured sand
- fossil specimen collections

The Fossil Record *(continued)*

Outcomes

Students will be expected to

- explain and describe the process of fossil formation (364-5)
- identify and describe science and technology-based careers related to the science they are studying (117-7)
- describe examples of Canadian contributions to science and technology (117-10)

Elaborations—Strategies for Learning and Teaching

At this point the students should be introduced to standard lithologic symbols and presented with more challenging problems in correlation. The information may be presented graphically or as data and then used to construct geologic columns. Discussion of overturned beds and methods of determining the original "up" direction of strata (graded sediments, mud cracks, ripple marks, etc.) may be included. The students can create diagrams of geologic columns with such features to be used as classroom references.

While fossils are very useful for correlation, their significance in recording successive changes in the life on Earth must also be emphasized. Using library and internet references, the students may examine the work of Darwin and the topics of adaptation and natural selection.

The students may complete a journal entry in which they explore a career in palaeontology. Possible formats might include a diary entry of a field researcher, a day in the life of a paleontologist, a job description, an employment ad, etc.

Using library and internet references, students should complete a case study in which they identify the contributions of Canadians (Tyrell, Burgess, etc.) to the science of palaeontology. Alternately, they may complete a biographical sketch of a Canadian scientist who has contributed to this area of science and submit it in the form of a poster presentation.

Students should participate in a field trip (virtual or otherwise) to a museum where fossils are featured so as to gain further insight into their use in unravelling Earth's history.

The Fossil Record *(continued)*

Tasks for Instruction and/or Assessment

Paper and Pencil

- Create a newspaper employment opportunity ad in which you indicate the knowledge and experience required of candidates for a position relating to palaeontology. (117-7, 364-5, 117-10)

Resources/Notes

Geological Time

Outcomes

Students will be expected to

- define and differentiate between relative and absolute age dating (364-1)
- determine absolute age using the principles of radioactive decay (364-4)
- communicate questions, ideas and intentions, and receive, interpret, understand, support and respond to the ideas of others (215-1)

Elaborations—Strategies for Learning and Teaching

The ages of rocks may be stated in both relative and absolute terms. Determining relative ages of rock layers through the use of geologic principles and fossil records is a key element of geologic mapping. The work of William Smith in the coal canals of England and Georges Cuvier and Alexandre Brongniart in the Paris Basin laid the foundation for a relative time scale. Determining the absolute age of a rock became possible after it was discovered that radioactive materials could be used as geologic clocks. The discoveries of Becquerel, Rutherford, Soddy and Boltwood confirmed the great extent of Earth's history proposed by Hutton. Student teams may create a poster display based on research into the contributions of these and other scientists toward the development of concepts in geologic time.

Radioactive decay is the breakdown of radioactive parent material and the formation of stable daughter material. The half-life of a radioactive isotope is the time it takes for half of the parent material to decay into the daughter material and each isotope has its own unique half-life. Various models of radioactive decay should be examined and discussed. The decay process occurs at a constant rate and by measuring the amounts of parent and daughter material, the age of a specimen can be determined. Students should practice establishing decay curves by graphing. With the x-axis labelled in half-lives for the given isotope and the y-axis as the parent particle count (beginning with 100 parent particles is suggested), the students plot points and draw the decay curve for the parent material. (an accumulation curve for the daughter can also be added) A variety of questions based on the graph should be posed.

Students should plot the decay curve for 100 parent particles of a given isotope and then determine the ratios of parent to daughter particles at various half-lives: first half-life = 1:1, second half-life = 1:3, third half-life = 1:7, etc. Provide the students with tubs containing 100 two-colour counters (as used in elementary math) or pennies (heads/tails) to represent parent and daughter particles. The students can then shake and pour out the "particles" to create a "specimen" and determine the parent to daughter ratio and from that information, interpolate to determine the age.

