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Numerical simulation of lava flows at Mt. Etna

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Simulations of lava flow emplacement attempt to understand how the complex interaction between a flow's physical properties and emplacement characteristics lead to the final flow dimensions and morphology observed in the field. Unfortunately, it is very difficult to establish straightforward relationships between physical properties of a lava flow and its morphologic parameters such as length or surface structure. The forecasting of lava flow paths is a typically complex problem, especially when it consists of an unconfined multiphase stream whose temperature, rheologic parameters, and local flow rate all vary with space and time. The velocity of lava flowing in a channel depends on the physical properties of the lava (density, viscosity, yield strength), environmental factors (gravity, underlying topography), and the channel dimensions. Lava viscosity and yield strength can, in turn, be related to temperature and crystallization. The problem is more difficult to solve when lava runs down a real topography, considering that the relations between characteristic parameters of flow are typically nonlinear. An alternative approach to standard differential equation methods in modelling complex phenomena is represented by paradigms of parallel computing paradigms, whose evolution is based on local interactions of their component parts. We have been taken advantage of the Cellular Automata (CA) approach for modeling and simulating some lava flows down an effusive volcano such as Mt Etna. An algorithm based on Monte Carlo approach to solve the anisotropic problem which CA suffer has been introduced and a steady state solution of Navier Stokes equation in the case of isothermal laminar pressure-driven Binghamian fluid will be take into account as transition rules of CA (evolution function). Heat of lava flow is carried in accordance with the flow motion. Temperature of the lava in a cell is considered as isothermal. For the cooling mechanism, we consider the radiative heat loss only from the surface of the flow (the effect of conduction to the ground and convection to the atmosphere is neglected), and the change of the temperature due to mixture of lavas between cells with different temperatures. Moreover, some empirical relationship between the temperature and magma rheology, validated on Mt. Etna, have been introduced. An optimization algorithm is also used to estimate the global parameters of models. The achievements related to simulate the path of lava flow outpoured during the current flank eruption of Etna volcano are shown.