MISSION PLAN

Basic Planetary Geology
Earth Forces

GENERAL

This class will familiarize the Mission Team with planetary geology and develop a basic understanding of the different layers and spheres of the Earth. This class is presented to expand the terrestrial and space knowledge of all Galaxy Explorers in order to enhance their competence and confidence of all aspects of space.

LEARNING OBJECTIVES

SUBJECT AREA: Planetary Geology

TASK: You must be able to understand and identify the different layers that make up the structure of the Earth.

STANDARDS. Must demonstrate an understanding of a cross-section of the Earth
Must be able to identify the spheres of the Earth.

3. PRESENTATION GUIDE

a. Introduction (_____ minutes)

Example: Good morning/afternoon, I am _____ and I will be your instructor for Planetary Geology. In this lesson you will learn about the different layers that make up the planet Earth. You will learn the features that characterize each layer so you can differentiate between them. Furthermore, you will learn about the five spheres that make life on this planet possible.

MAIN LECTURE

1) The Three Layers of Earth

The Earth is composed of three different layers. Many geologists believe that as the Earth cooled all of the materials of the planet separated; the heavier materials sank to the center and the lighter materials rose to the top. Because of this, the crust is made of the lightest materials and the core consists of heavy metals.

The crust is the layer that you live on. The mantle below it is much hotter and has the ability to flow. The core is the hottest layer, with very high pressure.

a) **The Crust**

The Earth's Crust is like the skin of an onion. It is very thin in comparison to the other two layers. The crust is only about 3-5 miles thick under the oceans and about 25 miles thick under the continents (continental crust). The crust of the Earth is broken into many pieces called plates. The plates "float" on the soft, plastic mantle that is located below the crust. These plates move slowly above the mantle, usually quite smoothly. However, sometimes they stick and build up pressure. When this pressure builds up, an earthquake usually results.

The crust is composed of two basic rock types. The first type is granite, and it makes up the crust of the continents. The crust of the ocean consists of basaltic rock. Basaltic rocks of the ocean plates are much heavier than the granitic rock of the continental plates. Because of this the continents ride on the denser oceanic plates. The crust and the upper layer of the mantle together make up a zone of rigid, brittle rock called the Lithosphere. The layer below the rigid lithosphere is a zone of asphalt-like consistency called the Asthenosphere. The Asthenosphere is the part of the mantle that flows and moves the plates of the Earth.

b) **The Mantle**

The mantle is the layer located directly under the crust. It is 1800 miles thick, and the largest layer of the Earth. The mantle is composed of very hot, heavy rock. This layer of rock even flows like asphalt under a heavy weight. This flow is due to great temperature differences from the bottom to the top of the mantle. The movement of the mantle is the reason that the plates of the Earth move like oil floating on water.

Many geologists believe that the mantle "flows" because of convection currents. **Convection currents** are caused by the very hot material at the deepest part of the mantle rising, then cooling, sinking again and then heating, rising and repeating the cycle over and over. When the convection currents flow in the mantle they also move the crust. The crust gets a free ride with these currents. A conveyor belt in a factory moves boxes like the convection currents in the mantle moves the plates of the Earth.

c) **The Core**

The core of the Earth is like a ball of very hot metals. The rotation of the core is what causes the magnetic poles of the Earth. The Earth's core is divided into two parts.

The *outer core* is so hot that the metals in it are all in the liquid state. The outer core is located about 1800 miles beneath the crust and is about 1400 miles thick. It is composed of the melted metals nickel and iron.

The inner core of the Earth has temperatures and pressures so great that the metals are squeezed together and are not able to move about like a liquid, but are forced to vibrate in place as a solid. The inner core begins about 4000 miles beneath the crust and is about 800 miles thick. The temperatures may reach 9000 degrees F. and the pressures are 3,000,000 times the air pressure on you at sea level!!!