Geological Time

Tasks for Instruction and/or Assessment

Performance

- Build a model or prepare a diagram to illustrate the meaning of radioactive decay. (364-4, 215-1)
- Using manipulatives, demonstrate the concept of "half-life." (364-4)
- Given a set of counters representing parent and stable daughter particles, determine the ratio of the particles, the half-lives that have elapsed and the percentage of parent material remaining. (364-4)

Journal

- Comment in you journal on the famous quotation from James Hutton regarding geologic time: "No vestige of a beginning, no prospect of an end." (364-1, 215-1)

Paper and Pencil

- Given the number of particles of a specific isotope and its half-life, construct a decay curve for the isotope and label the parent to daughter ratios and percentage of parent material remaining at each half-life. (364-4)
- Complete a biographical sketch of a scientist whose work contributed to the development of radiometric dating procedures. (364-1, 364-4, 215-1)

Resources/Notes

Print

- *The Geological Highway Map of Nova Scotia* (Atlantic Geoscience Society)
- Minerals and Energy Maps (NS Natural Resources)

Video

- *The Science of Change* (LRT)
- *Appalachian Story* (LRT)
- *The Recent Ice Age* (LRT)

World Wide Web Key Words

- Nova Scotia Natural Resources
- Cuvier
- Brongniart
- Becquerel
- Rutherford
- Soddy
- Boltwood
- radioactive decay
- isotopes
- radiometric dating
- half-life
- geologic time
- geologic time scale

Geological Time *(continued)*

Outcomes

Students will be expected to

- define and differentiate between relative and absolute age dating (364-1)
- illustrate the geologic time scale and compare it to human time scales (332-4)
- communicate questions, ideas and intentions, and receive, interpret, understand, support and respond to the ideas of others (215-1)

Elaborations—Strategies for Learning and Teaching

Student groups can explore library and internet resources to identify various isotopes used in radiometric dating, their half-lives, daughter materials and applications and report their findings to the class. It is important for the students to realize that when radiometric dating is used, the age determined is the age at which the parent isotope became locked into the rock. Dating feldspar grains in sandstone does not date the sandstone, but the cooling of the granite it was derived from. Elaborate on the unique applications of Carbon-14 and its use in dating Nova Scotia's mammoth finds.

To explore the concept of absolute and relative time lines, the students should use adding machine tape to create an illustrated personal time line with 10 cm = 1 year. Beginning with their time of birth at the bottom of the scale, they may plot the events in their lives to the present day. The final time lines can be presented in class.

Student teams should construct a scale model of a geologic time line on adding machine tape with 1mm = 1 million years. From a variety of references they gather geological and biological information and plot this at the appropriate intervals on the line. The students should be encouraged to illustrate major geologic events and the predominant life forms.

A Geologic Time Scale should be examined with respect to the relative and absolute ages of various geological and biological events that are illustrated. Students may enjoy creating mnemonic devices to help them remember the order of the periods and epochs. (... Chilly Oysters Seldom Develop Charming Pearls Though Jewellers Covet Them Quietly!)

Students should be given the opportunity to practice interpreting geologic cross-sections and determining ages based on the fossils present. Given such diagrams, the students determine the sequence of geological events and using appropriate references, establish the absolute and relative ages of the strata.

With reference to the Geological Highway Map of Nova Scotia and other resources, the students should prepare an illustrated article which summarizes the geological history of their region for inclusion in their portfolios.

Geological Time *(continued)*

Tasks for Instruction and/or Assessment

Paper and Pencil

- Given a decay curve for a particular isotope and a parent to daughter ratio for a specimen, determine the radiometric age of a specimen. (332-4, 215-1)
- Discuss the personal time lines you have constructed with reference to relative and absolute time. (332-4, 215-1)
- Given a diagram or model of a geologic cross-section with index fossils present, infer the geologic history represented by the section and report on the relative ages of events. With reference to a Geologic Time Scale and other appropriate materials, the age of the fossil-bearing layers can be established and relative ages of the associated layers estimated. The geologic period in which the section formed may be reported. (364-1)
- Complete a research assignment that reports on the appropriate uses for various isotopes in radiometric dating. (215-1)

Resources/Notes

Suggested Manipulatives

- two-colour counters
- adding machine tapes
- Geologic Time Scale
- geology models
- geologic time charts

Environmental Geology

Unit Overview

Environmental geology studies the impact of human activity on the Earth's lithosphere, hydrosphere, atmosphere and biosphere. In this unit the students investigate the relationship between society and the geological aspects of our environment as they complete case studies and conduct classroom and laboratory activities that support their case study research activities.

Environmental geologists are primarily involved with the study of land use and the effects such use may have on our environment. The problems faced by environmental geologists seldom have simple solutions. Economic, political, and emotional issues often cloud a straightforward, scientific solution. Issues may be very complex, affecting the atmosphere and climate, the hydrosphere and supplies of ground water or the rock and soil of the lithosphere.

