This document represents an updating of the 1995 IRP. This updating has been undertaken for the purpose of

- clarifying the Prescribed Learning Outcomes
- introducing Suggested Achievement Indicators
- addressing content overload

Resources previously recommended for the 1995 version of the curriculum, where still valid, continue to support this updated IRP. (See the Learning Resources section in this IRP for additional information.)

Earth Science 11 and Geology 12

Integrated Resource Package 2006

Ministry of Education

IRP 143

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Acknowledgments

Preface

Introduction to Earth Science 11 and Geology 12

Considerations for Program Delivery

Prescribed Learning Outcomes

Student Achievement

Learning Resources

This document has been updated from the 1995 IRP to include suggested achievement indicators, a more clear and succinct set of prescribed learning outcomes, a snapshot of the course's key elements, and other minor refinements, while maintaining the original intent and essence of the 1995 curricular content.

Many people contributed their expertise to the Earth Science 11 and Geology 12 IRP. The Project Manager (2005-2006) was Mr. Waël Afifi of the Ministry of Education, working with other ministry personnel and our partners in education. We would like to thank all who participated in this process, including the teams of educators who developed the 1995 Earth Science 11 and Geology 12 IRP, and the following individuals who contributed to the 2005-2006 updating of this document:

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This Integrated Resource Package (IRP) provides basic information teachers will require in order to implement Earth Science 11 and Geology 12. This document supersedes the *Earth Science 11 and Geology 12 Integrated Resource Package* (1995).

The information contained in this document is also available on the Internet at www.bced.gov.bc.ca/irp/irp.htm

The following paragraphs provide brief descriptions of the components of the IRP.

Introduction

The Introduction provides general information about Earth Science 11 and Geology 12, including special features and requirements.

Included in this section are

- a rationale for teaching Earth Science 11 and Geology 12 in BC schools
- information about graduation program requirements and provincial examinations
- listings of the curriculum organizers – groupings for prescribed learning outcomes that share a common focus
- suggested time allotments for each course

Considerations for Program Delivery

This section of the IRP contains additional information to help educators develop their school practices and plan their program delivery to meet the needs of all learners.

Prescribed Learning Outcomes

This section contains the *prescribed learning outcomes*, the legally required content standards for the provincial education system. The learning outcomes define the required knowledge, skills, and attitudes for each subject. They are statements of what students are expected to know and be able to do by the end of the course.

Student Achievement

This section of the IRP contains information about classroom assessment and measuring student achievement, including sets of specific achievement indicators for each prescribed learning outcome. Achievement indicators are statements that describe what students should be able to do in order to demonstrate that they fully meet the expectations set out by the prescribed learning outcomes. Achievement indicators are not mandatory; they are provided to assist in the assessment of how well students achieve the prescribed learning outcomes.

Also included in this section are key elements – descriptions of content that help determine the intended depth and breadth of the prescribed learning outcomes.

Learning Resources

This section contains general information on learning resources, and provides a link to titles, descriptions, and ordering information for the recommended learning resources in the Earth Science 11 Geology 12 Grade Collections.

Introduction

Earth Science 11 and Geology 12

This Integrated Resource Package (IRP) sets out the provincially prescribed curriculum for Earth Science 11 and Geology 12. The development of this IRP has been guided by the principles of learning:

- Learning requires the active participation of the student.
- People learn in a variety of ways and at different rates.
- Learning is both an individual and a group process.

In addition to these three principles, this document recognizes that British Columbia's schools include students of varied backgrounds, interests, abilities, and needs. Wherever appropriate for this curriculum, ways to meet these needs and to ensure equity and access for all learners have been integrated as much as possible into the learning outcomes and achievement indicators.

This document represents an updating of the 1995 IRP. This updating has been undertaken for the purpose of

- clarifying the prescribed learning outcomes
- introducing suggested achievement indicators
- addressing content overload

Resources previously recommended for the 1995 version of the curriculum continue to support this updated IRP. (See the Learning Resources section later in this IRP for additional information.)

Earth Science 11 and Geology 12, in draft form, was available for public review and response from November to December, 2005. Feedback from educators, students, parents, and other educational partners informed the development of this updated IRP.

Rationale

The science curriculum of British Columbia provides a foundation for the scientific literacy of citizens, for the development of a highly skilled and adaptable work force, and for the development of new technologies. It is a foundation on which teachers can develop a science program that provides a comprehensive set of knowledge, skills, and experiences related to science.

School science programs that are planned to develop scientifically literate students provide experiences that

- help students become flexible and adaptable while acquiring specialized knowledge
- develop the capacity to think critically
- call for a wide range of knowledge, methods, and approaches that enable students to analyse personal and societal issues critically
- encourage students to examine the impact of scientific knowledge on their lives, society, and the environment
- develop a positive attitude toward science
- cultivate students' appreciation of the scientific endeavour and their potential to contribute to it

The science curricula of British Columbia provide a framework of opportunities for students to become scientifically literate by

- examining basic concepts, principles, laws, and theories through scientific inquiry
- actively gaining knowledge, skills, and attitudes that provide the basis for sound and ethical problem solving and decision making
- developing an understanding of the place of science in society and history and its relationship to other disciplines
- making informed and responsible decisions about themselves, their homes, workplaces, and the global community

Requirements and Graduation Credits

Earth Science 11 and Geology 12 are two of the courses available for students to satisfy the Grade 11-12 Graduation Program science requirement.

Earth Science 11 and Geology 12 are each designated as four-credit courses, and must be reported as such to the Ministry of Education for transcript purposes. Letter grades and percentages must be reported for these courses. It is not possible to obtain partial credit for these courses.

The course codes for Earth Science 11 and Geology 12 are ESC 11 and GEOL 12. These courses are also available in French (Science de la terre 11, Géologie 12; course codes SCTF 11, GEOLF 12).

Graduation Program Examination

Geology 12 has an optional Graduation Program examination, worth 40% of the final course mark for students who choose to write it. Although students are not required to take this exam to receive credit for the course, they should be advised that some post-secondary institutions require Grade 12 exams to meet entrance requirements, and that writing Grade 12 exams also provides opportunities for provincial scholarships.

For more information, refer to the Ministry of Education examinations web site: www.bced.gov.bc.ca/exams/

Curriculum Organizers

A curriculum organizer consists of a set of prescribed learning outcomes that share a common focus. The prescribed learning outcomes for Earth Science 11 and Geology 12 are grouped under the following curriculum organizers.

Note that the ordering of organizers and outcomes in the Earth Science 11 Geology 12 curriculum is not intended to imply an order of instruction.

Earth Science 11					
Introduction to Earth and Space Science	**Astronomy**	**Earth Materials (Rocks and Minerals)**	**Geological Time**	**Internal Processes and Plate Tectonic Theory**	**Surface Processes and the Hydrosphere**
Geology 12					
Introduction to Geology 12	**Earth Materials (Rocks and Minerals)**	**Earth Resources**	**Geological Time**	**Internal Processes and Plate Tectonic Theory**	**Surface Processes and the Hydrosphere**

Suggested Timeframe

Provincial curricula are developed in accordance with the amount of instructional time recommended by the Ministry of Education for each subject area. Teachers may choose to combine various curricula to enable students to integrate ideas and make meaningful connections.

Earth Science 11 and Geology 12 each require approximately 90–110 hours of instructional time. Although a four-credit course is typically equivalent to 120 hours, this timeframe allows for flexibility to address local needs. The Student Achievement section of this IRP provides a suggested breakdown of this suggested time allotment by curriculum organizer.

Considerations for Program Delivery

Earth Science 11 and Geology 12

This section of the IRP contains additional information to help educators develop their school practices and plan their program delivery to meet the needs of all learners. Included in this section is information about

- Alternative Delivery policy
- addressing local contexts
- involving parents and guardians
- course requirements respecting beliefs
- safety considerations
- confidentiality
- inclusion, equity, and accessibility for all learners
- working with the school and community
- working with the Aboriginal community
- information and communications technology
- copyright and responsibility

Alternative Delivery Policy

The Alternative Delivery policy does not apply to Earth Science 11 and Geology 12.

The Alternative Delivery policy outlines how students, and their parents or guardians, in consultation with their local school authority, may choose means other than instruction by a teacher within the regular classroom setting for addressing prescribed learning outcomes contained in the Health curriculum organizer of the following curriculum documents:

- Health and Career Education K to 7, and Personal Planning K to 7 Personal Development curriculum organizer (until September 2008)
- Health and Career Education 8 and 9
- Planning 10

The policy recognizes the family as the primary educator in the development of children's attitudes, standards, and values, but the policy still requires that all prescribed learning outcomes be addressed and assessed in the agreed-upon alternative manner of delivery.