This concludes this part of the mission. Before I go on, I have a few questions for you.

a) Name the three layers of the Earth in order from the outside to the center of the Earth.

b) What causes the mantle to "flow"?

c) What are the two main metals that make up the outer and inner core?

d) Describe in your own words how the Earth's layers were formed.

3) **Lecture/Discussion continued. Continue to script.**

a) Hydrosphere

The hydrosphere includes all water on Earth. The hydrosphere is very large because 71% of the Earth is covered by water. The abundance of water on Earth is a unique feature that clearly distinguishes our "Blue Planet" from others in the solar system. Not a drop of liquid water can be found anywhere else in the solar system. It is because the Earth has just the right mass, the right chemical composition, the right atmosphere, and is the right distance from the Sun that permits water to exist mainly as a liquid. However, the range of surface temperatures and pressures of our planet permit water to exist in all three states: solid (ice), liquid (water), and gas (water vapor). Most of the water is contained in the oceans and the high heat capacity of this large volume of water (1.35 million cubic kilometers) buffers the Earth surface from large temperature changes such as those observed on the moon. Water is the universal solvent and the basis of all life on our Planet. It is an essential life-sustaining resource that led Benjamin Franklin to comment, "When the well's dry, we know the worth of water."

b) Atmosphere

The atmosphere is the gaseous envelope that surrounds the Earth and constitutes the transition between its surface and the vacuum of space. The atmosphere consists of a mixture of gases composed primarily of nitrogen, oxygen, carbon dioxide, and water vapor. It extends some 500 km above the surface of the Earth and the lower level, called the troposphere, constitutes the climate system that maintains the conditions suitable for life on the planet's surface. The next atmospheric level, the stratosphere (12 to 48 km), contains the ozone layer that protects life on the planet by filtering harmful ultraviolet radiation from the Sun. Since the Industrial Revolution, man has been altering the composition of the atmosphere by the burning of fossil fuels. Concern has been growing about rising concentrations of carbon dioxide, methane, nitrous oxide, and chloroflurocarbons in the atmosphere because these "greenhouse" gases trap heat energy emitted from the earth surface and increase global warming. In addition, chloroflurocarbons are effective at depleting the Earth's ozone shield that protects the earth surface from the harmful effects of ultraviolet radiation.

c) Biosphere

The biosphere is the life zone of the Earth and includes all living organisms, including man, and all organic matter that has not yet decomposed. Life evolved on earth during its early history between 4.5 and 3.8 billion years ago and the biosphere readily distinguishes our planet from all others in the solar system. The chemical reactions of life (e.g., photosynthesis-respiration, carbonate precipitation, etc.) have also imparted a strong signal on the chemical composition of the atmosphere, transforming the atmosphere from reducing conditions to and oxidizing environment with free oxygen. The biosphere is structured into the food chain whereby all life is dependent upon the first tier, also known as the producers. Energy and mass is transferred from one level of the food chain to the next. All organisms are linked to their physical environment and the relationship between an organism and its environment is the study of ecology. The biosphere can be divided into distinct ecosystems that represent the interactions between a group of organisms forming a trophic pyramid and the environment or habitat in which they live.

d) Geosphere

The geosphere is the solid Earth that includes continental and oceanic crust as well as the various layers of the Earth's interior. Ninety-four percent of the earth is composed of the elements oxygen, iron, silica, and magnesium, and the interior of the earth is layered both chemically and mechanically. The geosphere is not static, but its surface (crust) is in a constant state of motion that gives rise to movement of the continents. The unifying theory that explains how continental drift is possible is called plate tectonics, which was developed by geologists in the 1960s.

e) Anthrosphere

Man and his direct ancestors (hominids) have existed on this planet for only about three million years. For almost all of this period the human population totaled less than 5 to 10 million individuals. Homo sapiens have increased their numbers from 1650 to present rising to the current population of 5.5 billion. If this growth continues, the human population will reach 14 billion in the year 2010 and 60 billion in the year 2020. However, unlimited growth in an environment of depleting resources is impossible because growth will eventually use up the available resources and the population will collapse. Indeed one of the kindest things that the human species could do for planet Earth is to control the rate of growth of the anthrosphere.