Focus and Context

The focus of this unit is problem solving. As students explore print and other media to study land use and the effects such use has on our environment of the geological sciences, the relevance of geology in their daily lives and the work of geologists is linked. The students examine the importance of the development of technology and its impact on geological processes. The unit then proceeds to investigate natural geological hazards, the issues surrounding the use of resources and waste disposal. The Earth is a closed system. Investigation into the impact of human activity on its complex systems and an awareness of our responsibilities are linked to geological knowledge. Students do research, construct models, carry out experiments, and report their findings in a variety of formats.

Science Curriculum Links

Students have already explored sustainability in grade 10 and ecosystems in grade 7. In this unit, they explore the relevance of geology to humanity and the Earth's resources and processes to which civilization is inextricably linked.

Curriculum Outcomes

STSE	Skills	Knowledge
Nature of Science and Technology • distinguish between scientific questions and technological problems (115-1) **Relationships between Science and Technology** • describe the functioning of domestic and industrial technologies, using scientific principles (116-5) **Social and Environmental Contexts of Science and Technology** • provide examples of how science and technology are an integral part of their lives and their community (117-5) • identify and describe science and technology-based careers related to the science they are studying (117-7) • compare the risks and benefits to society and the environment of applying scientific knowledge or introducing a technology (118-1) • construct arguments to support a decision or judgement, using examples and evidence and recognizing various perspectives (118-6) • propose a course of action on social issues related to science and technology, taking into account human and environmental needs (118-9)	**Initiating and Planning** • identify questions to investigate that arise from practical problems and issues (212-1) • design an experiment identifying and controlling major variables (212-3) **Performing and Recording** • use library and electronic research tools to collect information on a given topic (213-6) • select and use apparatus and materials safely (213-8) **Analysing and Interpreting** • propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan (214-15) • evaluate a personally designed and constructed device on the basis of criteria they have developed themselves (214-16) **Communication and Teamwork** • identify multiple perspectives that influence a science-related decision or issue (215-4)	• identify examples of geological hazards that impact on human settlement and ways in which humans have attempted to minimize the impact of these hazards (365-1) • identify factors that influence people to live in geologically hazardous areas (365-3) • demonstrate an understanding that Earth's systems are complex and cyclic and that the Earth operates chiefly as a closed system (365-4) • demonstrate an understanding of what is meant by a renewable and non-renewable resource and the concept of sustainable development (365-5) • identify stratigraphy as a key element of environmental geology and describe some technologies used to acquire stratigraphic data (365-6) • apply geological knowledge to the analysis of a local environmental issue or problem (365-9)

Geological Hazards

Outcomes

Students will be expected to

- distinguish between scientific questions and technological problems (115-1)
- construct arguments to support a decision or judgement, using examples and evidence and recognizing various perspectives (118-6)
- identify questions to investigate that arise from practical problems and issues (212-1)
- propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan (214-15)

Elaborations—Strategies for Learning and Teaching

At the outset of this unit in Environmental Geology the students should be presented with a selection of issues from which to choose a topic that will be researched as a case study. While a wide variety of teaching ideas are presented under Elaborations, it is not the intention that all be implemented. The instructor should choose lesson ideas which will best support the students as they develop their case studies in environmental geology. Working as teams the students may use library references, internet resources and interviews to research their chosen topic. Where possible, the issue should be developed with relevance to the environment of Nova Scotia. Teachers should preview the entire unit prior to presenting suggestions for case studies.

With respect to geologic hazards some issues may include:
radon gas and associated health hazards
land slides and human modification of the landscape
flood prevention and prediction
attempts to control earthquake damage

Issues related to Earth resources could include
- strip mining
- open pit mining
- treatment of mine tailings
- soil degradation
- ground water contamination

Issues of waste disposal to consider may include
- siting landfills
- groundwater monitoring
- tar ponds
- toxic waste dumps
- disposal of nuclear waste

Once student teams are established, they should identify the specific issue that their case study will look at. The team then develops questions regarding the issue and identifies the information required to address these. Based on their research they make recommendations for action and list professionals who might be consulted. The final presentations to the class may include a guest speaker who responds to the team's questions.

