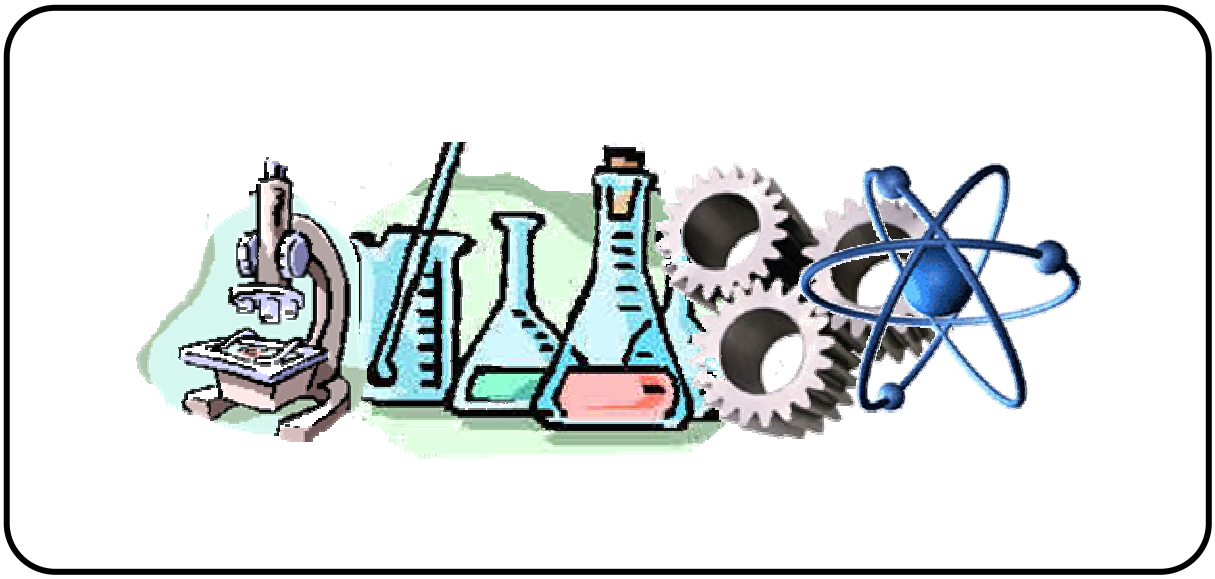
# Project EASE

(Effective and Alternative Secondary Education)

# INTEGRATED SCIENCE I



## MODULE 12

**BUREAU OF SECONDARY EDUCATION**
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# Module 12
# Inside the Solid Earth

## What this module is about

You have observed changes on the surface of the Earth. Some changes occur slowly while others occur fast. Why is the surface of the Earth never flat? What are the forces responsible for these changes? This module provides you information and activities that will help you understand the solid part of the Earth. The lessons contained in this module are:

- **Lesson 1 - The Structure of the Earth**
- **Lesson 2 - Minerals and Rocks**
- **Lesson 3 - Different Landforms**
- **Lesson 4 - The Formation of the Continents.**
- **Lesson 5 - Igneous Activity**
- **Lesson 6 - Earthquake**
- **Lesson 7 - Soil Formation**

## What you are expected to learn

After going through this module, you are expected to:

1. describe the structure of the Earth;
2. discuss formation of rocks ;
3. distinguish the different kinds of rocks;
4. discuss the different movements of rocks that lead to the formation of different landforms;
5. explain the formation of the continents using evidences that support the continental drift theory, sea-floor spreading hypothesis, and plate tectonic theory
6. analyze the cause of the different natural phenomena such as volcanic eruption and earthquake
7. discuss how soil is formed and transferred to other places and how it affects the environment; and
8. suggest precautionary measures in cases of earthquake, volcanic activity and other hazardous natural phenomena.

## How to learn from this module

- Read the instruction carefully.
- Take the pretest before reading the rest of the module.
- Do all the activities and exercises.
- Use the concept discussed in each lesson to explain the results of activities or exercises.
- Take the posttest after you have finished the lesson and performed all activities or exercises.

## What to do before (Pretest)

**I. Multiple Choice**

**Direction: Encircle the letter of the word or group of words that best answers the question.**

1. Which of the following describes the interior of the Earth?
    a. Is hot
    b. Is solid
    c. is layered
    d. all of the above

2. Which of the following pairs of minerals dominate the continental crust?
    a. calcite and dolomite
    b. halide and gypsum
    c. hematite and limonite
    d. quartz and feldspar

3. Where does oceanic crust form?
    a. faults
    b. ridges
    c. trenches
    d. beaches

4. Which of the following best describe the characteristic of a mineral?
    a. solid  b. inorganic  c. definite composition  d. all of these

5. Which type of rock is abundant in volcanic regions?
    a. igneous
    b. sedimentary
    c. metamorphic
    d. both sedimentary and metamorphic

6. In which type of rocks are fossils formed and found?
    a. intrusive igneous
    b. extrusive igneous
    c. metamorphic
    c. sedimentary

7. When rocks are compressed, what is formed?
    a. downward folds
    b. upward folds
    c. rivers
    d. both a and b

8. Rocks formed by cooling magma are called
    a. igneous
    b. sedimentary
    c. metamorphic
    d. none of these

9. Which of the following best describes the plate tectonic theory?
    a. fossils are formed everywhere
    b. Continents move over the ocean floor
    c. Earth's surface is broken to many pieces
    d. A new crust is formed over the ocean floor

10. The magma in the magma chamber of a volcano has a very high amount of silica. If the volcano would erupt, which of the following might happen?
    a. there is a build up of pressure below the crater of the volcano
    b. the volcano would erupt violently
    c. the lava flow is very slow
    d. all of the above

11. There are different kinds of seismic waves that occur during an earthquake. Which of the following is most damaging to the structures on the surface of the Earth?
    a. secondary waves
    b. primary waves
    c. body waves
    d. all of the above

12. The occurrence of tsunami is one of the dangers of an earthquake. When is a tsunami produced?
    a. every time an earthquake occurs
    b. when the epicenter of the earthquake is on land
    c. when the epicenter of the earthquake is under water
    d. every time an earthquake accompanies volcanic eruption
13. In which of the following soil does water run through readily?
    a. clay
    b .loam
    c .sand
    e. soil with many pebbles
14. Which of the found is agent of erosion
    a. animals
    b. plant
    c. wind
    d. weathering

## II. Answer the following questions briefly

1. Give two ways to prevent soil erosion.

   a. _____ b. _____

2. Give two precautionary measures before, during and after an earthquake

   _____

   _____

Key to answers on page 39

Before you start the lessons, familiarize yourself with the following terms :

| Terms | Definition |
|---|---|
| Crust | - the outer portion of the earth |
| Continental Crust | - the thick parts of the Earth's crust, not located under the ocean |
| Oceanic Crust | - the thin parts of the Earth's crust located under the oceans. |

| | |
|---|---|
| Mantle<br>Lower Mantle (semi-rigid)<br>Upper Mantle (rigid)<br><br>Upper Mantle (flowing)<br>Asthenosphere | <br>- the deepest parts of the mantle, just above the core<br><br>- the uppermost part of the mantle, part of the Lithosphere<br>- the lower part of the upper mantle that exhibits plastic (flowing) properties. It is located below the lithosphere (the crust and upper mantle) |
| Mohorovicic discontinuity | - separates the crust and the upper mantle |
| Lithosphere | - the crust plus the rigid, upper mantle |
| Plate | - A section of the earth crust that floats on the surface of the mantle |
| Glacier | - a field of ice which moves slowly downward over slope |
| Ridge | - a raised mass of land with long width and height |
| Continent | - big body of land on the globe |
| Drift | - that which is carried onward by a current |
| Fossils | - a remain or trace of organism in the past |
| Fissure | - a narrow opening; a slitting or break |
| Erosion | - a process by which sediments/soil are transported to places of lower level |
| Agents | - one which acts, any substance having the power to change |
| Enrich | - to fertilize, to adorn, to stock with |
| Bulk | - large mass |
| Trough | - a long, narrow container for water |

## Lesson 1 The Structure of the Earth

Have you ever wondered what is under the ground? You leave your footprints in sand and soil. You touch the soil and play with it. You get some soil samples and identify the substances present in the soil. But nobody has seen beyond the area humans have conducted mining activities.

