

高結晶度マグマの流れが生む組織：メルトチャネルと結晶定向配列

A new type of microstructure formed in a flowing crystal-rich magma: Formation of melt channels and two sets of preferred

川畑 博^{1*}, 西浦泰介¹, 大藤弘明², 阪口秀¹, 谷健一郎¹, 巽好幸¹

Hiroshi Kawabata^{1*}, Daisuke Nishiura¹, Hiroaki Ohfuji², Hide Sakaguchi¹, Kenichiro Tani¹,
Yoshiyuki Tatsumi¹

¹独立行政法人 海洋研究開発機構, ²愛媛大学

¹IFREE, JAMSTEC, ²GRC, Ehime university

Microstructures in a magma are important in controlling magma rheology when the crystallinity of the magma is high enough to result in significant interactions between crystals. We have investigated the shear-induced melt localization and the evolution of microstructures within a crystallizing magma based on petrology and 3-D numerical simulations. Within the Miocene Otozan lava flow in Shodo-shima Island, SW Japan melts and aqueous vapors have become localized in response to a flow-induced shear strain that developed in the lava flow. This texture is characterized by the groundmass plagioclase exhibiting two preferred orientations and the formation of liquid-rich channels. Reconstruction of the crystallization processes indicates that the observed crystal orientation and channel texture were produced before the magma reached a crystal fraction of ca. 0.6 and a temperature of ca. 900 °C. A 3-D numerical simulation, developed by coupling a discrete element method with computational fluid dynamics, was performed for a two-phase flow consisting of a viscous liquid and rigid tabular particles. This showed that for liquids made up of between 5 and 40 vol% particles, shear strain enhances the ordering of particles, and thus bulk viscosity decreases to a steady value. The point at which the steady viscosity is reached reflects when the steady-state microstructure forms. For liquids with 40 vol% particles, the steady-state microstructure is characterized by two domains that have distinct preferred particle orientations and different local liquid fractions. Both the crystal-rich and melt-rich domains are oblique to the bulk shear plane at ca. 30 degrees, and they appear alternately. This microstructure is consistent with that observed in the Otozan lava. In contrast, this liquid localization is not observed in the simulation of liquids with particle fractions lower than 40 vol%, which instead develop microstructures characterized by the alignment of the long axes of tabular crystals sub-parallel to the bulk shear plane. We propose, unlike many previous models, that the liquid localization does not require a fracturing event. The melt localization occurs as a mirror of the cyclic cluster formation. This self-organized texture is governed by a simple well-known rule that during simple shear flow a stress vector on a plane depends on the plane orientation.

Keywords: shear strain, melt segregation, rheology, texture