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Driving mechanisms for production of ash during the ∼1 km-deep Havre 2012 eruption, Kermadec arc – particles indicate high-rate fracturing and fuel-coolant interactions

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Havre caldera volcano's deep (∼1 km) submarine eruption in July 2012 produced an ∼80 km long vapour plume and ∼400 km2 pumice raft at the sea surface. The vapour plume indicates focused delivery of heat to the surface and indicates that the eruption formed some kind of narrow thermal plume. In 2015 during an NSF-funded research cruise we observed and sampled the eruption's deposits in situ with the remote operated vehicle Jason. High-resolution bathymetry was obtained with the autonomous underwater vehicle Sentry, providing a LiDAR-quality map with 1-m resolution of the entire caldera including the multiple vent sites of the 2012 eruption.
A surprising product of the eruption is extensive fine and very fine ash, forming part of a multi-layered deposit with local contributions from effusive sources. The main ash layers show no clear thinning or fining trends across the whole of the caldera floor and shoulders, implying wide dispersal. Since significant fractions of this ash show a texture different to the pumice it is unlikely that these grains have been produced by abrasion of the raft pumice. Analysis of the ash will help us determine the driving mechanisms for ash production, which have implications for the eruption dynamics, and for rates and mechanisms of heat transfer to the ocean. There are specific, identifiable energy costs to the process of fragmentation, but energy expended in fragmentation greatly enhances rates of heat transfer by forming additional surface area. The effect of the latter is well known for subaerial eruptions, in which ash production strongly controls generation of buoyant plumes.
For Havre's deep-sea eruption, we have conducted heat-transfer and fragmentation experiments by remelting products of the 2012 eruption. Both dense rock from lava domes, and seafloor-collected pumice, were remelted. Physical data from experiments has been combined with 2D and 3D shape analyses of both lab-generated volcanic particles and natural volcanic ash to reveal the dominant ash generation mechanisms involved in the 2012 Havre eruption. Experimental setups and applied analysing techniques will be presented. Preliminary results indicate that magma-water interaction, and specifically fuel-coolant interaction, probably induced, was important in generating most of the ash. This result rests primarily on characteristics of fractal dimension of natural and experimental particles, as assessed using high-resolution (sub-micron) micro-CT imaging and statistical T-tests of significant numbers of analysed particles. The result is interesting in the context of other analyses of the Havre 2012 products, which did not address ash formation, and which concluded that it was a non-explosive high-rate effusive eruption.