However, man has invented instruments to get information from the depths of the Earth. One such information is on vibration. These vibrations have been recorded and analyzed. Do you know that the Earth's interior is a layered structure composed of core, mantle and crust? Table 1 summarizes the nature of the different layers inside Planet Earth.

**Table 1.1 Layers of the Earth's Interior and their Characteristics**

| Layer | Characteristics | Chemical composition |
|---|---|---|
| Core<br>Inner<br>Outer | Very hot<br>Solid<br>liquid | Iron and nickel |
| Mantle | Upper layer is partially molten ( asthenosphere | Fe, Mg, Si, O |
| Crust<br>Oceanic<br><br><br>Continental | Solid<br>Basalt<br><br><br>Crystalline rocks like granite | Mostly O and Si , less amount of P, Al, Mn, Mg, Ca, K, Na<br><br>Dominated by quartz (SiO2) and feldspars (metal-poor silicates) |

Located between the crust and the mantle is the Mohorovicic discontinuity. It separates the crust and the upper mantle. The outermost layer of the Earth is divided into lithosphere and asthenosphere. Lithosphere is rigid, composed of the crust and upper part of the mantle. Asthenosphere is part of the mantle that flows like plastic.

The lithosphere is divided into continental lithosphere and oceanic lithosphere. The former is composed mostly of granite rocks rich in silica and aluminum. The latter comprises basalt rocks rich in magnesium and aluminum. Fig. 1 shows the cross-section of what is inside the solid Earth.

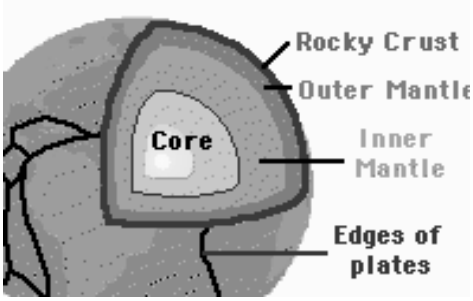



Fig. 1.1 The inside of the Earth

**Activity 1.1 Model of the Earth Structure**

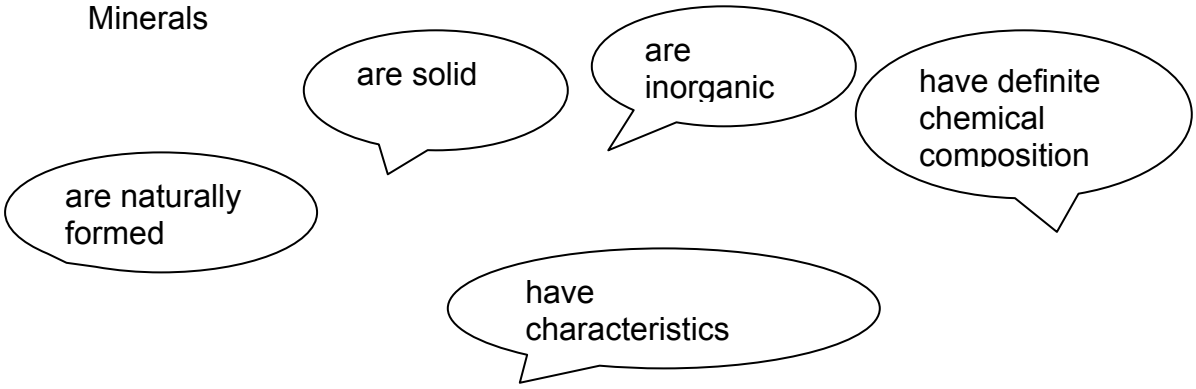
What you need: water
Old newspaper
Cooked starch
Basin

What to do:

1. Cut the old newspaper into tiny pieces.
2. Soak pieces of paper in the basin with water
3. Using the figure in Fig. 1 as basis, make a model of the earth's interior with the use of water-soaked pieces of paper and cooked starch

## Lesson 2 Minerals and Rocks

The crust is the only layer we can access directly. Why? We plant food crops on it. The elements listed in Table 1 do not exist as elements in the crust. Instead , each element is tightly linked or tied to other elements to form naturally occurring chemical compounds called ***minerals.***




There are different kinds of minerals. They are classified according to their properties, chemical composition or uses. Table 2.1 lists the common groups of minerals with corresponding examples and uses.

**Table 2.1 Common Groups of Minerals**

| Group | Example | Chemical composition | uses |
|---|---|---|---|
| carbonates | Calcite | $CaCO_3$ | chalk |
| Oxides | Quartz | $S1O_2$ | |
| | Magnetite | $Fe_3O_4$ | Source of iron |
| | Rutile | $TiO_2$ | paints |
| sulfides | Pyrite | $FeS_2$ | Source of iron |
| | Galena | PbS | Source of lead |
| sulfates | Gypsum | $CaSO_4.2H_2O$ | Plaster of paris |
| Native elements | Gold<br><br>Silver | Au<br><br>Ag | Jewelries and coins |
| phosphates | Apatite | $Ca_5(PO_4)_3(OH)$ | fertilizer |

## *What you will do*

**Activity 2.1**

1. What minerals can you find in your place?
2. How do you use the minerals found in your place?

**Key to answers on page 39**

Minerals are building blocks of rocks. What are rocks? Rocks are the most common materials we can see in our surrounding.

Rocks are ….

naturally occurring solids

non-living

composed of one or more minerals

One rock type can change into another types of rocks. For instance, an igneous rock can change into sedimentary and later into metamorphic rock. How do we call this chain of changes? It is called a **rock cycle.** Fig. 2 shows the rock cycle.

Igneous rock can change into sedimentary rock or into metamorphic rock. Sedimentary rock can change into metamorphic rock or into igneous rock. Metamorphic rock can change into igneous or sedimentary rock. When magma pours out on Earth's surface, magma is called lava. Lave is the same liquid rock matter that you see coming out of volcanoes.

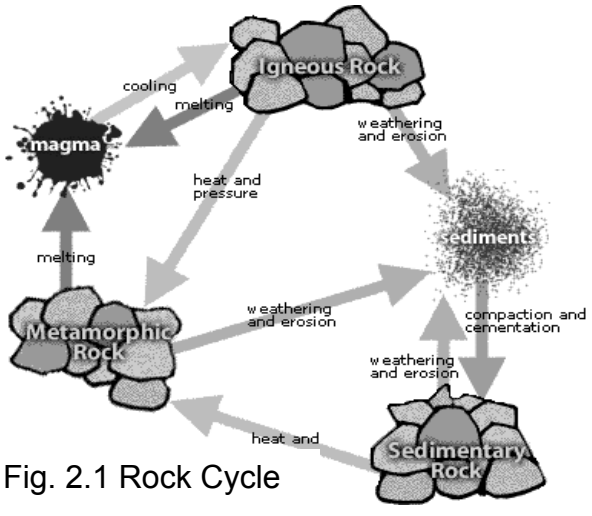



Fig. 2.1 Rock Cycle

Wind and water can break rocks into pieces. They can also carry rock pieces to another place. Usually, the rock pieces, called sediments, drop from the wind or water to make a layer. The layer can be buried under other layers of sediments. After a long time the sediments become a sedimentary rock.

As you can see in the discussion of rock cycle, there are three kinds of rocks. Each has a different texture and origin. Let's find out more about these rocks.

**Igneous rocks**

An igneous rock is formed by the hardening and crystallization of molten material that originates from deep within the earth. The rock material is called magma.

An igneous rock is divided into 2 groups,- extrusive and intrusive. Extrusive rocks form when magma flows onto the surface of the earth or floor of the ocean through deep cracks or fissures and at volcanic vents. The magma then cools and hardens. An intrusive rock results when magma solidifies beneath the earth's surface. Extrusive rocks have finer grained texture than intrusive rocks. Intrusive rocks vary from thin sheets to huge, irregular masses.

Examples of igneous rocks are obsidian, pumice and peridotite

**Sedimentary Rocks**

Sedimentary rocks develop from sediments. Sediments are tiny grains of dirt, sand, mud and clay weathered or worn off rocks. These are then washed into streams, rivers, lakes and oceans and they settle in the bottom of these bodies of water. Minerals in the water and very tiny sea animals become mixed with the dirt and sand to form layers of sediment. Every day more sediments are added. After thousands and millions of years deep accumulations of sediment are produced. The weight and pressure from the upper layers turn the sediment in the bottom into sedimentary rocks.

Examples of sedimenetary rocks are limestone, conglomerate, shale and sandstone. The Island of Cebu is famous for its limestone and dolomite deposits.

