Rheology of clay paste and application to the investigation of formation process of surface topography on the Mars

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Mars is known to have many terrains formed by water, which is one of important candidates for future exploration places. For example, RSL (Reccuring Slope Lineae) is repeating disappearance and occurrence by seasonal variation, so it suggests that RSL was formed by water. However, there is a hypothesis that RSL is formed by sands, and formation process of RSL is still unclear.
Considering that flowing water is mixed with grain of sands and clay powders, and becomes pastes (colloidal suspension). It is valuable to understand properties of pastes. Since pastes have many unique properties, they are attracting widespread interest in various fields. Pastes are classified as attractive or repulsive according to a force among particles. Rheology of repulsive colloidal suspension has been studied so far. On the other hand, rheology of attractive colloidal suspension is still unknown. To understand the surface topography on Mars, it is important to study the rheology of clay paste, one of typical attractive colloidal suspension, because clay minerals are widely found on the surface of Mars. As the formation of some landforms, such as RSL, are considered to be dependent on temperature, we focused on the temperature dependence of their rheology, such as an yield stress and a viscosity, of attractive colloidal suspension.
We used paste of magnesium carbonate hydroxide because their properties are similar to clay minerals; their inter-particle force is attractive and makes a card house structure. We used rheometer (Anton Paar, Physica, MCR-301) for measuring. We measured rheology of paste at four different temperatures and five different solid volume fractions. We found that the yield stress of paste of magnesium carbonate hydroxide is an increasing function of a temperature. The yield stress of usual elastoplastic media is known to decrease as the temperature increases. However, our experimental study revealed that the yield stress of attractive colloidal suspension is an increasing function of the temperature, the result of which is an inverse behavior to that of usual elastoplastic media. The temperature dependence of the yield stress of attractive colloidal suspension is much more drastic when it is compared to the theoretical prediction for the repulsive colloidal suspension with the linear dependence to its absolute temperature.
As for the viscosity of attractive colloidal suspension, its behavior is similar to that of Newtonian viscous fluid with its viscosity a decreasing function of the temperature. We consider that this is because the viscosity of solvent, i. e., water, decreases as the temperature of an colloidal suspension increases.
These facts suggest that temperature dependence of rheology was caused by what kind of force is working among particles. As a mechanism of these results, we suggest that changing charge on the surface of particles or changing viscosity of water. In order to reveal why interaction is changed with increasing temperature, we need further verification.
In the future work, we will make use of these results for understanding the process of forming subsurface terrains on Mars.

Keywords: Mars, RSL, rheology, yield stress, clay paste

