3.9 FROM ISLANDS TO ATOLLS

OBJECTIVES

The students

- Listen to a description of the formation of volcanic islands, fringing reefs, barrier reefs, and atolls.
- Observe and participate in a simulation of this four-stage process.
- Identify the development stage of their home island.

CLIMATE EDUCATION FRAMEWORK

- 3-5Climate.A.4 Many tropical Pacific islands that have at least one high mountain have one part of the island that gets a lot of rain, and other areas that get very little rain.
- 3-5Systems.B.8 Earth is shaped like a huge ball. Things on or near the Earth are pulled towards Earth's center by gravity.
- 3-5Impacts.A.1 Erosion is the movement of Earth materials (such as coastal land) by forces such as moving water (waves, currents, floods) and wind. Erosion and floods threaten homes, roads and other coastal development.

BACKGROUND

In this activity the students explore how a volcanic island over a *very* long period of time evolves into a coral atoll through a four-stage process. Pacific Islands are at different stages. The teacher is encouraged to *tell the story* as the simulation is constructed (and destructed) with the help of the students.

Some History and Other Notes

Charles Darwin first suggested the following theory of how coral atolls are formed. His theory has since been validated by scientists who drilled deep holes into atolls and discovered the same sequence of rock layers as Darwin had predicted.

Coral reefs are only found near the equator. The reason for this is that coral only grows in warm water. This makes a good topic for research.

This geological process occurs over millions of years. Students are not likely to comprehend the enormity of such a time span. It is fine to just stress that it took a *very, very* long time.

Gravity plays an important role in this process. If student understanding of gravity is minimal, consider using Appendix E GRAVITY to develop this concept.

The Hawaiian Islands are unique in that all four stages are represented from one end of the island chain to the other. At the old, northwest end of the chain is Kure Atoll. Loihi at the new, opposite end, is an active volcano that has not yet reached the surface to become an island. It is currently a developing seamount. If it erupts at the same rate as the volcanoes on the big island, it will reach sea level in a few tens of thousands of years.

Stage 1
The Pacific Islands were all originally high, volcanic islands. These were formed when undersea volcanoes broke through the surface of the ocean shooting up lava that eventually created the islands. Once an island is formed, coral begins to grow around its edges forming a fringing reef.
• This activity is probably best done at the beach. To begin the simulation scoop out a shallow depression in the sand about a meter in diameter. This will be the ocean. Build a mound of sand in the middle about 25-cm high and 25-50-cm in diameter. This is the volcanic island coming up from the ocean floor. Use a sheet of plastic to cover the island and line the depression. Fill the plastic-lined depression with water to a depth of 10-cm or so. Build a fringing reef around the island with pieces of dead coral collected on the beach. The coral pieces need to reach all the way to the outer edges of the depression. They don't need to reach the surface of the water. A large dishpan or similar may also be used if a field trip to the beach is not possible.
Stage 2
Millions of years went by. *Gravity* caused the island to very slowly sink back into the ocean. *Wind, water and wave erosion* also played a part in this process. As the distance between the shrinking, sinking island grew, the fringe reef got further away from the island's shore. Water filled in the space between what was left of the island and the original fringe reef so that it eventually became the barrier reef.
• Gently push on the sand island causing it to slowly sink under the plastic. You may need to push more on the outer edges of the mound to be sure to decrease not only the height but also the diameter. As the mound of sand goes down a space should form between the island and the fringing reef. Water should flow into this space to create a barrier reef around the island.
Stage 3
More time passed during which the volcanic island evolved into a small island in the middle of the lagoon.
• Continue to push on the sand mound until there is just a small, low pile of sand with water all around. Push the coral out a bit to build up the outer barrier reef—the coral keeps growing.
Stage 4
The island continued to sink and the waves eventually washed it away until all that was left was the outer barrier reef or coral atoll. In the case of the Northwest Hawaiian Islands and Majuro, sufficient sedimentation and other soil forming processes occurred (erosion and decomposition for example) such that the coral atolls became able to sustain life.
• Push the sand island down below the water surface and sprinkle some sand (soil) on the coral atoll. Once the island *sinks* below the surface of the water you may need to add water to fill the lagoon—as the ocean fills the lagoon through breaks in the reef.

