PhD position at the Physics Dept. of Pisa with INGV

Thermal and fluid-dynamical modeling to inform statistical emulators of volcanic plumbing system dynamics

A INGV (Istituto Nazionale di Geofisica e Vulcanologia) funded PhD position in Physics is available at the Physics Department of the University of Pisa via the Swiss National Science Foundation collaborative grant 'VAMOS - Data-driven imaging of volcanic plumbing systems'.
The VAMOS project aims at forecasting the magnitude and duration of volcanic eruptions by combining petrological and statistical analyses of erupted samples, modeling of volcanic plumbing system evolution and statistical emulation. The PhD candidate will work at Istituto Nazionale di Geofisica e Vulcanologia in Pisa under the supervision of Dr. Chiara Montagna, in close collaboration with the whole multidisciplinary project team based at the Unversities of Geneva (Earth Science and Statistics department) and Bologna (Statistics department), which includes 4 professors, 2 post-docs and 4 more PhD students, with expertise spanning from computational fluid dynamics to statistics and machine learning to volcanology.
The candidate will focus on developing models of magma flow within volcanic plumbing systems. The main task will be development and tuning of OpenFOAM-based **computational fluid dynamics** solvers for the thermal and dynamical evolution of magmas at shallow depths within the Earth's crust. Magmas are multiphase (solid, liquid and gas) fluids with transport properties (density, viscosity) that strongly depend on their thermodynamics, and that vary in space and time by orders of magnitudes. The PhD candidate will start by modeling the thermal evolution of a magmatic body, that changes its phase assemblage as a function of temperature and pressure. Flow regimes will be identified and their dynamics tackled with different approximations with respect to phase coupling (from full coupling, to Lagrangian transport, to two-way interactions, possibly to collective particle behavior). Lagrangian particle tracking will provide the first important results in terms of solid particle trajectories in phase space to be compared with observations on erupted volcanic products.
The computationally expensive numerical simulations results obtained in the different regimes will be used to build **statistical emulators**, by training **machine learning** algorithms that will reproduce simulated outputs at much lower costs, allowing for the exploration of a much larger parameters' space. Preliminary results obtained by the project team are very promising, and collaboration with the Statistics Department at the University of Geneva (Prof. S. Guerrier, Dr. L. Insolia) is foreseen to build robust surrogate models of multiphase magma flow dynamics. Statistical emulators are able to reproduce the temporal evolution of flow patterns and can be used to reconstruct the most probable processes that originated any given observational dataset such as rock geochemistry.
INGV Pisa offers state-of-the-art computational facilites that will be fully available to the PhD candidate. Specific OpenFOAM solvers for multiphase flow dynamics of magmas have been developed at INGV Pisa, and will be available to build upon within the VAMOS project.

Qualifications

The applicant should hold a Master Degree in Physics, Mathematics, Computer Sciences, Engineering. She/he should preferably have some knowledge of fluid dynamics, as well as an interest in applying advanced physical models to natural system dynamics. Within the project, frequent meetings are foreseen aimed at both cooperating with partners and studying volcanic systems in the field. Interested applicants are welcome to contact the project PI Dr. Chiara Montagna chiara.montagna@ingv.it; applications will be submitted through the Univesity of Pisa portal.