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Fluid dynamics beneath 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 aiming at understanding the dynamics of fluids beneath 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 a large amount (100%) of CO_2 in the ground at the summit crater, however with very low value of SO_2 (less than 10 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 which was concurrent with the swarms of LP events. Hereafter, swarms of volcano-tectonic (VT) and local-tectonic (LT) earthquakes started. We focus here on analyzing the LP events with the following manner. First, we estimate the source location of LP events by applying a non-linear hypocenter algorithm including topography. We then study the waveforms and spectral characteristics of LP events and investigate whether or not these events are due to source effect. We compute the complex frequencies (f and Q) for the coda of the LP events using the Sompi method and subsequently, we estimate the physical processes related to the observed temporal variations in the complex frequencies by following the fluid-filled crack model. We divide the swarms of LP events into two periods. The first period occurred between June and July 2011 (48 LP events) while the second period started from September to October 2011 (36 LP events). The dominant frequencies (f) of LP events observed during these periods range between 1.1 and 6.2 Hz while the attenuation factors (Q) are widely scattered between 20 and 400. We estimate the compositions of fluids inside the crack during both periods 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 would 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 future eruptions behavior and volcanic hazards assessment and therefore contribute to volcanic risk mitigation.