Conduit geometry and evolution of effusion rate during basaltic effusive events: Insights from numerical modeling

Alvaro Aravena[1], Raffaello Cioni[1], Mattia de' Michieli Vitturi[2],
Marco Pistolesi[3], Diego Coppola[4], Maurizio Ripepe[1], Augusto Neri[2]

[1]*Dipartimento di Scienze della Terra, Università di Firenze, Italy*
[2]*Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Pisa, Italy*
[3]*Dipartimento di Scienze della Terra, Università di Pisa, Italy*
[4]*Dipartimento di Scienze della Terra, Università di Torino, Italy*

The dynamics of effusive events is controlled by the interplay between conduit geometry and source conditions. Dyke-like geometries have been commonly employed for describing conduits during effusive eruptions, but their depth-dependent and temporal modifications are largely unknown. Here we present a novel model that describes the evolution of conduit geometry during effusive eruptions by using a quasi-steady state approach based on a 1D conduit model and appropriate criteria to model the geometric evolution of the conduit due to fluid shear stress and elastic deformation. Such approach provides time-dependent trends for effusion rate, conduit geometry, exit velocity and gas flow, among other output variables. Fluid shear stress leads to upward widening conduits, whereas elastic deformation becomes relevant only during final phases of the eruptions. Since the model is able to reproduce different trends of effusion rate, it was employed for addressing the effects of magma source conditions and conduit properties on the main characteristics of the resulting effusive eruptions (e.g. duration, erupted mass, maximum effusion rate). We show that the total erupted mass is mainly controlled by magma reservoir dimensions and their conditions before the eruption (i.e., initial overpressure), whereas conduit processes and geometry are able to affect the magma withdrawal rate and thus the eruption duration and effusion rate. The resulting effusion rate trends were classified in different types, and associated to the curves described in the literature for different volcanic events. Results well reproduce these trends and provide new insights for interpreting them, highlighting the importance of reservoir overpressure and the initial dimensions of the feeding dyke on the resulting effusion rate curve.