**Metamorphic rocks**

These rocks can come from igneous rocks, sedimentary rocks or even from other metamorphic rocks. How are these rocks formed? When a rock is subjected to high temperature, high pressure and chemically active fluids, it becomes unstable and begins to re-crystallize into different stable minerals. This causes change in the composition of the rock as well as the rock type. Some examples of metamorphic rocks are listed in Table 2.

The Island of Romblon is famous for its marble rocks. Mindoro Island has marble rocks ,too.

Table 2 Examples of metamorphic rock

| Metamorphic rock | Origin |
|---|---|
| marble | limestone |
| slate | shale |
| quartzite | Quartz sandstone |
| Schist | slate |

## *What you will do*

**Activity 2.2 Where do I use rocks?**

1. Visit a area in your place where you can find rocks such as river, park, construction store, etc. Note the rocks that interest you.
2. Request your father or relatives to accompany you to the place where you found the rocks.
3. Ask your companion the local name of the rocks and how people used the rocks. You may also ask the reason/s for its use

## *What you will do*

**Self-Test 2.1**

**I. Write the letter corresponding to the right answer.**

1. There are many elements present in the crust. Which is the most dominant element found in the crust?
   a. carbon  c. oxygen
   b. nitrogen  d. phosphorus
2. The lithosphere is composed of the

   a. crust only  c. crust and mantle

   b. mantle only  d. upper layer of mantle

3. Which of the following rocks are formed from sediments accumulated at the bottom of the oceans thousands of years ago?
   a. extrusive igneous rocks
   b. intrusive igneous rocks
   c. metamorphic rocks
   d. sedimentary rocks

II. Match the rocks in column A with its mineral or uses in Column B

| A | B |
|---|---|
| 1. limestone | a. jewelry |
| 2. marble | b. $CaCO_3$ |
| 3. gypsum | c. plaster of Paris |
| 4. gold | |

**Key to answers on page 39**

## Lesson 3 Different Landforms

Look at Figure. 3. Notice the high and low points of the surface of Planet Earth. These elevations and depressions are called landforms. Landforms are natural features of the landscape or natural physical features of the earth's surface. Can you name some of them? What makes these landforms? To answer these questions, let's do Activity 3. 1.

Figure 3.1 Different landforms

### *What you will do*

**Activity 3.1 Formation of Landforms**

What you need: old newspapers, modeling clay, and scotch tape
What to do:

1. Place two or more sheets of old newspaper one on top of the other.
2. Put your finge tips at each end of the pile of newspapers. Push the newspaper towards each other. Observe and record what you see.
3. Pull the sheets of newspaper away from each other. Observe and record what you observe.
4. Make another pile of newspapers. Place the second pile beside the first pile. Secure the piles with adhesive tape so the newspaper sheets in each pile will not separate from each other. Slide the piles side to side.
5. What does the newspaper represent?
6. What is represented by the push, pull and slide?

In Activity 3.1, the newspaper pile represents the crustal rocks. The pile of newspapers ( rocks) were subjected to stress such as push (compression) , pull (tension) and slide (shearing). Compression, tension and shearing change the rocks' volume, shape or both. It causes rocks to fold or crack. As rocks are compressed, they produce wrinkles. The upward fold in the rock is the ***anticline*** which forms hills and mountains. The downward fold is the ***syncline*** which forms valleys.

As you pull rocks apart, the middle of the rock becomes thinner. When rocks slide past each other, a break or fault is formed. If there are many faults in an area, what are formed? You have a series of uplifted areas (mountains) and valleys between mountains.

Other land forms are plateaus and domes. What are they and how are they formed? Plateaus are raised rock layers that remain flat. If a river separate one large plateau into smaller ones, you have canyons. The most beautiful canyon is the Grand Canyon in the Colorado Plateau. Baguio City is a plateau.

How about a dome? A dome is an uplifted area created by rising magma. It is shaped like the top half of a sphere.

You can see other landforms due to forces operating below the surface of the earth as shown in Table 3.1

**Table 3.1 Other landforms**

| **Other landforms** | **Description** |
|---|---|
| 1. volcanic pipes | - are short conduits that connect a magma chamber to the surface |
| 2. volcanic necks | -are resistant vents left standing after erosion has removed the volcanic cone such as Ship Rock, New Mexico |
| 3. Calderas | - Steep-walled depressions at the summit of a volcano formed by the collapse of the roof of magma chamber after cooling and shrinking of magma<br>- Size generally exceeds 1 km in diameter |
| 4. lava plateaus | - regional expanse of thick lava flow<br>- formed when thick stacks of laterally extensive lava flows and hardened through time.<br>- Columbia River Plateau, U.S.A. and Deccan Traps, India are famous examples |

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## *What you will do*

**Self-Test 3.1**

Name places in the Philippines where there are beautiful mountains, valleys, plateaus and domes.

**Key to answers on page 39**

## Lesson 4 The Formation of the Continents

Get a map or a globe and try to locate the seven continents – Africa, Antarctica, Asia, Australia, Europe, North America and South America, The seven continents are separated by the seven famous world's oceans. You may be wondering where and how the continents were formed. Let us do activity 4.1.

## *What you will do*

**Activity 4.1 The Continental Puzzle**

What you need : globe or map pair of scissors
bond paper pencil
paste

What to do

1. Draw the seven continents
2. Cut out your drawing of the seven continents
3. Place the continents of similar edges side by side to form a close fit.

Question:

Which continents do you think were neighbors before?

You could have produced a figure similar to Fig. 4.1. This was what Alfred Wegener figured out in 1912.

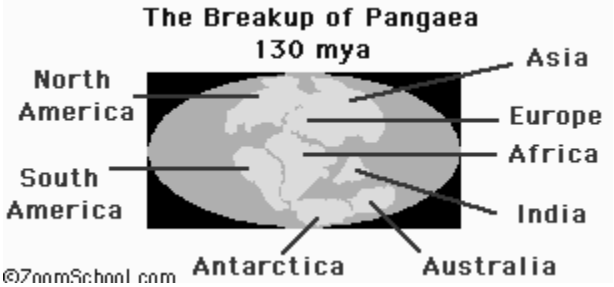



Fig. 4.1 Seven continents

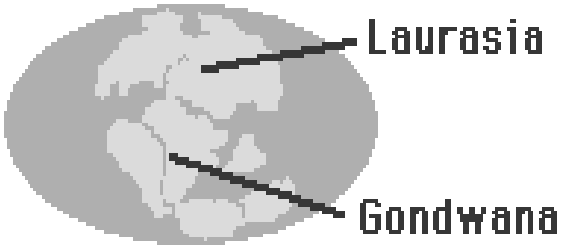



Fig. 4.2 Two smaller continents

Wegener proposed that there was a gigantic supercontinent that existed 200 million years ago, which he named Pangaea ( "All-earth"). Pangaea broke up first into two smaller continents - *Gondwanaland and Laurasia.* The two smaller continents as shown in Fig. 4.2 were separated by Tethys Sea.

The two continents further broke up. In 1915, he proposed the Theory of Continental Drift which states that parts of the Earth's crust slowly move away from each other on top of a liquid core. What are the evidences? The evidences that supported the continental drift theory are the following:

A. Fit of the margin of the continents like
1. Africa and South America
2. Europe and North America

B. The presence of similar fossils found in places he thought were once connected. For instance, fossils of *Mesosaurus* (one of the first marine reptiles, even older than the dinosaurs) and the fossil plant *Glossopteris* were found in both South America

C. Rocks deposits left by glaciers
D. Deposits of salts , coal and limestone

Wegener's idea left queries in the science community unanswered. An example of these questions is, "How can continents plow through hard, solid ocean floor"? These questions pushed scientists to make more studies which led to the discovery of mid-oceanic ridge. A mid- oceanic ridge is an underwater mountain. One of this is the famous Mid-Atlantic Ridge, a vast undersea mountain chain in the Atlantic Ocean. It has a gigantic cleft about 32-48 km long and 1.6 km deep. The ridge is offset by fracture zones or rift valleys.

In this cleft, the liquid rock called basaltic magma from the mantle rises up to the floor of the ocean. The hot magma cools down and hardens to form new oceanic crust. The new crust pushed the older rocks away from the ridge. This is called seafloor-spreading theory by Harry Hess (1962) and R. Deitz (1961). What findings support the seafloor spreading theory?

