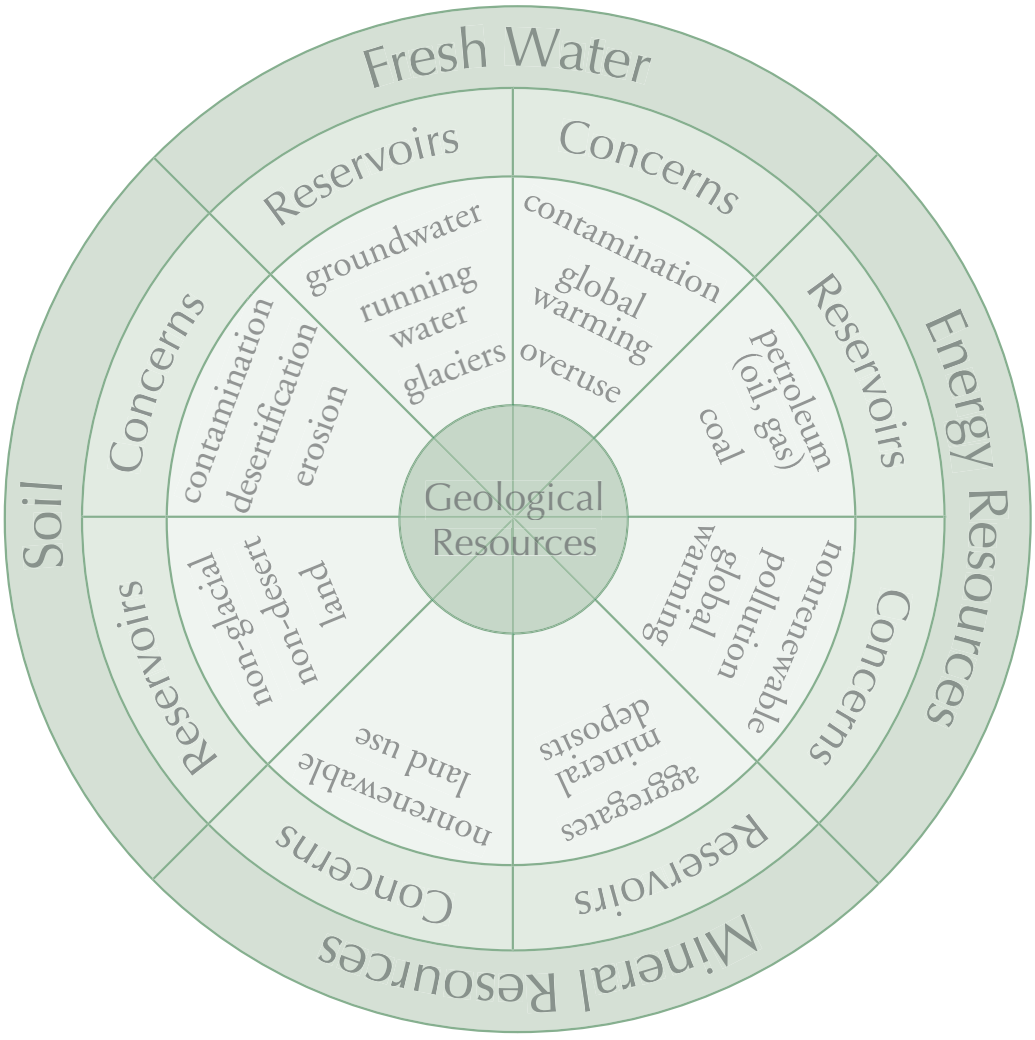
# The Nature of Geology
# Unit 1



# WHAT IS GEOLOGY?

## LESSON 1.1

*'THIS EARTH WE KNOW.*
*THE EARTH DOES NOT BELONG TO US;*
*WE BELONG TO THE EARTH.*
*THIS WE KNOW.*
*ALL THINGS ARE CONNECTED*
*LIKE THE BLOOD WHICH UNITES ONE FAMILY.*
*ALL THINGS ARE CONNECTED.'*

