The Role of the Ocean in Modulating the Dynamics of Silicic Submarine Volcanic Eruptions

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Submarine volcanoes can produce silicic magmas that can erupt variably from small-volume lava domes to devastating large-volume caldera-forming eruptions. However, eruption into water instead of air can give rise to eruption styles distinct from those on land due to: 1) higher confining pressures, and (2) the seawater medium, which has a higher heat capacity, density and viscosity than air.

Only two examples of high volume silicic submarine eruptions are historically recorded: The eruption of Kolumbo submarine volcano in 1650 (Mediterranean), and Havre volcano in 2012 (Kermadec Arc, NZ). The Havre event provides observational, stratigraphic, vent depth, timing and magma flux constraints that elucidate magma ascent, eruption into seawater, and particle transport processes.

Seafloor and satellite observations reveal that the ~1km^3 Havre pumice raft was erupted from a vent depth of 900m at magma fluxes of ~9 x 10^6 kgs^{-1}. 1D conduit models using Havre magma chemistry and melt inclusion water contents of 5.8wt.% show that at ~9MPa of pressure buoyant magma was extruded into the ocean where it rose, quenched and fragmented to produce meter-sized clasts – this eruption was therefore a clast-generating effusive event. Subsequent to this style of eruption, the fate of clasts is driven by their ability to ingest water. At Havre, 70% of the erupted pumice was dispersed off the volcanic edifice.

A well constrained sample suite of submarine pumice deposits erupted from modern seafloor volcanoes exists. This sample suite spans a spectrum of eruption intensities: 1) powerful explosive caldera-forming, 2) cone building, 3) effusive dome spalling, 4) passive dome effusion. The modeling and experimental constraints from Havre provide a framework to begin to infer the style and intensity of other less-constrained silicic eruptions, possibly leading to the start of an intensity-based classification for submarine silicic volcanic eruptions comparable to that already available for subaerial eruptions.