It is important to note the significance of the term "alternative delivery" as it relates to the Alternative Delivery Policy. The policy does not permit schools to omit addressing or assessing any of the prescribed learning outcomes within the health and career education curriculum. Neither does it allow students to be excused from meeting any learning outcomes related to health. It is expected that students who arrange for alternative delivery will address the health-related learning outcomes and will be able to demonstrate their understanding of these learning outcomes.

For more information about policy relating to alternative delivery, refer to www.bced.gov.bc.ca/policy/

Addressing Local Contexts

There is some flexibility in the Earth Science 11 and Geology 12 curriculum, providing opportunities for individual teacher and student choice in the selection of topics to meet learning outcomes. This flexibility enables educators to plan their programs by using topics and examples that are relevant to their local context and to the particular interests of their students. When selecting topics it may be appropriate to incorporate student input.

Involving Parents and Guardians

The family is the primary educator in the development of students' attitudes and values. The school plays a supportive role by focussing on the prescribed learning outcomes in the Earth Science 11 and Geology 12 curriculum. Parents and guardians can support, enrich, and extend the curriculum at home.

It is highly recommended that schools inform parents and guardians about the Earth Science 11 and Geology 12 curriculum, and teachers (along with school and district administrators) may choose to do so by

- informing parents/guardians and students of the prescribed learning outcomes for the subject by sending home class letters, providing an overview during parent-teacher interviews, etc.
- responding to parent and guardian requests to discuss course unit plans, learning resources, etc.

Course Requirements Respecting Beliefs

For many students and teachers, the study of some science concepts may lead to issues and questions that go beyond the immediate scope of curriculum (e.g., science is used to meet many industrial requirements, but industrial decision makers must consider factors other than scientific feasibility before adopting a particular process). The technological application of science in areas such as genetic engineering, human reproduction, and medical technology raises questions of ethics and values. Because these social questions arise, in part, from capabilities that science makes possible, they should be addressed. It must be made clear to students, however, that science only provides the background for what is hoped will be informed personal and social decisions. Teachers must handle these questions objectively and with sensitivity.

Reconciling scientific discoveries (for example, in age dating) and religious faith poses a particular challenge for some students. While respecting the personal beliefs of students, teachers should be careful to distinguish between knowledge based on the application of scientific methods, and religious teachings and associated beliefs such as creationism, theory of divine creation, or intelligent design theory.

Safety Considerations

Science education is an activity-based process that provides an exciting method of teaching and learning. However, experiments and demonstrations may involve inherent risks for both the teacher and the student.

Safety guidelines must be discussed with students. These safety guidelines must support and encourage the investigative approach generally and laboratory instruction specifically, while at the same time promoting safety in the classroom and laboratory. Encouraging a positive safety attitude is a responsibility shared among the board, school administrators, teachers, and students in every school district. The co-operation of all these groups helps develop a strong safety consciousness both inside and outside our schools.

Field work and field trips require special vigilance with respect to traffic and road safety, safe practices in study areas and when obtaining samples, and an awareness of changes in weather.

Another important aspect of in-school safety is the Workplace Hazardous Materials Information Systems (WHMIS). Through labelling, material safety data sheets, and education and training, WHMIS is designed to ensure that those using hazardous materials have sufficient information to handle them safely. Each school district should have an individual trained in WHMIS who can work with teachers to establish safe, well-ventilated classroom and laboratory working conditions.

To assist teachers in providing a safe science-learning environment, the Ministry of Education publishes the *Science Safety Resource Manual*, which has been distributed to every school.

The *Science Safety Resource Manual* is available online at www.bced.gov.bc.ca/irp/resdocs/scisafety.htm

Confidentiality

The Freedom of Information and Protection of Privacy Act (FOIPPA) applies to students, to school districts, and to all curricula. Teachers, administrators, and district staff should consider the following:

- Be aware of district and school guidelines regarding the provisions of FOIPPA and how it applies to all subjects, including Earth Science 11 and Geology 12.
- Do not use students' Personal Education Numbers (PEN) on any assignments that students wish to keep confidential.
- Ensure students are aware that if they disclose personal information that indicates they are at risk for harm, then that information cannot be kept confidential.
- Inform students of their rights under FOIPPA, especially the right to have access to their own personal information in their school records. Inform parents of their rights to access their children's school records.
- Minimize the type and amount of personal information collected, and ensure that it is

used only for purposes that relate directly to the reason for which it is collected.
- Inform students that they will be the only ones recording personal information about themselves unless they, or their parents, have consented to teachers collecting that information from other people (including parents).
- Provide students and their parents with the reason(s) they are being asked to provide personal information in the context of the Earth Science 11 and Geology 12 curriculum.
- Inform students and their parents that they can ask the school to correct or annotate any of the personal information held by the school, in accordance with Section 29 of FOIPPA.
- Ensure students are aware that their parents may have access to the schoolwork they create only insofar as it pertains to students' progress.
- Ensure that any information used in assessing students' progress is up-to-date, accurate, and complete.

For more information about confidentiality, refer to www.mser.gov.bc.ca/FOI_POP/index.htm

Inclusion, Equity, and Accessibility for All Learners

British Columbia's schools include students of varied backgrounds, interests, and abilities. The Kindergarten to Grade 12 school system focusses on meeting the needs of all students. When selecting specific topics, activities, and resources to support the implementation of Earth Science 11 and Geology 12, teachers are encouraged to ensure that these choices support inclusion, equity, and accessibility for all students. In particular, teachers should ensure that classroom instruction, assessment, and resources reflect sensitivity to diversity and incorporate positive role portrayals, relevant issues, and themes such as inclusion, respect, and acceptance.

Government policy supports the principles of integration and inclusion of students for whom English is a second language and of students with special needs. Most of the prescribed learning outcomes and suggested achievement indicators in this IRP can be met by all students, including those with special needs and/or ESL needs. Some strategies may require adaptations to ensure that those with special and/or ESL needs can successfully achieve the learning outcomes. Where necessary, modifications can be made to the prescribed learning outcomes for students with Individual Education Plans.

For more information about resources and support for students with special needs, refer to www.bced.gov.bc.ca/specialed/

For more information about resources and support for ESL students, refer to www.bced.gov.bc.ca/esl/

Working with the School and Community

This curriculum addresses a wide range of skills and understandings that students are developing in other areas of their lives. It is important to recognize that learning related to this curriculum extends beyond the science classroom.

School and district-wide programs support and extend learning in Earth Science 11 and Geology 12. Community organizations may also support the curriculum with locally developed learning resources, guest speakers, workshops, and field studies. Teachers may wish to draw on the expertise of these community organizations and members.

Working with the Aboriginal Community

The Ministry of Education is dedicated to ensuring that the cultures and contributions of Aboriginal peoples in BC are reflected in all provincial curricula. To address these topics in the classroom in a way that is accurate and that respectfully reflects Aboriginal concepts of teaching and learning, teachers are strongly encouraged to seek the advice and support of local Aboriginal communities. Aboriginal communities are diverse in terms of language, culture, and available resources, and each community will have its own unique protocol to gain support for integration of

local knowledge and expertise. To begin discussion of possible instructional and assessment activities, teachers should first contact Aboriginal education co-ordinators, teachers, support workers, and counsellors in their district who will be able to facilitate the identification of local resources and contacts such as elders, chiefs, tribal or band councils, Aboriginal cultural centres, Aboriginal Friendship Centres, and Métis or Inuit organizations.

In addition, teachers may wish to consult the various Ministry of Education publications available, including the "Planning Your Program" section of the resource, *Shared Learnings*. This resource was developed to help all teachers provide students with knowledge of, and opportunities to share experiences with, Aboriginal peoples in BC.

For more information about these documents, consult the Aboriginal Education web site: www.bced.gov.bc.ca/abed/welcome.htm

Information and Communications Technology

The study of information and communications technology is increasingly important in our society. Students need to be able to acquire and analyse information, to reason and communicate, to make informed decisions, and to understand and use information and communications technology for a variety of purposes. Development of these skills is important for students in their education, their future careers, and their everyday lives.