*CHIEF SEATTLE (1854)*

## SPECIFIC CURRICULUM 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)

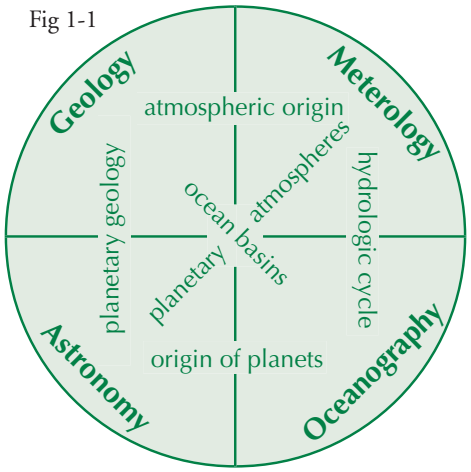
## BACKGROUND READING:

What images come to mind when the word geology is spoken? For most people, the word geology conjures up images of volcanoes, rocks, earthquake damage, landscapes, etc. These images are not entirely wrong, but they would misrepresent the science of geology. *Geology*, from the Greek words *geo* and *logos*, literally means the study of the Earth. Geology includes investigations into Earth's make-up - rock, water, air and life and the internal and external processes that have shaped and continue to shape the Earth. A better expression for this natural science is Earth Sciences. The science of geology is actually a component of Earth Sciences (Figure 1-1).

Earth Sciences also includes oceanography, meteorology, and astronomy. Together these disciplines provide a holistic view of our planet Earth. Today's earth scientists are mapping the ocean floor, discovering new mineral and energy resources, finding methods to predict earthquakes and volcanic eruptions, finding new groundwater resources, describing and attempting to solve environmental problems, and so on.

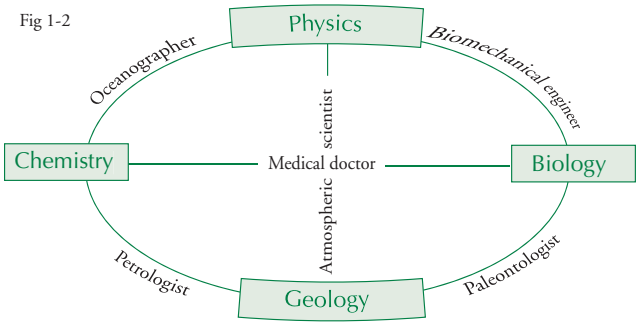
Figure 1.1 depicts various areas of study in Earth Sciences. Notice that Earth Science topics overlap.

Fig 1-1




Geology is a science, just like physics, chemistry and biology. High schools tend to isolate these sciences by teaching them separately. However, the Earth does not operate in this way. The planet cannot be described using one science. All sciences on Earth are interconnected and do not operate in isolation. The diagram on the next page visually depicts the interconnection and gives examples of professions that bridge more than one science. For example, an oceanographer studying a wave will use the laws of physics to describe the wave motion, yet take into account the nature of water and the water molecule. A study of the water molecule would fall under the realm of chemistry.

Fig 1-2




*Consider the following scenario:*

Water levels in a river rise from snowmelt, flow rates increase and sediment from the river banks wash downriver. Along with debris, sediment deposits at the mouth of the river, forming a fertile floodplain. Vegetation quickly establishes itself on the floodplain. With the subsidence of the snowmelt, the river flow returns to normal levels. However, the course of the river has changed from a meandering shallow stream to a straighter, deeply cut, river valley. New pools have formed and several species of fish have congregated, feeding on small insects, who in turn feed on bacteria in decomposing plant debris.

This natural scenario cannot be described with one science alone. However, for easier study and manageability, natural systems are broken down into components. For example, the above scenario involves geology as an aspect of Earth (its surface). When you look at the scenario more closely, you can see the interconnection of the other sciences. A study of the fish species inhabiting the new pools is primarily a study in biology. The change in the discharge or flow of the river involves movement, which is a study in physics. The increased fertility (because of the addition of minerals) of the floodplain soil is a study in chemistry.

So, although the scenario is a geological one, you can clearly see the connection of the other sciences. Geology is a science that operates with other sciences in an attempt to explain our planet's appearance and make-up. For that reason, geology is often called a hybrid science.

## STUDENT ASSIGNMENT

1. For each of the photos listed below, you are to:
   a) describe the natural scenario depicted by the photograph
   b) describe how all sciences (geology, biology, chemistry and physics) are connected by the scenario. In other words, how would a geologist view the scenario? A biologist? A chemist? A physicist?

