Experimental model of a volcanic conduit: Acoustic and seismic signals associated with an overpressure release

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Bubble bursting at the top of a volcanic conduit – and, more generally, any overpressure release, generate acoustic and seismic signals, whose characteristics can be linked to the source properties. However, the relation between the amplitude and frequency of both signals and the source parameters (e.g. bubble length, conduit diameter, initial overpressure) has not yet been demonstrated. In order to quantify which information can be obtained from these signals, we performed laboratory experiments. An overpressurized gas cavity is initially closed either by a thin liquid film, or an elastic membrane. We measure the acoustic signal produced when the film or membrane bursts, as well as the pressure variations inside the cavity. This well-controlled experiment makes it possible to tune all the parameters of the system: cavity length, diameter, overpressure and film/membrane properties.

In a first series of experiments (thin liquid film), we show that the rupture time is the key parameter for the generation of an acoustic wave. The amplitude of the signal depends on the film opening dynamics, and drastically decreases when the rupture time increases. Therefore, the measurement of the amplitude of the acoustic wave, alone, cannot provide any information on the overpressure inside the bubble before explosion. This could explain the low energy partitioning between infrasound, seismic and explosive dynamics often observed on volcanoes. Experiments performed with liquid films of different viscosities put forward not only the role of the rupture time, but also of the opening dynamics, from a single hole growth to filaments breaking.

In a second series of experiment (elastic membrane), we explore the acoustic limit by increasing the overpressure initially loaded in the cavity, up to values above the atmospheric pressure. We point out a regime for which the acoustic amplitude after bursting reaches a plateau. The membrane opening dynamics is monitored by a fast camera, up to 14000 img/sec. We analyze the pressure signals inside and outside the cavity, depending on the initial membrane position, either at the open end or inside the conduit. Accelerometers at the surface, far from the cavity aperture, monitor the 'seismic' signal associated with the membrane opening. The characteristics of this signal are analyzed in regards to the acoustic signal and the initial overpressure in the cavity.

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