Literacy in the area of information and communications technology can be defined as the ability to obtain and share knowledge through investigation, study, instruction, or transmission of information by means of media technology. Becoming literate in this area involves finding, gathering, assessing, and communicating information using electronic means, as well as developing the knowledge and skills to use and solve problems effectively with the technology. Literacy also involves a critical examination and understanding of the ethical and social issues related to the use of information and communications technology. When planning for instruction and assessment in Earth Science 11 and Geology 12, teachers should provide opportunities for students to develop literacy in relation to information and communications technology sources, and to reflect critically on the role of these technologies in society.

Copyright and Responsibility

Copyright is the legal protection of literary, dramatic, artistic, and musical works; sound recordings; performances; and communications signals. Copyright provides creators with the legal right to be paid for their work and the right to say how their work is to be used. The law permits certain exceptions for schools (i.e., specific things permitted) but these are very limited, such as copying for private study or research. The copyright law determines how resources can be used in the classroom and by students at home.

In order to respect copyright it is necessary to understand the law. It is unlawful to do the following, unless permission has been given by a copyright owner:

- photocopy copyrighted material to avoid purchasing the original resource for any reason
- photocopy or perform copyrighted material beyond a very small part – in some cases the copyright law considers it "fair" to copy whole works, such as an article in a journal or a photograph, for purposes of research and private study, criticism, and review
- show recorded television or radio programs to students in the classroom unless these are cleared for copyright for educational use (there are exceptions such as for news and news commentary taped within one year of broadcast that by law have record-keeping requirements – see the web site at the end of this section for more details)
- photocopy print music, workbooks, instructional materials, instruction manuals, teacher guides, and commercially available tests and examinations
- show videorecordings at schools that are not cleared for public performance

- perform music or do performances of copyrighted material for entertainment (i.e., for purposes other than a specific educational objective)
- copy work from the Internet without an express message that the work can be copied

Permission from or on behalf of the copyright owner must be given in writing. Permission may also be given to copy or use all or some portion of copyrighted work through a licence or agreement. Many creators, publishers, and producers have formed groups or "collectives" to negotiate royalty payments and copying conditions for educational institutions. It is important to know what licences are in place and how these affect the activities schools are involved in. Some licences may also require royalty payments that are determined by the quantity of photocopying or the length of performances. In these cases, it is important to assess the educational value and merits of copying or performing certain works to protect the school's financial exposure (i.e., only copy or use that portion that is absolutely necessary to meet an educational objective).

It is important for education professionals, parents, and students to respect the value of original thinking and the importance of not plagiarizing the work of others. The works of others should not be used without their permission.

For more information about copyright, refer to www.cmec.ca/copyright/indexe.stm

Prescribed Learning Outcomes

Earth Science 11 and Geology 12

Prescribed learning outcomes are content standards for the provincial education system; they are the prescribed curriculum. Clearly stated and expressed in measurable and observable terms, learning outcomes set out the required knowledge, skills, and attitudes – what students are expected to know and be able to do – by the end of the specified course.

Schools have the responsibility to ensure that all prescribed learning outcomes in this curriculum are met; however, schools have flexibility in determining how delivery of the curriculum can best take place.

It is expected that student achievement will vary in relation to the learning outcomes. Evaluation, reporting, and student placement with respect to these outcomes are dependent on the professional judgment and experience of teachers, guided by provincial policy.

Prescribed learning outcomes for Earth Science 11 and Geology 12 are presented by grade and by curriculum organizer, and are coded alphanumerically for ease of reference; however, this arrangement is not intended to imply a required instructional sequence.

Wording of Prescribed Learning Outcomes

All learning outcomes complete the stem, "It is expected that students will…."

When used in a prescribed learning outcome, the word "**including**" indicates that any ensuing item **must be addressed**. Lists of items introduced by the word "including" represent a set of minimum requirements associated with the general requirement set out by the outcome. The lists are not necessarily exhaustive, however, and teachers may choose to address additional items that also fall under the general requirement set out by the outcome.

Domains of Learning

Prescribed learning outcomes in BC curricula identify required learning in relation to one or more of the three domains of learning: cognitive, psychomotor, and affective. The following definitions of the three domains are based on Bloom's taxonomy.

The **cognitive domain** deals with the recall or recognition of knowledge and the development of intellectual abilities. The cognitive domain can be further specified as including three cognitive levels: knowledge, understanding and application, and higher mental processes. These levels are determined by the verb used in the learning outcome, and illustrate how student learning develops over time.

- *Knowledge* includes those behaviours that emphasize the recognition or recall of ideas, material, or phenomena.
- *Understanding and application* represents a comprehension of the literal message contained in a communication, and the ability to apply an appropriate theory, principle, idea, or method to a new situation.
- *Higher mental processes* include analysis, synthesis, and evaluation. The higher mental processes level subsumes both the knowledge and the understanding and application levels.

The **affective domain** concerns attitudes, beliefs, and the spectrum of values and value systems.

The **psychomotor domain** includes those aspects of learning associated with movement and skill demonstration, and integrates the cognitive and affective consequences with physical performances.

Domains of learning and, particularly, cognitive levels, inform the design and development of the Graduation Program examination for Geology 12.

Prescribed Learning Outcomes: Earth Science 11

It is expected that students will:

Introduction to Earth and Space Science

A1 explain the significance of Earth and space science

Astronomy

B1 compare various methods used to study the universe
B2 demonstrate knowledge about the origins of the universe and about astronomical entities
B3 summarize scientific findings and views about the origin and components of the solar system
B4 explain the relationship between the sun, the Earth, and its moon
B5 assess space technologies and their applications

Earth Materials (Rocks and Minerals)

C1 differentiate between rocks and minerals
C2 assess the extraction and use of geological resources

Geological Time

D1 assess the significance of age dating, the fossil record, and the Geological Time Scale

Internal Processes and Plate Tectonic Theory

E1 explain the significance of seismology
E2 compare extrusive and intrusive volcanic features and action
E3 outline the development of plate tectonic theory

Surface Processes and the Hydrosphere

F1 explain the characteristics and significance of the atmosphere
F2 describe the function of the hydrologic cycle
F3 relate the processes associated with weathering and erosion to the resulting features
F4 describe features and processes associated with physical oceanography

Prescribed Learning Outcomes: Geology 12

It is expected that students will:

Introduction to Geology

A1 explain the significance of geology as a discipline

Earth Materials (Rocks and Minerals)

B1 differentiate between igneous, sedimentary, and metamorphic rocks
B2 classify minerals and mineral groups according to their chemical composition
B3 compare igneous rocks
B4 compare igneous features
B5 compare sedimentary rocks
B6 relate sedimentary features to their depositional environments
B7 compare metamorphic rocks

Earth Resources

C1 trace the origins of geological resources including mineral deposits, coal, petroleum, and natural gas
C2 explain the significance of geological resources and their economic development

Geological Time

D1 relate relative age dating to the development of the Geological Time Scale
D2 contrast relative and absolute age dating
D3 relate the fossil record to the Geological Time Scale

Internal Processes and Plate Tectonic Theory

E1 analyse and evaluate applications of seismology
E2 demonstrate knowledge of the Earth's layers
E3 relate rock formations and structures to the forces that create them
E4 analyse structures, processes, and evidence that support plate tectonic theory

Surface Processes and the Hydrosphere

F1 analyse features and processes associated with weathering and erosion
F2 analyse features and processes associated with stream erosion and deposition
F3 evaluate the importance of ground water
F4 explain the processes and features associated with glaciation

Student Achievement

Earth Science 11 and Geology 12

This section of the IRP contains information about classroom assessment and student achievement, including specific achievement indicators to assist in the assessment of student achievement in relation to each prescribed learning outcome. Also included in this section are key elements – descriptions of content that help determine the intended depth and breadth of prescribed learning outcomes.

Classroom Assessment and Evaluation

Assessment is the systematic gathering of information about what students know, are able to do, and are working toward. Assessment evidence can be collected using a wide variety of methods, such as

- observation
- student self-assessments and peer assessments
- quizzes and tests (written, oral, practical)
- samples of student work
- projects and presentations
- oral and written reports
- journals and learning logs
- performance reviews
- portfolio assessments

Assessment of student performance is based on the information collected through assessment activities. Teachers use their insight, knowledge about learning, and experience with students, along with the specific criteria they establish, to make judgments about student performance in relation to prescribed learning outcomes.

Three major types of assessment can be used in conjunction to support student achievement.

