Andesite magmas ascend rapidly from the mid crust at Soufriere Hills Volcano, West Indies

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We show that enstatite crystals in andesites erupted during vulcanian explosions at Soufriere Hills Volcano, Montserrat preserve a record of the water content of the melt in which they grew. Furthermore, the record suggests that the pyroxenes were sourced from a range of depths in the crust on fast timescales (~5-10 hours) prior to explosive eruption. Water concentrations were measured along profiles in enstatites in pumices using both secondary ion mass spectrometry and Fourier transform infrared spectroscopy. Enstatites contain up to 229 ppm H_2O and up to 1.15 wt% Al_2O_3, with significant variability between crystals and from core to rim in individual crystals. The Al content of the pyroxene was used to estimate a melt-pyroxene partition coefficient for H_2O and hence the H_2O contents of the rhyolitic melts in which the enstatite crystals grew. The data show that the cores record higher melt water contents than the rims of the crystals. Melt H_2O concentrations reach up to 9 wt%, which implies fractionation from a primitive basaltic melt with a minimum of 4 wt% H_2O, consistent with arc basalts elsewhere. A depletion in water in the outer 50 microns of the crystals suggests diffusive loss of hydrogen during magma ascent, which, when combined with the range in diffusivities from the literature, gives an estimated range in decompression timescales of up to 5-10 hours. We suggest that the relatively cool, crystal-rich magma preserved the hydrogen zoning in the enstatites prior to decompression. Melt inclusions recorded in plagioclase typically contain up to 6 wt% H_2O, suggesting that these were trapped in the shallower parts of the storage system, or during undercooling and magma ascent. These timescales are similar to inter-explosion timescales during sequences of explosions in 1997, raising the possibility that the driving force for this repetitive explosive behaviour lies not in the shallow system, but in the deeper parts of a vertically protracted crustal magma storage system.