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A cellular automata model for the formation of lava tubes

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Lava flows represent a problem particularly challenging for physically based modeling because the mechanical and thermal features of lava change over time. In order to generate complex trajectories due to the interactions between lava flows and the underlying topography, we need to model the main mechanical features of lava and the way they evolve over time depending on temperature. We developed a model for lava flow simulations based on Cellular Automata, called MAGFLOW. An algorithm based on Monte Carlo approach to solve the anisotropic problem was included. A steady state solution of Navier Stokes equation, in the case of laminar pressure-driven Binghamian fluid, was taken into account as evolution function of CA. The model takes into account a vertical thermal structure in the flow. To this aim two layers are considered: a lower layer, where the temperature is homogeneous and an upper layer across which heat is transferred by conduction. At free surface of the flow, we have heat radiation to the atmosphere. The upper layer is taken to coincide with the plug, defined as the region where no shear deformation takes place in a Bingham flow. The cooling mechanism is controlled by the increase of yield stress, which produces a thicker plug and makes the heat loss slower. As result of heat loss into the atmosphere, a crust, defined as the layer which is above the isothermal surface at the solidus temperature, is gradually formed on the upper surface of the flow. We assume that a lava tube is formed when such a crust is sufficiently thick to resist the drag the underlying flow and sustain itself under its own weight. The achievements related to simulate the path of lava flow

outpoured during some eruption of Etna volcano are shown.