This concludes this part of the mission. Before I go on, I have a few questions for you.

a) Name the five spheres of the Earth.

b) Which sphere makes up the most of the Earth?

c) What sphere do humans make up?

c. Conclusion. (_____ minutes)

In conclusion, I provided you information on basic planetary geology, and we discussed on the layers of the Earth and the different spheres of life in the planet. I hope this information

provides you a little insight into the structure of the planet that you live on. Furthermore, I hope that you now understand many of the processes that take place on Earth and how they affect life on this planet.

ACTIVITY

There activities illustrate some aspects of the five spheres of Earth. Mission Teams can conduct any or all of these experiments.

Activity 1. Weighing the Earth's atmosphere.

Earth's air has many characteristics. Scientists have developed different ways of investigating these characteristics. In this exercise Mission Team members will investigate an important question about air: Does it have weight?

Materials (per small group)
Two small latex balloons
Two 15-cm pieces of string
30.5-cm ruler
Piece of notebook paper
Tape

Procedure
Divide Mission Team into small groups. Each group should attach a balloon to each end of a ruler, being careful to use exactly the same lengths of string or tape to attach each balloon. Suspend the ruler on a string at approximately the 15-cm mark to create a balance. With tape, attach the top of the string to a wall about eye level. Tape the notebook paper to the wall behind the ruler. Put a pencil mark on the paper above and below each end of the ruler to mark its beginning position. Remove one of the balloons and blow into it, inflating it as much as possible. Tie and reattach the balloon with the same piece of string. Gently pull the string suspending the ruler away from the wall, allowing the ruler to readjust. Carefully release the string and check the ruler's new position. Mark the paper with the pencil again.

Discussion
1. Does the ruler still balance?
2. Does one balloon now weigh more than the other?
3. What does this tell you about air?
4. Was your hypothesis correct? When a number of different experiments give the same results, the hypothesis may be accepted as a theory.

Activity 2. Watching the effect of weight of Earth's atmosphere.

Let's watch the effect of the weight of the atmosphere in action. This experiments involves filling a one-gallon plastic jug (usually for milk) with water. The water is emptied through a garden hose creating a vacuum in the jug. The weight of the atmosphere crushes the jug.

Procedure:

1. Have each Mission Team group seal a 5-foot length of garden hose around the opening of the one-gallon plastic jug. This garden hose can be screwed on or covered with duct tape. It is important that this seal not leak.
2. Hold the seal tightly and raise the jug up so that the water empties out through the hose. (This should be done over a sink or outside)
3. The weight of the atmosphere will crush the water jug.

Activity 3. Observing patterns of change. Creating models of rocks weathered by water

Materials
Pictures of rock formations showing signs of weathering
Small balloons
Dough mixture
Water
Wax paper
Resealable plastic bag

Procedures
Prepare trays with a balloon, wax paper, and a plastic bag. Ask: *Are you the same now as you were when you were a baby? How have you changed?* Show Mission Team member's pictures of land formations that show signs of weathering. Lead a discussion by asking: *How do you think the rock formations looked way back in time? Have Mission Team member volunteers go to the chalkboard and draw what they think the rocks might have looked like back in time.* (If one of the pictures shows a large arch, perhaps the Mission Team members will fill in the space under the arch. They might make a mountain peak taller.)

Distribute trays for each pair of Mission Team members and distribute balls of dough. Make containers of water available at various places in the room. Have Mission Team members fill the balloon with enough water to make it look like a golf ball. Direct them to tie the balloon so only water is in the balloon (very little if any air space).

Have Mission Team members flatten a ball of dough until it is about 1/2 cm thick. Have Mission Team members wrap the dough around the balloon making sure none of the balloon shows through the dough, and there are no cracks.