   *Photos to be used from your Physical Geology textbook*:

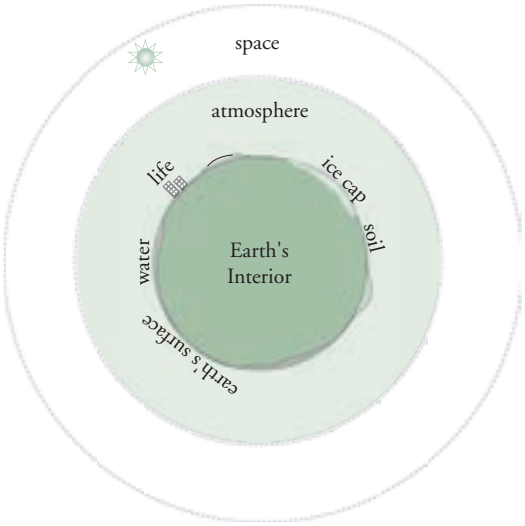
   i) Figure 11.14A; page 268
   ii) Figure 13.14A; page 323
   iii) Figure 18.1B; page 441
   iv) Figure 7.18; page 168
   v) Figure 16.15B; page 393

# GEOLOGY IN YOUR LIFE

## LESSON 1.2

*'HURT NOT THE EARTH,*
*NEITHER THE SEA,*
*NOR THE TREES...'*

*REVELATION 7:3*




## SPECIFIC CURRICULUM 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)

## BACKGROUND READING

*Geology* is a very broad science and it encompasses a range of other science disciplines. You cannot study or discuss geology without also including *physics*, *chemistry*, and/or *biology*. Planet Earth is a very complex system and its study requires a perspective from all points of view, the geological, the biological, the chemical, and the physical. No single discipline can be used to study the Earth in its entirety.

The study of the Earth can be considered in terms of layers as depicted in the diagram above right. The *Earth's interior*, which itself is layered, forms the innermost component of the Earth system. The *Earth's surface* includes features of the landscape, water as liquid and ice, and the majority of the biosphere or life. The *atmospheric layer* surrounds Earth to a height of up to 200 kilometres. The final layer is the Solar System our planet belongs to, and the Universe beyond. Each of these layers of Earth impacts our lives. Each of these layers is composed of smaller layers. For example, the Earth's atmosphere can be divided into four broad layers - the troposphere (the layer in which we live), the stratosphere, the mesosphere, and the thermosphere.

Geology studies the processes that have created and shaped planet Earth - from the iron-rich inner core to the boundary between the atmosphere and outer space. Living on the Earth's surface the bulk of our knowledge is of the processes occurring at the Earth's surface. These are the processes that have the greatest impact on our lives. However, the study of all of Earth's layers forms the basis of the science of geology. For this course, the study of Earth has been compiled into five major overlapping themes:

- the materials that form our planet
- the internal processes that have formed and continue to modify Earth's interior

- the external processes that formed and continue to modify Earth's surface
- historical geology and the concept of geological time
- environmental issues (both human-induced and natural) and their impact

Notice throughout the course that these themes are interconnected. For example, Mt. Pinatubo's eruption in 1991 had its origins long before 1991. Extremely slow processes occurring in the Earth's interior (e.g plate subduction and melting) eventually led to the formation of Mt. Pinatubo and the expulsion of lava and volcanic ash. The lava expelled buried much of the area around the volcano, including some habited areas. Almost 400 people were killed. The volcanic ash emitted by Mt. Pinatubo was so great in volume that it caused a temporary decrease in global atmospheric temperatures for two years.

Why study geology? By studying geology, we have a clearer (but not complete) picture of our planet and the processes that shape its interior and surface. Understanding these processes (both past and present), allows us to foresee potential problems (such as earthquakes, landslides, etc.), and mitigate the effects of those problems, perhaps even avoid them. We gain a better appreciation for the planet's resources, their use by humans, and the effects of their extraction from the Earth. Finally, geology can allow us to reflect on the changes our presence has imposed on the planet, and hopefully allow us to understand that we are just one small part of the Earth system. While we are a small part of the Earth system, we have altered the planet more than any other.

It is the goal of this course to provide you with the information necessary to make informed decisions concerning your environment, whether its the development of a waste disposal site in your neighbourhood, the construction of a dam on a river for a water supply, or the introduction of legislation limiting the release of carbon dioxide from motor vehicle exhaust fumes. A study of geology can provide you with answers to some of your questions and/or allow you to formulate your questions for society's decision makers.

