- sustainable development

Lesson 7

Sustainable Development

Learning Outcomes

After completing this lesson you will be able to

- ❑ identify environmental, social, and economic factors and different viewpoints that should be considered when making decisions about land use

What's Your Point of View?

When decisions related to land use must be made, several aspects are taken into consideration. Governments in Canada follow a philosophy of **sustainable development**, where social, economic, and environmental factors are studied before a decision is made.

Read the following scenario describing a land-use issue.

What Should the City Do? A Land-Use Issue

A large city is running out of land in which to dump its garbage. The city is looking for possible places to build a landfill site. A large open-pit mine, several hundred kilometers to the north, has been closed down and is suggested as a possible dump site. The community adjacent to the old mine is considering this proposal, taking into account a variety of related issues.

The new state-of-the-art landfill project will provide needed jobs for the community, which is still feeling the effects of the closed mine. The community has recently focused on attracting tourists and new residents on the basis of a clean, quiet environment. Unless this proposed venture is successful, or another industry takes its place, the people who still live in the community will pack up and move elsewhere.

Some scientists suspect that the community's drinking supply may be at risk of becoming contaminated because of aquifers located beneath the fissured rocks (rocks containing small cracks) that line the open-pit mine.

Questions: Concerned Citizens

1. The following list identifies the "concerned citizens" of the city — people who feel strongly in favour of, or opposed to, the proposed landfill project. What opinions do you think each person has on the issue?

   For each concerned citizen, indicate whether you think they would be in favour of the proposal or opposed to it. Provide a reason for your answers.

   a) a city official in charge of garbage disposal

   b) a landfill company representative

   c) an unemployed person living in the community near the proposed landfill site

d) a new community resident

e) a long-term community resident

f) a community official in charge of attracting tourists

g) a geologist/scientist

h) an official in a nearby city that extracts its drinking water from a river running through the area

2. a) Look back at the reasons you provided in question #1. Label each reason according to which of the following aspects it relates to:

   - the environment (env) — conserving and regenerating the life-sustaining processes and natural resources of the Earth
   - the economy (ec) — access to resources and opportunities, often associated with the availability of jobs
   - human health and well-being (hw) — the well-being of individuals, families, and communities

   Note: These three areas may overlap.

   b) Look at how many times you referred to each aspect. Which one did you refer to the most?

   _____

   Which one did you refer to the least?

   _____

   What implications might this have for decision making?

   _____

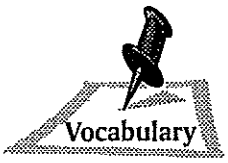
   _____

   _____

   c) Go back and add more reasons to your list in one of the areas that was not as well-represented (e.g., add more economic reasons if you were lacking in "ec" labels).

3. Do decision makers balance all of the different perspectives and make a decision? Why do you think this might be a difficult task?

Notes



- continental drift theory
- Pangaea
- theory of Plate Tectonics
- sonar
- Seismograph
- magnetometer
- radioactive dating
- deep sea drilling

Lesson 8

Plate Tectonics

Learning Outcomes

After completing this lesson you will be able to

- ❑ recognize the importance of evidence in the acceptance of new theories and the role technology plays in gathering evidence
- ❑ explain why the continental drift theory was not generally accepted by scientists
- ❑ describe the Theory of Plate Tectonics and how this theory can explain geological occurrences such as earthquakes and volcanoes

