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How pore-fluid pressure due to heavy rainfall influences volcanic eruptions, example of 1998 and 2008 eruptions of Cerro Azul (Galapagos)

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Small stress changes that are external to the magmatic system can have an influence on the occurrence of volcanic eruptions. Among them, we found earthquakes (Walter and Amelung, 2007), edifice collapse (Pinel and Jaupart, 2005) or icecap melting (Albino et al., 2010). These works have focused in terms of static stress changes and did not consider poro-elasticity processes that may occur in the upper crust. However, in the past two decades, many worldwide seismic studies have shown a strong correlation between rainfall and tectonic earthquakes (Costain and Bollinger, 2010). Such correlation is well explained by the mechanism of hydro-seismicity: an increase of pore-fluid in the rocks reduces the normal stress on faults, which triggers shear failure. Here, we investigate if a similar correlation exists between rainfall and eruptions, as tensile failure of a magma reservoir is also pore pressure dependent. In a preliminary study, we show that the pore pressure has more influence on the tensile failure than the reservoir depth or the edifice loading. An increase of pore-fluid pressure largely reduces the overpressure required to initiate magma intrusions. We propose that an increase of pore-fluid pressure during heavy rainfall can encourage volcanic eruptions. To validate this hypothesis, we combine 1) 1D pore pressure diffusion model to quantify the spatio-temporal evolution of pore pressure caused by rainfall, and 2) 2D poro-elastic numerical model to characterize the change of the failure overpressure associated. Sensitivity analysis is performed to understand the influence of the poro-elastic parameters and the geometry of the reservoirs. The methodology is finally applied to Cerro Azul volcano in Galapagos where the 1998 and 2008 eruptions started just after strong rainfall events. If pore-fluid pressure changes can trigger volcanic eruptions, hydrological data are important to improve eruption's forecast, especially in equatorial regions where monsoons or hurricanes can frequently occur.