Have Mission Team members write their names on a new sheet of notebook paper. Have the Mission Team members draw step-by-step illustrations of how they created their *rocks.*
Explain to the Mission Team members that they will take their rocks home. The rocks must harden on the wax paper for two or three days. Tell Mission Team members that when the rocks are dry, to place them in a freezer overnight.

Mission Team Leader Notes
Prepare dough the night before.
Recipe for dough: Mix 1 cup of flour, ¼ cup salt, 2 T cream of tartar, 1 cup water, and 1 T of oil in a pot over medium heat. Stir for 3-5 minutes. For a large group, it may be necessary to make a

double batch. When the mixture forms a ball, knead and store it in a resealable plastic bag so it will be kept moist.

Activity 4. Making models of metamorphic rocks Understanding about the formation of rocks

Mission Team Leader Notes
Place ice cube trays filled with balls of modeling clay into the freezer overnight for use.

Materials
Per teams of 4:
Frozen balls of modeling clay
Books or other heavy weights
Wax paper
Optional:
6 slices of bread (white and wheat)
Microwave oven

Procedures
Explain to the Mission Team members that today they will create models of the last of the three types of rocks, *metamorphic* rocks. Explain that metamorphic rocks are formed from the effects of heat and pressure from igneous and sedimentary rocks. Tell them that rocks that are not very dense or have many holes in them become very packed and heavy (dense).

Divide the Mission Team members into teams of four. Place two small sheets of wax paper at every team's work area. Remove the ice cube trays from the freezer and circulate around the room placing three or four frozen balls of clay on one of each team's sheets of wax paper. Direct the teams to place the second sheet of wax paper on the top of the clay balls. (The purpose of the sheets of wax paper is to protect the desks and the books.)

Have Mission Team members place three or four books on top of the wax paper. Invite the Mission Team members to predict what they think will happen. Have the Mission Team members bend their heads to desktop level and watch for changes. While they wait, have the Mission Team members write their names on clean sheets of notebook paper and describe the procedures for this activity. Explain that, at the completion of the activity, they will write the results and form a conclusion about the activity.

While the Mission Team members await the results of the first activity they can observe the same process using a different technique.

Have two Mission Team members take turns stacking the six bread slices one on top of the other, alternating the type of bread used for each layer. Have two more volunteers place a heavy book on top of the layers and take turns pressing on the books. When this is accomplished, remove the books and wax paper and show the Mission Team members the metamorphic sandwich. Ask: *The materials have had pressure applied by the weight of the rock layers above. What are they still missing?*

Place the sandwich on a sheet of wax paper in the microwave oven and heat it for one minute. The sandwich will be left in the microwave oven for five minutes and then brought back for

Mission Team members to see. Display the metamorphic sandwich and circulate around the room allowing the Mission Team members a closer view and an opportunity to touch it. Ask: *How has it changed and what were the causes of the change?*

Have Mission Team members continue to monitor the first activity with the now melting clay balls. Have them note the changes and write the descriptions on their papers.

Activity 5. Studying a force of nature that causes changes of landforms

Materials
Writing Paper
Modeling clay
World map of plate tectonics (below)

Procedures
Ask: *What is an earthquake? Have you ever felt an earthquake?* Allow Mission Team members to share their personal knowledge of earthquakes. Explain to the Mission Team members that, over a long period of time, scientists have had many theories about what causes an earthquake. The most current belief is the theory of *plate tectonics.* Tell Mission Team members that scientific discoveries have supported the idea that the *lithosphere* (which is the crust and the upper part of the next layer called the *mantle*) is broken into huge plates that float on the more plastic or moveable part of the mantle. The movements of the plates can be so slow that noticeable changes don't occur for millions of years. Explain to Mission Team members that the lithosphere is made of 25 plates but that even of the plates are responsible for major movements over time. These plates have the names of the continents or the oceans they carry. Use the map below to point out some of the plates.