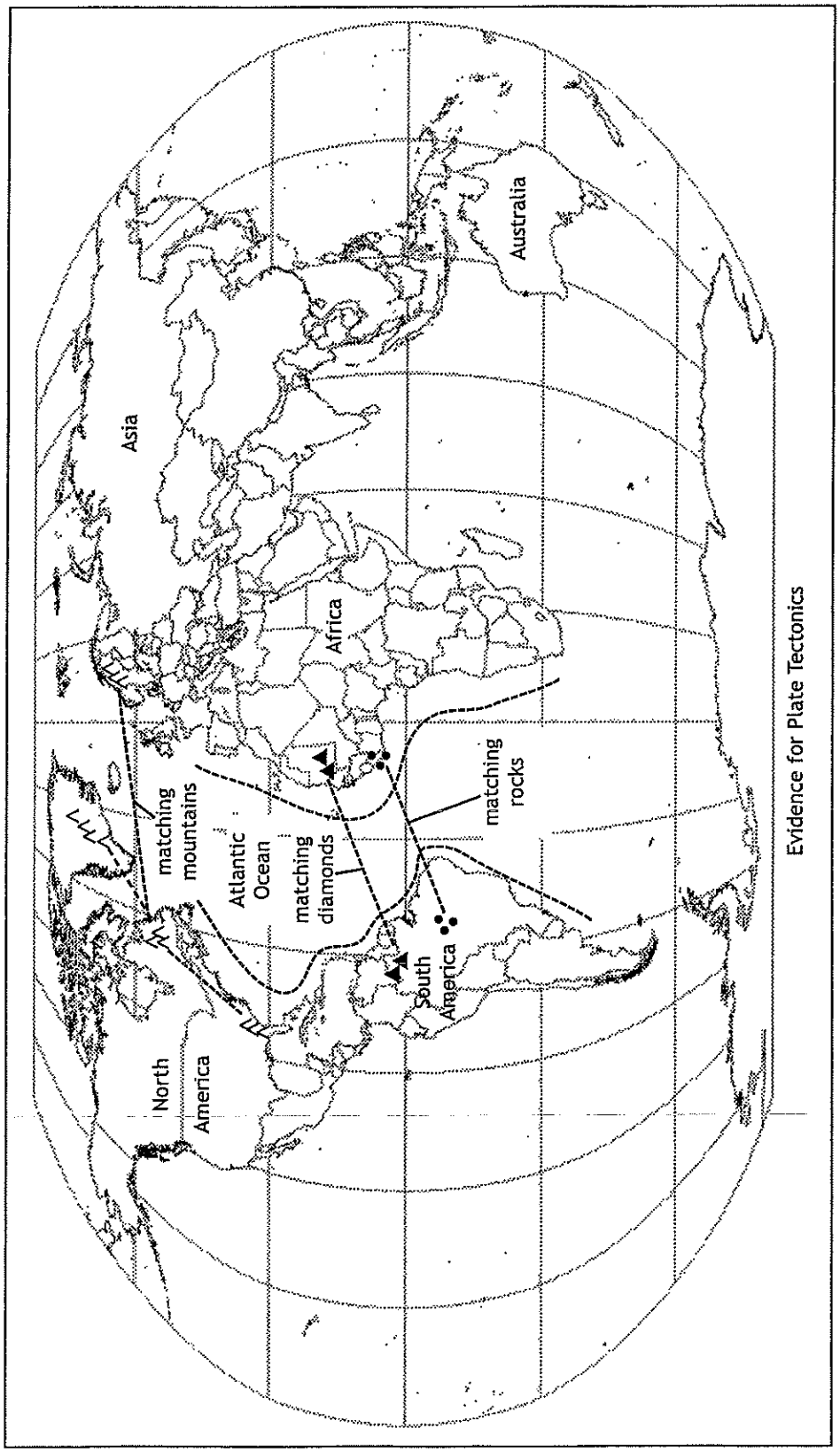
Continental Drift Theory

Scientists have been trying to explain how the present-day geological features of the Earth came to be for many years. The scientist Alfred Wegener based his theory, called **continental drift**, on the shape of continental coastlines. He observed that some continents appeared to fit together like a jigsaw puzzle. This led him to believe that approximately 200 million years ago, the continents had been joined together to form a super continent, called **Pangaea**.

Fossil evidence supported his theory, when similar plant and animal fossils were found on the coastlines of the matching continents. In addition, similar mountain ranges were found on the continents thought to be joined in the "super continent," and this gave further evidence to the belief. Deposits of like minerals were also found in matching coastlines.

Still, most scientists did not believe Wegener's theory because Wegener could not explain what caused the movement. Remember, it is difficult for a hypothesis to become generally accepted by scientists.

Study the diagram below and answer the questions provided.



Questions: Part A

1. What was the giant landmass of 200 million years ago called?

2. How do the shapes of different coastlines support the theory of continental drift?

3. Which continents seem to fit together?

4. Name two continents on which matching rock and minerals are found.

5. Name two continents on which matching mountains are found.

Questions: Part B

Complete each statement using a term or terms from the list below. Write your answers in the spaces provided. Some words may be used more than once.

mountain ranges	Wegener	continental drift
one	Pangaea	200 million years
coastlines	rocks and minerals	
fossils	continues	move apart

1. More than 200 million years ago, the earth had only _____ large land mass.

2. The Earth's original landmass is called _____ .

3. About 200 million years ago, the Earth's single land mass broke up and started slowly to _____ . That movement _____ even today.

