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Petrological insights into the 1976-2000 eruption episode of White Island, New Zealand: an eruption fuelled by repeated mafic recharge

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White Island is a partially submerged volcano located ∼ 50 km to the NE of North Island, New Zealand. It is New Zealand's most active volcano and the island is a popular tourist destination. Surprisingly, little is known about the magmatic processes that led to historical eruptions given the potential vulnerability of tourists and its high level of historical activity. In addition, the volcano has been monitored with an array of methods since 1967; from geodetic surveying techniques to geochemical analyses of fluids and gases. Access to an excellent sample record has allowed us to examine a temporal record of magmatic processes, through the careful analysis of scoria clasts. We have then been able to compare apparent timescales of magmatic events to monitored signals. In this work we examine an extended eruptive episode (1976-2000) in order to determine the causes of signals produced throughout this sequence.

Previous petrological and geophysical analysis of the 1976-2000 eruptive episode suggested that magma resided at a very shallow depth (i.e. ∼ 500 m) for extended periods. This was primarily based on the focussed deformation signal and the low H_2O (< 0.5 wt %) contents of phenocryst-hosted melt inclusions. We have examined a suite of samples during that eruption episode and analysed melt inclusions, groundmass glass and all major mineral phases.

We find that throughout the eruption episode, mafic injections have occurred at least 5 times. Evidence of these mafic injections includes mingled groundmass glass (mafic and dacitic) in the early part of the sequence, with euhedral olivine present in the mafic portion, and variably resorbed olivine phenocrysts in distinct scoria through time.

Our analysis of phenocryst-hosted melt inclusions exhibits a range in the H_2O contents (between 0 and ∼ 3 wt %) using the volatiles by difference method. Furthermore, when we compare the composition of the phenocryst rims and the groundmass glass with petrological modelling, it is difficult to reconcile such shallow residence as modelled previously. Instead, we suggest that White Island magma resided at > 1 km depth prior to eruption. Significant magma degassing into the hydrothermal system was likely responsible for the deformation signal and is unrelated to very shallow magma residence. Taken together, these data provide an important link between petrology and geophysical monitoring at White Island.