Have the Mission Team members hold their hands out flat in front of them with the palms down. Have them move their hands together until the edges touch. Tell the Mission Team members to press the hands together pretending they are experiencing great pressure. Model this for them and suddenly thrust the thumb edges upward. Ask: *If your hands represent two different plates bumping together, what would it look like if the edges of the real plates pushed upward? What would happen if two plates were rubbing past each other?* Explain that this is another motion that causes earthquakes. Show the Mission Team members the area in California where the North American Plate and the Pacific plate come together. Inform Mission Team members that California frequently experiences earthquakes.

Explain that, sometimes when the plates come together, the edge of one plate moves below the edge of the other plate. Ask: *What does an earthquake feel like to the inhabitants of the area? What types of damage does it do to the cities and towns near the earthquake?*

Have Mission Team members work with modeling clay to imitate the motion of the plates. Direct them to make a thick flat layer of clay. Have them push the ends together and observe the clay rising in the middle like mountains. Suggest that Mission Team members divide the flat strip and try to push one edge forward along the other and notice what happened to the edges of the clay.

Another more appetizing way of illustrating the results of plate tectonics is to have Mission Team members use graham cracker cookies to represent the Earth's crust and chocolate frosting to represent the soft mantle. What happens when the crackers are pushed towards each other atop the soft layer of frosting? Feel free to eat results**. Be cautious of children with food allergies!**

