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Impact of hydrothermal alteration on lava dome stability: a numerical modelling approach

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Lava domes are a common feature of many volcanoes worldwide. They represent a serious volcanic hazard as they are prone to repeated collapses, generating devastating debris avalanches and pyroclastic flows. While it has long been known that hydrothermal alteration degrades rock properties and weakens rock mass cohesion and strength, there is still little quantitative information allowing the description of this effect and its consequences for assessing the stability of a volcanic rock mass such as a lava dome. In this study, we use the finite difference numerical model FLAC 3D to investigate the impact of hydrothermal alteration on the stability of a volcanic dome lying on a flat surface. Different hydrothermal alteration distributions were tested to encompass the variability observed in natural lava domes. Rock shear strength parameters (minimum, maximum and mean cohesion "c" and friction angle "φ" values) representative of various degrees of hydrothermal rock alteration were used in the simulations. The model predicts that reduction of the basement rock's shear strength decreases the factor of safety significantly. A similar result is found by increasing the vertical and horizontal extension of hydrothermal alteration in the basement rocks. In addition, pervasive hydrothermal alteration within the lava dome is predicted to exert a strong negative influence on the factor of safety. Through reduction of rock porosity and permeability, hydrothermal alteration may also affect pore fluid pressure within a lava dome. The results of new FLAC 3D runs which simulate the effect of hydrothermal alteration-induced pore pressure changes on lava dome stability will be presented.