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Hydrothermal alteration favoring phreatic eruption processes at Solfatara (Campi Flegrei)

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Solfatara and Pisciarelli fumaroles are the main surface manifestations of the strong hydrothermal activity within the Campi Flegrei caldera system and pointing to a significant risk for phreatic eruptions in this densely populated area. Phreatic eruptions, triggered by various processes are hardly predictable in occurrence time and size. Despite their hazard potential, these eruptions, as well as the influence of hydrothermal alteration on their likelihood, magnitude and style, have so far been largely overlooked in experimental volcanology.
The physical properties and the mechanical behavior of volcanic rocks are highly dependent on their original magmatic microstructure and on any eventual alteration of those microstructures due to hydrothermal reactions. We have therefore investigated the potential effects of hydrothermal alteration on rock microstructure and, as a consequence, on fragmentation dynamics.
Rock samples from the vicinity of the Solfatara and Pisciarelli fumaroles have been characterized 1) geochemically (X-ray fluorescence, X-ray diffraction), 2) physically (density, porosity, permeability and elastic wave velocity) and 3) mechanically (uniaxial compressive strength, tensile strength). We furthermore have investigated the effects of hydrothermal alteration on fragmentation processes using a shock-tube apparatus, operating with Argon gas, water vapor and superheated water at temperatures up to 400°C and maximum pressures of 20 MPa. Fragmentation and ejection dynamics in the presence of three different energy sources within the pores have been investigated: overpressure by 1) Argon gas; or 2) water vapor and due to 3) steam flashing of superheated water. Fragmentation speed, fragmentation efficiency and fragmented particle ejection velocity were measured. Our results indicate on the one hand, that steam flashing provides the highest energy - resulting in increased fragmentation speed and particle ejection velocity and also a significant higher fragmentation efficiency. On the other hand we show, that for the investigated samples, hydrothermal alteration increases porosity and permeability and decreases strength – leading to a lowering of the fragmentation threshold.
Based on our results, we aim to constrain the influence of hydrothermal alteration on the dynamics of phreatic explosions. Furthermore we emphasize that steam-flashing phreatic eruptions, which may prove to be the least predictable of all eruptions, are apparently also those containing the highest specific energies for fragmentation and its consequences not only at Campi Flegrei but also at any other hydrothermal system worldwide. These findings may provide valuable information for the hazard assessment of well characterized, hydrothermally active areas.