## TEXTBOOK SUPPORT:

*"Who Needs Geology?"* on pages 4-8, and 10.
*"An Overview of Physical Geology-Important Concepts"* on pages 10, 12-16, and 19.
*"Geologic Time"* on page 19.

## STUDENT ASSIGNMENT

1. As stated in the *Background Reading* section of the lesson, this course deals with five main themes. These are:

   - the materials that form our planet
   - the internal processes that have formed and continue to modify Earth's interior
   - the external processes that have formed and continue to modify Earth's surface
   - historical geology and the concept of geological time
   - environmental issues (both human-induced and natural) and their impact

The list below presents some of the topics that will be studied in detail in this course. It is your task to assign the topic to the one or more of the themes previously stated. By performing this exercise, it will clarify how Earth processes are interconnected.

For example, volcanism - this topic relates to several of the themes. First, volcanism produces rock from lava which transforms the surface of the Earth. This relates both to Earth materials and surficial processes. However, the workings of the volcano begin deep within the Earth and is a part of internal processes. Depending on the extent, style, and location, volcanism may have an environmental impact.

For each of the following, list the theme(s) for each topic and explain your reasoning.

a) the extinction of the dinosaurs 66 million years ago
b) the contamination of groundwater by a landfill site
c) the formation of coal in tropical swampy environments
d) magnetism produced by the Earth's liquid outer core
e) radiometric dating of crystals within rocks

# EARTH'S SPHERES

## LESSON 1.3

*'ALL PARTS OF THE SYSTEM MUST BE CONSTRUCTED WITH REFERENCE TO ALL OTHER PARTS.*

*THE FAILURE OF ONE PART TO COOPERATE WITH THE OTHER PARTS DISORGANIZES THE WHOLE*

*AND RENDERS IT INOPERATIVE FOR THE PURPOSE INTENDED.'*

*THOMAS EDISON - INVENTOR (1847-1931)*

## SPECIFIC CURRICULUM OUTCOMES:

*STUDENTS WILL BE EXPECTED TO:*

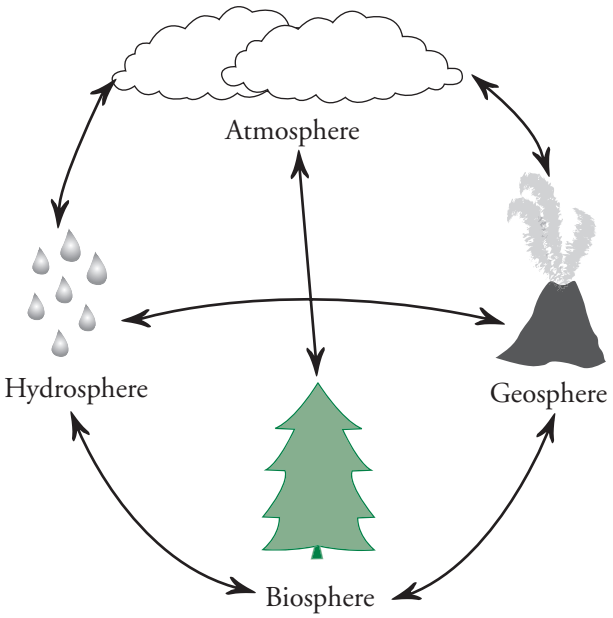
- describe and give examples of interrelationships between Earth's spheres (360-6)

## BACKGROUND READING

Earth can be viewed as a system with various components or parts working together to form a whole, much like a human body requires the functioning of various organs, muscles, hormones, etc. Each component of the human body has a specific function (or several), yet that particular component does not operate in isolation. Human cells require oxygen, which is supplied by the blood. The blood in turn is circulated through the human body by the heart. Oxygen is supplied by the lungs. When one component is compromised, others are affected, often to the detriment of the entire body. The Earth operates in a similar fashion. Its various components rarely operate in isolation.

Planet Earth is composed of four parts - the *geosphere* (sometimes called the lithosphere), the *hydrosphere*, the *atmosphere*, and the *biosphere*. The *geosphere*, or solid Earth, includes all the rock on planet Earth (including molten material). The *hydrosphere* or water sphere includes all water (liquid, vapour or solid) on Earth. The *atmosphere* describes the layer of gases surrounding Earth and the *biosphere* includes all living things on Earth.