4. The idea that the Earth's land masses were once just one large land mass is called _____ .

5. It took about _____ for the continents to look as they do today.

6. The idea of continental drift started from the study of the continent's _____ .

7. The theory of continental drift was first proposed by the scientist _____ .

8. Evidence from _____ , _____ , _____ , and the shapes of _____ support the theory of continental drift.

The Theory of Plate Tectonics

The major reason Wegener's hypothesis of continental drift was not accepted by scientists was because he could not explain *how* the continents could possibly move apart. Other scientists continued to work on this puzzle, and eventually a new theory was developed, incorporating Wegener's work, as well as work by other scientists, called the **Theory of Plate Tectonics**.

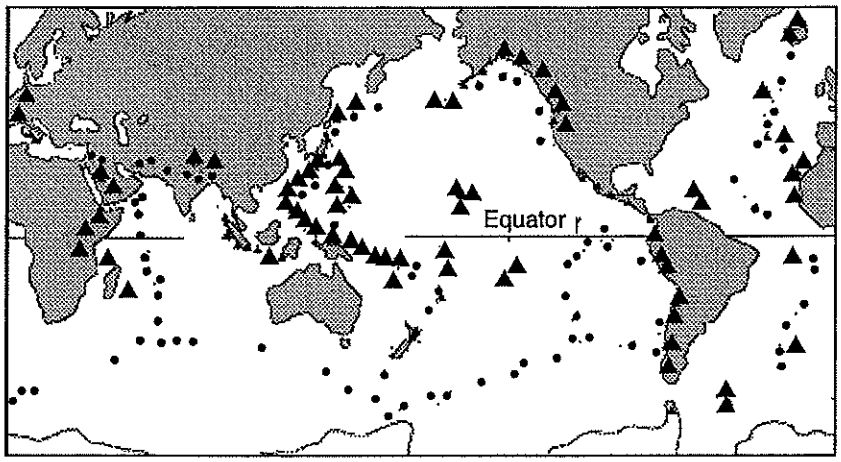
According to this theory, the surface of the Earth is broken into large plates. The size and position of these plates change over time. The edges of these plates, where they move against each other, are sites of intense geologic activity, such as earthquakes, volcanoes, and mountain building. The main features of plate tectonics are as follows:

- The Earth's surface is covered by a series of crustal plates.
- The ocean floors are continually moving, spreading from the centre, sinking at the edges, and being regenerated.
- Convection* currents beneath the plates move the crustal plates in different directions.
- The source of heat driving the convection currents is radioactivity deep in the Earth's mantle.

*Convection refers to the transfer of heat in a liquid by the circulation of liquids. In Lesson 1 you learned about the structure of the Earth and how its very hot internal temperatures cause materials to melt. These materials then rise and cooler materials sink down to replace them. This constant flow causes the currents known as convection currents.

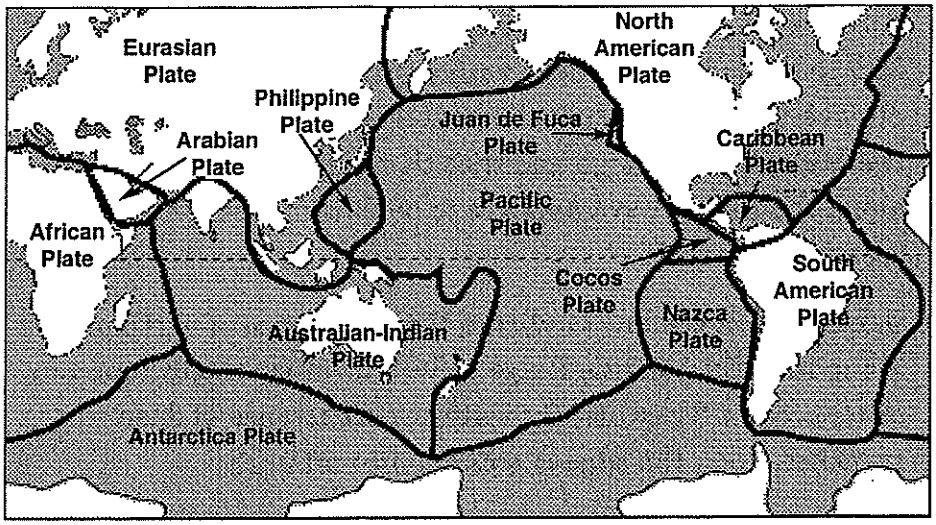
Location of Plate Boundaries

Earthquakes and volcanoes, evidence of unrest in the Earth, help geologists locate the edges of plates. Earthquakes are distributed in narrow, linear belts that circle the Earth. Volcanoes are also distributed in long belts that circle the Earth. A dramatic example is the line of volcanoes that circles most of the Pacific Ocean. This belt is known as the "Ring of Fire" because it is the site of frequent volcanic eruptions.