**Findings that support seafloor spreading theory**

1. Rocks are younger at the mid-ocean ridge
2. Rocks far from the mid-ocean ridge are older
3. Sediments are thinner at the ridge
4. Rocks at the ocean floor are younger than at the continents

How did they explain the observations listed above? New crusts were added at the ridges of the ocean floor, pushing the old rocks away from the ridges. Also, old crusts were reabsorbed in the ocean trench. A trench is the deepest part of the ocean floor.

Just like continental drift theory, the seafloor spreading theory left some gaps. From these two theories, a new theory evolved. This is called Plate Tectonic Theory. This theory states that the lithosphere is broken into a number of rigid moving slabs called plates. The plates are either oceanic plates ( under the ocean) and continental plates ( in the continents) as shown in Fig. 4.3.

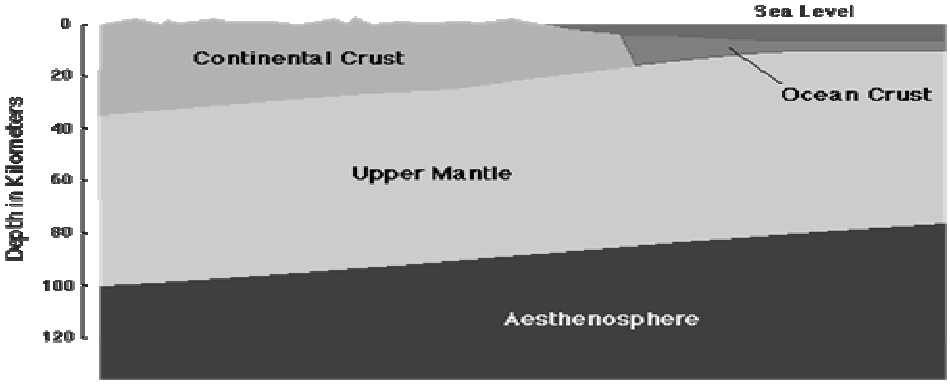



**Fig 4.3 . The arrangement of lithosphere and asthenosphere**.

The plates move relative to each other above a hotter, deeper, more mobile zone, the asthenosphere. The asthenosphere is kept plastic-like by heat produced from unstable light elements. How do we explain the movement of the lithospheric plates? The very hot substance in the asthenosphere is light and it rises towards the crust where it cools. Cold material is denser and sinks downward. The repeated rising and sinking of materials creates convection currents similar to the event shown in Fig. 4.4.

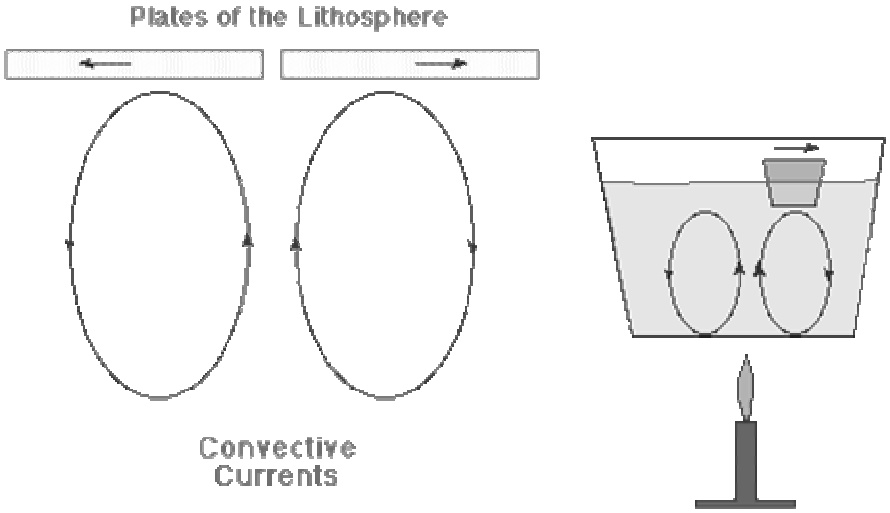



**Fig. 4.4 Convection Current**

The convection currents provide horizontal forces on the plates that cause them to move. The moving tectonic plates produce deformations at *plate boundaries*. Plate boundaries are sections where plates meet and interact. The deformations formed by these tectonic motion result to various landforms on the surface of the Earth.

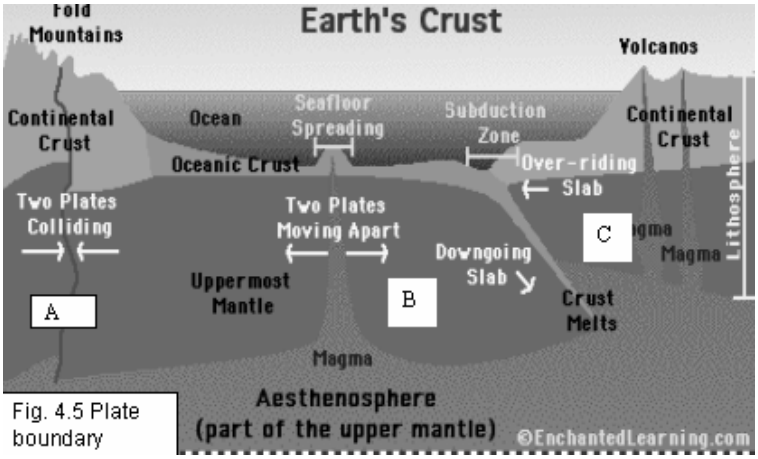



Fig. 4.5 Plate boundary

The theory helps explain the formation of the earth's crust and its movements, collisions, and destruction. It also explains the origin of volcanoes, earthquakes and mountains.

There are three types of plate movements – separation of two plates (divergent) , collision of two plates ( convergent) and sliding past each other ( transform). What is formed at plate boundaries as the plates move relative to each other ? Study at Fig. 4.5.

Fig. 4.5 can help you understand plate tectonics. At Point A, continental plate collides with another continental plate. A fold is formed as what you observed when you pushed two sheets of newspapers. The fold is the mountain. Mt. Everest and the Himalayan mountain range were formed in this manner as the Indian plate collided with the southern part of Asia. We call this the convergent plate boundary movement.

At Point B, two plates move away from each other. This is a divergent plate boundary. This results to the formation of new crust to widen the sea floor, new ocean basin or a rift valley such as the great African Rift Valley.

At Point C, an oceanic plate collides with a continental plate. The heavier oceanic plate sinks while the lighter continental plate moves up. These movements form a trench and a volcanic arc. This is a convergent plate boundary.

Not shown in Fig. 4.5 are the collision of an oceanic plate with another oceanic plate as well as the side-to-side movement of plates (lateral slipping or transform). The collision of two oceanic plates forms a trench and an island arc. This is how the Philippines and Japan were formed.

When two plates move sideways against each other, great friction is developed. The movement is jerky. The plates slip, then stick together as friction and pressure increase . This pressure is suddenly released resulting to an earthquake.

Earthquakes, volcanoes, oceanic trenches, mountain range formation, and many other geologic phenomenon are deformations at plate boundaries.

## *What you will do*

**Self-Test 4.1**

1. Match Column A with Column B

| Column A | Column B |
|---|---|
| 1. the name of Wegener's large continent | a. sea floor spreading |
| 2. large underwater mountain chain around the earth | b. Pangaea |
| 3. the earth's surface is broken into many pieces | c. plate tectonics |
| 4. supercontinent broke up and drifted away | d. mid-ocean ridge |
| 5. continent moves over the ocean floor | e. continental drift |

2. Match A with B

| A | B |
|---|---|
| 1. large underwater mountain chain around the earth | a. convergent |
| 2. plate boundary movement that forms new crust | b. divergent |
| 3. plate boundary movement that destroys crust | c. lateral slipping |
| 4. plate boundary movement that produces friction | d. mid-ocean ridge |

3. What is formed when crustal rocks are compressed?

a. valleys b. ocean c. wrinkles d. fault

4. What is formed when plates are pulled away from each other?

a. Island arc
b. Rift valley
c. Volcanic arc
d. Mountain range

5. Explain why the Philippines has many volcanoes, experiences lots of earthquakes, and is composed of many islands.

6. How is Saudi Arabia formed?

**Key to answers on page 39**

## Lesson 5. Igneous Activity

Have you heard of igneous activity? Igneous activity is the process of bringing material from the deep interior of a planet and spilling it on the surface. This may lead to the formation of new crust. How is the new crust formed? It starts from the hot material from below. This hot material called magma comes from two sources. It may be produced when given two lithospheric plates, one slab of crust is forced back down into the deeper regions of the Earth as shown in Figure 5.1. This process is called subduction. The slab that is forced back into the Earth usually undergoes melting when the edges get to a depth which is hot enough.

