Geophysical Research Abstracts
Vol. 21, EGU2019-6143-2, 2019
EGU General Assembly 2019

Phreatic eruptions from wet volcanic systems: Insights from the 27 April 2016 eruption from White Island, New Zealand

Bruce Christenson (1)

(1) BW Christenson, National Isotope Centre, GNS Science, Lower Hutt 5010, New Zealand (b.christenson@gns.cri.nz), (2) B Kennedy, Geological Sciences, University of Canterbury, Private Bag 4800, 8140 Christchurch, New Zealand, (3) AG Reyes, GNS Science, Lower Hutt 5010, New Zealand, (4) A Farquhar, Department of Geology, Colorado College, Colorado Springs, CO 80903, USA, (5) M Heap, Géophysique Expérimentale, Institut de Physique de Globe de Strasbourg (UMR 7516 CNRS, Université de Strasbourg/EOST), 5 rue René Descartes, 67084 Strasbourg cedex, France,, (6) RW Henley, Department of Applied Mathematics, Research School of Physics, The Australian National University, ACT 0200, Australia

A small but dangerous ballistic-laden phreatic surge eruption occurred through a rapidly evaporating crater lake in the eruption crater complex of White Island on 27April 2016. The eruptive activity lasted for 35 minutes, and was characterized by 6 distinct seismo-acoustic pulses sourced from at least 3 vents on the lake floor. No juvenile material was recognized. A large proportion of the ballistics showed extensive hydrothermal alteration, exhibiting both dissolution of primary mineral phases and varying amounts of sulphate mineral precipitation as both groundmass replacement and veining. Permeabilities vary inversely with dry rock density in a suite of some 15 ballistic samples (ranging $5x10^{-18}$to $5x10^{-14}$), largely reflecting the effects of protolith dissolution. However, some highly altered samples are also of low permeability, containing vug and vein fillings of silica (cristobalite/chalcedony), natroalunite and anhydrite, whereas hydraulically fractured samples typically show fracture fillings of natroalunite and anhydrite. Fluid inclusions homogenizing in the liquid phase within anhydrite have entrapment temperatures of between ca. 160 ˚C to 230 ˚C. A number of these inclusions are clathrate bearing, with indicative entrapment pressures ranging up to 40 bar.

TOUGH2 modelling of the vent environment provides valuable insights into physical processes operating beneath the lake. Magmatic vapors, simulated as mixtures of H_2O and CO_2, flow into the liquid saturated sub-lake environment along vertical zones of elevated permeability (fumarolic conduits). With free degassing of the conduit at the surface, this has the combined effect of both heating the conduit and adjacent aquifer environments, but it also convectively draws adjacent aquifer fluids (of lake composition) towards the conduit along a positive thermal gradient. Uncoupled reactive transport modelling (X1t) of crater lake waters flowing along such gradients shows that they become supersaturated with respect to natroalunite at temperatures of ca. 200 ˚C, leading to precipitation of this phase and the drastic reduction of permeability along fairly narrow lateral intervals. Higher in the system, uncoupled reactive transport modelling of magmatic vapour flowing into the lower temperature, shallower lake (i.e., liquid-saturated) environment shows rapid precipitation of elemental sulfur and associated sulfate mineral phases, which also abruptly decreases permeability. In time, both processes serve to encapsulate the upper conduit passage, effectively sealing it from the adjacent hydrothermal environment.

Once established, such sealed environments take the form of vertically-oriented volumes, open at the base and resembling “silos” enclosing the conduits. These have the potential to become loci for the collection of non-condensable and compressible gas columns (principally CO_2). The maximum pressure derived from clathrate stability of ca. 40 bars equates to a hydrostatic pressure at the base of the sealed column at a depth of 400 m. The tensile strength of the natroalunite seal material is measured at 31.7 bar, and suggests a confining pressure of 8.3 bar, thus constraining a seal failure depth of between 50 m and 85 m (hydrostatic and lithostatic depths, respectively). The occurrence of multiple vents in close proximity to one another points to the formation of multiple near-surface silos, all connected to a common pressure source at depth.