Global distribution of volcanoes (▲) and earthquakes (•••) based on Simkin and others (1989).

The distribution of earthquakes and volcanoes coincides at most locations. The Ring of Fire is an excellent example. Geologists believe that areas of intense geologic activity, indicated by earthquakes, volcanoes, and/or mountain building, mark the boundaries between lithospheric plates. The distribution of earthquakes, volcanoes, and mountain ranges define seven large plates and 20 smaller plates.



Major tectonic plates of the world.

Role of Technology in the Development of Plate Tectonics

The following information shows how the development of technology led to the gathering of evidence to substantiate the theory of plate tectonics.

- World War I (1914 -1918): **Sonar** (sound navigation and ranging) technology is developed to detect objects underwater. This technology works on the concept that sound waves are reflected.
- World War II (1935-1945): Sonar is improved and is used to map ocean depths. Guyots (underwater volcanoes) are discovered.
- 1940s: **Seismograph** (a device used to detect and record seismic waves/vibrations in the Earth) is used to study the layers of rock under the Atlantic Ocean. Depth of sediment is discovered to be only 1 km thick.

- 1950s: Sonar is used to map large areas of ocean floor. The Mid Atlantic Ridge (a deep valley with very steep sides) is discovered. Seismograph shows there is volcanic activity at the Mid Atlantic Ridge and that there is little or no sediment along the Ridge. Lava appears to be flowing out of ridge and creating new rock.
- Seismograph readings indicate the occurrence of earthquakes along the Mid Atlantic Ridge as well as other ridges found in other oceans. They also indicate the occurrence of deep trenches along the edge of some continents.
- After World War II: The **magnetometer**, a device for measuring magnetism in rocks, is used to record magnetic patterns on the ocean floor. Magnetic "stripes" of rock are seen to face different directions, according to where magnetic north was during different periods of time. This allows for the rough dating of different portions of the ocean bottom. The sea floor is not all the same age.
- Later the development of **radioactive dating** allows scientists to determine the age of the rocks comprising the seafloor. With radioactive dating, scientists measure how much of two particular radioactive elements are located in a rock. With the knowledge that one of the element turns into the other and how long it takes to do this, scientists can determine the age of the rock.
- 1960s: **Deep sea drilling** was initially developed for use in the oil industry. This technology brought real proof in the form of rock samples from along the ridges. These samples showed that the rock was newly formed.

Did you know . . . that there are volcanoes in Canada? The volcanoes here are not active ones (presently erupting lava) but dormant ones that were formed thousands of years ago.

Volcanoes usually occur where two tectonic plates meet and where one of the plates is being pushed beneath the other one. The plate that is being pushed beneath the surface undergoes a lot of heat and pressure and begins to turn into molten rock. Sometimes, the pressure builds up so much that the magma is pushed towards the surface of the Earth where it comes out as lava.

Check out this website for more information about Canada's volcanoes. <http://volcano.und.nodak.edu/vwdocs/volc_images/north_america/canada/Canada.html>

Point to Ponder

Using examples from the examples of the development of technologies presented above, explain what is meant by the following statement:

Science and technology work hand in hand.

Notes

Lesson 9

Careers

Learning Outcomes

After completing this lesson you will be able to

- ❑ describe the career of a volcanologist, someone who needs an understanding of the Earth's structure to do their work
- ❑ identify careers that involve the study of the Earth's crust

You've learned a great deal about the Earth's crust in this module. There are many people who use similar knowledge every day in their jobs. There are many, many careers that are related to studying the Earth or working with the Earth's resources. The following interview takes place with someone who has a very specialized type of career, that is, studying volcanoes. Read the interview and answer the questions that follow.

Ask a Volcanologist

Question: Do you have a job description for a volcanologist?

Answer: I study the geochemistry of older volcanoes (1-30 million years). The chemistry tells me something about the mantle where the magma originated. I can say what minerals where present and how much of the rock melted to make the magma. I also am interested in what happens to the magma as it rises to the surface. Sometimes crystals settle out or the surrounding rocks melt and are added to the magma. Using all this information I construct the history of the volcanic field.

(continued)

Ask a Volcanologist: Reprinted from *VolcanoWorld*: <http://volcano.und.nodak.edu/vwdocs/ frequent_questions/group2_newhtml>. Used by permission of space.edu.