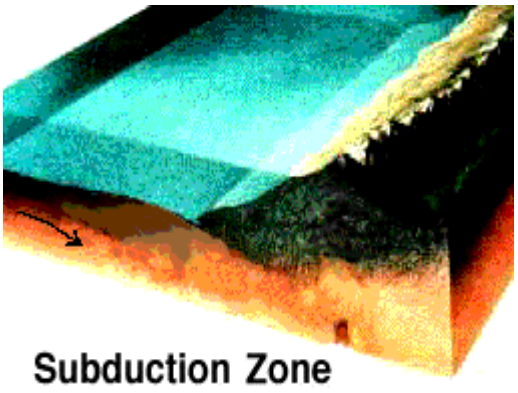
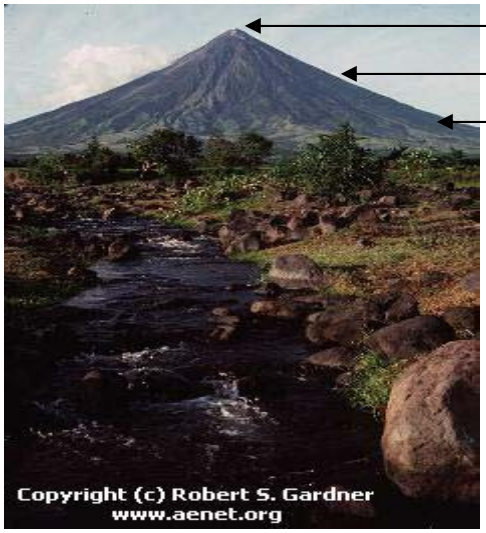



Fig. 5.1 Subduction

The magma may also come from the deeper part of the interior of the earth. The hot magma rises and gathers at a reservoir found in a weak portion of the overlying rock called the magma chamber. The magma comes to the surface to form a volcano or island.

A volcano is a place on the Earth's surface where molten rock, gases and pyroclastic debris erupt through the earth's crust.




Crater

slope

base

What are the parts of a volcano? A volcano has a **summit**, **slope** and **base**. At the summit, you have an opening called vent. A vent may be a crater or caldera. A c**rater** is a funnel-shaped depression at the top of a volcano formed as a result of explosive eruptions. A volcano may have one crater like the Mayon Volcano or more than one crater like the Taal Volcano, which has 47 craters.

**Fig. 5.2 Parts of a volcano**

Volcanoes erupt in two ways. Some volcanoes erupt through a circular vent above a tube-shaped chimney. Other volcanoes erupt out of a long crack, called fissure, and produce a curtain of lava as shown in Fig. 5.3

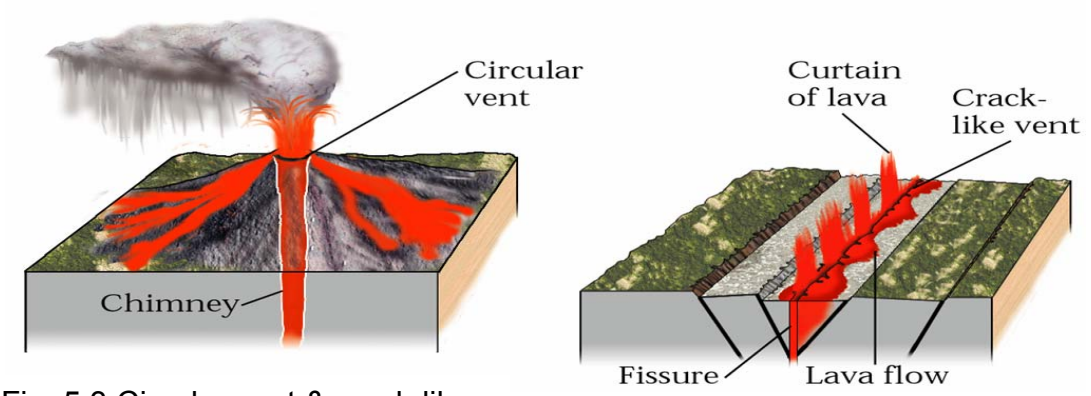



Fig. 5.3 Circular vent & crack-like

Activity 5.1 My volcano

What you need : old newspapers water cooked starch
Basin cardboard small milk can

1. cut newspapers into small pieces.
2. soak pieces of paper in water
3. Based on the discussion about parts of a volcano, build a model of a volcano with the use of water-soaked newspaper pieces and cooked starch.

What determines the nature of eruption? It depends on the viscosity of the magma. Viscosity is a measure of a material's resistance to flow **.** Higher viscosity materials flow with great difficulty . Viscosity is controlled by

temperature of the magma

chemical composition of the magma

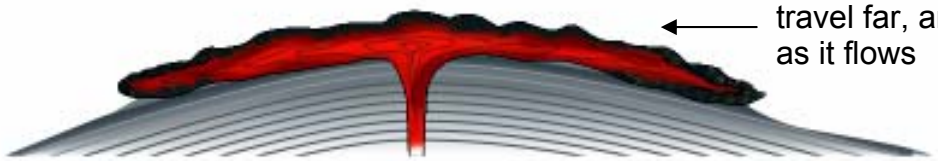
presence of dissolved gases in the magma

The higher the temperature , the less viscous the magma is. An important substance in the magma is silica (SiO2). The higher the silica present in the magma, the higher its viscosity. Dissolved gases also affect the mobility of the magma. Gases expand within a magma as they get near the Earth's surface due to decreasing pressure. The violence of an eruption is related to how easily gases escape from magma. Fluid basaltic lavas generally produce quiet eruptions. Highly viscous lavas (rhyolite or andesite) produce more explosive eruptions. The magma of Philippine volcanoes has high silica content. Thus, our volcanoes erupt violently.

Many Filipinos have witnessed the damage done to Central Luzon when Mt. Pinatubo erupted in 1992. What did the volcano release? One material released was the

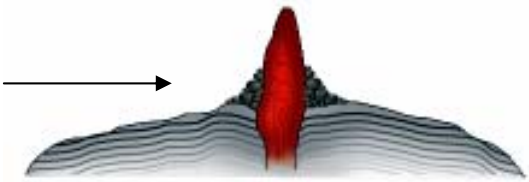
lava. Lava may be thrown into air or may flow out of the opening of the volcano. Lava flows depend on the viscosity of the magma. The collage below shows the different lava flows.

**Basaltic flow** is very fluid-like and can travel a great distance forming a thin sheet



**Andesitic flow** is too viscous to travel far, and tends to break up as it flows

**Rhyolitic spire** – in some cases, rhyolitic lava is too viscous to flow at all, and rises out of the vent as a columnar plug



**Rhyolitic dome** - rhyolitic lava is so viscous that it piles up at a vent as a dome

**Volcanic eruptions release pyroclastics such as**

- ash and dust - fine, glassy fragments
- pumice - porous rock from "frothy" lava
- lapilli - walnut-sized material
- cinders - pea-sized material
- particles larger than lapilli
  –Blocks - hardened or cooled lava
  –bombs - ejected as hot lava

Volcanic eruptions also release gases such as carbon dioxide, steam, ammonia, and sulfur dioxide.

Mt. Pinatubo contributed to the depletion of the ozone layer. How? It released sulfur dioxide into the air

It was raining when Mt. Pinatubo erupted, hence mass of mud and lava formed mudflows or lahar . Lahar or mudflows destroyed everything on their path.

Let's look at the different kinds of volcanoes.

| **Cinder cone** | **Shield volcano** | Composite cone |
|---|---|---|
| –Built from ejected lava (mainly cinder-sized) fragments<br>–has steep slope angle<br>–is rather small in size<br>–Frequently occurs in groups<br>- Famous example is Paricutin in Mexico and Sunset Crater in Arizona | –has broad, slightly domed-shaped<br>–is composed primarily of basaltic lava<br>–generally covers large areas<br>–is produced by mild eruptions of large volumes of lava<br>–examples are Mauna Loa and Kilauea in Hawaii | –Most are located adjacent to the Pacific Ocean<br>- Large, classic-shaped volcano (thousands of ft. high & several miles wide at base)<br>–Composed of interbedded lava flows and layers of pyroclastic debris<br>- Examples are Mt. Fujiyama, Mt. St. Helens, Mt. Pinatubo, Mt. Mayon. |

Cracks form in the rocks surrounding the magma chambers. Magma from the magma chamber creeps up very slowly into these cracks. These areas are colder than the magma chamber. What will happen to the invading magma? The magma cools down slowly without reaching the surface. The result of this slow process is igneous rock structures called plutons**.** Plutons are classified according to shape -–tabular (sheetlike)"and or " massive. What are the different types of plutons or intrusive igneous features?

