Geophysical Processes At Mid-Ocean Ridges And Hotspots

Rodey Batiza; University of Hawaii, Dept. of Geology & Geophysics

Several lines of evidence indicate that terrestrial life began in the vicinity of hydrothermal vent systems similar to those active in modern oceans. Since hydrothermal systems are hosted by submarine volcanoes, this suggests an important link between submarine volcanic processes and the origin of terrestrial life. While some aspects of submarine volcanism in the early earth probably differed significantly from today, many of the fundamental geophysical controls on submarine volcanic activity were most likely similar. This means that a better understanding of modern submarine volcanism may help to shed light on the origin of terrestrial life and may also provide a rationale for bioastronomical exploration of other planetary bodies. Terrestrial volcanism today, as in the past, is basically a manifestation of the loss of internal heat via convection of the silicate mantle. In the present earth, internal heat is generated by radioactive decay, whereas in the early earth additional heat from accretion and core formation could have been available. Today, and probably for the last two billion years or so, volcanism occurs mostly at the boundaries of tectonic plates: divergent (continental rifts and mid-ocean ridges) and convergent (island arc) ones. Some volcanism does occur in plate interiors and commonly leads to the formation of linear island chains like the Hawaii-Emperor chain. This so-called hotspot volcanism is thought to result from plumes of upwelling mantle material, plumes that are possibly integral parts of the mantles convective regime.

At mid-ocean ridges and hotspots, the magma for volcanism is produced by decompression melting of upwelling mantle material, whereas in island arcs the magma is thought to be the result of volatile fluxing of hot dry mantle material in the wedge above the downgoing lithospheric slab. Regardless of how the melt is generated and migrates upward, it appears that longlived and extensive hydrothermal activity requires that prior to eruption, the magma be stored at relatively shallow levels in the crust. This stored magma provides the primary source of heat needed to drive hydrothermal convection, although cooling lava flows in the overlying volcanic edifice may support transient and less vigorous activity. Since hydrothermal systems also require permeable pathways for water circulation, the processes that control cracking, faulting and fissuring of volcanic edifices exert an important imfluence on the extent of hydrothermal circulation. Some of these processes may be controlled by far field regional tectonic stresses, however others are controlled by the dynamics of the volcanic edifice itself. For example, linear volcanic rift zones, calderas, radial fault patterns, and other volcanic features may result from magma migration, withdrawal (*e.g.* by eruption), and inflation-deflation patterns due to cyclic patterns of magma supply and eruption. In general, the characteristics of submarine volcanoes, including the type and extent of hydrothermal systems present, result from the interplay of a variety of geophysical and geologic processes acting on a range of spatial and temporal scales.