Effective parametric inversion of pre-eruptive ground deformation for hydrokinetic model of magma plumbing system

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We numerically simulated a transient magma accumulation process in the magma plumbing system beneath an active Showa Crater of Sakurajima Volcano (Japan). Our objective is to find what would be dominant geophysical parameters in the accumulation process before eruption. Geodetic observations showed that a periodic inflation and deflation event had lasted 30 hours before an explosive eruption on April 9, 2009. Our model consists of two reservoirs, one shallower filled mainly with gas and the other deeper filled with magma, connected by a volcanic conduit as inferred from the past geophysical observations. A pressure difference between the two reservoirs forces the magma to move from the deeper up to the shallower reservoir. We assumed a constant rate of magma supply to the deeper reservoir as an input to the magma plumbing system. In a cylindrical volcanic conduit, a viscous multiphase magma flow is simulated by either Hagen-Poiseuille or permeable flow with the effects of the relative motion of gas in magma, the exsolution of volatiles in melt, the crystallization of microlites in groundmass, the change in height of magma head, etc. As a result of comparison between the observed and calculated volumetric variations in the reservoirs, we found the permeable model could reproduce the observed event observed before the eruption than the Hagen-Poiseuille flow model. We also found that the radius of the volcanic conduit, the bulk modulus of the deeper reservoir and the relative gas permeability in magma are the key parameters to reproduce the observed volumetric variations before the eruption. Among these parameters, our sensitivity analysis indicates that the initial height of magma head, the temperature and the radius of the magma reservoir would have much less influence on the volumetric variations of the reservoirs than the key parameters. We propose our numerical model as one of quantitative simulation methods that could be applied to the future eruptive events not only at Sakurajima Volcano but for the other volcanoes.