Geological Hazards

Tasks for Instruction and/or Assessment

Performance

- Design an experiment that investigates the effect of groundwater on the downslope movement of earth materials. Various earth materials such as clay, sand, gravel, and topsoil can be placed in short lengths of vinyl rain gutter lined with cardboard. In each trial the gutter is tilted and the angles at which the material slides measured. Drip water your samples in various amounts and determine the effects of moisture on slope stability. Attempt to control the slides, testing the effectiveness of various ground covers (grass clippings, fabric, kitty-litter, pebbles, etc.) for improving slope stability. (214-15, 118-6)

Journal

- Complete an illustrated journal entry dealing with a specific hazard that is of interest to you. Describe the hazard and identify the specific risks to humans. Any scientific questions and technological problems related to the hazard should be explained. (115-1, 118-6, 212-1)

Presentation

- Using a geologic hazard case study, in teams, construct a variety of arguments supporting different decisions based on differing ideologies. (118-6, 214-15)

Resources/Notes

Video

- *Earthquakes in Canada* (LRT)
- *Fate of the Earth: The Impact of Man* (LRT)

Geological Hazards *(continued)*

Outcomes

Students will be expected to

- identify multiple perspectives that influence a science-related decision or issue (215-4)
- identify examples of geological hazards that impact on human settlement and ways in which humans have attempted to minimize the impact of these hazards (365-1)
- identify factors that influence people to live in geologically hazardous areas (365-3)

Elaborations—Strategies for Learning and Teaching

As the students begin their examination of the geologic processes that threaten or affect people, discussion should take place with reference to the multi-disciplinary aspects of environmental geology. The scientific questions that arise may be addressed by geophysicists, geochemists or hydro-geologists. The technical problems that must be answered to correct certain situations may fall within the realm of the architect or engineer. With reference to a specific hazard (landslide, debris flow, flooding) the students may identify and differentiate between the related scientific questions (what is the role of ground water in slope failure?) and technical problems (how can a slide be diverted?)

The students may complete a jigsaw exercise in which they research a number of geologic hazards and the impact of these on society. Using this information, they could then prepare a video documentary for class presentation.

Radon is a colourless, odourless radioactive gas formed from uranium, commonly associated with granitic rocks such as those which occur under much of the southern mainland of Nova Scotia and elsewhere in the province. Radon presents a health hazard when it enters the basements of newer, energy-efficient homes. Students may role-play a community meeting among environmental geologists, contractors, landlords, residents and home owners as they discuss the issues surrounding radon gas in their community.

While the most devastating landslides occur in mountainous regions, all regions experience them on some scale. Landslides and debris flows often occur as a result of land mismanagement and poor designing. Students can arrange to interview a professional engineer, geotechnician or contractor with experience in landslide prevention and discuss the causes and prevention of landslides. Using the internet and library resources they may produce illustrated magazine articles which elaborate on actual landslides or debris flows, their causes and affects.

As students travel along Nova Scotia's roads they should look for signs of slope instability and note some of the practices used to overcome the problems.

Geological Hazards *(continued)*

Tasks for Instruction and/or Assessment

Performance

- Working individually or collectively, construct a model that illustrates methods of flood prevention. The model could include dams, reservoirs, diversion channels, levees and flood walls. Associated hazards such as slope failures could also be depicted. (365-1, 365-3)

Presentation

- Create a model or poster that demonstrates landslide warning signs. Signs include slowly developing cracks in the ground or pavement, cracks in new foundations, bulging at the base of slopes, tilting utility poles, fences and trees, broken utility lines, and so on. (365-3, 365-1, 215-4)

Resources/Notes

World Wide Web Keywords

- environmental geology
- geologic hazards
- landslide
- volcano
- earthquake
- radon
- flooding
- Earth resources
- soil degradation
- siltation
- waste management
- waste disposal

Geological Hazards *(continued)*

Outcomes

Students will be expected to

- apply geological knowledge to the analysis of a local environmental issue or problem (365-9)
- compare the risks and benefits to society and the environment of applying scientific knowledge or introducing a technology (118-1)

Elaborations—Strategies for Learning and Teaching

Students may investigate and report on problems in Nova Scotia associated with land subsidence. This event may occur when underground mine workings collapse or in cases where water dissolves soluble minerals causing the land to settle. Students may prepare posters illustrating karst features, such as sinkholes, found in Nova Scotia's gypsum deposits.

Nova Scotia is fortunate in that today we are not subject to the devastation associated with major earthquakes. Nearly all earthquakes are natural events that occur as shock waves are produced when rocks slip along a fault zone. Some have resulted from human activity. Using the internet and library references the students can investigate the actions of humans that have resulted in earthquakes, such as loading of the Earth's surface with artificial water reservoirs, the deep injection of hazardous waste and underground nuclear testing. Are these practices justifiable? Students may Write-Pair-Compare & Share their views. Many people choose to live in earthquake zones and attempts to reduce earthquake damage have resulted in many architectural innovations. The students can create a bulletin board display that illustrates seismic design innovations. Models of specific structures may be constructed.