Although we can categorize objects, materials, and processes on Earth, it is important to remember that these spheres are not isolated from each other. On the contrary, in the everyday workings of planet Earth, the spheres are interconnected.




Take soil for example. Soil is defined as material that can support plant life. It is actually composed of four substances: weathered fragments of rock (*geosphere*), water (*hydrosphere*), bubbles of air (*atmosphere*), and organic material (*biosphere*). Soil is an amalgamation of all four of Earth's spheres.

Without one of these spheres, soil would not be able to support plant life.

## STUDENT ASSIGNMENT

1. Construct a four column table with the headings *Geosphere*, *Hydrosphere*, *Atmosphere*, and *Biosphere*. Place each item in the following list in the appropriate column. Note that some items may belong to more than one sphere.

| | |
|---|---|
| ozone molecule | volcanic ash |
| sheet of paper | gold ring |
| Atlantic lobster | St. Lawrence River |
| wind | sand |
| dinosaur fossil | cloud |
| glacier | decaying oak leaf |

2. The following newspaper headlines, although fictional, represent possible events on planet Earth. For each headline, clearly describe, in a short paragraph, the relationship between all of the spheres involved.

   For example:
   ***Underwater Earthquake in the South Pacific Ocean Creates Massive Tsunami***

   Answer: The earthquake is created with the movement of the Earth's upper layers (lithosphere). The earthquake actually occurs in the geosphere. Since the earthquake occurred underwater, the movement created affected the ocean water (part of the hydrosphere) and created a tsunami. The geosphere (earthquake) created a disturbance in the hydrosphere (tsunami).

   a) ***Flood Waters Force the Evacuation of Residents of Anyville, Nova Scotia***

   b) ***Mt. Photo's Violent Eruption Leads to Lower Global Atmospheric Temperatures***

   c) ***Canadian Geologist Discovers Large Diamond Deposit in Northern Canada***

   d) ***Giant Clams Feed on Bacteria at Underwater Volcanoes***

   e) ***Hurricane Threatens Caribbean Coral Reefs***

# GEOLOGICAL RESOURCES

## LESSON 1.4

*'THERE ARE STRANGE THINGS DONE IN THE MIDNIGHT SUN,*
*BY THE MEN WHO TOIL FOR GOLD'*

*ROBERT SERVICE - WRITER (1874-1958)*

## SPECIFIC CURRICULUM OUTCOMES:

*STUDENTS WILL BE EXPECTED TO:*

- provide examples of the relevance of mining to everyday materials used in our lives (117-5)
- explain how a knowledge of geology might influence our decisions about how we use Earth's resources (360-7)

## BACKGROUND READING

Our western culture depends on the Earth for energy resources and materials we use every day. When you think of *geological resources*, images of metals, minerals, and fossil fuels come to mind. However, there are other objects in our environment that are not directly from the geosphere, that require materials from the geosphere for their growth, processing, etc.

Consider the natural fibres in your clothes, e.g. cotton. These are linked to mining because farmers growing the natural fibers use fertilizers. Fertilizers contain minerals that are extracted from Earth by mining. Another example to consider is wood products, e.g. paper, furniture, etc. These are not the products of mining, but the harvesting of forests does require the use of equipment and machinery fabricated from metal. The fuel required by the machinery is also extracted from the Earth. The majority of objects in our everyday environment are either directly or indirectly dependent on either energy or mineral resources from planet Earth.

It has been estimated that for each North American, a total of 15,000 kilograms of Earth resources are extracted each year. These 15,000 kilograms include 3000 kg of sand and gravel, 500 kg of iron, 20 kg of aluminium, 8 kg of copper and over 8000 kg of energy resources (coal and petroleum). We are a very consumptive society.