The different types of plutons or intrusive igneous features are:

•**Dike** – a tabular, discordant pluton

**Sill** – a tabular, concordant pluton

**Laccolith**
–Similar to a sill
–Lens or mushroom-shaped mass
–Arches overlying strata upward

These igneous features through time are lifted up by various mountain-building processes. The overlaying rocks into which they have invaded are weathered, eroded and stripped away.

## *What you will do*

**Self-Test 5.1**

1. How many volcanoes do we have in the Philippines? Name 10 of these volcanoes.

2. If lava is very thick, the volcano would erupt

   a. silently  b. violently  c. cannot be determined

**Key to answers on page 39**

Our country has 220 volcanoes and 21 volcanoes are active. Examples are Taal Volcano and Mayon Volcano. There are dangers during volcanic eruptions. Volcanic eruption may occur when there is intense storm. We learned earlier that volcanic ash fall and release of other pyroclastics are dangers of volcanic eruptions. Landslides may also occur. The boxes below may help you what to do in midst of these dangers.

**What to Do Before Intense Storms**

1. Be familiar with the land around you to better assess your risk of danger.
2. Watch the patterns of storm-water drainage on slopes near your home.
3. Watch the hillsides around your home for any signs of land movement, such as small landslides or debris flows, or progressively tilting trees.

**What to Do During Intense Storms**

1. Stay alert and awake.Listen to a National Oceanic and Atmospheric Administration (NOAA) Weather Radio or portable, battery-powered radio or television for warnings of intense rainfall.
2. If you are in areas susceptible to landslides and debris flows, consider leaving if it is safe to do so.
3. Listen for any unusual sounds that might indicate moving debris, such as trees cracking or boulders knocking together. A trickle of flowing or falling mud or debris may precede larger landslides.
4. Be alert for any sudden increase or decrease in water flow and for a change from clear to muddy water near streams or river channel.

## What to do in case of an ashfall

### General Principles

- In ashy areas, use dust masks and eye protection. If you don't have a dust mask, use a wet handkerchief.
- Keep ash out of buildings, machinery, air and water supplies, downspouts, stormdrains, etc.
- Stay indoors to minimize exposure -- especially if you have respiratory ailments.
- Minimize travel
- Don't tie up phone line with non-emergency calls.
- Use your radio for information on the ashfall.
- Keep the following at home:

  Extra dust masks.
  Enough non-perishable food for at least three days.
  Enough drinking water for at least three days (one gallon per person per day).
  First aid kit and regular medications.
  flashlights with extra batteries.
  Extra blankets and warm clothing.
  Cleaning supplies

### What to do during and after an ashfall

- Close doors, windows and dampers. Place damp towels at door thresholds and other draft sources; tape drafty windows.
- Dampen ash in yard and streets to reduce resuspension.
- Put stoppers in the tops of your drainpipes (at the gutters).
- Protect dust sensitive electronics.
- Since most roofs cannot support more than four inches of wet ash, keep roofs free of thick accumulation. Once ashfall stops, sweep or shovel ash from roofs and gutters. Wear your dust mask and use precaution on ladders and roofs.
- Remove outdoor clothing before entering a building. Brush, shake and pre-soak ashy clothing before washing.

### What to do during the clean up period

- Minimize activities that resuspend ash.
- Remove as much ash as you can from frequently used areas. Clean from the top down. Wear a dust mask.
- Dampen ash to ease removal. Be careful to not wash ash into drainpipes, sewers, storm drains, etc.
- Use water sparingly. Widespread use of water for clean-up may deplete public water supply.
- Wet ash can be slippery. Use caution when climbing on ladders and roofs.

**What to do before landslides**

1. Inform affected neighbors. Your neighbors may not be aware of potential hazards. Advising them of a potential threat may help save lives. Help neighbors who may need assistance to evacuate.
2. Evacuate. Getting out of the path of a landslide or debris flow is your best protection

**What to Do During a Landslide**

1. Quickly move out of the path of the landslide or debris flow.
2. If escape is not possible, curl into a tight ball and protect your head. This position will provide the best protection for your body.

**What to Do After a Landslide**

1. Stay away from the slide area. There may be danger of additional slides.
2. Check for injured and trapped persons near the slide, without entering the direct slide area. Direct rescuers to their locations.
3. Help neighbors who may require special assistance--infants, seniors and people with disabilities.
4. Listen to local radio or television stations for the latest emergency information.
5. Watch for flooding, which may occur after a landslide or debris flow. Floods sometimes follow landslides because they may be started by the same event.
6. Look for and report broken utility lines to appropriate authorities. Reporting potential hazards will get the utilities turned off as quickly as possible, preventing further hazard and injury.
7. Check the building foundation, chimney and surrounding land for damage. Such damage may help you assess the safety of the area.
8. Replant damaged ground as soon as possible since erosion caused by loss of ground cover can lead to flash flooding.
9. Seek the advice of a geotechnical expert for evaluating landslide hazards or designing corrective techniques to reduce landslide risk.

## Lesson 6 Earthquake

Look at Fig. 6.1. Determine the extent of damage done to this place. What caused this damage? Probably, this is due to an earthquake.

Fig. 6.1 Damaged building

Have you experienced earthquake? If not, ask your elders to describe the shaking of the earth during an earthquake. Do Activity 6.1.

### *What you will do*

**Self-Test 6.1 Individual Account of Earthquake Experience**

What to do:

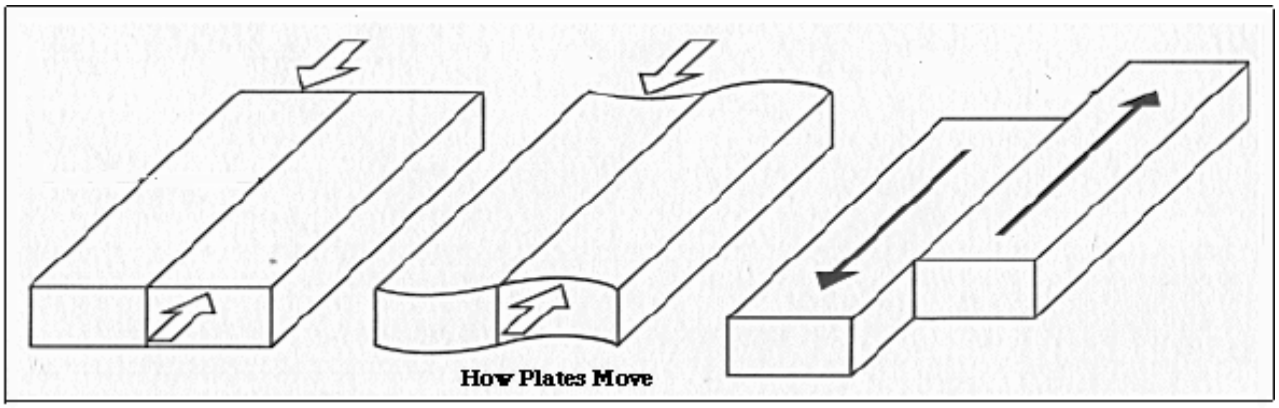
1. Interview a friend, an elder or school officials who have unforgettable experience of an earthquake. You may interview several individuals.
2. Get the following information:
    a. Date of Earthquake (Month and Year)_____
    b. Time it occurred _____
    c. Where were you? _____
    d. If you were inside, describe building and specific room. If outside, describe location (e.g.; sidewalk in front of department store).
    e. What were you doing when the earthquake occurred?
    f. f. What happened? What did you see, hear, feel? What did you and those around you do?
    g. How did you feel?

**Key to answers on page 40**

The people you have interviewed may gave you the following: - ground rumbles, hanging lamps swing back and forth, bookshelves rattles, water spills from a shaking glass, floor and walls sway, and so on.

