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Fluid dynamics inside a "wet" volcano inferred from the complex frequencies of long-period (LP) events: An example from Papandayan volcano, West Java, Indonesia, during the 2011 seismic unrest

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We present results of our study aimed at understanding the dynamics of fluids inside a “wet” volcano through the analysis of swarms of long-period (LP) events accompanying the 2011 seismic unrest at Papandayan volcano, West Java, Indonesia. Prior to this unrest, we measured an extremely high percentage (100 %) of CO_2 in the ground at the summit crater, however with a very low value of SO_2 flux ($\sim$6 tons/day). Increase in volcanic activity was also observed from the records of a tiltmeter. A long-term inflation was followed by an abrupt deflation that took place concurrently with the swarms of LP events. Thereafter, swarms of local-tectonic (LT) and volcano-tectonic (VT) earthquakes started. We focus here on analyzing the LP events in the following manner. First, we estimate the source location of LP events by applying a 3-D non-linear hypocenter localization algorithm which includes topography. We then study the waveforms and spectral characteristics of LP events recorded at different stations and investigate whether or not these characteristics are due to source effects. Subsequently, we compute the oscillation frequencies (f) and the decay characteristics (Q factor) in the complex frequency domain of the coda part of the LP events by using the Sompi method which is based on a homogeneous auto-regressive (AR) equation. The rectangular fluid-filled crack model is used to estimate the physical processes related to the observed temporal variations in the complex frequencies. We divide the swarms of LP events into two intervals. The first interval occurred between June and July 2011 (48 LP events), while the second interval extended from september to October 2011 (36 LP events). The frequencies of LP events observed during these intervals range between 1.1 and 6.2 Hz while the Q factors are widely scattered between 20 and 400. We estimate the compositions of fluids inside the crack during both intervals as either water foam (mixtures of water and H_2O gas/steam) or misty gas (mixtures of water droplets and H_2O gas/steam). We finally suggest that if an eruption were to have taken place following the 2011 unrest, it would have been in phreatic style rather than magmatic style. The results of our study therefore contribute to the effort in the prediction of the behavior of future eruptions, and to volcanic hazards assessment, and therefore to volcanic risk mitigation.