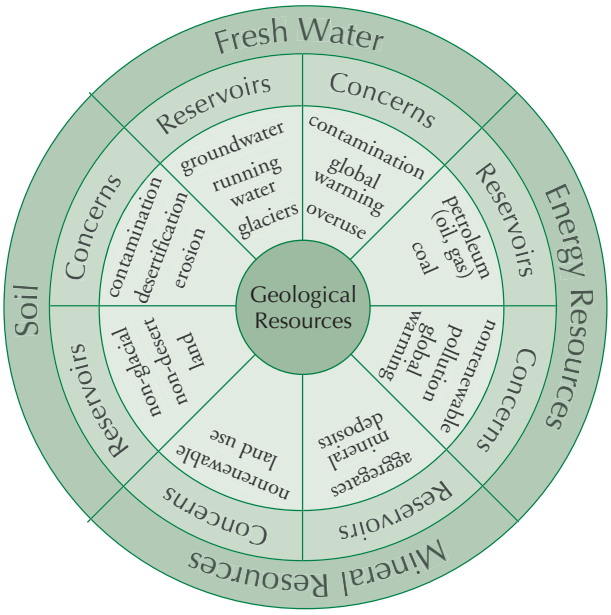
These resources are not man-made - they have only one source - the Earth itself. Energy and mineral resources are extracted from the Earth by mining. As society uses these resources, their supply must be replenished with continued mining and/or the search for new previously untapped reserves.

The geologic resources extracted from the Earth are *nonrenewable* - these resources will not be replenished within the Earth in our lifetime. As more resources are extracted from the geosphere, there is less of those resources within the geosphere.

Today, the world's population, particularly the western developed world, is faced with diminishing energy resources. Many argue that the diminishing supply of energy resources has an impact on domestic and foreign economic policies. Eventually, the world's population will also be faced with diminishing mineral resources.

As a result, people will have to make informed decisions on the continued extraction of geologic resources, the possible use of substitutes for those resources, and the role of recycling in our environment. An understanding of some of the basics of geology may provide people with the information necessary to make informed decisions.

The figure below provides an overview of the Earth's geologic resources, the sources of these resources, and modern environmental concerns for these resources.




## TEXTBOOK SUPPORT:

*"Supplying Things We Need"* on pages 7-8.
*"Environmental Geology - Delivering Alaskan Oil - The Environment Vs. The Economy"* on page 9.
*"Geologic Resources"* on page 520.

## STUDENT ASSIGNMENT

1. Figure 21.1 on page 520 of the textbook *Physical Geology* is of a pencil and the source of all materials that contributes to the pencil's make-up. This simple example illustrates the importance of geologic resources in our everyday lives. Your task is to list the components of the pencil and describe the geologic resource needed for each component.

2. North America has about six to seven per cent of the world's population, yet its citizens use up to 40 per cent of the world production of many resources. Underdeveloped countries do not share the same standard of living as North Americans. However, these countries are on the road to industrialization. What effect will this have on the world demand for geologic resources? As the supply of geologic resources on Earth diminishes, where will the needed resources for underdeveloped countries come from?