- Assessment **for** learning is assessment for purposes of greater learning achievement.
- Assessment **as** learning is assessment as a process of developing and supporting students' active participation in their own learning.
- Assessment **of** learning is assessment for purposes of providing evidence of achievement for reporting.

Assessment for Learning

Classroom assessment for learning provides ways to engage and encourage students to become involved in their own day-to-day assessment – to acquire the skills of thoughtful self-assessment and to promote their own achievement.

This type of assessment serves to answer the following questions:

- What do students need to learn to be successful?
- What does the evidence of this learning look like?

Assessment for learning is criterion-referenced, in which a student's achievement is compared to established criteria rather than to the performance of other students. Criteria are based on prescribed learning outcomes, as well as on suggested achievement indicators or other learning expectations.

Students benefit most when assessment feedback is provided on a regular, ongoing basis. When assessment is seen as an opportunity to promote learning rather than as a final judgment, it shows students their strengths and suggests how they can develop further. Students can use this information to redirect their efforts, make plans, communicate with others (e.g., peers, teachers, parents) about their growth, and set future learning goals.

Assessment for learning also provides an opportunity for teachers to review what their students are learning and what areas need further attention. This information can be used to inform teaching and create a direct link between assessment and instruction. Using assessment as a way of obtaining feedback on instruction supports student achievement by informing teacher planning and classroom practice.

Assessment as Learning
Assessment as learning actively involves students in their own learning processes. With support and guidance from their teacher, students take responsibility for their own learning, constructing meaning for themselves. Through a process of continuous self-assessment, students develop the ability to take stock of what they have already learned, determine what they have not yet learned, and decide how they can best improve their own achievement.

Although assessment as learning is student-driven, teachers can play a key role in facilitating how this assessment takes place. By providing regular opportunities for reflection and self-assessment, teachers can help students develop, practise, and become comfortable with critical analysis of their own learning.

Assessment of Learning
Assessment of learning can be addressed through summative assessment, including large-scale assessments and teacher assessments. These summative assessments can occur at the end of the year or at periodic stages in the instructional process.

Large-scale assessments, such as Foundation Skills Assessment (FSA) and Graduation Program exams, gather information on student performance throughout the province and provide information for the development and revision of curriculum. These assessments are used to make judgments about students' achievement in relation to provincial and national standards. There is no large-scale provincial assessment for Earth Science 11. The large-scale provincial assessment for Geology 12 is the optional graduation program examination, worth 40% of the final course mark for students who choose to write it.

Assessment of learning is also used to inform formal reporting of student achievement.

For Ministry of Education reporting policy, refer to www.bced.gov.bc.ca/policy/policies/student_reporting.htm

Assessment *for* Learning	Assessment *as* Learning	Assessment *of* Learning
Formative assessment is *ongoing in the classroom* • teacher assessment, student self-assessment, and/or student peer assessment • criterion-referenced – criteria based on prescribed learning outcomes identified in the provincial curriculum, reflecting performance in relation to a specific learning task • involves both teacher and student in a process of continual reflection and review about progress • teachers adjust their plans and engage in corrective teaching in response to formative assessment	**Formative assessment is** *ongoing in the classroom* • self-assessment • provides students with information on their own achievement and prompts them to consider how they can continue to improve their learning • student-determined criteria based on previous learning and personal learning goals • students use assessment information to make adaptations to their learning process and to develop new understandings	**Summative assessment occurs** *at end of year or at key stages* • teacher assessment • may be either criterion-referenced (based on prescribed learning outcomes) or norm-referenced (comparing student achievement to that of others) • information on student performance can be shared with parents/guardians, school and district staff, and other education professionals (e.g., for the purposes of curriculum development) • used to make judgments about students' performance in relation to provincial standards

For more information about assessment for, as, and of learning, refer to the following resource developed by the Western and Northern Canadian Protocol (WNCP), *Rethinking Assessment with Purpose in Mind.*

This resource is available online at www.wncp.ca/

Criterion-Referenced Assessment and Evaluation
In criterion-referenced evaluation, a student's performance is compared to established criteria rather than to the performance of other students. Evaluation in relation to prescribed curriculum requires that criteria be established based on the learning outcomes.

Criteria are the basis for evaluating student progress. They identify, in specific terms, the critical aspects of a performance or a product that indicate how well the student is meeting the prescribed learning outcomes. For example, weighted criteria, rating scales, or scoring guides (reference sets) are ways that student performance can be evaluated using criteria.

Wherever possible, students should be involved in setting the assessment criteria. This helps students develop an understanding of what high-quality work or performance looks like.

Criterion-referenced assessment and evaluation may involve these steps:

Step 1	Identify the prescribed learning outcomes and suggested achievement indicators (as articulated in this IRP) that will be used as the basis for assessment.
Step 2	Establish criteria. When appropriate, involve students in establishing criteria.
Step 3	Plan learning activities that will help students gain the knowledge, skills, and attitudes outlined in the criteria.
Step 4	Prior to the learning activity, inform students of the criteria against which their work will be evaluated.
Step 5	Provide examples of the desired levels of performance.
Step 6	Conduct the learning activities.
Step 7	Use appropriate assessment instruments (e.g., rating scale, checklist, scoring guide) and methods (e.g., observation, collection, self-assessment) based on the particular assignment and student.
Step 8	Review the assessment data and evaluate each student's level of performance or quality of work in relation to criteria.
Step 9	Where appropriate, provide feedback and/or a letter grade to indicate how well the criteria are met.
Step 10	Communicate the results of the assessment and evaluation to students and parents/guardians.

Key Elements

Key elements provide an overview of content in each curriculum organizer. They can be used to determine the expected depth and breadth of the prescribed learning outcomes.

Achievement Indicators

To support the assessment of provincially prescribed curricula, this IRP includes sets of achievement indicators in relation to each learning outcome.

Achievement indicators, taken together as a set, define the specific level of knowledge acquired, skills applied, or attitudes demonstrated by the student in relation to a corresponding prescribed learning outcome. They describe what evidence to look for to determine whether or not the student has fully met the intent of the learning outcome. Since each achievement indicator defines only one aspect of the corresponding learning outcome, the entire set of achievement indicators should be considered when determining whether students have fully met the learning outcome.

In some cases, achievement indicators may also include suggestions as to the type of task that would provide evidence of having met the learning outcome (e.g., a constructed response such as a list, comparison, analysis, or chart; a product created and presented such as a report, drama presentation, poster, letter, or model; a particular skill demonstrated such as interpreting graphs).

Achievement indicators support the principles of assessment *for* learning, assessment *as* learning, and assessment *of* learning. They provide teachers and parents with tools that can be used to reflect on what students are learning, as well as provide students with a means of self-assessment and ways of defining how they can improve their own achievement.

Achievement indicators are not mandatory; they are suggestions only, provided to assist in the assessment of how well students achieve the prescribed learning outcomes.

Achievement indicators may be useful to provincial examination development teams and inform the development of exam items. However, examination questions, item formats, exemplars, rubrics, or scoring guides will not necessarily be limited to the achievement indicators as outlined in the Integrated Resource Packages.

Specifications for provincial examinations are available online at www.bced.gov.bc.ca/exams/specs/

The following pages contain the suggested achievement indicators corresponding to each prescribed learning outcome for the Earth Science 11 and Geology 12 curriculum. The achievement indicators are arranged by curriculum organizer for each grade; however, this order is not intended to imply a required sequence of instruction and assessment.

Student Achievement

Earth Science 11

Key Elements: Introduction to Earth and Space Science

Estimated Time: 4–6 hours

By the end of this course, students will understand various aspects, methods, and applications of Earth and space science.

Vocabulary

geologist, mapping, petroleum, remote sensing, satellite, telescope

Knowledge

- major branches of Earth and space science
- methods and tools used to obtain and analyse information about the Earth and space
- careers associated with Earth and space science

Skills and Attitudes

- differentiate Earth and space science from other sciences

INTRODUCTION TO EARTH AND SPACE SCIENCE

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
A1 explain the significance of Earth and space science	❑ identify the major branches of Earth and space science and show how each branch relates to everyday life (e.g., mineral exploration providing raw materials for consumer goods) ❑ describe the major tools and activities of Earth and space scientists (e.g., use of telescopes and satellites to gather information) ❑ identify careers related to both local and regional Earth and space science (e.g., exploration or petroleum geologists) ❑ describe methods of obtaining, visualising, and analysing local and regional information about the Earth and space (e.g., remote sensing, mapping)

Key Elements: Astronomy

Estimated Time: 27–30 hours

By the end of this course, students will have an understanding of current scientific thinking about the origins and components of the universe and the solar system, as well as some of the methods and technologies used by astronomers.