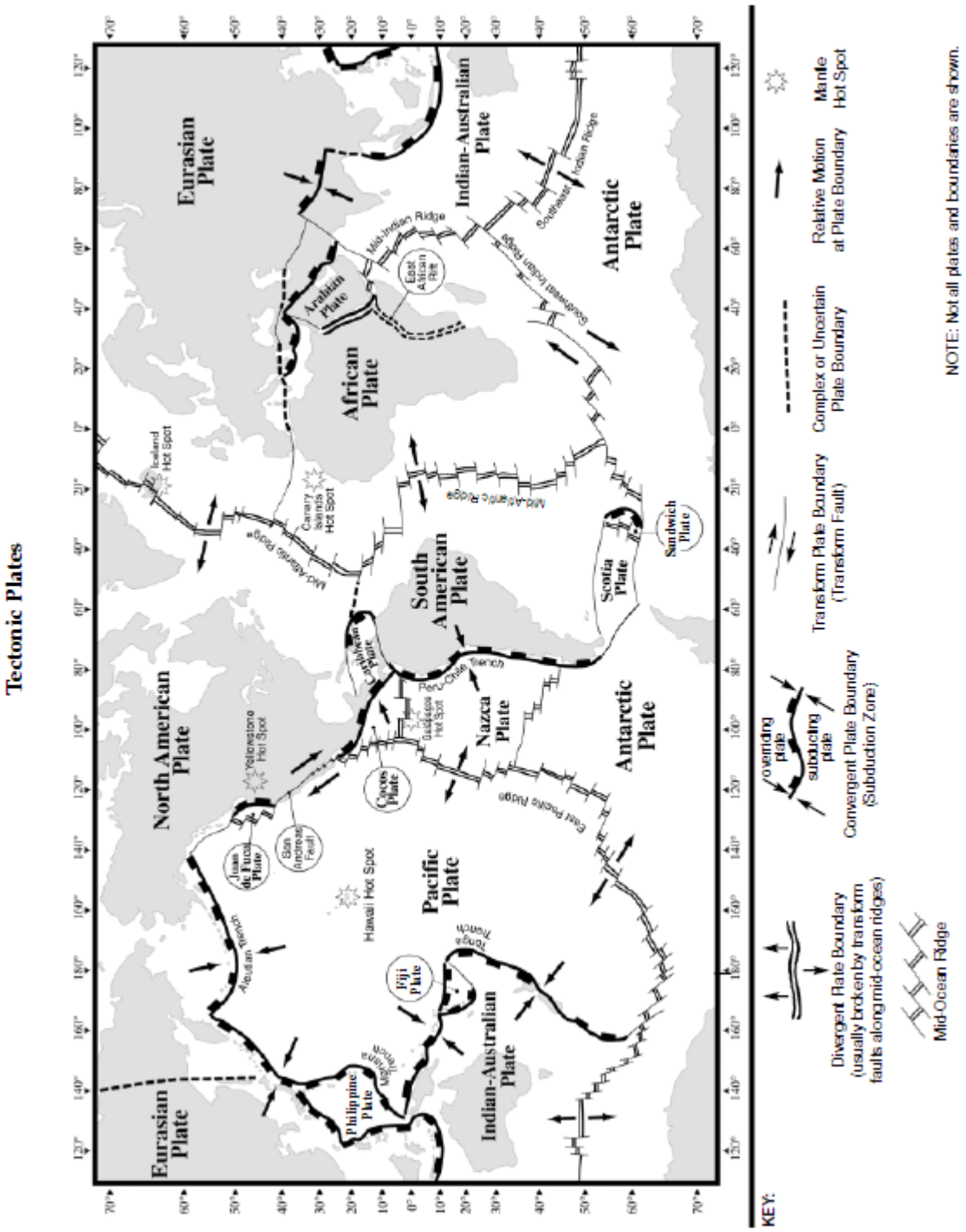
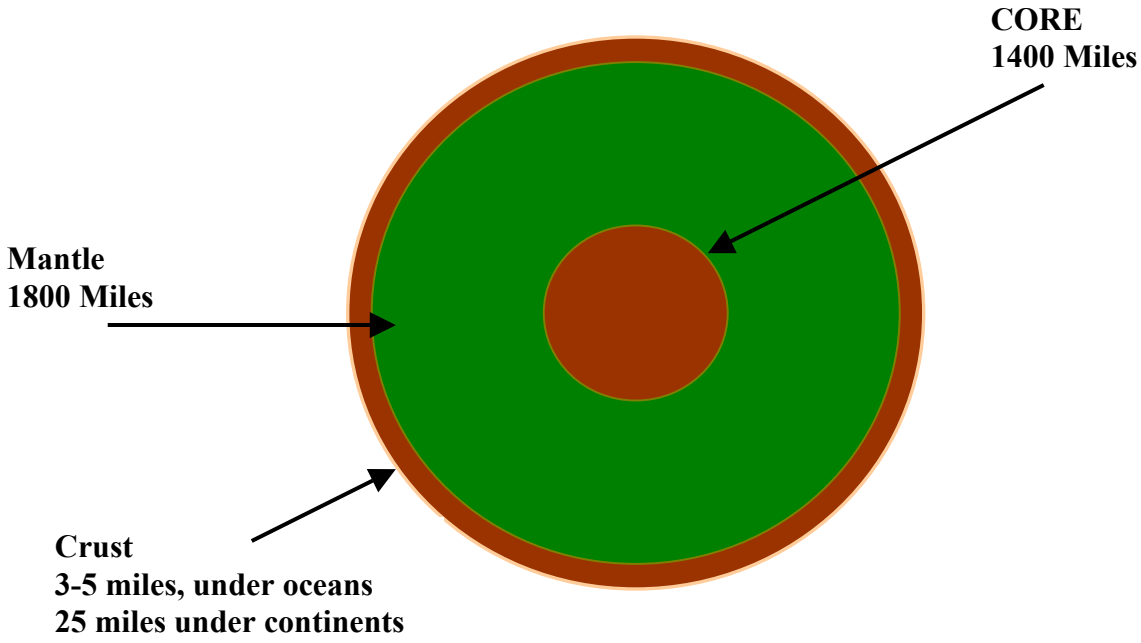
Illustration: Layers of Earth