# THE GEOLOGISTS

## LESSON 1.5

*'CIVILIZATION EXISTS BY GEOLOGICAL CONSENT, SUBJECT TO CHANGE WITHOUT NOTICE.'*

*WILL DURANT, PHILOSOPHER, HISTORIAN (1885-1981)*

## SPECIFIC CURRICULUM OUTCOMES:

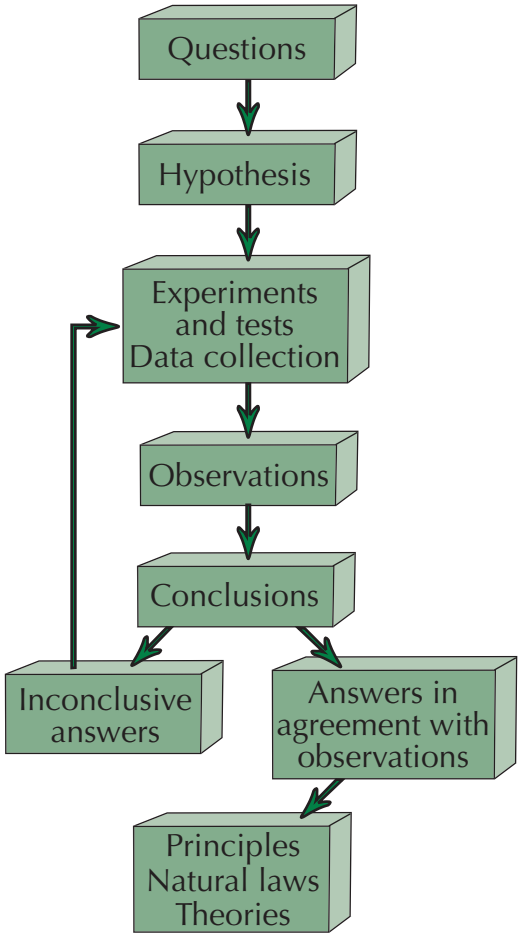
*STUDENTS WILL BE EXPECTED TO:*

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

## BACKGROUND READING

A *geologist* is a scientist that studies the Earth. This is quite a broad study, and no geologist is an expert on all aspects of planet Earth. There are many subdisciplines of geology and many fields of study or specialities. Some geologists are involved in searching for groundwater resources. Other geologists specialize in exploring for mineral and energy resources. Others are experts in the study of minerals and rocks, and still others are involved in making predictions about earthquakes and volcanic eruptions.

Regardless of the number of subdisciplines of geology, all geologists adhere to the assumption that the natural world behaves in a consistent and predictable manner. Understanding the geological processes of the natural world is the role of geologists. In their attempts, geologists employ the *scientific method*, depicted in the figure above.




The *scientific method* provides a very organized and step-by-step process to investigate geological questions. The reading on pages 17 and 18 of the textbook *Physical Geology* describes how the scientific method was employed to formulate the theory of plate tectonics, a theory that revolutionized the science of geology.

## TEXTBOOK SUPPORT

*"Geology as a Career"* on page 11 and *"Plate Tectonics and the Scientific Method"* on pages 17-18.

## STUDENT ASSIGNMENT

1. Geology is a very broad science and can be broken down into several specialities. Several

are listed below. Using your textbook or any other resource, briefly state the main area of interest for each branch of geology:

a) volcanology

b) hydrology

c) palaeontology

d) mineralogy

e) seismology

f) meteorology

g) glaciology

# INDEPENDENT INVESTIGATION

## LESSON 1.6

*'A CONTINENT AGES QUICKLY ONCE WE COME.'*

*ERNEST HEMINGWAY, AUTHOR*
*(1899-1961)*

## SPECIFIC CURRICULUM OUTCOMES:

*STUDENTS WILL BE EXPECTED TO:*

- communicate questions, ideas, and intentions (215-1)
- identify questions to investigate that arise from practical problems and issues (212-1)
- define and delimit problems to facilitate investigation (212-2)

## BACKGROUND READING

A major component of this course is an *independent investigation* into an issue of a geological nature. This issue may be local, regional, or provincial in nature. During the course of the investigation, you will be evaluating the geological, environmental, economic, and social factors of the issue. Some examples of possible topics for the investigation include:

- issues concerning groundwater (contamination; quantity)
- concerns over landfills
- local mining operations
- agricultural practices and its effects on soil
- effects of pesticide use on groundwater resources
- modification of local landscapes from running water, glaciation, etc.

The topics listed are examples only. You do not have to choose from the list.

The investigation will include various resources, such as interviewing relevant individuals, Internet search results, books, newspaper and magazine articles, etc. The final lesson in each unit of the course will act as a guide in your investigation.

The submission of the independent investigation will be a research paper approximately 10 pages in length. Details on the format of the paper will be given in a later lesson. Before the next lesson concerning the investigation, research should begin. It is important that you do not rely on only one source of information. If possible, seek out and interview individuals that may have expertise in the topic you have chosen. Conduct searches for information in your local library or on the Internet. Government agencies, particularly the *Department of Natural Resources* and the *Department of the Environment*, may also be able to provide you with information concerning your topic.

An outline of sub-topics for the investigation will be requested at the end of the next unit.

## END OF UNIT ASSIGNMENTS

EACH QUESTION WILL BE MARKED OF 10 PER CENT

1. You are a hydrogeologist in search of a new groundwater resource for a large city. Why would each of the following sciences be of interest to you? Describe an aspect of your search that would be related to each of the sciences below.

   a) biology b) geology c) chemistry d) physics

2. The following environmental issues are at the forefront of modern scientific research. Choose the one issue that you feel affects you the most. In a short essay (200 words), discuss how the issue either directly or indirectly affects you; the role a study of geology may play in understanding the effects/mechanics of the issue; and the types of questions you would ask of a geologist to learn more about the issue.
   a) carbon dioxide emissions from burning coal to produce electricity are believed to contribute to the phenomenon of global warming
   b) depletion of the ozone layer by man-made chemicals like chlorofluorocarbons (CFC) and methyl bromides (used in some fertilizers)
   c) the loss of topsoil due to poor forestry and agricultural practices
   d) the input of toxic chemicals into waterways and groundwater supplies
   e) acid precipitation caused by sulphur dioxide emissions from industrial activities
   f) the issue of waste disposal
   g) the melting of glaciers and ice sheets