STUDENT ROLE
Geologist

MATERIALS

Beach Simulation
- sand (beach)
- coral pieces
- water containers
- shovels (optional)
- water
- plastic sheeting such as a tarp or shower curtain about 2-m (6 ft) by 2-m (6 ft)

Classroom Simulation
- large dishpan or small plastic wading pool
- large plastic garbage bag
- sand
- coral pieces

PRODUCTS

Model of process
Working definition of system

PROCEDURES

1. Have the students help prepare for the simulation.

Help them
- Review beach and ocean safety rules.
- Assemble necessary equipment.
  ✔Include containers for carrying water, a plastic shower curtain or similar, and shovels (optional).
- Collect pieces of dead coral from the beach.

2. Help the students set up Stage 1 of the simulation.

Have them
- Dig a shallow depression in the sand about one meter in diameter.
  ✔This will represent the ocean.
- Build a mound of sand in the center of the depression about 25-cm high and 25-50-cm at the base.
  ✔This represents the volcanic island.
- Cover the island and depression with the plastic sheet.
  ✔Be careful not to flatten the island.
- Fill the depression around the island with water to a depth of 10-cm or so at the deepest point.

3. Begin Stage 1 of the simulation.

- Tell the story using something like the following

  The Pacific Islands were originally high, volcanic islands. These were formed when undersea volcanoes broke through the surface of the ocean shooting up lava that eventually created islands. This is one such *volcanic island*. As soon as the island was formed, coral began to grow around the shores of the island creating a *fringing reef*.
- Have the students place pieces of coral around the island all the way to the outer edge of the depression.

4. Continue with Stage 2 of the simulation.

- Continue the story with something like the following

  Millions of years passed. The island very slowly sank back into the ocean. Wind, rain, and wave erosion also played a part in this process. The distance from the shores of the shrinking, sinking island grew further and further from the fringe reef. Water began to fill in the space between what is left of the island and the original fringe reef so that eventually the fringe reef became a *barrier reef*.
- Gently push down the island around the sides and from the top to decrease its diameter and height of the island.

  ✔You may need to push the coral a bit toward the outer edges to produce the proper effect of the water coming between the reef and the island.

5. Continue with Stage 3 of the simulation.

- Continue the story with something like the following

  Still more time passes. The wind blows, the rain washes away the soil, the waves erode the shore of the island. Gravity does its work. The once majestic island continues to sink ever so slowly into the sea until all that remains of the once tall volcanic island is a small flat island in the middle of a large lagoon enclosed by an outer barrier reef.
- Keep gently pushing on the sand mound as described above until just a small island remains above the water.

6. Complete Stage 4 of the simulation.

- Finish the story with something like this

  The island continues to sink to the bottom of the lagoon and the waves eventually washed it completely away. All that remains now is the outer barrier reef or *coral atoll*. In the case of Majuro for example, sufficient sedimentation and other soil forming processes occurred so that the coral atolls became able to sustain life.
- Push the sand island down below the water surface and sprinkle some sand (soil) on the remaining coral atoll. Add a small plant if available.

  ✔Once the island *sinks* below the surface of the water you may need to have the students add more water to fill the lagoon.

7. **Have the students discuss the simulation.**
   Ask such questions as these
   - Where did the land for the island come from?
     ✔ The lava from undersea volcano that grew until it got taller than the ocean was deep.
   - Does anyone know of any undersea volcanoes that are now starting to make new islands?
     ✔ One example is Loihi off the coast of Hawaii's Big (and youngest) Island. It will be tens of thousands of years before it gets to the ocean's surface if it ever does.
   - Where does a fringing reef grow?
   - What is a fringing reef made of?
     ✔ Live and dead corals.
   - What caused the island to shrink and sink?
     ✔ Gravity and wave, water, and wind erosion.
   - How was the lagoon formed?
   - How does water get into the lagoon?
     ✔ Through a break in the barrier reef.
   - Where is the island now?
     ✔ At the bottom of the lagoon.

8. **Help the students identify and discuss at which stage their local island environment is in this process**.
   Ask such questions as
   - At what stage do you think our Pacific island home is in this geologic process?
   - Why do you think so?
   - What evidence do you have?
   - How could you find out if you are correct?