Vocabulary

absolute magnitude, apparent magnitude, asteroid, astronomical unit, Big Bang, black hole, blue giant, comet, constellation, Doppler effect, galaxy, gas giant, Hertzsprung-Russell diagram, Kepler's Laws, light-year, luminosity, main sequence star, meteoroid, moon, moon phases, nebular theory, oscillating universe, parallax, planet, quasar, red dwarf, red giant, red shift, revolution, rotation, satellite, solar system, spectra, spectroscope, telescope, terrestrial planet, tides, triangulation, white dwarf

Knowledge

- origin and components of the universe and solar system
- relationship between the Earth and moon

Skills and Attitudes

- compare methods used to study stellar objects and the universe
- interpret graphs (e.g., Hertzsprung-Russell)
- assess space technologies and their applications

ASTRONOMY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
B1 compare various methods used to study the universe	❑ describe the historical role of constellations in mythology and navigation ❑ describe the purpose and function of various tools and instruments (e.g., telescopes, spectroscopes, space probes) used in astronomy to gather information ❑ describe a variety of methods for estimating the distance to stellar objects (e.g., parallax, triangulation, red shift) ❑ distinguish between an astronomical unit and a light-year ❑ define the apparent magnitude, absolute magnitude, and luminosity of a star ❑ explain how spectra are used to determine the temperature, composition, and motion of a star ❑ describe the Doppler effect and how it can be used to determine the velocity of stellar bodies
B2 demonstrate knowledge about the origins of the universe and about astronomical entities	❑ critique a theory that explains the origin of the universe (e.g., Big Bang, Oscillating Universe) ❑ describe the characteristics of astronomical entities, including galaxies, quasars, and black holes ❑ outline the life cycles of stars ❑ group stars using a Hertzsprung-Russell diagram (e.g., giants, main sequence, white dwarfs)
B3 summarize scientific findings and views about the origin and components of the solar system *Organizer 'Astronomy'* *continued on page 30*	❑ relate features of the solar system (e.g., proximity of gas giants to terrestrial planets) to the Nebular theory ❑ describe major characteristics of the sun (e.g., mass, diameter) ❑ describe a method to measure the diameter of the sun ❑ predict the motion of orbiting bodies using Kepler's laws ❑ outline the general features of each of the following components of the solar system: – inner planets – outer planets – comets – meteoroids – asteroids – planetary satellites (moons)

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Astronomy' *continued from page 29*	
B4 explain the relationship between the sun, the Earth, and its moon	❑ describe ways (e.g., satellite technologies) to determine the volume, density, shape, and circumference of the Earth ❑ discuss the variation in day length over a year for different latitudes ❑ outline evidence that shows the Earth rotates about its axis and revolves around the sun ❑ describe the motion of stars and planets caused by rotation and revolution of the Earth ❑ use models to explain phases of the moon ❑ relate the motions of the moon to low and high tides
B5 assess space technologies and their applications	❑ describe uses of space technologies (e.g., Global Positioning Systems) ❑ research some recent advances (e.g., Canadarm, space stations, Mars rovers) in space technology ❑ debate the pros and cons of space exploration

Key Elements: Earth Materials (Rocks and Minerals)

Estimated Time: 15–20 hours

By the end of this course, students will understand how rocks and minerals are formed and identified and will assess the extraction and use of geological resources.

Vocabulary

concentrating ore, conservation, crystal, extraction, extrusive, felsic, fossil fuel, fractionation, habitat, igneous, intrusive, mafic, metamorphic, non-renewable resource, ore, plutonic, renewable resource, sedimentary, texture

Knowledge

- geological processes
- types of rocks and minerals
- rock cycle
- rock formations and features
- geological resources
- resource conservation

Skills and Attitudes

- differentiate between rocks and minerals
- classify rocks and minerals
- identify rock features and relate them to their environments
- assess methods of extraction and use of geological resources
- assess methods of resource conservation

EARTH MATERIALS (ROCKS AND MINERALS)

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
C1 differentiate between rocks and minerals	❑ use physical (e.g., hardness, lustre) and chemical properties (e.g., felsic vs. mafic) to identify and classify selected rocks and minerals ❑ describe the formation of igneous, sedimentary, and metamorphic rocks and relate them to the rock cycle ❑ classify rocks as igneous, sedimentary, or metamorphic using texture and composition ❑ describe the relationship between crystal size and cooling rate in igneous rocks ❑ classify igneous rocks as volcanic (extrusive) or plutonic (intrusive) on the basis of texture
C2 assess the extraction and use of geological resources	❑ recognize ways in which the study of rocks relates to geology and industry (e.g., gravel deposits used for construction materials) ❑ distinguish between renewable and non-renewable resources (e.g., wind and solar vs. fossil fuels) ❑ identify the uses of ore minerals, rock and sediment materials, and fossil fuels (e.g., extracting metals) ❑ describe several methods of extraction employed in the development of ore minerals, rock and sediment materials, and fossil fuels (e.g., open pit vs. underground mining) ❑ describe the methods of concentrating and refining ore minerals and fossil fuels (e.g., fractionation of fossil fuels) ❑ identify environmental problems (e.g., habitat loss, water contamination) related to development of a natural resource such as coal, oil and gas, or any metallic or non-metallic mineral of economic value ❑ suggest strategies to conserve both material and energy resources ❑ describe the value of resource conservation

Key Elements: Geological Time

Estimated Time: 10–12 hours

By the end of this course, students will understand how the geological time scale has been developed and appreciate its significance.

Vocabulary

absolute age dating, absolute time, correlation, fossil, geological sequences, Geological Time Scale, mass extinction, radioactive, relative age dating, relative time

Knowledge

- age dating
- Geological Time Scale
- fossil record

Skills and Attitudes

- use half-life data (e.g., graphs) to determine absolute age
- correlate sequences of rock (introduction)
- interpret cross sections and examine geological maps

GEOLOGICAL TIME

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
D1 assess the significance of age dating, the fossil record, and the Geological Time Scale	❑ distinguish between relative and absolute time ❑ relate principles of relative age dating and absolute age dating to the interpretation and correlation of geological sequences ❑ outline the process of absolute dating by means of radioactive elements and solve simple problems related to absolute time ❑ explain the processes of fossil formation ❑ describe the significance of fossils in interpreting past events ❑ describe the Earth's geological history in terms of the development of life ❑ describe major events in the Earth's history (e.g., accumulation of oxygen in the atmosphere, mass extinctions) using the Geological Time Scale

Key Elements: Internal Processes and Plate Tectonic Theory

Estimated Time: 18–22 hours

By the end of this course, students will understand the significance of seismology, volcanology, and plate tectonics theory.

Vocabulary

batholith, continental drift, convergent, dike, divergent, extrusive, hot spot, intensity, intrusive, lava, L-wave, magnetic reversal, magnitude, mantle convection, plate boundary, plate tectonic theory, P-wave, rift, seismograph, seismology, sill, subduction, S-wave, transform

Knowledge

- seismology
- volcanic features and activities
- Earth layers and tectonic plates
- continental drift theory
- plate tectonic theory

Skills and Attitudes

- interpret graphs (seismograms)
- locate epicentres using appropriate seismographic data
- predict and interpret dynamics of plate tectonics
- assess hazards and methods of earthquake preparedness

INTERNAL PROCESSES AND PLATE TECTONIC THEORY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
E1 explain the significance of seismology	❑ relate elastic rebound theory to earthquakes ❑ describe the properties of P-, S-, and L-waves ❑ explain how a seismograph works (e.g., model or diagram) ❑ locate the epicentre of an earthquake, given appropriate seismographic data ❑ distinguish between earthquake magnitude and earthquake intensity ❑ outline limitations in the prediction of earthquakes ❑ describe earthquake effects, earthquake hazards, and methods of preparedness (e.g., seismic upgrading) ❑ describe the relationship between seismology and our understanding of the Earth's layers
E2 compare extrusive and intrusive volcanic features and action	❑ distinguish magma from lava ❑ identify intrusive and extrusive igneous features (e.g., sill, dike, batholith) ❑ describe types of eruptions (e.g., cinder cone, composite, shield, basalt plateau, rift), the volcanoes or extrusive events that produce them, and their effects
E3 outline the development of plate tectonic theory	❑ describe evidence for continental drift theory ❑ identify the sources of heat that drive dynamic changes in the interior of the Earth ❑ identify the world distribution of volcanoes and earthquakes ❑ apply understanding of divergent, transform, and convergent plate boundaries to provide evidence supporting plate tectonic theory (e.g., magnetic reversal data, age of sea floor) ❑ relate rift, hotspot, and subduction zone eruptions to plate tectonic theory ❑ relate mantle convection theory to plate movement

Key Elements: Surface Processes and the Hydrosphere

Estimated Time: 16–20 hours

By the end of this course, students will be able to describe the geological features and processes that are affected by the atmosphere and hydrosphere.