River flooding is a natural process that humans have attempted to control. Those controls have sometimes given the many people who settle on the deep soils of flood plains a false sense of security. Students may construct models illustrating various methods used to control flooding. In Nova Scotia, the Salmon River and North River near Truro present problems with flooding. The students can investigate and discuss the concept of flood-risk mapping and explain how this knowledge is applied to zoning and land-use. They should examine the affect of urban development on natural infiltration of water and the increased runoff that results.

Geological Hazards *(continued)*

Tasks for Instruction and/or Assessment

Performance

- Plan and conduct a field trip to photograph a geologic hazard in your region (or a virtual field trip). Prepare a photo-essay that summarizes your observations. Having identified a hazard, develop a course of action which could reduce the associated risks. (118-1)

Presentation

- Create an illustrated brochure outlining precautionary and safety considerations for a geologically hazardous area. This item and others may be selected for inclusion in the students' portfolios. (365-9, 118-1)

Resources/Notes

Suggested Manipulatives

- materials as required for model buildings

Geological Hazards *(continued)*

Outcomes

Students will be expected to

- propose a course of action on social issues related to science and technology, taking into account human and environmental needs (118-9)
- provide examples of how science and technology are an integral part of their lives and their community (117-5)
- describe the functioning of domestic and industrial technologies, using scientific principles (116-5)

Elaborations—Strategies for Learning and Teaching

Many people live with volcanic risks such as lava, ash fall and poisonous gas on a daily basis. The students may examine some of history's more famous eruptions and complete journal entries in which they describe the event and its impact. Some notable eruptions include those of Mount St. Helen's, Surtsey, Pinatubo, Katmai, Mont Pelee, Paricutin, Krakatau, Tamboro and Vesuvius. Students can take virtual field trips to a variety of volcanic sites via the Internet. Discussion can include the reasons people are attracted to volcanic regions (rich soils, attractive landscapes) and the benefits derived from volcanos (fertile soils, construction material, abrasives, cleaning agents, raw materials for manufacturing, geothermal energy.)

The students may complete a jigsaw activity in which they identify and describe areas known to be at geologic risk and illustrate how science and technology are used to minimize these risks.

Geological Hazards *(continued)*

Tasks for Instruction and/or Assessment

Paper and Pencil

- Identify and describe areas known to be at geological risk and illustrate how science and technology are used to minimize these risks. (118-9, 116-5, 117-5)

Resources/Notes

Resource Issues

Outcomes

Students will be expected to

- demonstrate an understanding that Earth's systems are complex and cyclic and that the Earth operates chiefly as a closed system (365-4)
- describe the functioning of domestic and industrial technologies, using scientific principles (116-5)
- identify and describe science and technology-based careers related to the science they are studying (117-7)

Elaborations—Strategies for Learning and Teaching

In this section the students explore issues in environmental geology relating to Earth's resources.

Discussion of the terms resource and reserve should take place at the beginning of this section. What is a resource? A resource is simply some naturally occurring, useful material. In terms of mineral resources, the occurrence must be of an economic concentration. The reserve is the portion of the resource that has been located and that is possible to extract.

To begin their examination of resource issues student teams can brainstorm and create lists of Earth resources necessary to build, furnish and supply a home. These might be grouped as building materials, utility and insulation materials, finishing and decorating materials, furnishings and appliances, landscaping material, food, clothing and medicine. They then classify each resource as renewable or non-renewable with justification for their classification.

Earth does recycle its resources but in most cases the process is so slow (example—soil formation) that we consider many of them non-renewable. While most industries still depend heavily on non-renewable raw materials and energy, there are those for which recycled materials are a primary resource. Using the internet and other research tools, teams of students may identify industries that are leaders in recycling technology and complete illustrated articles in which they elaborate on their philosophy and processes. If facilities permit, the articles may be desktop published in the classroom in magazine format.

Renewable resources are only renewable for as long as the environmental conditions allow the regeneration to occur. The students may address this topic in the form of a jigsaw activity in which they identify and describe a number of renewable resources and the environmental conditions that must exist for this classification to continue. They may then identify, in a global context, any current practices or situations that put the necessary conditions in jeopardy.

