ZONATION OF PERIPHERAL INDICATORS OF MID-OCEAN RIDGE HYDROTHERMAL VENT ACTIVITY

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ABSTRACT

This study addresses the effects of composite (low- and high-temperature) hydrothermal vent systems on the local benthic environment through research into sedimentation and the biogeography of the near-vent region (i.e., within several kilometers of the locus of high-temperature vent activity). A conceptual model is developed that describes the transition from active high-temperature vent exit sites to conditions more typical of the benthic environment in terms of surface indicators of vent activity. The model (based on photographic data from Ashes Vent Field, Juan de Fuca Ridge) distinguishes three zones transitional between vent and nonvent environments: (1) a central vent zone within 100 m of high-temperature chimneys that is dominated by vent organisms and hydrothermal sedimentation; (2) a distal zone of low-temperature venting that extends to 725 m from hot vent sources; and (3) the nonvent impact zone, a region that appears to be affected by the hydrothermal system even though there is no evidence for vent activity in the area.

The biogeography of invertebrate megafauna in the near-vent region can be related to the zonation model. Maximum densities of vent organisms (tube worms, clams, bacterial mats), crabs, and anemones occur in the central vent zone; whereas the distal zone of low-temperature venting supports maximum densities of echinoderms, including holothurians, sea stars, and urchins. Although visual evidence for vent activity is limited to within about 800 m of the locus of high-temperature vent structures at Ashes Vent Field, the density of glass sponges reaches a maximum (thirty times higher than in nonvent regions of the

caldera) more than a kilometer from the center of the vent field. These results suggest that hydrothermal vent systems impact the benthic environment to a greater distance than indicated by cursory photographic surveys of vent organisms alone, and that processes associated with deep-sea vent activity result in an enhanced living environment for organisms common to the regional benthos, in addition to specialized vent fauna.

Sediment geochemical studies of samples collected from the rift valley of the Galapagos Spreading Center at 85°50.5' W and from Ashes Vent Field indicate that high-temperature venting results in marked mineralogical differences within < 20 m of vent exit sites. The same is possibly true of low-temperature vent activity, although low-temperature fluid upflow zones are less well-defined, making it difficult to determine whether these sediments are dispersed from vent sources. The fact that vent exit sites are essentially point sources (relative to pelagic sedimentation), the dynamics of plume transport, and the instability of hydrothermal phases under ambient seawater conditions result in a constrained depositional pattern for mineralogically distinct hydrothermal precipitates at active and inactive vent sites. Metal sulfides and goethite (and, in some cases, anhydrite) are the primary sedimentary phases associated with high-temperature vent exit sites that are marked by the presence of massive sulfide deposits. These samples are restricted to the immediate vicinity of massive sulfide deposits, corresponding to the central vent zone. Mn oxides appear to be forming directly from low-temperature hydrothermal fluid in a restricted area of the rift valley, or in response to redox gradients in the sediment column; whereas nontronite and amorphous Fe oxide are relatively widespread, yet still within 500 m of vent exit sites in the distal vent zone.

Near-vent hydrothermal sediments from the central and distal vent zones are mineralogically and chemically similar to sediment collected 20 km south of the rift valley at the Galapagos Mounds hydrothermal field, but distinctly different from typical, dispersed metalliferous sediments. Elevated metal contents of metalliferous sediments indicate that effects of hydrothermal venting on sediment chemistry are far-reaching; however such sediments are linked to regional hydrothermal activity, rather than effects of individual vent fields.