28th IUGG Conference on Mathematical Geophysics, June 7-11, 2010, Pisa, Italy
Session 2: Geophysical fluid dynamics II - Sub-surface and surface flows

Numerical Study of the role of Korteweg stress in magma dynamics

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Keywords: *Korteweg stress; magma dynamics; numerical modelling*

The Korteweg Stress theory predicts the existence of capillary stresses arising at the interface between two miscible liquids characterised by a sharp compositional gradient. Such stresses may result in a series of effects that include interface relaxation and breakup, in analogy to surface tension-induced instabilities in immiscible liquids. In the last decade both computer models and fluid dynamical experiments have been devised, in various areas of research, in order to investigate Korteweg stresses and provide both a deeper theoretical insight and unequivocal evidence of their effects. However, only recently attention has been drawn on the possible role of Korteweg Stress in geophysical systems. In this study, a series of numerical experiments have been performed with the aim of ascertaining whether magma dynamics may be affected by the action of Korteweg stresses. In particular, attention was focussed on the simulation of the development of micro-scale emulsion textures in systems comprising two miscible magmas. Such textures have been observed, in the literature, in both natural and experimental samples. The results show that, depending on the physico-chemical properties of the interacting magmas (e.g. viscosity, diffusivity), surface minimization can be induced by processes of interface relaxation, breakup and coalescence, potentially leading to the formation of emulsion-like textures. Furthermore, a parametric study is performed with the aim of investigating the extent of Korteweg stress-driven instabilities in the presence of other processes related to buoyancy, momentum diffusivity, etc. New dimensionless numbers are defined, which relate Korteweg stresses to the other forces acting on the system, and may be used to infer at which scales and for which combinations of melts Korteweg stresses may affect the evolution of a magmatic system.