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Source parameters of eruptions generated by rapid decompression of volcanic rocks

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Seismic evaluation of well-controlled experimental volcanic-explosions simulations offers the hope of a better understanding of source mechanisms in natural volcanic seismicity. Here, we present the first investigation of the dynamics of explosive eruptions of volcanic rocks under controlled laboratory conditions. Specifically, we analyzed the micro-seismicity generated by the rapid depressurization of volcanic rocks in a shock tube apparatus, which represents the seismic mechanism. Our well-constrained physical mechanism consists of the slow pressurization of the system (using Argon gas) followed by rapid depressurization of natural volcanic samples (ash, pumice and fragmented particles of volcanic rocks) contained in a steel pipe-like conduit. The resonance response of the apparatus is well characterized in order to discriminate between the waves produced by the natural resonance of the system due to the pressure shock and the waves generated by the rapid depressurization of the samples. Several experiments with samples with different porosity were performed under controlled pressure conditions (ranging from 4 to 20 MPa), at room temperature. In the micro-seismic records the inflation-deflation states of the pipe-like conduit and the fragmentation process after the rapid removal of the diaphragm can be clearly recognized. We used these records to quantify the volumetric change, the force system and the source parameters of the seismic mechanism. Based on the recorded pressure drop curves of the system recorded and the duration of maximum amplitudes of micro-seismic waves, the source time function of the system is determined. We investigated the relationships between pressure and decompression time versus maximum amplitudes, the source duration, the decay of seismic waves and the force, considering different combinations of gas and solids in the reservoir, and evaluated the contribution of the volumetric change and the force. From these relationships, the pre-eruption conduit state can be estimated in volcanic systems, and thus the ejection velocity can be calculated in order to evaluate the implications for hazards analysis. In addition, we discuss important considerations regarding the deduction of parametric scaling laws for volcanic explosions using field seismic data. This experimental approach and the high quality of seismic records allow us to obtain a direct measure of the source parameters of the physical mechanism and evaluate the viability of the theoretical single force model to quantify real volcanic eruptions.