3. Take a look around. Your environment has been affected to a certain degree by geological processes. Perhaps you are looking out a window and see a forest. The vegetation requires soil for growth. Soil consists of air, water, organic material, and mineral matter. This mineral matter is formed by the weathering or breakdown of rocks, a surficial geological process. Or perhaps you are looking at your computer screen. Computer components include silicon (for chips) and metals for intricate wiring. These materials were once part of the Earth and have been extracted and refined before becoming part of your computer.
   a) Describe two ways in which geology affects your everyday life.
   b) Describe two ways in which you affect the planet in your everyday life. Be sure to explain each example in some detail.

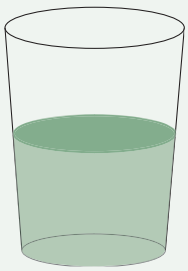
4. The textbook *Physical Geology* contains many photographs and diagrams that depict interrelationships between the spheres.

   For example, Figure 14.21 (page 349) depicts a coastline. The erosive power of the waves (hydrosphere) is modifying the coastline (geosphere), forming cliffs and sandy beaches. The figure depicts a relationship between the geosphere and the hydrosphere. For each of the following combinations of spheres, you are to find an image/diagram in the textbook *Physical Geology* that depicts a relationship between those spheres. Provide the figure number, page number, and a short description of the relationship between the spheres.

   a) biosphere and hydrosphere
   b) geosphere and atmosphere
   c) hydrosphere and atmosphere
   d) biosphere and geosphere

5. Choose one of the everyday objects listed below and write a brief biography (or autobiography) of the object. Within the biography, the source of the object must be clearly described. The connection between the object and geology must be the focus of the biography. You may use any resource you wish (textbooks, Internet, etc.), but be sure to state your references.

   For example: I am a water glass



Natural glass is called obsidian. It is created when volcanic lava cools rapidly. This rapid cooling prevents the formation of crystals. I am man-made glass. I am the product of heat and high-quality beach sand. Sand is mainly compose of the mineral quartz. Sand with an abundance of quartz is called glass sand. When melted at a high temperature the glass sand material is poured into glass shaped moulds and cooled rapidly. The rapid cooling prevents crystals from growing. This is how I was made.

Items to choose from:

- copper penny
- steel (cutlery)
- salt
- gyprock
- baking soda
- emery board (corundum)
- aluminium foil
- talcum powder
- plant fertilizer

6. Geology can be subdivided into the following areas: volcanology, hydrology, palaeontology, mineralogy, seisomology, meteorology, and glaciology. Choose one of the subdisciplines of geology and write a journal entry for that geologist. The entry should be approximately 200 words and should indicate the type of work conducted. The technology used by that particular geologist may also be included.

7. Imagine that you have discovered the groundwater supply for a small town of 5000 people has been contaminated. Using the scientific method, describe, in step-by-step format, the procedure you would follow in attempting to explain the groundwater contamination. In your response, include the questions to be asked, a possible hypothesis, and the types of tests or experiments that can be conducted to answer the questions asked.

8. Write a proposal of the investigation you intend to conduct for your final course project. In your proposal, be sure to state:

   a) the main objective of your investigation
   b) any background information that you have on the subject
   c) the importance of the investigation

   State your proposal clearly, concisely and completely.

   *For example, an acceptable proposal could be:*
   The investigation will include an examination of the water supply of the town of Anyville, Nova Scotia. Topics to be investigated include the water's source, its treatment and its transport to the citizens of Anyville. Potential concerns with the water supply and quality will also be examined.

   *An unacceptable proposal could be:*
   I will ask questions about where Anyville gets its drinking water.

9. List five possible sources of information for your investigation. At this stage, these sources will be very general (i.e. no specific websites, etc.)

10. Using your research proposal topic, list the Earth's spheres involved in the issue. Be specific and describe the component of each sphere involved. Write a statement that links the spheres of your issue.

SEND YOUR END OF UNIT ASSIGNMENTS TO YOUR MARKER NOW