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A comparison of black smoker hydrothermal plume behavior at Monolith Vent and at Clam Acres Vent Field: Dependence on source configuration

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Abstract

Quantitative visualization of acoustic images is used to compare the properties and behavior of high temperature hydrothermal plumes at two sites with different source configurations, increasing our understanding of how plume behavior reflects source configuration. Acoustic imaging experiments were conducted at the Clam Acres area of the Southwest Vent Field, 21° N East Pacific Rise and at Monolith Vent, North Cleft segment, Juan de Fuca Ridge. At Clam Acres, black smokers discharge from two adjacent chimneys which act as point sources, whereas multiple vents at Monolith Vent define a distributed elliptical source. Both plumes exhibit consistent dilution patterns, reasonable fits to the expected power law increase in centerline dilution with height, and simple bending of plume centerlines in response to ambient currents. Our data suggest that point source vents are associated with ordered plume structure, normal entrainment rates, and initial expansion of isosurfaces while distributed source vents are associated with disorganized plume structure, variable entrainment rates, and initial contraction of isosurfaces.

Introduction

Hydrothermal plumes have been cited as agents of transport for microbes and larvae of vent organisms (Mullineaux and France, 1995). Understanding this transport requires the ability to characterize hydrothermal plumes. Acoustic backscatter from metallic mineral particles can be used to image hydrothermal plumes (Palmer et al., 1986; Rona et al., 1991). Methods for visualizing and analyzing acoustic backscatter images are presented in previous studies (Rona et al., 1998; Bemis et al., 2000) and in a companion paper (Rona et al., submitted). Here we apply these methods to compare acoustic imaging data sets of hydrothermal plumes collected at two different locations on the mid-ocean ridges: the East Pacific Rise (EPR) at 21°N in 1990 (Clam Acres area of Southwest Vent Field; Rona et al., 1991) and the Juan de Fuca Ridge at Monolith Vent on North Cleft Segment in 1996 (Bemis et al., 1997). The comparison of plumes at these two locations leads to an increased understanding of how plume behavior reflects differences in source configuration.

We present data sets from three imaging runs; two at Monolith Vent and one at Clam Acres. We compare the plumes imaged in these three runs using innovative visualization methods that enable quantitative comparison of plume behavior and response to ambient conditions. This methodology and associated analysis uses a simple plume model (Morton et al., 1956) as a guide to interpreting measured plume properties including centerline concentration, dilution factors, plume radii, isodilution surface radii, and centerline shape as presented in a companion paper (Rona et al., submitted).

Geologic setting

Monolith Vent lies on the spreading axis of the North Cleft Segment of the Juan de Fuca Ridge at approximately 44°59.5′ N, 130°12.1′ W (Figure 1; Table I) near the eastern edge of a fissure on fissured sheet and lobate lava flows within the axial valley (Embley and Chadwick, 1994; Koski et al., 1994). It consists of a large sulfide edifice (8 m long by 5 m wide and 5 m high) with more than 10 active black smoker chimneys