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Phreatic activity in the Valley of Desolation, Dominica (Lesser Antilles) – constraints from field investigations and experimental volcanology

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Dominica has one of the highest concentrations of potentially active volcanoes worldwide, flanked by abundant surficial geothermal manifestations: The Boiling Lake – Valley of Desolation area represents one of the most vigorous ones, hosting hot springs, mud pools, fumaroles, and steam vents. Intense alteration, together with predominantly phreatic explosive features of varying scales, characterize the whole area. The last historic eruptions in Dominica occurred at the Valley of Desolation. Phreatic eruptions are also the most likely type of volcanic activity to occur in the near future at Dominica in general and the Valley of Desolation in particular. Phreatic eruptions are up to date largely unpredictable in time and magnitude, strongly asking for constraints of eruptive conditions as well as trigger mechanisms.

We conducted sampling and field mapping, together with the determination of in situ physical (density, humidity, permeability) and mechanical (strength, stiffness) properties to characterize the main active surficial area which possesses a high probability for a phreatic event. Rapid decompression experiments performed on selected samples from this area give insight into the fragmentation and ejection behavior of steam driven eruptions. These experiments were flanked by chemical analyses and laboratory measurements as porosity and granulometry.

The results indicate that advanced argillic alteration in the proximity of degassing vents significantly changes the rock properties, which in turn play a crucial role for the degassing of hydrothermal systems. High-temperature acidic fluids lead to an intense alteration of the host rocks, and thereby cause the formation of a kaolinite-rich, low permeable layer above the vent. In addition, alteration enhances slope instabilities causing landslides which may cover and clog the outgassing vents. Such processes increase the likelihood of the site experiencing a pressurization, which may result in a steam-blast (phreatic) eruption. We show the distribution of surficial, hydrothermal features and highlight the range of possible phreatic events in the Valley of Desolation. Our results further contribute to a better understanding of the conditions and the dynamics of phreatic eruptions, especially the ejection dynamics of heavily altered unconsolidated material. Thereby we provide a valuable input to the hazard assessment of these frequently visited sites on Dominica and similar hydrothermally active areas worldwide.