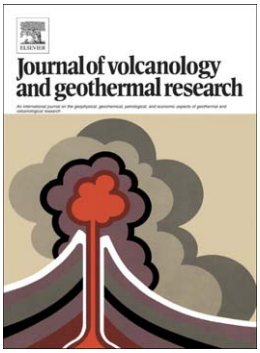

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Counter-current convection in a volcanic conduit

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Abstract

Volcanoes of Strombolian type are able to maintain their semi-permanent eruptive states through the constant convective recycling of magma within the conduit leading from the magma chamber. In this paper we study the form of this convection using an analytic model of degassing two-phase flow in a vertical channel. We provide solutions for the flow at small Grashof and large Prandtl numbers, and we suggest that permanent steady-state counter-current convection is only possible if an initial bubbly counter-current flow undergoes a régime transition to a churn-turbulent flow. We also suggest that the magma in the chamber must be under-pressured in order for the flow to be maintained, and that this compromises the assumed form of the flow.

Keywords: Counter-current convection, Strombolian dynamics, Two-phase flow, Flow régime transition

1 Introduction

Strombolian volcanic eruptions (Vergniolle and Mangan 2000) are characterised by regular explosions from the magmatic vent, in which gases are released in a rhythmic fashion. The manner of the explosions is not very violent, and the eruptions are sometimes characterised by the extreme longevity of the sequence. The type example, Stromboli, which sometimes erupts in a Strombolian eruptive style, is thought to have been erupting continuously for thousands of years.

Volcanoes which erupt in a Strombolian manner are characterised by relatively low viscosity (10^2–10^3 Pa s) gas-rich basaltic magma, and it is thought that the eruptive gases (H_2O, CO_2, SO_2 for example) are exsolved from the magma as it is depressurised on its ascent. Many examples of Strombolian-type volcanoes are known, e. g., Villarrica, Chile (Witter *et al.* 2004), Izu-Oshima, Japan (Kazahaya *et al.* 1994), Satsuma-Iwojima, Japan (Kazahaya *et al.* 2002), Stromboli, Italy and Mount St. Helens, United States (Stevenson and Blake 1998). Some of these possess