MISSION PLAN

Basic Geology: Plate Tectonics, Volcanism, Graduation and Cratering

1. GENERAL

This class will familiarize the Mission Team with Planetary Geology and develop a basic understanding of the Earth processes known as plate tectonics, volcanism, graduation, and cratering. 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.

2. LEARNING OBJECTIVES

SUBJECT AREA: Planetary Geology

TASK: You must be able to understand essential ideas about the planetary progressions which continuously change the face of the planet.

STANDARD. Must demonstrate an understanding of the processes discussed.
Must be able to identify and use terminology correctly.

3. PRESENTATION GUIDE

a. Introduction (_____ minutes) **(*Show any training aid(s) needed*)**

Example: Good morning/afternoon, I am _____ and I will be your teacher for Planetary Geology. Today you will be learning about a few of the natural processes that occur on Earth. First, we will discuss the theory of plate tectonics; that the world is really a giant jigsaw puzzle. Then, I will tell you about graduation, which is the planet's way to change the form of rocks. After that we will see how a volcano erupts, and finally we will learn about impact cratering on different planets.

b. Development (_____ minutes) MAIN LECTURE

a) Plate Tectonics

Plate tectonics is a relatively new theory that has revolutionized the way geologists think about the Earth. According to the 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. Plate tectonics is a combination of two earlier ideas, continental drift and sea-floor spreading. Continental drift is the movement of continents over the Earth's surface and in their change in position relative to each other. Sea-floor spreading is the creation of new oceanic crust at mid-ocean ridges and movement of the crust away from the mid-ocean ridges.

The existence of tectonic plates tells us that the Earth is a very active planet. In fact, many millions of years ago, the face of the Earth was vastly different than it is today! There are currently seven continents, but scientists such as Alfred Wegner, a German meterologist, believe that 225 million years ago there may have been only one! They have named that supercontinent Pangaea.. Wegener used the fit of the continents, the distribution of fossils, a similar sequence of rocks at numerous locations, ancient climates, and the apparent wandering of the Earth's polar regions to hypothesize that all of the present-day continents were once part of a single supercontinent called Pangaea. This was a theory of continental drift.

These plates, a part of the Earth called the lithosphere, rest upon the deeper, hot, flowing asthenosphere. This inner furnace of the Earth is the engine that powers the movement of the plates, moving some apart, sliding some parallel to each other, and even forcing some plates to collide.

A fault is a fracture in the Earth's crust along which motion may occur. It marks the boundary between two plates. There are three main types of faults.

- A **divergent fault** occurs when two plates are moving away from each other.
- When two plates come together, the result is a **convergent fault**.
- A fault that occurs when two plates slide past each other is known as a **transform fault**.

What happens at a fault boundary depends, in part, on whether the adjacent plates are made of continental or oceanic crust. Continental crust makes up the landmasses we live on. It is lighter, less dense, and thicker than the oceanic crust that lies under the seas and oceans of the world.

Questions:

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

a) What is *Pangea*?

b) Who came up with the theory of continental drift, and what is it?

c) What are the three faults?

b) Graduation/Weathering

Weathering is a set of physical, chemical and biological processes that alter the physical and chemical state of rocks and soil at or near the earth's surface. Rock and soil is altered

physically by disintegrating and chemically by decomposing. Nearly all weathering involves water. Some examples of this are frost shattering, wetting and drying, salt weathering, and all chemical weathering is in solution. Because weather and climate occur at the earth's surface, the intensity of weathering decreases with depth and most of it occur within less than a metre of the surface of soil and rock.

Physical weathering

Physical weathering is the disintegration of rock by mechanical forces concentrated along rock fractures. The separation of rock into concentric layers is called *exfoliation* in rock masses and spheriodal or onion skin weathering in boulders. *Frost shattering* is the force of water in rock fractures as it freezes and expands. The water fills the cracks in the rocks and expands when it freezes. Therefore, the cracks in the rocks gradually become larger. Frost weathering is the most common physical weathering process, and it is most effective in coastal arctic and alpine environments where there are hundreds of frost cycles per year.

Another type of weathering is pressure/stress release. This is the exfoliation of a rock mass as it expands in response to the removal of an adjacent rock. The most common mechanism of stress release is the erosion of overlying rock by erosion. Due to erosion, the rock disintegrates along fractures which increase with depth, therefore causing the disintigration of the overlying rock.

