

Research Report
Earthquake Research Institute
University of Tokyo
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General description of my work:

From February 6 to March 30, 2023, I visited the Earthquake Research Institute (ERI) and principally collaborated with Dr. Ichihara and Dr. Tapia on the project *rheology of granular suspensions with application to magma and lava flows*, see next section. This collaboration started a few years ago and has already been concretized by a paper on the transition from the viscous to inertial rheology in granular suspensions [1] and we anticipate further results on the applications to geophysical flows.

I also had discussions with Dr. Kuwano together with Dr. Ichihara and Dr. Tapia on the pressure-imposed rheology of dry and fluid-immersed granular suspensions. In particular, we discussed the pressure-imposed rheometer that has been build at ERI and his application to particles suspended in fluids. This starting collaboration will be continued in the future.

On March 1, 2023, I gave a course to the students at ERI on granular suspensions which was followed by questions and lively discussions. My slides were distributed to the students.

On March 7, 2023, I visited Tokyo University of Agriculture and Technology together with Dr. Ichihara and Dr. Tapia. I had a laboratory tour in Mechanical and Chemical Engineering and met with Dr. Hanasaki, Dr. Kameda, Dr. Nagatsu, Dr. Nishimura, Dr. Tagawa, and Dr. Takada. I gave a seminar entitled *Rheology of dense granular suspensions: from Newtonian to Bagnoldian rheology*.

From March 8 to 11, 2023, a field trip to the island of Kyushu was organized by Dr. Ichihara. Dr. Ichihara, Dr. Sánchez, Dr. Tapia and myself participated to this trip. A theoretical seismologist, Dr. Ando, who is working on fault rheology joined the trip and showed us his field near Nagasaki. We visited the Unzen volcano which experienced a major eruption in 1991-1995. We observed the structure of the lava dome and visited some remnants of damages by the pyroclastic flows and avalanches as well as the geothermal areas and hot springs.

Research project: rheology of granular suspensions with application to magma and lava flows.

My research interests are in the field of particulate multiphase flows with a special focus in the understanding of the microstructural details of particle-particle and particle-fluid interactions which are key to the understanding of the macroscopic behavior of these systems. My recent line of research into such particle-laden flows addresses the rheology of dense suspensions as well as sedimenting, eroding, and re-suspending particulate flows.

Many environmental phenomena involve the flow of solid-fluid mixtures over complex and erodible topography. Sediment transport and erosion contribute to shaping landscapes, creating volcanic eruptions, and give rise to self-formed morphologies such as ripples and dunes. These flows also present hazards: avalanches, landslides, mud and debris flows, as well as volcanic plumes and pyroclastic flows. In particular, volcanic processes are strongly influenced by the rheological properties of lavas which are a complex function of the chemistry, temperature, pressure, crystal and bubble contents. Assessing hazard prevention and control requires predicting the flow behavior of these dramatic events, i.e. predicting their rheological behaviors.

There is thus a compelling needs for understanding the rheological behavior of granular suspensions in connection with the above natural situations. Gravity plays an important role as it controls the level of stress experienced by the grains. This rheological situation, termed pressure-imposed, has been the subject of significant recent advances [1, 2, 3, 4]. The research during my visit has focussed on understanding how some of new key concepts in suspension rheology [5] can help in deciphering some of the magma and lava flow processes.

Acknowledgement:

I would like to thank Dr. Ichihara for hosting me during these two months at ERI. I would like also to thank the students, postdocs, and researchers I have interacted with, and the staff at the ERI International Office for making my visit so pleasant and enjoyable.

References

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- [5] Guazzelli, É., & Pouliquen, O., Rheology of dense granular suspensions, *Journal of Fluid Mechanics*, **852**, P1 (2018).