Resource Issues

Tasks for Instruction and/or Assessment

Interview

- Interview a development officer or contractor to determine why percolation rates must be established before a building site is developed. (117-7, 116-5, 365-4)

Performance

- Using your percolation testing set-up, introduce a contaminant (water with a food dye added) and determine the rate at which the contaminant is leeched from various soil types by determining the amount of clean water that must enter the system before the draining water is clear again. (365-4)

Journal

- Write a journal entry discussing the importance of conserving Earth's resources. (365-4, 117-5)

Paper and Pencil

- Suggest strategies for conserving resources when building a new home. Consider both materials used and future energy requirements. An illustrated article may be used to present your ideas. (116-5, 365-4)
- Using a cross-section diagram of a groundwater system, identify key features and predict the movement of water within the system. (365-4)
- Identify an example of what you believe to be sustainable development and then explain your reasoning. (116-5)
- Identify a source of groundwater contamination and design a method of controlling it, to be presented either as a model or a poster. (365-4, 116-5, 117-5)
- Prepare a poster of a groundwater system which illustrates how point-source contaminants might enter the system and affect a supply of drinking water. (365-4)

Resources/Notes

Print

- Minerals and Energy Maps (NS Department of Natural Resources)
- Minerals and Energy Publications (NS Department of Natural Resources)
- *The Natural History of Nova Scotia* (The Nova Scotia Museum)

Software

- Ocean Planet (LRT)

Video

- *Cohasset Project* (LRT)
- *Ground Water* (LRT)
- *Geoscience Mapping* (LRT)
- *Mineral Vignettes* (LRT)
- *Mineral Wealth of Atlantic Canada* (LRT)
- *Offshore Oil and Natural Gas* (LRT)
- *Uranium, the Nova Scotia Experience* (LRT)

Resource Issues *(continued)*

Outcomes

Students will be expected to

- identify and describe science and technology-based careers related to the science they are studying (117-7)
- select and use apparatus and materials safely (213-8)
- identify stratigraphy as a key element of environmental geology and describe some technologies used to acquire stratigraphic data (365-6)

Elaborations—Strategies for Learning and Teaching

Students may conduct interviews with persons employed in the recycling processes and industries.

Fresh, potable water is one of our most precious resources and in many regions of the world today the human populations routinely drink water from contaminated sources. Through discussion students should identify sources and uses of freshwater.

Using a groundwater model or cross-section diagrams, the students should identify groundwater structures and aquifers and discuss the factors that control groundwater movement.

Ground water is the world's greatest source of fresh water, but is threatened by point-source contamination (storage tanks, septic systems, etc.) and non-point source contamination (seawater infiltration, air pollution, etc.) After discussing the water table and its components, student teams from one half of the class should conduct research to identify and describe point source contaminants and present their information to the class in poster presentation format. In similar fashion, the other half of the students should examine non-point source contamination.

Students may conduct water quality testing procedures, examining water hardness, dissolved salts and pollutants.

Students can tour a municipal water-supply system from watershed area to treatment and distribution facilities. They may investigate the issue of water purification and chlorination and prepare flow charts that illustrate the sequence of treatment processes.

Students may conduct percolation testing on a variety of soil types. Percolation is a measure of the rate at which water travels through the soil. It also determines the speed at which pollutants may travel through soils, or be leached from them. Using 2 l milk cartons cut to a height of about 15 cm, the students may punch a small hole in the bottom and add 3 cm of the soil being tested. They then place 250 ml of water in the carton and record the time required for a specified volume to drain out (try 100 ml.) Discuss the results with reference to hydrostatic absorption and particle/pore size.

Resource Issues *(continued)*

Tasks for Instruction and/or Assessment

Performance

- Role play a community meeting to discuss the proposed development of an open pit mine near your home and adjacent to a major river system. Assign specific roles to prepare that might include mine managers, business persons, geologists, biologists, home owners, fishers, environmental groups and politicians. An alternative plan could focus on offshore oil and gas development or an appropriate regional issue. (117-7, 213-8)
- Design, carry out and present data gathered from an experiment using different types of soils in a percolation test. (213-8)

Paper and Pencil

- Prepare a photo-essay that identifies and describes the stages in the development of a mineral resource and the environment issues that must be addressed during exploration, site development, mining, milling and treatment of tailings. (117-7, 213-8)
- Design a poster which identifies the environmental concerns that challenge the mining industry and the potential affects of mineral resource recovery on each of Earth's spheres. (365-6)

