Physical Volcanology (4331/6331)

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Course Overview:
Volcanic eruptions are the surface expression of the transfer of mass and volatiles from the deep interior of the planet. Violent eruptions rapidly transform the landscape and impact the atmosphere on short timescales, and the integrated history of magmatism has played a central role in the production of the crust and the degassing history of the planet. The fluid dynamics of volcanoes span a vast array of phenomena from viscous magma flows to turbulent, multiphase eruptions. This course will trace the path of magmas from their ultimate source in the mantle, storage and evolution in the crust, through eruption at the surface where they interact with the landscape and atmosphere. This course is intended to introduce students to applied fluid dynamics in the context of volcanology while also introducing them to ongoing work in the field on the evolution of crustal structure and atmospheric interaction of volcanic eruptions.

No required textbook. Supplemental texts:
Flavio Dobran, *Volcanic Processes: Mechanisms in Material Transport*

Course Outline
1. Overview of volcanic eruption styles and their connection to planetary heat and volatile transfer.
2. Derivation of conservation equations (mass, energy and momentum).
3. Mantle melting and melt properties: The role of water in planetary volcanism.
4. Magma in the crust: Diffusive and convective heat transfer in magma chambers.
5. Crystal-melt separation and crustal production: the crustal mass balance paradox.
6. Multiphase flow in viscous systems – Darcy flow, compaction and crystal suspensions.
7. Fragmentation and conduit dynamics: Why do some magmas fragment while other erupt effusively?
8. Effusive eruptions, lava flows and large igneous provinces. Discussion of flood basalts and their volatile transfer to the atmosphere. How can we infer the volatile content of past eruptions?
9. Explosive eruptions, turbulence and the Stokes number: Lagrangian dynamics of particles in the atmosphere.
10. Volcanic plumes and atmospheric interaction; multiphase flow at high Reynolds numbers.
11. Pyroclastic flows and gravity currents; Scaling arguments and granular mechanics.
12. Super-eruptions: Caldera forming eruptions.

Coursework
1. Weekly problem sets. (30%)*
2. Course project on a topic of active debate/controversy in the field of volcanology. (20%)*
3. Midterm Exam (20%)
4. Final Exam (30%)

* Students registered for the graduate level course will have additional homework problems, and will be expected to complete a longer term project at a higher level of depth/complexity than students registered for the 4331 level undergraduate course. In particular, graduate students are expected to complete a relevant calculation, data analyses or experiment as part of their project. The 4331 course project is a literature review. Students registered for the 4331 level undergraduate course will have exams graded to a standard that reflects their expected course background.