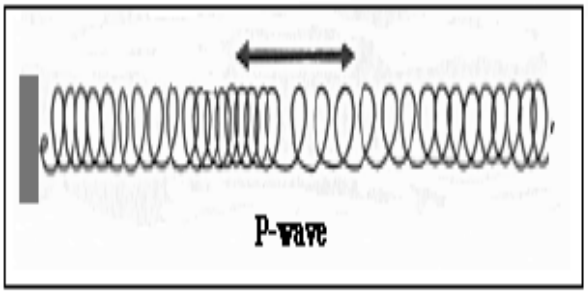
Plate Tectonic Theory can be used to explain the occurrence of an earthquake. The crust has lots of large and small cracks called faults. But you can not see the faults even if they are very long. The cracks are buried deep underground and the pieces of crust are compressed together very tightly. The powerful forces that compress these crustal pieces also cause them to move very slowly. When two pieces that are next to each other get pushed in different directions, they will stick together for many years. However, these forces pushing on them will break apart cracks and separated cracks move. This sudden shift in the rock shakes all of the rock around it. These vibrations, called ***seismic waves***, travel outward in all directions. We call the shaking of the earth as an ***earthquake***. The underground location where the rock first broke apart or shifted is called the ***focus*** of the earthquake. The area above the focus is called ***epicenter***.

What are the different ways the crust at the cracks shake? The pieces may move side by side as shown in the figure below or up and down. The movement creates different kinds of waves.

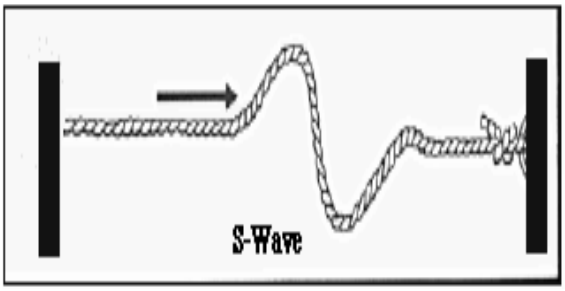


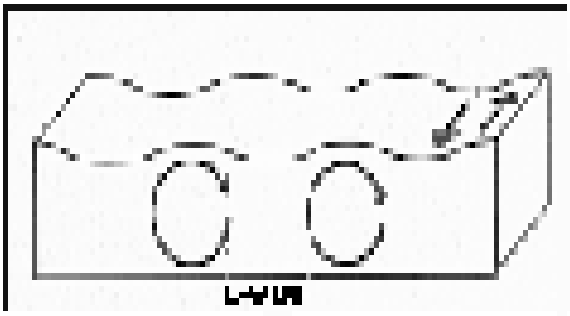
How Plates Move

1. Primary or P waves cause rocks to push or pull forward. It is the fastest wave and travels down into the earth




2. Secondary or S waves cause rock to move side to side like a snake. It is the second fastest wave and travels deep into the earth.



3. Surface (L) waves cause rock to move up-and-down (rolling) or side-to-side motion of the earth surface. It is the slowest earthquake waves. It travels along the surface of the earth. L waves usually cause the most damage.

The shaking would last for a few seconds to a couple of minutes. After shock may follow. There are thousands of earthquakes annually but many are not felt. What are the dangers of an earthquake?

landslide

Fire due to damage on gas and electrical wiring

Soil turns fluid (Liquifaction) which happened in La Union and Dagupan during the Cabanatuan and Baguio Eathquakes

ground subsidence

Extent of damage depends on intensity and duration of vibrations, nature of materials where structures are located and design of the structure

Tsunami, a giant wave, is produced when the epicenter is under water.

Earthquake may also be caused by volcanic eruptions. People in the vicinity of Mt Pinatubo felt many quakes prior to the actual eruption.

How do we locate the origin of earthquake? We can use an instrument called a seismograph.

How do we convey information about an earthquake? How do we know how vigorous the shaking of the crust was? Scientists in universities and government agencies like the Philippine Institute of Volcanology and Seismology (PhiVocs) determine the intensity or magnitude of the earthquake. Intensity is the measure of the human reaction to the ground movement and the damage done to the ground surface such as cracks and landslides. Table 3 shows the Rossi-Forel Scale of Earthquake Intensity, used widely in the Philippines.

Table 3 Rossi-Forel Scales 1873 (Short Version)

| Scale | Description | Indicator/Results |
|---|---|---|
| I | Microseismic shock | Recorded by a single seismograph or by seismographs of the same model, but not by several seismographs of different kinds: the shock felt by an experienced observer. |
| II | Extremely feeble shock | Recorded by several seismographs of different kinds; felt by a small number of persons at rest |
| III | Very feeble shock | Felt by several persons at rest; strong enough for the direction or duration to be appreciable. |
| IV | Feeble shock | Felt by persons in motion, disturbance of movable objects, doors, windows, cracking of ceilings |
| V | Shock of moderate intensity | Felt generally by everyone; disturbance of furniture, beds, etc., ringing of some bells |
| VI | Fairly strong shock | General awakening of those asleep; general ringing of bells; oscillation of chandeliers; stopping of clocks; visible agitation of trees and shrubs; some startled persons leaving their dwellings. |
| VII | Strong shock | Overthrow of movable objects, fall of plaster; ringing of church bells. general panic , without damage to buildings. |
| VIII. | Very strong shock | Fall of chimneys; cracks in the walls of buildings. |
| IX. | Extremely strong shock | Partial or total destruction of some buildings, |
| X. | Shock of extreme intensity | . Great disaster; ruins; disturbance of the strata, fissures in the ground, rock falls from mountains. |
| From: *Earthquakes and Volcanic Eruptions. A Handbook on Risk Assessment* by Herbert Tiedemann. Swiss Reinsurance Company, Zurich, 1992. | | |

Globally, scientists measure magnitude. *Magnitude* is a measure of the amount of energy released during an earthquake expressed in Richter scale or other magnitude scales. The magnitude is calculated by measuring the amplitude of waves recorded on a seismogram, correcting for the distance between the recording instrument and the earthquake epicenter. The magnitude scale is logarithmic. Thus, an earthquake of magnitude 6 produces vibrations with *amplitudes* 10 times greater than those from a magnitude 5 earthquake and 100 times greater than those from a magnitude 4 earthquake.

In terms of *energy*, an earthquake of magnitude 6 releases about 30 times more energy than an earthquake of magnitude 5 and about 1000 times more energy than of an earthquake of magnitude 4.

The country is located in volcanic and earthquake belt. We should adopt precautionary measure for the occurrence of earthquakes. The best protection against earthquakes is to avoid construction in high-risk areas and to use earthquake- resistant construction techniques. Firms, whose business is to build houses and high rise buildings, should have knowledge of the geology of the place. It must make provisions for calamities such as an earthquake. As an individual, what should you do before, during and after the earthquake?

**Before an Earthquake**

1. Secure anything that can be toppled by an earthquake
2. Know how to turn off electricity in your house.
3. Note the nearest accessible exit whenever you enter a building for the first time.
4. Hold fire and earthquake drill at home, in school and offices so everyone will know what to do and where to go.

**During an Earthquake**

1. Keep calm, do not panic.
2. If you are outdoors, move out into an open area away from buildings, which might collapse, and from electric power lines which can snap and electrocute.
3. If caught indoors or in a high-rise building, take cover under tables, desk or bed. You can stay under door frames. Do not use elevator.
4. In school or office, do what you practiced during the earthquake and fire drills.
5. Turn off electricity.

**After an Earthquake**

1. Check electrical devices for any damage before using them again.
2. Inspect house for cracks in its support.
3. Do not go inside collapse structures to get belongings. After shocks may occur anytime.
4. Do not go sightseeing. It is dangerous and you may hamper rescue operations and relief works.
5. Tune in to emergency channels or radio stations for latest information from local authorities on what to do and where to get medical assistance, food and water supplies, temporary shelter and other vital information. .

## *What you will do*

**Self-Test 6.1**

1. Look at the picture below. Make an essay about the picture to explain your concern as criterion to avoid such thing to happen.

2. With this picture, identify the following
   a. What caused the earthquake?
   b. Where do earthquakes mostly happen?
   c. What should have been done by the structural engineer to avoid the collapse of the bridge in the picture?

**Key to answers on page 40**

## Lesson 7. Soil Formations

Have you ever asked anyone where soil came from? There are five important factors that lead to soil formation.

1. It all started with a parent material such as bedrock, organic material, an old soil surface, a deposit from water, wind, glaciers, volcanoes or material moving down the side of a mountain being exposed to agents.

