EGU23-1068, updated on 27 Feb 2024
https://doi.org/10.5194/egusphere-egu23-1068
EGU General Assembly 2023

Numerical thermo-mechanical modelling of lava dome growth during the 2007-2009 dome-building eruption at Volcán de Colima

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Lava domes form during effusive eruptions due to an extrusion of highly viscous magmas from volcanic vents. We present here a study of the lava dome growth at Volcán de Colima, Mexico during 2007-2009 using numerical modelling. The mathematical model treats the lava dome extrusion dynamics as a thermo-mechanical problem. The equations of motion, continuity, and heat transfer are solved with the relevant boundary and initial conditions in the assumption that the viscosity depends on the volume fraction of crystals and temperature. Numerical experiments have been performed to analyse the internal structure of the lava dome (i.e., the distributions of the temperature, crystal content, viscosity, and velocity) depending on various heat sources and thermal boundary conditions. It was demonstrated earlier that the lava dome dynamics at Volcán de Colima during short (for a couple of months) dome-building episodes can be modelled by an isothermal lava extrusion with the viscosity depending on the volume fraction of crystals. We show here that cooling plays a significant role during long (up to several years) dome-building episodes. A carapace develops as a response to a convective cooling at the lava dome interface with the air. The carapace becomes thicker if the radiative heat loss at the interface is also considered. The thick carapace influences the lava dome dynamics constraining its lateral advancement. The latent heat of crystallization leads to higher temperatures inside the lava dome and to a relative flattening of the dome. The developed thermo-mechanical model of lava dome dynamics at Volcán de Colima can be used elsewhere to analyze effusive eruptions, dome carapace evolution and its failure potentially leading to pyroclastic flow hazards.