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Rheological Characteristics Leading to Magma Flow Instability

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During volcanic eruptions alternate transitions between two contrasting states are known to generate oscillatory phenomena. Switching between tremor stage and non-tremor stage and periodic transition between eruption stage and quiescent doom growth stage are typical examples. These should reflect dynamics of magma inside volcanoes, which gives us indispensable information about physics of volcanic eruption. One of the main causes for this transition is instability due to double-valued relation between flow rate and driving pressure. It indicates that two flow rates exist at one pressure and jump between two states causes transition. The origin of this double-valued nature of magma flow has not been clarified yet though volatile-dependent viscosity is suggested. To figure out the dynamics of this transition and physical origin of the double-valued relation, rheology of magma should be a key. ?Similar phenomenon is known as spurt in the fields of polymer science. It is controlled by a jump of flow rate due to the wall friction controlled by the double-valued relation of stress and strain rate. In this phenomenon an abrupt increase in flow rate under certain range of driving pressure is observed.

We focus on rheology of suspension and explore the possibility of the rheology, which has the double-valued nature. In this study PNIPAM aqueous suspension was used as an analogue material of multiphase magma. Since the volume fraction of PNIPAM systematically changes with the concentration of gel powder and temperature, it is possible to measure change of rheology continuously associated with change of the fraction of solid phase. By experiments with controlled shear rate, we revealed the double-valued relation in shear stress and shear rate at certain range of volume fraction of the solid phase. We would like to remark magma has a similar characteristic rheology, which can explain volcanic oscillatory phenomena. This work was collaborated with E.D Giuseppe and A. Davaille.

Keywords: Magma, Rheology, PNIPAN, Instability, Complex fluid