2. The agent such as heat, rain, ice, snow, wind, sunshine and other environmental factors break down the parent material

3. Plant roots and animals help break the rock into pieces. Microorganisms also release substances such as acid which can make rock brittle.

4. Then Dead plants and animals become organic matter that makes the soil rich.

5. Topography influences how climate affect soil formation. More water is present at the bottom of the hill than at the slope. The side of the landscape facing the sun is drier than away from the sun

Soil is the important product of break up of rocks, usually termed as **weathering. Weathering** is physical, chemical, biological or combination of the three processes. It takes millions of years to form a small amount of soil. Soil varies from place to place, which explains why different places in the country grow different crops. The way the soil looks if we cut a section of the soil out of the ground is called **soil profile.** A sample soil profile is shown in Fig. 7.1. Every soil profile is made up of layers called **soil horizons** as thin as a few millimeters or thicker than a meter. The top layer is called **A horizon or top soil**, where most of the biological activities occur. Humus is the most prominent organic matter in the A Horizon. The next layer is **B Horizon or subsoil**. It is the lighter, more compact layer. Below the sub soil is **C Horizon or parent material** where the soil comes from.


Fig. 7.1 Soil profile

What will happen to soil once formed? Do Activity 7.1

## *What you will do*

**Activity 7.1 What happen to soil?**

**What you need**

2 wooden troughs, garden soil, water, Sprinklers or can, grass, 2 basins

**What to do**

1. Fill both troughs with garden soil. Plant one trough with grass
2. Place a wood under one end of the troughs to tilt it slightly.
3. Place a basin in front of the untilted end of the troughs.
4. Pour the same amount of water at one end of the trough and observe the flow of water.
5. Collect the water that flows into the basin.
6. Compare the presence of soil particles in the collected water in both troughs.
7. How do plants prevent erosion?
8. How do we prevent soil erosion?

Give the effects of erosion to the environment.

**Key to answers on page 40**

From the activity, you found out that soil could be transported from one place to another. This process is called **erosion.** There are different agents of erosion. In the activity that we have done, the agent of erosion is water. Other agents are wind, gravity and even man. The transported materials are deposited in low-lying areas, rivers, lakes and oceans. Once they reach the ocean, they are re-deposited as marine sediments.

Because of more soil formation and erosion, soil profiles change as you move across a landscape and as you move downward deeper into the soil at one location.

## *What you will do*

**Self-Test 7.1**

**Direction: Answer the following questions.**

1. What are the soil-forming factors?
2. What are the agents of soil erosion?
3. What are the layers of soil?
4. How do we prevent soil erosion?

**Key to answers on page 40**

## *Let's summarize*

We have learned the following:

1. There are three layers of the Earth's interior – core, mantle and crust. Each has unique characteristics
2. Crust is the only layer directly accessible to humans. It contains different kinds of minerals. Minerals aggregate to form rocks
3. There three kinds of rocks-igneous rocks, sedimentary rocks, and metamorphic rocks.
4. Different kinds of rocks are formed in different ways. Igneous rocks are formed through slow or fast cooling of magma that escape the magma chamber. Metamorphic rock is under intense pressure and temperature. Sedimentary rock is formed through deposition, compaction and cementation of sediments.
5. The surface of the earth is always changing. Thus, there are many landforms such as mountains, valleys, volcanoes, plateaus, domes, etc.
6. There are two opposing forces that shape the surface of the earth – subsurface activity and surface activity. An example of subsurface activity is igneous activity. Weathering is a surface activity.
7. Continental drift theory, sea-floor spreading theory and plate tectonic theory are used to explain the changes on the surface of the earth due to subsurface activities that produce mountains , volcanoes and islands

8. Surface activity like weathering causes wear and tear of the crust leading to formation of soil.
9. Sediments are products of weathering and are transported and deposited in other areas.
10. Water and wind are agents of erosion
11. There are five factors that form soil.

## *Posttest*

**Direction: Encircle the letter of the word or group of words that best answers the questions.**

1. Which of the following layers of the earth's interior is in liquid form?
    a. outer core
    b. inner core
    c. mantle
    d. crust
2. The core of the earth is made up of
    a. oxygen and silicon
    b. iron and nickel
    c. iron and silicon
    d. copper and iron
3. Which of the following is a mineral?
    a. oil
    b. coal
    c. calcite
    d. limestone
4. Two convergent plate boundaries lie adjacent to each other. If plate is oceanic and the other is continental, what is formed when these two plate boundaries move?
    a. volcanic arc
    b. mountains
    c. island arc
    d. rift valley
5. Which type of rock Mindoro and Romblon Island are famous for?
    a. Igneous rock
    b. sedimentary rock
    c. metamorphic rock
    d. both sedimentary and metamorphic rock
6. Which type of rocks that may include plant and animal parts?
    a. a. Igneous rock
    b. sedimentary rock
    c. metamorphic rock
    d. both sedimentary and metamorphic rock

7. Which of the following stresses results to cracks in the crust?

a. tension b. shearing c. compression d. none of these

8. Folds are formed when the earth's crust bends. Which of the following is formed during formation of folds?

a. the syncline becomes a plateau while anticline forms the plain
b. the syncline becomes the lain while the anticline forms the ocean bed.
c. the syncline becomes the mountains while the anticline forms the valley.
d. the syncline form into valley while the anticline becomes the mountains

9. Rocks change continuously. How do we call this continuous change?

a. biogeochemical cycle c. erosional cycle

b. intrusion cycle d. rock cycle

10. A landform that is not faulted or folded but raised and its top is flat is called

a. volcano b. plateau c. dome d. basin

11 . If the temperature of the magma of a volcano is high and it contains low silica. The lava flows _____ and the volcano would erupt _____.

a. slowly , violently c. slowly, silently
b. very fast, violently d. fast, silently

12. Which of the following seismic waves travels fastest?

a. primary waves c. body waves
b. secondary waves d. they all travel at the same speed

13. Tsunami is one of the many dangers of earthquake. When does it occur?

a. epicenter is above water c. epicenter is on land
b. epicenter is under water d. a volcano erupts

14. In which part of the soil where microorganisms are most active?

a. A Horizon
b. B Horizon
c. C Horizon
d. Bed rock

15. A soil has specific profile. Which layer would have the most biological activities?

a. parent material c. top soil

b. sub soil d. all of these

III. Answer the following questions briefly.

1. Give 2-3 practices in your locality which prevent soil erosion

**Key to answers on page 40**

## Key to answers

**Pretest**

1. A
2. D
3. C
4. D
5. A
6. D
7. D
8. A
9. C
10. B
11. C
12. C
13. C
14. C

**Self Test 2.1**

Test I
1. C
2. C
3. D

Test II
1. B
2. B
3. C
4. A

**Self-Test 3.1**

Mt. Apo in Davao City
Banawl in Mountain Province
Marikina Valley
Sierra Madre
Bukidnon - Plateau
Mt. Makiling in Laguna
Baguio City
Sto. Tomas Mountain in Cordillera
Mt. Maculot in Batangas
Montalban, Rizal

**Self-Test 4.1**

1. 1. B 3. C 5. A
   2. D 4. E
2. 1. D
   2. A & B
   3. A & B
   4. C
3. C
4. B
5. The Philippines is located where there is active plate boundary movement
6. Saudi Arabia is formed by the boundary movement of divergent plates.

**Self-Test 5.1**

1**. Volcanoes**

- Mt. Mayon, Bicol Region
- Taal Volcano, Batangas
- Hibok-Hibok Volacano, Camiguin
- Mt. Pinatubo, Zambales
- Mt. Canlaon, Negros
- Mt. Makiling, Laguna
- Mt. Apo, Davao
- Mt. Isarog, Bicol
- Dadicas Volcano, Babuyan Island
- Mt. Balatocan , Misamis Oriental

2. B

**Self-Test 6.1**

1.
2. a. plate tectonics
   b. most earthquakes happen along the boundaries of tectonic plates
   c. structural engineers should implement strict building codes when constructing houses, buildings and bridges

**Self-Test 7.1**

1. exposed parent rocks, agents of soil formation , plants and animals, topography, time
2. wind, water, rain, sun
3. top soil, subsoil, parent rock
4. plant trees, terracing

**Post Test**

| | | |
|---|---|---|
| 1. B | 6. B | 11. D |
| 2. B | 7. C | 12. A |
| 3. C | 8. D | 13. A |
| 4. A | 9. D | 14. A |
| 5. C | 10. B | 15. C |

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