Some volcanologists study earthquakes in volcanoes (this type of volcanologist might also be called a seismologist). They use a network of instruments and computers to determine the location and distribution of earthquakes. This information indicates where the magma originates and where it moves within the volcano. If your students like computers (and prefer to stay inside) they might consider being this type of volcanologist.

Some volcanologists use remote sensing data to study volcanoes on Earth and other planets. Data are supplied from satellites. Maps can be made much like the those constructed by mapping geologists but not quite to the same resolution. By studying volcanoes on other planets we better understand the physical processes within and at the surface of other planets. This type of volcanologist also provides hazard warnings associated with ash plumes from large eruptions. These ash plumes have caused problems for jet airplanes.

Some volcanologists monitor active volcanoes. They use different types of data to forecast and predict eruptions. They interpret measurements of ground deformation, gas compositions, and earthquake distribution and size. They have to decide what the volcano will most likely do and pass this information on to local authorities.

Question: When you go to study a volcano are you scared? Did you have to study a lot in college? Is it a cool job?

Answer: Sometimes when you go to study a volcano you are kind of scared. A little fear is a healthy thing to have because it means you are going to be careful and think about the things you do and the risks you take. If you are really scared it either means that you are not prepared or that you are prepared but the situation has become too dangerous. In either case you should leave, and nobody will make fun of you for leaving.

(continued)

I had to study a number of subjects in college because when you are studying volcanoes you need to know a little about a lot of things. For example, you need to know some chemistry to be able to interpret the different kinds of lavas and minerals you see. You need to know a little bit of physics to be able to understand how lavas flow or how ash particles fly through the air. You need to know a little computer science so that you can make computer simulations of the things you are studying. It helps to know a little bit of art since you will often have to make drawings and diagrams. It helps to know a couple other languages since most volcanoes are in countries where English isn't the first language.

The main thing you really need is a love of science, nature, the outdoors, and figuring out puzzles.

It is a really cool job, but sometimes it gets kind of hot!

Question: How do you become a volcanologist?

Answer: As for becoming a volcanologist, you first have to really like science and working outside. Take as many science classes as you can, in all sciences, not just Earth science. Then, when you go to college you major in geology. You don't really start to specialize in volcanology until graduate school. Then, if you are lucky you can get a job studying volcanoes. The learning never ends, though.

Questions: Job/Career

1. What was your reaction to reading about this very specialized type of career, something you probably have never heard before (e.g., did you find it interesting, surprising, strange, etc.)?

_____

_____

_____

_____

_____

2. a) Specialized scientists like volcanologists need to use technology in their work. List some of the technologies that were mentioned in the article.

b) Why do you think technology is so important to science?

3. Throughout this module and in the readings you have done, other jobs/careers related to the Earth's resources have been mentioned. Name some of those jobs.

Lesson 10

Reviewing

Congratulations! You have now completed the work in Module 4. Your next step is to write the Module 4 self-test. This lesson contains four studying techniques that could help you prepare for it. You may also wish to refer to the suggestions provided in the previous modules.

Technique 1: Three-Point Approach

Go back through the module and organize the vocabulary information, using the Three-Point Approach.

<table>
<tr><td rowspan="2">Definition</td><td>Word or Concept</td><td rowspan="2">Diagram</td></tr>
<tr><td>Example/Synonym</td></tr>
</table>

Three-Point Approach: Adapted from Simons, Sandra M. *Strategies for Reading Nonfiction.* Copyright 1991 by Spring Street Press. Used by permission of the publisher.

Technique 2: Concept Frame

Using a Concept Frame, organize your information about the Theory of Plate Tectonics. See the Concept Frame map on the following page.

Technique 3: Concept Overview

Using a Concept Overview, organize your information about continental drift. See the Concept Overview map.

Concept Frame

Concept

Examples

Characteristics

What is it like?

What is it like?

Can you illustrate it?

Definition

Concept Frame: Used by permission of Lynda Matchullis and Bette Mueller, Nellie McClung Collegiate, Pembina Valley S.D. NO. 27, Manitoba.

Concept Overview

Key word or concept.

Write an explanation or definition in your own words. You will be paraphrasing.

Draw a figurative representation.

List facts (at least five).

Create your own questions about the concept.

Create an analogy.

Concept Overview Frame: Used by permission of Lynda Matchullis and Bette Mueller, Nellie McClung Collegiate, Pembina Valley S.D. NO. 27, Manitoba.

Notes