17
DEEP-SEA HYDROTHERMAL VENTS

The earth's surface is a thin crust of rocky plates that float on a molten core. These floating tectonic plates include continental and oceanic plates.

Color the diagram of the rift zone along the oceanic ridge. Next color the research submersible *Alvin*. Color each member of the vent community as it is discussed.

Rift zones occur along *mid-oceanic ridges* on the deep-sea floor of the oceans' basins, where volcanic activity, deep in the earth, pushes up molten rock (*magma*). This new rock material added to the edges of the oceanic plates results in sea-floor *spreading*. The heavy oceanic plates grow and spread away from the rift zone, and push against the lighter continental plates. Along this margin, they slide underneath, to be consumed by the molten core.

In 1977, marine geoscientists used the deep-diving research submarine *Alvin* to explore a rift zone 368 km (229 miles) northeast of the Galapagos Islands. The scientists expected the rift zone to be a volcanic wasteland, instead they were surprised by a thriving bottom community 2700 meters (almost 9000 ft) deep that existed entirely independent of the productivity of the ocean's lighted surface.

Rift zone communities have now been studied in some detail. Sea water seeps through fissures created in the spreading sea floor and contacts the molten rocks below. Here the water is super-heated and rises through chambers or vents back up to the ocean floor. As the super-heated sea water rises, it leaches materials from the rocks and sediments. The heated water contains high concentrations of these materials, especially hydrogen sulfide. Hydrogen sulfide is a high-energy chemical compound. Anaerobic bacteria can extract this chemical energy by adding oxygen (oxidation) and trapping the released energy to run their metabolism. This process, called chemosynthesis, uses a chemical energy source to drive the synthesis of carbon compounds (not light energy, as with photosynthesis). Hydrogen sulfide is highly poisonous to oxygen-breathing organisms. It binds with a critical chemical component of the respiratory pathway and shuts down respiration. However, over evolutionary time several marine animal groups have joined in symbiosis with sulfide bacteria to reap the energy benefit of hydrothermal vents.

The most conspicuous symbiont member of the hydrothermal vent community is the large Galapagos tube worm, *Riftia*. This worm reaches a meter (3 ft) in length and resides in white, chitinous tubes over 3 meters (9 ft) long. A large tentacular plume projects about 30 cm (12 in) beyond the tube. The tentacles, attached at right angles to a stiff base and layered one upon the other, receive a rich blood supply from the worm's circulatory system, giving them a bright red color. *Riftia's* blood contains two different blood proteins. One is hemoglobin, which is used to bind oxygen for the worm's respiration. The second blood protein binds hydrogen sulfide in such a way that it cannot harm the worm. The bound hydrogen sulfide is carried by the worm's circulatory system to a special organ, the trophosome, which is packed with symbiotic sulfide bacteria. The bacteria metabolize the hydrogen sulfide and part of the energy captured by the bacteria is released to the worm. The worm is totally dependent on this symbiotic relationship because it has completely lost its digestive system.

Two bivalve molluscs, a *clam*, *Calyptogena*, and a *mussel*, *Bathymodiolus*, also utilize symbiotic bacteria which they harbor in their gills. Growth studies of these bivalves reveal the high-energy nature of the hydrothermal vent environment. These molluscs grow just as fast or faster than bivalves in shallow-water communities and dramatically faster than other deep-sea animals, which are severely limited by the small amount of available food.

Some members of the rift community feed directly on *bacterial mats* which grow on the bottom. Others feed by filtering suspended bacteria from the water, as is the case with the large tube-dwelling polychaete called the *Pompeii worm*. There are also *crabs* and *shrimp* that are either predators or scavengers.

The water surrounding vent communities has a distinct thermal profile. The *heated water* may emerge as a gentle stream of 25°C (77°F) water, or jet out of chimney-shaped vents called *smokers*, where the water temperature reaches 300–400°C (600–750°F). The "smoke" is created when concentrated minerals rising with the heated water are precipitated by mixing with the cold bottom water. Near the mouths of the vents, where the *Riftia* occur, the water is quickly cooled by the surrounding sea to 16°C (61°F). Comparing the thermal profile to the distribution pattern of the vent community members reveals that each organism has a preferred thermal niche.

Hydrothermal vent communities are now known to be common along many ocean ridges. Apparently due to the highly volatile nature of the volcanically-influenced rift zones, the vent communities are fairly short-lived. Scientists have discovered dead communities along rift areas in which the hot, sulfurous water no longer welled out of the sea floor and the food chain collapsed. They estimate a community may persist for only 20 to 75 years.

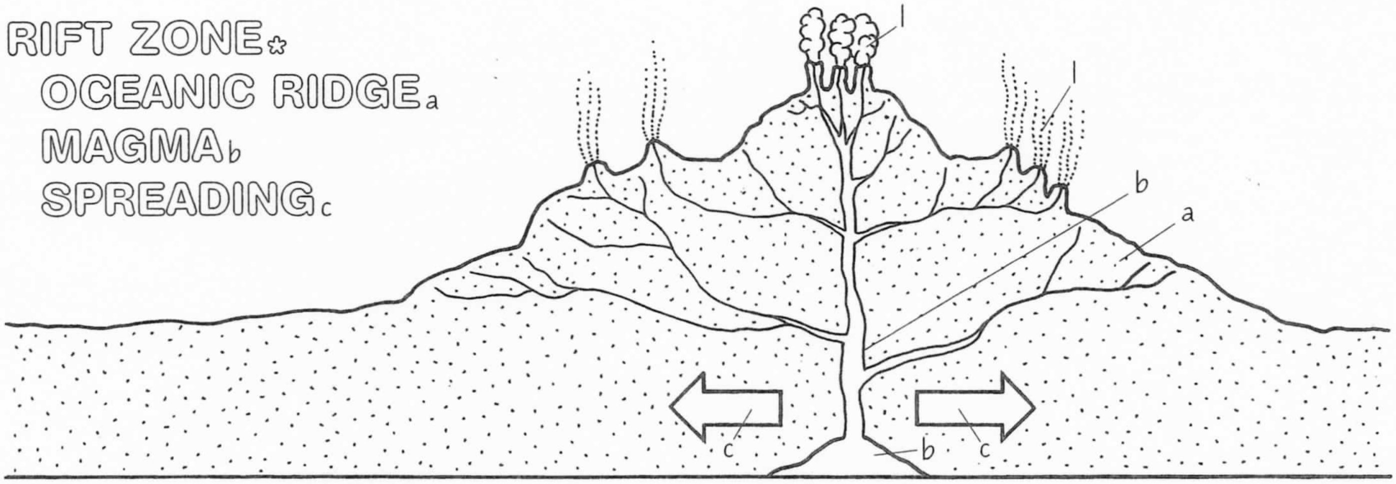
Name/Period/Date

Deep-Sea Hydrothermal Vent

1. Where do rift zones occur?
2. Explain why rift zones contain so much life.
3. On what symbiotic relationship are tube worms dependent?
4. Why is the hydrothermal vent community considered extreme?
5. Color!

DEEP-SEA HYDROTHERMAL VENTS

RIFT ZONE*
OCEANIC RIDGE a
MAGMA b
SPREADING c



HYDROTHERMAL VENT COMMUNITY*

ALVIN d
RIFTIA e
CLAM f
MUSSEL g
BACTERIAL MAT h

POMPEII WORM i
CRAB j
SHRIMP k
HOT WATER l
SMOKER m