Postdoctoral position (12 months)
Numerical study of a non-isochoric and fluidized dense granular model

Scientific context. Dense granular flows involved in some pyroclastic density currents (PDCs) during explosive volcanic eruptions are inherently complex and the physical mechanisms involved are still poorly understood. The basal part of PDCs, while dense (30-50% of particles per volume unit) behaves like a fluid and can travel long distances on almost horizontal slopes. These flows are major natural hazards that can cause extreme human and material damage and have environmental consequences on a continental or even global scale. Understanding the mechanisms that control the run out distance of pyroclastic flows and modeling these devastating natural phenomena is a major challenge for fundamental research and for the study of natural hazards.

In [1] and [2], numerical simulations with a 2D model of granular flows at constant volume fraction based on the equations of conservation of mass and momentum with yield rheology have successfully reproduced results of laboratory experiments [3] of collapse of a dense granular column. This approach suffers from shortcomings and limitations: the volume fraction of particles being constant, dilation/compression effects cannot be taken into account, restricting the study to dense compacted flows. In a recent work [4], a non-isochoric granular model taking into account local variations in the volume of the medium is proposed. The flow being no longer incompressible, new numerical schemes should be investigated and implemented.

Research project. The postdoctoral fellow will contribute to the development and implementation of novel numerical schemes to discretize the non-isochoric granular model introduced in [4]. Numerical simulations of the collapse of weakly expanded granular columns will be performed and compared with the results of experiments conducted at the Magmas and Volcanoes Laboratory (LMV, UCA) [3]. For instance, experimental measurements of the front velocity, flow shape and internal dynamics as well as the length of the final deposit in the collapse configuration of a dense, fluidized and weakly expanded granular column will be used.

The fellow will be member of the EDPAN team in Blaise Pascal Mathematics Laboratory (LMBP, UCA) and will have access to the parallel cluster of the LMBP as computing facilities. The expected outcomes are the production of numerical simulations, comparisons with experiments as validation step, and participation in the writing of a research article. The ability to work in collaboration with the project leaders will be essential to achieving the objectives.

Information. This position is financed by the Institute of Mathematics for Planet Earth (CNRS). This project is the result of a collaboration between the LMBP and the LMV. Applicants should have a background in scientific computing and numerical analysis of partial differential equations. Parallel programming skills are welcome but not mandatory. To apply candidate must send a resume and a motivation letter. The contract will start in autumn 2024. For further information, contact Thierry Dubois and/or Laurent Chupin.

References

[1] A. Aravena, L. Chupin, T. Dubois, O. Roche. The influence of gas pore pressure in dense granular flows: numerical simulation versus experiments and implications for pyroclastic density currents, Bull. Volcanol., 83:77, 2021.

[2] L. Chupin, T. Dubois, M. Phan, O. Roche, Pressure-dependent threshold in a granular flow: Numerical modeling and experimental validation, J. Non-Newtonian Fluid Mech., 291, 2021.

[3] O. Roche, Depositional processes and gas pore pressure in pyroclastic flows: an experimental perspective, Bull. Volcanol. 74(8), 1807-1820, 2012.

[4] L. Chupin, T. Dubois. Non-isochoric stable granular models taking into account fluidisation by pore gas pressure, J. Fluid. Mech., 979(A14), 2024.