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Thermo-poromechanical induced seismic effects during diking

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Dike propagation in the earth crust, often a precursor of major volcanic eruptions, usually generates a seismic response by activating small fractures (micro-seismicity) and larger existing faults (greater magnitude events). The conceptual interpretation is essentially viewed as a fluid-driven fracture advancing in the rock mass and altering the existing state of stress in its surroundings. Because dikes are filled with high-temperature magma, which can exceed 1000 °C, it is likely that they will alter the initial temperature while propagating. The temperature increase can generate pore water pressurization as a function of its rate of change. Pore pressure in turns diffuses through the porous and fractured rock, altering the initial effective stress state. Additionally, hot dikes also generate thermally-induced stresses. The stress changes in the rock are therefore affected by temperature and pore pressure as much as they are by mechanically induced fracturing. In this contribution, we have studied the coupled processes of temperature, pore pressure and deformation induced by diking. We have employed finite element analyses to solve the boundary value problem of a progressing dike. The main goal is to highlight the effects generated by temperature increase in the rock surrounding the dike. Thermal pressurization depends on heat loading rate, hence on diking advancement speed, and on surrounding rock permeability. Rock permeability also controls the diffusion of pore pressure, the size of the area affected by pressurization and the magnitude of pressurization. Results from numerical models show that positive Coulomb stress changes (instabilities) can be triggered by thermal effects at several hundred meters away from the dike, implying that even non-advancing dikes could generate a seismic response. We prove the importance of accounting for thermo-poromechanical effects in studying the seismic response during diking, a widely unexplored field which could have major implications for the assessment of volcanic eruptions' precursory signals.