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Lava flows and volcanic landforms

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Lava flows constitute a large portion of the edifice of basaltic volcanoes. The substantial difference existing between the emplacement dynamics of different basaltic lava flows suggests a relation between the dominant flow dynamic and the overall shape of the ensuing volcano. Starting from the seminal works of Walker (1971, 1973) it is proposed that the rate of heat dissipation per unit volume of lava can be the founding principium at the roots of the emplacement dynamics of lava flows. Within the general framework of the thermodynamics of irreversible processes, a conceptual model is presented, in which the dynamic of lava flows can evolve in a linear or in a nonlinear regime on the basis of the constraint active on the system: a low constraint promotes a linear dynamic (i.e. fluctuations are damped), a high constraint a nonlinear one (i.e. fluctuations are enhanced). Two cases are considered as end-members for a linear and a nonlinear dynamic in lava flows: the typical "Hawaiian" sheet flow and the classic "Etnean" channelized flow (respectively). In lava flows, the active constraint is directly proportional to the slope of the topography and to the thermal conductivity and thermal capacity of the surrounding environment, and is inversely proportional to the lava viscosity and to the supply rate. The constraint indicates the distance from the equilibrium conditions of the system, and determines the rate of heat dissipation per unit volume. In subaerial flows, the heat dissipated during the emplacement is well approximated by the heat lost through radiation, which can be retrieved through remote-sensing techniques and can be used to correlate dynamic and dissipation. The model presented recombines previously unrelated concepts regarding the dynamics and the thermal regimes observed in different lava flows, providing a global consistent picture.

References
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