Vocabulary

abrasion, abyssal plain, chemical weathering, conduction, continental margin, convection, Coriolis effect, dissolution, erosion, exfoliation, glacier, greenhouse effect, hydrologic cycle, mechanical weathering, mid-ocean rise (ridge), ozone, radiation, remote sensing, rift, seamount, submarine canyon, trench, turbidity, weathering

Knowledge

- structure and function of the atmosphere and hydrologic cycle
- weathering, erosion, and deposition
- running water and glacier
- introduction to physical oceanography

Skills and Attitudes

- predict the effects of changes in composition of the atmosphere
- identify various erosional and depositional features
- creating illustrations and diagrams (e.g., hydrologic cycle, cross section of the sea floor)

SURFACE PROCESSES AND THE HYDROSPHERE

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
F1 explain the characteristics and significance of the atmosphere	❑ demonstrate and explain the relationships among air volume, density, pressure, and temperature ❑ describe the effects of the sun's radiation on the atmosphere, including the greenhouse effect, conduction, convection, and radiation ❑ describe the structure of the atmosphere and the abundance of various substances in it ❑ predict the effects of changing the composition of the atmosphere (e.g., ozone depletion, adding water vapour, greenhouse gases, and pollutants) ❑ outline the complex wind circulation patterns over the Earth ❑ describe wind deflection due to the Coriolis effect
F2 describe the function of the hydrologic cycle	❑ illustrate the hydrologic cycle, including how temperature and pressure are related to phase changes of water in the atmosphere and to relative humidity ❑ identify the characteristics of the main kinds of air masses (e.g., continental polar) and the resulting weather patterns
F3 relate the processes associated with weathering and erosion to the resulting features	❑ distinguish between weathering and erosion ❑ use examples (e.g., exfoliation) to distinguish between mechanical and chemical weathering (including weathering by biological organisms) ❑ describe the origin and function of soil ❑ identify the processes (e.g., abrasion, dissolution) by which glaciers, running water, wind, and wave action erode rock and sediment ❑ differentiate between erosional and depositional features formed by glaciers, running water, wind, and wave action
F4 describe features and processes associated with physical oceanography	❑ identify techniques used to study the ocean and ocean floor (e.g., remote sensing) ❑ diagram a typical ocean floor including continental margins, mid-ocean rise (ridge), rift, trench, abyssal plain, and seamounts ❑ relate the formation of turbidity currents to submarine canyons ❑ identify the physical properties of sea water (e.g., temperature, density) ❑ explain the general pattern of major currents in oceans

Student Achievement

Geology 12

Key Elements: Introduction to Geology

Estimated Time: 3–5 hours

By the end of this course, students will understand the methods, applications, and key principles of geology as a discipline.

Vocabulary

geophysical, nebular theory, uniformitarianism

Knowledge

- differences between geology and other sciences
- uniformitarianism
- nebular theory
- varying rates of change in geological processes
- careers related to geology
- methods and tools used to obtain and analyse information about the Earth
- Earth's unique characteristics relative to other planets

Skills and Attitudes

- calculate rates of change associated with geological processes

INTRODUCTION TO GEOLOGY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
A1 explain the significance of geology as a discipline	❑ describe unique aspects of geology (e.g., range of embedded scientific disciplines, long timeframes that are too large to reproduce in the lab) ❑ identify various careers associated with geological technologies and sciences ❑ describe methods of obtaining, displaying, and analysing information about the Earth (e.g., geophysical surveys) ❑ recognize the significance of uniformitarianism as a fundamental principle of geology ❑ recognize and calculate the varying rates of change associated with geological processes ❑ relate Earth's geology to – its formation (with reference to the nebular theory) – the densities, compositions, and distribution of planets in our solar system

Key Elements: Earth Materials (Rocks and Minerals)

Estimated Time: 25–30 hours

By the end of this course, students will be able to distinguish and classify rocks and minerals and explain their formation.

Vocabulary

aa, amphibole, andesite, asbestos, ash flow, augite, azurite, basalt, batholith, biochemical, bioclastic, biotite, bornite, breccia, Bowen's Reaction Series, calcite, carbonate, chalcopyrite, chert, cinder cone, clastic, cleavage, coal, columnar jointing, composite volcano, conglomerate, contact, country rock, crossbedding, crystal, deposition, dike, diorite, dome, extrusive, feldspar, felsic, fluorite, foliate, fracture, gabbro, galena, garnet, geochemical, gneiss, gold, granite, graphite, graded bedding, gypsum, halide, halite, hardness, hematite, hornblende, hydrothermal, igneous, intrusive, intrusion, intermediate, lahar, lava plateau, limestone, limonite, lithification, lustre, mafic, magma, magnetite, malachite, marble, metaconglomerate, metamorphic, metamorphic grade, Mohs' hardness scale, molybdenite, mud cracks, muscovite, native elements, nuée ardente, obsidian, olivine, oxide, pahoehoe, pegmatite, peridotite, permeability, phyllite, pillow lava, plagioclase, pluton, plutonic, porosity, precipitate, porphyry, potassium feldspar, pumice, pyrite, pyroclastic, pyroxene, quartz, quartzite, rhyolite, ripple marks, rock cycle, sandstone, schist, sedimentary, shale, shield volcano, silicates, sill, siltstone, silver, solution, sorting, specific gravity, sphalerite, stratification, streak, stock, sulphates, sulphides, talc, tuff, ultramafic, varves, vesicular, volcanic, volcano, xenolith

Knowledge

- the rock cycle
- types of rocks and minerals and their distinguishing features
- Bowen's Reaction Series
- formation of igneous, sedimentary, and metamorphic rocks

Skills and Attitudes

- identify and classify rocks and minerals
- identify rock formations and features and relate them to their environments
- apply Bowen's Reaction Series

EARTH MATERIALS (ROCKS AND MINERALS)

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
B1 differentiate between igneous, sedimentary, and metamorphic rocks	❑ describe the formation of igneous, sedimentary, and metamorphic rocks ❑ classify rocks as igneous, sedimentary, or metamorphic ❑ interpret a rock cycle diagram
B2 classify minerals and mineral groups according to their chemical composition	❑ outline the importance and abundance of various elements in the Earth's crust ❑ differentiate between rocks and minerals ❑ demonstrate an ability to use the following properties in identifying minerals: – simple crystal shape – cleavage – fracture – hardness (with reference to Mohs' hardness scale) – specific gravity (relative density) – colour – streak – lustre – special properties (e.g., magnetism, reaction to dilute HCl) ❑ describe, identify, and classify the following minerals, using references or tests as appropriate: – *silicates* (quartz and varieties of quartz; potassium feldspar and plagioclase feldspar; muscovite, biotite, and talc; augite/pyroxene and hornblende/amphibole; garnet; asbestos; olivine) – *oxides* (hematite, limonite, magnetite) – *sulphides* (pyrite, chalcopyrite, galena, sphalerite, molybdenite, bornite) – *carbonates* (calcite, malachite, azurite) – *sulphates* (gypsum) – *phosphates* (apatite) – *native elements* (graphite, gold) – *halides* (halite, fluorite)
Organizer 'Earth Materials (Rocks and Minerals)' continued on page 44	

