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# Stoping of chamber margins into mafic intrusions: Magma mingling at Soufriere Hills volcano, Montserrat

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In July 2003, the Soufrière Hills volcano (Montserrat, British West Indies) experienced the largest dome collapse event within the history of the current eruption (1995–present). During this event, there were two syn-collapse Vulcanian explosions that deposited tephra throughout the island of Montserrat, and clasts from these fall deposits have been examined texturally and chemically to deduce information concerning conduit dynamics during the dome collapse and contemporaneous explosions. One clast, erupted from Soufrière Hills volcano during the syn-collapse Vulcanian explosions of July 13, 2003 reveals several incorporated silicic zones within a vesiculated, more mafic host. In hand sample, this clast appears to show evidence of oxidation possibly resulting from extended residence time within the extruding lava dome. However, closer examination of clast microtextures using scanning electron microscopy (SEM) shows that, in some cases, these characteristics may actually result from processes occurring at depth in the chamber or lower conduit.

One particular silicic inclusion (zone A) shows evidence of heating in several mineralogical features, including oxidized magnetites and pyroxenes, highly fractured quartz and plagioclase phenocrysts, and completely pseudomorphed hornblende crystals that broke down over a period of 37–78 days. The phase assemblage of zone A suggests that, prior to heating, the inclusion initially crystallized within the chamber at a temperature low enough to allow quartz precipitation, as there are approximately 15 quartz phenocrysts and microphenocrysts present in an area roughly 6 mm in diameter. Secondary ion mass spectrometry (SIMS) analyses of the plagioclase shows consistent compositions throughout individual crystals, averaging 53 ($\pm$ 4) mol% anorthite. Assuming an $H_2O$ pressure of 130 MPa, these anorthite values allow calculation of the magma temperature during crystallization, and result in an average temperature of 833 ($\pm$ 21) $^{\circ}$C. This range safely brackets the temperature required for quartz precipitation at equivalent pressures (less than 825 $^{\circ}$C). Within the groundmass, no pyroxene microlites are visible, suggesting a crystallization pressure of more than 100 MPa, based upon decompression experiments on a representative magma. Additionally, plagioclase phenocrysts show no obvious zoning in their anorthite compositions as would result from ascent through the conduit. SEM X-ray element maps reveal percolation of calcium-rich melt into the margins of zone A, suggesting sustained contact between this silicic inclusion and the intruding mafic magma that resulted in isolation and heating of a stoped chamber margin.

The characteristics of this single tephra sample suggest that magma mingling at Soufrière Hills may not only result from disaggregation of mafic inclusions during transport through the conduit, but also from stoping of the crystallized chamber margins into the intruding mafic magma. The more mafic portions of the erupted clast display high vesicularity, indicating that a volatile-rich portion of the mafic intrusion (perhaps a foam layer at the mafic/resident magma interface) ascended or convected into the chamber and incorporated portions of the chamber margins 37–78 days prior to the July 2003 dome collapse. Although initial examination of the tephra in hand sample shows evidence of oxidation typically attributed to sustained residence in the lava dome, in some cases this oxidation may actually result from heating within the system prior to ascent through the conduit. Thus, effects of mafic magma intrusion at Soufrière Hills may not only involve heating of the resident magma, but also disaggregation and incorporation of stoped chamber margins, indicating another possible method of magma mingling at this active volcano.