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Constraining the evolution of magmatism at Soufrière Hills Volcano, Montserrat, through accessory mineral geochronology and isotope and trace element geochemistry

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Soufrière Hills Volcano, a stratovolcano on the Caribbean island of Montserrat is an active geological hazard. Its only historical eruption has had five discrete phases of extrusion between 1995 and 2010. Recent activity includes dome growth, vulcanian explosions and destructive pyroclastic density currents. All pose a threat to the local population - the southern half of the island is currently an uninhabitable exclusion zone. Monitoring data, e.g., gas emissions, indicate the magmatic system is still potentially active. So, characterisation of magmatic drivers of past behaviour is critical to understand volcano long term dynamics.

Early in the eruption basic driving forces for activity were inferred to be deep magma storage and source processes reflected in the composition of the volcanic products (1). Mafic magma recharge apparently triggered the 1995-2010 eruptions remobilising magma chamber 'andesitic mush' by addition of heat and volatiles (2). As eruptions progressed ideas about magma interactions developed and long-term monitoring and rock record data pointed to continued recharge and complex magma storage and plumbing. Mafic magma remnants are preserved as mingled enclaves entrained in host andesites. Despite being one of the world's most studied volcanoes, to date zircon has not been documented in mafic and intermediate magmatic components at Soufrière Hills. We will undertake characterisation of zircon, melt inclusions therein, and associated apatite in standard petrographic thin sections of the mafic enclaves and host andesites sampled throughout the eruption. Analyses will include apatite (Sr-Nd-Pb isotopes and trace elements) and zircon (Hf isotopes and trace elements, U-Pb and U-series geochronology). Apatite composition combined with zircon age and Hf isotopes is a powerful tool for understanding eruptive products of volcanoes.

New data will shed light on storage architecture and dynamics of the current eruption. Our aim is to systematically date inherited and antecryst zircons and also analyse the composition of accessory minerals in remobilising and remobilised products in recent volcanic deposits to help elucidate mafic and intermediate magma sources. The relationship between pre-eruptive evolution, eruptive timing, eruptive style and, thus, potential future risk of the volcanic centre will be considered. We will provide preliminary constraints, where currently there are none, on accessory minerals age range and composition.

With respect to history of events, cathodoluminescence imaging of Soufrière Hills zircons has revealed patchy, zoned and overgrowth textures pointing towards complex growth and the presence of inherited and magmatic crystals. In addition, widespread apatites which, from their uniform euhedral shape and lack of internal growth disjunctions, appear to be phenocrysts, have marked diffuse gradational cathodoluminescence zonation.

Where present, inherited zircons (U-Pb dating target) will provide information about magma sources and crystallisation events prior to current activity. Magmatic zircon antecrysts (U-series dating target) may track mineral recycling processes thus constraining the age range of magma components. Zircon phenocrysts, too young to be dated, may be related to crystallisation likely, although not necessarily, directly prior to eruption.

1. Sparks and Young 2002. doi: 10.1144/GSL.MEM.2002.021.01.03

2. Murphy et al. 2000. doi.org/10.1093/petrology/41.1.21