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Earth Materials (Rocks and Minerals)' continued from page 43	
B3 compare igneous rocks	❑ describe factors affecting crystal size (e.g., cooling rate, flow behaviour) ❑ relate texture to rate of crystallization for extrusive (volcanic) and intrusive (plutonic) igneous rocks ❑ identify and classify igneous rocks according to their texture (coarse or fine grained, vesicular, glassy, fragmental-pyroclastic) and composition (felsic, intermediate, mafic) ❑ describe the features of the following igneous rocks: granite, diorite, gabbro, peridotite (ultramafic), andesite, tuff, rhyolite, basalt, volcanic breccia, obsidian, pegmatite, pumice, porphyry ❑ explain the order of crystallization of minerals from a magma (Bowen's reaction series)
B4 compare igneous features	❑ distinguish among the following volcanic features: shield volcanoes, cinder cones, composite volcanoes, columnar jointing, volcanic domes, lava plateaus ❑ distinguish among the following types of extrusive materials by their composition, flow behaviours, and resulting rock or feature: lava, ash flows or nuée ardente, pillow lava, aa, pahoehoe ❑ identify and describe batholiths, sills, dikes, xenoliths, stocks, and plutons
B5 compare sedimentary rocks *Organizer 'Earth Materials (Rocks and Minerals)' continued on page 45*	❑ outline the origin and process of formation of sedimentary rocks ❑ contrast clastic sediments and chemical (precipitate or biochemical) sediments and the rocks they become ❑ describe the features of and identify the following sedimentary rocks: – conglomerate – breccia – sandstone – siltstone – shale – limestone – chert – gypsum – rock salt – coal

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Earth Materials (Rocks and Minerals)' continued from page 44	
B6 relate sedimentary features to their depositional environments	❑ identify the following sedimentary features: stratification, crossbedding, ripple marks, mud cracks, graded bedding, varves ❑ describe sedimentary features that affect porosity and permeability ❑ relate particle size, shape, sorting, fossils, and organic structures to particular depositional environments
B7 compare metamorphic rocks	❑ relate the types and characteristics of metamorphic rocks to parent rock, temperature, pressure, and chemical conditions ❑ describe the features of the following metamorphic rocks: slate, phyllite, schist, gneiss, metaconglomerate (e.g., stretched pebble), quartzite, marble ❑ contrast the two major categories of metamorphic rocks: foliated and non-foliated ❑ contrast the two types of metamorphism: contact and regional ❑ describe changes that occur in the country rock and in the intrusion at a contact ❑ explain the significance of metamorphic grade (e.g., with reference to coal)

Key Elements: Earth Resources

Estimated Time: 5–7 hours

By the end of this course, students will understand the origin and significance of Earth resources.

Vocabulary

coal, conservation, evaporite, geochemical, geophysical, grade, hydrothermal, natural gas, oil, ore, permeability, petroleum, placer, porosity, reservoir

Knowledge

- origin and economic importance of Earth resources
- exploration and development of resources

Skills and Attitudes

- predict the location of geological resources from geological data
- analyse the effects and economic significance of the extraction of geological resources
- assess the risks and benefits of resource extraction

EARTH RESOURCES

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
C1 trace the origins of geological resources including mineral deposits, coal, petroleum, and natural gas	❑ describe the origin of the following resources: – mineral deposits including hydrothermal, evaporite, placer (sediment and gravel) – petroleum, natural gas – coal (low to high grade) ❑ explain the role of permeability and porosity in creating oil and gas reservoirs and traps
C2 explain the significance of geological resources and their economic development	❑ describe how simple geochemical or geophysical data can be used to locate various geological resources ❑ explain how a variety of factors can be used to determine whether or not it is economically feasible to extract a geological resource (e.g., price, concentration, accessibility, size, and environmental considerations) ❑ describe the uses of geological resources in British Columbia, including chalcopyrite, galena, gold, sphalerite, molybdenite, gypsum, limestone, construction materials, coal, oil, and gas

Key Elements: Geological Time

Estimated Time: 18–22 hours

By the end of this course, students will be able to relate relative and absolute age dating and the fossil record to the development of the geological time scale.

Vocabulary

absolute age, adaptive radiation, arthropoda, brachiopoda, carbonization, cast, colenterata, conodont, correlate, cross-cutting, cross section, echinodermata, evolution, faunal succession, foraminifera, fossil, fossil assemblage, fossil record, geological era, geological time scale, graptolite, half-life, index fossil, invertebrata, mold, mollusca, natural selection, original horizontality, permineralization, punctuated equilibrium, radiometric, relative age, stratification, stratigraphy, superposition, trace fossil, trilobite, uniformitarianism, unconformity, vertebrata

Knowledge

- rates of geological processes
- age dating
- geological time scale
- fossil record

Skills and Attitudes

- interpret and correlate sequences of rock
- determine absolute age using appropriate data (half-life graph)

GEOLOGICAL TIME

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
D1 relate relative age dating to the development of the Geological Time Scale *Organizer 'Geological Time'* *continued on page 50*	❑ define *relative age* ❑ determine the relative ages of different formations using the principles of – faunal succession – uniformitarianism – original horizontality – cross-cutting relationships – correlation – superposition – included fragments ❑ give examples of unconformities and interpret their significance (i.e., indicate a break in the time record) ❑ interpret the history of a sequence of rock units and structures from a cross-section, photograph, or diagram ❑ sequence major events in the Earth's history, such as – formation of Earth – formation of oldest rocks – beginning of each geological era – earliest recorded life – invertebrates dominated – first land plants – fishes dominated – formation of coal forests – reptiles dominated – amphibians dominated – mammals dominated – appearance of flowering plants – appearance of humans – Pleistocene glaciation – Rocky Mountain orogeny ❑ determine the geological history of Earth and other terrestrial bodies within the solar system, using relative age dating techniques

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Geological Time' *continued from page 49*	
D2 contrast relative and absolute age dating	❑ define *absolute age dating* ❑ explain how the half-lives of radioactive elements are used in estimating the ages of materials ❑ determine the age of a sample using radiometric data ❑ evaluate the sources of error in estimating a radiometric age (e.g., loss of daughter material) ❑ determine the approximate age range of a sedimentary rock using absolute age data from associated intrusive or extrusive igneous rocks ❑ use the Geological Time Scale to help interpret the history of a sequence of rocks
D3 relate the fossil record to the Geological Time Scale	❑ define *fossil* ❑ identify the conditions necessary for the preservation of fossils (e.g., rapid burial, low energy environment) ❑ describe the processes of original preservation, carbonization, replacement, permineralization, mold formation, and cast formation ❑ differentiate between fossils and trace fossils ❑ analyse the characteristics of a fossil that would make a good index fossil (e.g., short time range) ❑ identify and classify the following fossils using appropriate references: – foraminifera – mollusca – brachiopoda – echinodermata – arthropoda (trilobites) – coelenterata (corals) – vertebrata – graptolites – conodonts – plants ❑ relate the principles of evolution (natural selection, adaptive radiation, punctuated equilibrium) to the interpretation of the fossil record ❑ describe the probable environment suggested or indicated by a fossil assemblage ❑ correlate sequences of rock with each other using index fossils or rock data

Key Elements: Internal Processes and Plate Tectonic Theory

Estimated Time: 25–30 hours

By the end of this course, students will be able to explain the development and significance of plate tectonics, recognize and interpret geological structures, and identify applications of seismology.

Vocabulary

anticline, basin, block diagram, compressional force, confined water table, continental drift, convergent, convection, cross section, dilatancy, dip, dip-slip, divergent, dome, earthquake, elastic rebound, epicentre, fault, fault creep, focus, fold, geological map, hotspot, intensity, isostacy, joint, liquefaction, lithosphere, magnitude, Mercalli scale, normal fault, orogeny, overturned fold, plate tectonic theory, recumbent fold, reverse fault, Richter scale, shear force, sea floor spreading, seismic, seismic gap, seismograph, slab pull, strike, strike-slip, subduction, syncline, tensional force, terrestrial, thrust fault, transform, tsunami, unconformity

Knowledge

- seismology
- Earth layers and tectonic plates
- rock structures
- plate tectonic theory

Skills and Attitudes

- interpret graphs (time-distance graph)
- locate epicentres
- interpret cross sections, block diagrams, and geological maps
- predict and interpret dynamics of plate tectonics
- assess hazards associated with plate motion and methods for preventing or reducing possible harm to humans