Resources/Notes

World Wide Web Key Words

- Earth systems
- renewable resources
- non-renewable resources
- groundwater
- aquifer
- porosity
- permeability
- percolation testing
- water contamination
- contamination plumes
- point-source contaminants
- water table
- water testing
- water treatment
- mineral resources
- geophysical exploration
- remote sensing
- mining
- milling
- mine tailings
- energy resources

Resource Issues *(continued)*

Outcomes

Students will be expected to

- work cooperatively with team members to develop and carry out a plan and troubleshoot problems as they arise (215-6)
- demonstrate an understanding of what is meant by a renewable and non-renewable resource and the concept of sustainable development (365-5)
- use library and electronic research tools to collect information on a given topic (213-6)

Elaborations—Strategies for Learning and Teaching

Students may examine soil maps of their region and identify areas of clay-rich versus sandy soils and discuss the potential problems that could occur with respect to septic systems and wells as related to these soil types.

To introduce the topic of mineral resources the students should conduct a jigsaw activity in which they investigate exploration technology and report their findings to the class. Topics may include remote sensing, mapping, core sampling, and geophysical techniques. A guest speaker from the field of mineral exploration may be invited to speak with the class.

Using the Internet and other visual resources the students should view examples of the various types of ore deposits and locate any examples that may occur in Nova Scotia. They should discuss the origin of each deposit and the extraction process used. Student teams may examine the mining, milling and refining process for a Nova Scotia mineral resource and prepare posters which illustrate these processes and identify environmental concerns relevant to each stage.

Resource Issues *(continued)*

Tasks for Instruction and/or Assessment

Interview

- Interview a person employed in the mining, milling, and/or refining industry. (365-5)

Paper and Pencil

- Investigate renewable energy projects in Nova Scotia. Include in your report environmental benefits and risks and the technology and geological knowledge associated with the project. (365-5, 213-6, 215-6)

Resources/Notes

Suggested Manipulatives

- sediment and soil samples
- short lengths of rain gutter
- food dyes
- groundwater model

Resource Issues *(continued)*

Outcomes

Students will be expected to

- propose a course of action on social issues related to science and technology, taking into account human and environmental needs (118-9)

Elaborations—Strategies for Learning and Teaching

Students may prepare questions for and conduct an interview with a person employed in the mining, milling, or refining industry.

Students may create models of mines and mill sites with labels to indicate areas of environmental concern.

Student teams may examine Nova Scotia's energy resources and elaborate on their formation, occurrence, recovery and environmental impact in written or oral presentations.

Students may prepare a video or multimedia presentation in which they report on their research of a renewable energy resource.

Resource Issues *(continued)*

Tasks for Instruction and/or Assessment

Paper and Pencil

- Using library and Internet resources, investigate issues related to our petroleum resources. Elaborate on the benefits of such projects to the provincial economy and examine the environmental concerns of habitat disturbance, brine waste, pipeline construction, oil spills, air pollution and acid rain. (118-9)

Resources/Notes

Waste Management

Outcomes

Students will be expected to

- compare the risks and benefits to society and the environment of applying scientific knowledge or introducing a technology (118-1)
- evaluate a personally designed and constructed device on the basis of criteria they have developed themselves (214-16)

Elaborations—Strategies for Learning and Teaching

Increased environmental awareness and more rigorous regulations have caused both industries and municipalities to improve their waste management practices. In Nova Scotia we are now beginning to practice what has been proposed for some time. With recycling and composting programs in place the amount of waste destined for landfills has been dramatically reduced. But landfills are still a necessity.

As an introduction to this section on waste management the students can become familiar with the terminology of landfill management by developing an illustrated glossary as a class project. It should include, but not be limited to: active life, buffer zone, cell, composting, cover material, design volume, final cover, lateral expansion, leachate, liner, methane, natural boundaries, open burning, recovery, solid waste stream, vectors, white goods and waste management plans.

The students should plan a field trip which would allow them to visit the waste management facilities in their region, to view the recycling, composting and landfill operations.

Students may be challenged to design and construct models of environmentally friendly, energy efficient, waste management facilities.

Perhaps in no other area of environmental geology are economic, political and emotional concerns so much in the forefront as in the issue of landfill siting. The environmental complexities of site selection are often overshadowed these factors. The students should first investigate the criteria used for siting landfills. They then may role play a variety of community members at a town hall meeting at which time the public is to have input regarding the location of a new landfill.