Hydration is the wetting, swelling and disintegration of soil and fine grained rocks. It is caused by the expansion and contraction with wetting and drying. Furthermore, the pressure of air drawn into pores under dry conditions and then trapped as water advances into soil and rock

Insolation or *thermal* weathering is the expansion and contraction of a rock body due to wetting and drying.

Chemical weathering

Chemical weathering is the decomposition of rock by chemical reactions. This occurs in water, especially soil water and groundwater are rich in dissolved carbon dioxide produced during the decomposition of plants.

Hydrolysis is a process where mineral cations are replaced by hydrogen ions to form acidic water. This is one of the most common weathering processes. The products created by this weathering form a clay, which is the first stage of soil development. Therefore, hydrolysis creates soil.

Oxidation and carbonation are other forms of chemical weathering. Oxidation is the loss of an electron is to dissolved oxygen, whereas carbonation is the dissolving of limestone in acidic water.

Questions:

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

a) What is the difference between physical and chemical weathering?

b) Name a chemical weathering process?

c) What is frost shattering?

c) Volcanism

Volcanic eruptions are among the Earth's most powerful and destructive forces. Imagine hearing a volcano erupt thousands of miles away, or looking through binoculars and seeing the top of a mountain collapse. Imagine discovering an ancient Roman city that had been buried in volcanic ash.

Volcanoes are also creative forces. The Earth's first oceans and atmosphere formed from the gases given off by volcanoes. In turn, oceans and an atmosphere created the environment that made life possible on our planet. Volcanoes have also shaped the Earth's landscape. Many of our mountains, islands, and plains have been built by volcanic eruptions.

Why Do Volcanoes Erupt?

Deep within the Earth it is so hot that some rocks slowly melt and become a thick flowing substance called **magma**. Because it is lighter than the solid rock around it, magma rises and collects in magma chambers. Eventually some of the magma pushes through **vents** and **fissures** in the Earth's surface. A volcanic eruption occurs! Magma that has erupted is called **lava**.

Some volcanic eruptions are explosive and others are not. How explosive an eruption is depends on how runny or sticky the magma is. If magma is thin and runny, gases can escape easily from it. When this type of magma erupts, it flows out of the volcano. Lava flows rarely kill people, because they move slowly enough for people to get out of their way, but they can cause considerable destruction to buildings in their path.

If magma is thick and sticky, gases cannot escape easily. Pressure builds up until the gases escape violently and explode. In this type of eruption, the magma blasts into the air and breaks apart into pieces called **tephra**. Tephra can range in size from tiny particles of **ash** to house-size boulders.

Explosive volcanic eruptions can be dangerous and deadly. They can blast out clouds of hot tephra from the side or top of a volcano. These fiery clouds race down mountainsides destroying almost everything in their path. Ash erupted into the sky falls back to Earth like powdery snow, but snow that won't melt. When hot volcanic materials mix with water from streams or melted snow and ice, mudflows form. Mudflows have buried entire communities located near erupting volcanoes.

Where Do Volcanoes Erupt?

Volcanoes occur because the Earth's **crust** is broken into plates that resemble a jigsaw puzzle. There are 16 major plates. These rigid plates float on a softer layer of rock in the Earth's **mantle**. As the plates move about they push together or pull apart. Most volcanoes occur near the edges of plates.

When plates push together, one plate slides beneath the other. This is a **subduction zone**. In the subduction zone the overlying plate melts to form magma, which can move upward and erupt. At **rift zones**, plates are moving apart and magma comes to the surface and erupts. Some volcanoes occur in the middle of plates at areas called **hotspots** - places where magma melts

through the plate and erupts.

Why Do Volcanoes Grow?

Volcanoes grow because of repeated eruptions. There are three main kinds, or shapes, of volcanoes based on the type of materials they erupt.

Stratovolcanoes build from eruptions of lava and tephra that pile up in layers, or strata, much like layers of cake and frosting. These volcanoes form symmetrical cones with steep sides.

Cinder cones build from erupting lava that breaks into small pieces as it blasts into the air. As the lava pieces fall back to the ground, they cool and harden into cinders that pile up around the volcano's vent. Cinder cones are very small cone-shaped volcanoes.