INTERNAL PROCESSES AND PLATE TECTONIC THEORY

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
E1 analyse and evaluate applications of seismology	❑ describe fault creep and elastic rebound as they relate to seismic activity ❑ describe the generation and propagation of body waves (P- and S-waves) and surface waves (L-waves) ❑ distinguish between magnitude and intensity ❑ compare and contrast the Richter and Mercalli scales ❑ use seismograms to determine the distance and location of an earthquake ❑ assess the seismic risks for a particular area using – geographic location – topography – ground strength – rock types – proximity to faults – construction design ❑ evaluate methods of earthquake prediction (e.g., dilatancy data, seismic gap, animal behaviour)
E2 demonstrate knowledge of the Earth's layers	❑ give evidence to support the conclusion that the Earth is layered ❑ diagram or model the interior of the Earth, labelling all principal parts and showing the approximate thickness of each layer ❑ describe the characteristics of the various layers of the Earth
E3 relate rock formations and structures to the forces that create them	❑ describe the factors (e.g., temperature, pressure, chemical composition) that determine whether a rock will behave in a plastic or brittle manner when stressed ❑ distinguish between faults and joints ❑ distinguish between dip-slip (normal, reverse, thrust), strike-slip (left lateral, right lateral), and transform faults from maps, cross-sections, or photographs ❑ relate compressional, tensional, and shear forces to the various types of faults and folds ❑ interpret the dip and strike of an outcrop to determine subsurface structures ❑ diagram domes, basins, anticlines, synclines, over-turned folds, and unconformities, and identify these structures in maps, cross-sections, or photographs ❑ show the interrelationships among a geological map, a cross-section, a block diagram, and the subsurface structure and geological history of an area (e.g., construct a geological map using appropriate data)

Organizer 'Internal Processes and Plate Tectonic Theory' continued on page 53

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Internal Processes and Plate Tectonic Theory' continued from page 52	
E4 analyse structures, processes, and evidence that support plate tectonic theory	❑ outline evidence for continental drift theory ❑ explain seafloor spreading and outline evidence to support it ❑ describe lithospheric plate motion and convergent, divergent, and transform fault plate boundaries ❑ relate plate motion to mantle convection and slab pull ❑ describe the origin of magma formed during plate tectonic processes ❑ relate volcanic activities and features to plate tectonic theory ❑ describe the geological activities that occur at lithospheric plate boundaries (e.g., earthquakes) ❑ relate the rock cycle to plate tectonics ❑ analyse the adjustment of the lithosphere to changes in loads associated with volcanism, mountain building, erosion, and glaciation by using the concept of isostasy ❑ relate scientific understanding of terrestrial bodies within the solar system to tectonic features, magnetism, cratering, and internal structures on Earth

Key Elements: Surface Processes and the Hydrosphere

Estimated Time: 14–16 hours

By the end of this course, students will be able to analyse features and processes associated with the hydrosphere.

Vocabulary

aquifer, arête, avalanche, bedload, Bowen's Reaction Series, chemical weathering, cirque, confined water table, conservation, debris flow, deposition, discharge, drumlin, erosion, erratic, esker, glaciation, gradient, ground water, hanging valley, horn, impermeable, kame, kame terrace, mass wasting, meander, mechanical weathering, moraine, perched water table, permeability, physical weathering, porosity, saltation, soil creep, solution, sorting, stream load, suspension, water table, weathering, zone of aeration, zone of saturation

Knowledge

- weathering, erosion and sediment deposition
- features and processes associated with the hydrosphere
- features and processes associated with streams, glaciers, and ground water

Skills and Attitudes

- assess effects of human activities on ground water and mass wasting
- assess sustainability of various human uses of the hydrosphere

SURFACE PROCESSES AND THE HYDROSPHERE

Prescribed Learning Outcomes	Suggested Achievement Indicators
It is expected that students will:	*The following set of indicators may be used to assess student achievement for each corresponding prescribed learning outcome.* *Students who have fully met the prescribed learning outcome are able to:*
F1 analyse features and processes associated with weathering and erosion	❑ distinguish between weathering and erosion ❑ describe the processes and effects of physical (mechanical) and chemical weathering, including weathering by biological organisms ❑ relate Bowen's Reaction Series to a mineral's susceptibility to chemical weathering ❑ identify types and causes of mass wasting (e.g., debris flow) ❑ evaluate methods to control mass wasting (e.g., retaining walls) ❑ compare features and processes associated with weathering and erosion on Earth with those on other terrestrial bodies (e.g., Mars, Moon)
F2 analyse features and processes associated with stream erosion and deposition *Organizer 'Surface Processes and the Hydrosphere' continued on page 56*	❑ identify the three types of stream load (solution, suspension, bedload) and describe how each type moves in a stream ❑ relate stream velocity to sediment sorting ❑ distinguish between stream, glacial, and wind deposits, with reference to particle size and shape, degree of sorting, and nature of sedimentary structures ❑ relate factors such as load, gradient, discharge, channel shape, sediment composition, and human activities to erosion and deposition by streams

Prescribed Learning Outcomes	Suggested Achievement Indicators
Organizer 'Surface Processes and the Hydrosphere' continued from page 55	
F3 evaluate the importance of ground water	❑ describe features associated with subsurface water, including – water table – zone of saturation – zone of aeration – perched and confined water tables – aquifers – impermeable layers ❑ describe how the abundance, availability, and movement of water can be affected by porosity and permeability of ground materials ❑ relate the position of the water table to the topographic profile ❑ describe how the following human activities affect the quality and quantity of ground water: – urbanization – waste disposal – agriculture – conservation
F4 explain the processes and features associated with glaciation	❑ identify a variety of erosional features, including – U-shaped valley – hanging valley – cirque – horn – arête – glacial striations ❑ identify a variety of depositional features, including – glacial erratic – moraine (ground, recessional, terminal, lateral, and medial) – drumlin – kame – kame terrace – esker ❑ explain the formation of alpine and continental glacial features ❑ reconstruct past glacial positions using erosional and depositional features

Learning Resources

Earth Sciences 11 and Geology 12

This section contains general information on learning resources, and provides a link to the titles, descriptions, and ordering information for the recommended learning resources in the Earth Science 11 Geology 12 Grade Collections.

What Are Recommended Learning Resources?
Recommended learning resources are resources that have undergone a provincial evaluation process using teacher evaluators and have Minister's Order granting them provincial recommended status. These resources may include print, video, software and CD-ROMs, games and manipulatives, and other multimedia formats. They are generally materials suitable for student use, but may also include information aimed primarily at teachers.

Information about the recommended resources is organized in the format of a Grade Collection. A Grade Collection can be regarded as a "starter set" of basic resources to deliver the curriculum. In many cases, the Grade Collection provides a choice of more than one resource to support curriculum organizers, enabling teachers to select resources that best suit different teaching and learning styles. Teachers may also wish to supplement Grade Collection resources with locally approved materials.

How Can Teachers Choose Learning Resources to Meet Their Classroom Needs?
Teachers must use either:

- provincially recommended resources OR
- resources that have been evaluated through a local, board-approved process

Prior to selecting and purchasing new learning resources, an inventory of resources that are already available should be established through consultation with the school and district resource centres. The ministry also works with school districts to negotiate cost-effective access to various learning resources.

What Are the Criteria Used to Evaluate Learning Resources?
The Ministry of Education facilitates the evaluation of learning resources that support BC curricula, and that will be used by teachers and/or students for instructional and assessment purposes. Evaluation criteria focus on content, instructional design, technical considerations, and social considerations.

Additional information concerning the review and selection of learning resources is available from the ministry publication, *Evaluating, Selecting and Managing Learning Resources: A Guide* (Revised 2002) www.bced.gov.bc.ca/irp/resdocs/esm_guide.pdf

What Funding is Available for Purchasing Learning Resources?
As part of the selection process, teachers should be aware of school and district funding policies and procedures to determine how much money is available for their needs. Funding for various purposes, including the purchase of learning resources, is provided to school districts. Learning resource selection should be viewed as an ongoing process that requires a determination of needs, as well as long-term planning to co-ordinate individual goals and local priorities.

What Kinds of Resources Are Found in a Grade Collection?
The Grade Collection charts list the recommended learning resources by media format, showing links to the curriculum organizers and suborganizers. Each chart is followed by an annotated bibliography. Teachers should check with suppliers for complete and up-to-date ordering information. Most suppliers maintain web sites that are easy to access.

Earth Science 11 Geology 12 Grade Collections

The Grade Collections for Earth Science 11 Geology 12 list the recommended learning resources for these courses. Resources previously recommended for the 1995 version of the curriculum, where still valid, continue to support this reformatted IRP. The ministry updates the Grade Collections on a regular basis as new resources are developed and evaluated.

Please check the following ministry web site for the most current list of recommended learning resources in the Earth Science 11 Geology 12 Grade Collections: www.bced.gov.bc.ca/irp_resources/lr/resource/gradcoll.htm