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Ash generation in the 2012 deep subaqueous Havre eruption: implications from particle water content and quench pressure

Arran Murch (1), Tobias Dürig (1), James White (1), and Alex Nichols (2)

(1) University of Otago, Dunedin, New Zealand (arranmurch@googlemail.com), (2) University of Canterbury, Christchurch, New Zealand

Understanding how the ocean affects volcanism, both directly and indirectly, during subaqueous eruptions is one of volcanology's grand challenges. The pressure dependency of water solubility in magma, together with the high cooling rates of ash in water, imply that dissolved volatile contents in ash can provide a precise record of syn-eruptive exsolution and the pressure of quenching, related to fragmentation depths and eruptive processes.

The 2012 Havre eruption from ∼1 km water depth produced a 400 km2 pumice raft and an 80 km long vapour plume at the sea surface. Early post-eruption AUV mapping, seafloor ROV observations, and sampling in 2015 make the 2012 Havre eruption an ideal laboratory for the study of deep subaqueous silicic eruption processes. Here we present water-speciation results from FTIR analysis of glassy ash (125 – 500 μm) from three subunits of the 2012 eruption's widespread Ash with Lapilli deposit. Subunit 1 (S1), Subunit 2 (S2), and Subunit 3 (S3) are inferred to have been generated by two contrasting eruption styles during the 2012 Havre eruption. S1 and S2 have distinct modal grain sizes of 250-500 μm and 16-31 μm, respectively, and are inferred to have been produced by explosive fragmentation during a single eruptive phase. In contrast S3 is mostly tubular-vesicle ash, and inferred to have been produced by weak pyroclastic ash venting during dome effusion.

Ash from all three subunits shows a similar range of total water contents (0.66 to 2.90 wt%). There is minor hydration, so pre-hydration water contents were calculated following the methods of McIntosh et al. (2017). Reconstructed pre-hydration water contents indicate unexpectedly low quench pressures (2.4 to 14.4 MPa) across all three subunits, suggesting the ash quenched as much as several hundred meters above the vent. Although a large gas jet allowing particle ascent and decompression to shallower depths before quenching could explain low quench pressures for S1 and S2, significant heights of particle ascent are not expected for the inferred ash-venting mechanism of S3. Possible explanations for this discrepancy include temperature effects, the presence of other volatiles that may decrease water solubility, or an unexpected process that transports ash-venting particles to shallow depths prior to quenching. We find these explanations unconvincing, and suggest that for the Havre 2012 eruption dissolved water content is not a reliable indicator of quench depth/pressure. We discuss implications for how we can use dissolved volatile contents to interpret submarine volcanism more broadly.

McIntosh et al., 2017, Am Min, 102, 1677, http://dx.doi.org/10.2138/am-2017-5952CCBY