Implications of lazy plumes for entrainment of vent larvae into seafloor hydrothermal vents

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Vent larvae are spawned near the vents of seafloor hydrothermal plumes, the adults live there lives near these vents, and yet genetic studies indicate that similar species occupy distant vent sites. One of the oft cited potential transport mechanisms is entrainment into and lofting by seafloor hydrothermal plumes. This study considers some aspects of the basic physics of such processes. Seafloor hydrothermal vents form a wide variety of chimney and mound structures ranging from single isolated chimneys (typical of the East Pacific Rise (EPR) at 9°N and 21°N) to mounds/chimney clusters with multiple orifices (typical of the Juan de Fuca Ridge (JdFR)) to mega-mounds with multiple chimney clusters (for example, TAG on the Mid-Atlantic Ridge).

Entrainment by plumes sets up a small (relative to ambient currents) but significant horizontal velocity field (predicted ~0.2 m/s for Main Endeavor Field (MEF), JdFR vents). This suggests that rising fluids and vent larvae "near" black smokers are likely to be entrained. "Near" can be determined by a consideration of the merging of plumes. Plumes merge when their velocity fields overlap: we predict merging of seafloor hydrothermal plumes when chimneys are closer than 1-5 m. Merging changes the balance of momentum, volume, and buoyancy fluxes because total volume flux is conserved. Acceleration, due to the dominance of buoyancy over the other fluxes in merged plumes, may result in a deficit of volume flux beneath the plume, which may facilitate entrainment of rising fluids near black smokers. The relative importance of volume (Q), momentum (M) and buoyancy (B) fluxes is quantified by a non-dimensional parameter: $\Gamma \sim BQ^2/M^{5/2}$.

The merging of plume is observed for most of the vent clusters in the Main Endeavour Field, JdF. Individual plumes usually have very low Γ (0.04-0.14 for a selection of plumes on the JdFR and EPR) in the vicinity of the chimney (vent). However, the larger scale plumes observed in acoustic images have higher Γ (1.4 –4.0).We present acoustic images and other data from 21°N EPR, North Cleft, JdFR and the MEF, JdFR to show that the plumes from small isolated chimneys (<10 m tall, >10 m spacing) are dynamically distinct from the plumes of large mounds (>10 m tall mound, <5 m chimney spacing) due to the effects of merging plumes. We predict that diffuse flow and vent larvae will be entrained primarily if emitted within a cluster of chimneys.

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