Shield volcanoes form from eruptions of flowing lava. The lava spreads out and builds up volcanoes with broad, gently sloping sides. The shape resembles a warrior's shield.

The Earth's **biosphere** - the realm of all living things - is affected during a volcanic eruption The force of the eruption on any medium substantial volcano would (as Mount St. Helens did) blow down giant trees like they were matchsticks. Almost all of the animals that lived in surrounding forests would be killed as well. Birds are often particularly hard hit. Some birds survive the eruption but died later because the insects and plants they ate had died

Questions:

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

a) What are the three types of volcanos?

b) Where do volcanos form?

c) How do volcanic eruptions affect Earth?

d) Cratering

What is an impact crater?

An impact crater is a hole excavated out of a surface (e.g. a planet, moon, asteroid, or comet) when a smaller mass moving at very high speed collides with it.

How do impact craters form?

When an impactor strikes a target, it has a great deal of kinetic energy. Physics tells us that the total amount of energy is conserved when two bodies strike each other. The energy, can't be lost, but only transferred. The large amount of energy goes into making several things happen:

- Some of the material from both impactor and target will be melted or even vaporized by the tremendous amount of heat generated by the impact

- A great deal of the energy and momentum will go into moving the material, part of which is driven downward, the rest of which will be ejected from the crater site.
- A shock wave will pass through both the impactor and the target.
- Some endothermic chemical reactions (ones which require energy) may be driven to occur, if they can happen fast enough, before the heat dissipates.

Let's look at the stages in which a crater forms. The following descriptions really would apply to a large impact on a planetary surface, like Earth or the moon.

Crater formation takes place in three stages:

1. Compression Stage: During this stage, the impactor punches a (relatively) small hole in the target, and a shock wave begins to pass through the target. This is when the impactor's energy is converted into heat and kinetic energy in the target, as the pressure generated by the impact is so great that even solid material can act like a fluid, and flow away from the impact site. There is very little material ejected up and out of the forming crater during this stage. This stage is very quick, lasting an amount of time on the order of the impactor's diameter divided by its speed at impact (D/v).

2. Excavation Stage: During this stage, the shock wave begun in the compression stage continues outwards through the material. A very interesting part of this, however, is the fact that this wave spreads out from a point below the surface of the target. As a result, the wave actually spreads upwards from the impactor, and sends some of the target material up and out from the impact site. This material is referred to as the "ejecta". Initially the ejecta forms a plume of hot vapor, melt droplets and fine debris. Then a cone-shaped "curtain" of material spreads upwards from the impact site. Some or all of this ejecta will land in the area surrounding the crater, forming an ejecta "blanket". The crater itself grows very large very quickly during this stage, and material at the lip of the crater folds over creating a rim.

3. Modification Stage: During this stage, loose debris from the impact will tend to slide down the steep crater walls. Some loosened material may slip in sheets, forming terraces along the crater sides. In some craters, a central peak may form as some of the target material splashes back upwards at the initial point of impact. This stage lasts about the same amount of time as the excavation stage, although of course the crater can be further modified by erosion, later impacts, lava flows or tectonic activity for millions of years afterwards depending upon conditions on the target.

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

a) How many stages are there in forming a crater?

b) What is an impactor and a target?

c) What is the loose material cast out of the crater called?

c. Conclusion. (_____ minutes)

Example of what might go here: In conclusion, I provided you information on basic geology and we discussed plate tectonics, graduation, volcanism and cratering. I hope this information provides you a little insight into some of the major planetary systems that shape and mold the face of our planet.

4. **ACTIVITY**

This activity is to construct a volcano. If there are enough materials, then divide the Mission Team into several groups and have each group make their own volcano.

Materials

Two teaspoons baking soda
Cake pan
Modeling cay or soil
Dish detergent
Red food coloring (optional)
¼ cup vinegar
One small plastic bottle with a narrow neck

First, pour two teaspoons of baking soda into a small, plastic soda bottle. (If you have a larger bottle, add more baking soda.) Add a squirt of dishwashing liquid. Place the bottle in the middle of a tin pie pan to help avoid a mess. Then, construct a volcano out of modeling clay or soil, around the bottle. Make sure it is one of the three types of volcanoes. You can add some red food coloring to the baking soda and foliage on the slopes of the volcano. After finishing off the surrounding landscape, add some vinegar to the plastic bottle, and then watch as the volcano erupts!