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エイジングサスペンションの流動不安定
Shear-induced instability of an aging suspension

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In general, magma is one of typical examples of complex fluids. First of all it is a multi-phase mixture of contrasting physical properties. The volume fraction can easily change with the environmental conditions so that interactions between the constituent phases are highly variable. The characteristics make the magma complex. Rheology is an intrinsic property characterizing the complex fluid. Magma also exhibits non-Newtonian behaviors such as the existence of yield stress [M. Saar et al., 2001], shear-thinning [H. Sato, 2005], thixotropy, which is a kind of aging property [H. Ishibashi and H. Sato, 2007], and shear localization [S. Okumura et al., 2013, A. Hale and H. Muhlhans, 2007] under certain conditions. Consequently magma flow is expected to be unstable by control of complex rheology and it might be related volcanic oscillation phenomena such as volcanic tremor. However there are few studies, which focus on flow behaviors caused by the complex characteristics of magma rheology so far since it is difficult to control flow in magma and obtain reproducible results at high pressure and high temperature.

For this reason, instead of using real magma but by using analog material this study aims to reveal possible control of complex rheology in magma flow dynamics. We particularly focus on shear-induced instability of the suspension such as shear-banding phenomena to drive unstable and oscillatory flows. As an analog material we utilized an aging suspension of fine silica particles (Ludox TM-40, Aldrich) with salt water. The suspension is known to have yield stress, aging behavior and thixotropic natures [Moller et al., 2008], which can be an analog for the magma complexity. A series of rheological experiments with the use of a rheometer (AR1000, TA Instrument) and 1D and 2D ultrasonic speckle velocimetries (USV) [S. Manneville, 2004] have achieved to observe global rheology and local velocity profiles in the flow simultaneously. By results from the experiments under various conditions changing applied shear rate and aging time, we conclude that the flow behavior can be divided into three types; fluidization, unstable shear banding, and stable shear banding. In the cases of fluidization and unstable shear banding, shear stress fluctuates when the width of shear band and slip velocity show large shift. In this way, it was revealed that fluctuation of shear stress could occur in this kind of suspension and both shear-banding and wall-slip are responsible for driving the shear-induced global instability.
Keywords: aging, rheology, suspension, shear band