Why is there so much waste? Students should examine their own lifestyle practices and choices and identify areas where changes could be made to reduce the amount of garbage entering the waste stream. Why do we throw so much away? Students should interview seniors and compare current purchase prices and repair costs of a selection of goods with those of the mid-twentieth century. A comparison of packaging methods can also be carried out.

Waste Management

Tasks for Instruction and/or Assessment

Performance

- Design an experiment that investigates the biodegradability of solid waste materials. (214-16)

Paper and Pencil

- Investigate the economics of recycling and composting programs and prepare a report. (118-1)
- Develop a closure plan for a sanitary landfill site that includes controls and monitoring systems. (118-1)

Resources/Notes

Print

- Maps, Illustrations and Publications (Nova Scotia Department of Natural Resources)
- *Environmental Science: 49 Science Fair Projects* (Robert Bonnet & G. Daniel Keen)
- *The Complete Guide to Environmental Careers* (The CEIP Fund)
- Environmental Science Activities Kit (Michael Roa)
- *Restoring Our Earth* (Lawrence Pringle)
- Various Publications (Clean Nova Scotia)

Activity

- Design a Landfill

Video

- *Fate of the Earth—Geochemical Circles* (LRT)
- *Fate of the Earth—The Impact of Man* (LRT)
- *Geothermal: The Energy Within* (LRT)
- *Ground Water* (LRT)

Waste Management *(continued)*

Outcomes

Students will be expected to

- identify and describe the environmental problems associated with waste disposal and management (365-8)
- apply geological knowledge to the analysis of a local environmental issue or problem (365-9)

Elaborations—Strategies for Learning and Teaching

Historically we do not have a good record with respect to waste management. The students may use topographic maps to locate older dump sites, many of which were adjacent to lakes and rivers. Based on their knowledge of ground water systems they can identify potential future problems and be challenged to propose measures that might reduce risks.

Incineration of waste is still an accepted practice in some regions. Students should describe the environment risks associated with incineration and evaluate the risks to society. The students may be presented with a case study and asked to propose an alternative method of disposal and defend their plan.

Toxic waste poses a significant, long-term risk to the environment. The students may identify examples and describe their characteristics. They may investigate the history of notorious toxic waste sites such as the Sydney Tar Ponds and Love Canal as case studies.

Nuclear power generation provides an alternative to fossil fuel based electrical generation but presents the problem of having to deal with the radioactive waste products. The students may be asked to identify the risks to society posed by nuclear generating stations. The students should differentiate between high level, transuranic and low level nuclear waste. They should describe what is unique about nuclear waste that sets it apart from other toxic wastes.

Various methods for disposing of nuclear waste have been proposed. These include deep well injection, launching it into deep space, burial in oceanic sediments, underground storage sites and incineration. These may be investigated using library and Internet resources. The students can then debate the merits and risks associated with each method.

Students can be asked if nuclear generation should continue? Should hydroelectric, wind, solar or geothermal developments be considered as alternatives? Should energy consumption be curtailed? After discussion, their written answers can form the basis of journal entries or articles for their portfolios.

Waste Management *(continued)*

Tasks for Instruction and/or Assessment

Performance

- Acting as investigative journalists, in teams, prepare a 15-minute news broadcast on a specific issue relating to waste management. (365-8, 365-9)

Paper and Pencil

- Write a persuasive letter to the editor of a local newspaper expressing concern over an issue relating to waste management. (365-8, 365-9)
- Write a speech for a political candidate on the topic of nuclear power generation and nuclear waste disposal. (365-8, 365-9)
- Given a description of a community and its local geography, geology and topography, develop a waste management plan and propose a method for disposal of the solid waste taking into consideration economic, political, social and environmental issues. (365-8, 365-9)
- Throughout this section you investigated various technologies that have evolved as society seeks ways of disposing of its waste. Prepare written reports on the implications of a particular disposal method on society and the environment. (365-8, 365-9)
- Choose a topic in waste management as the basis for a case study in this unit. (365-8, 365-9)
- Self-evaluate landfill models based on established criteria. (365-9, 365-8)

Resources/Notes

World Wide Web Key Words

- waste management
- solid waste
- landfills
- recycling
- composting
- sanitary landfills
- waste incineration
- toxic waste
- nuclear waste
- alternative energy

Suggested Manipulatives

- composting kits
- model landfill kits
- environmental testing kits
- pollution kits