

EPSC 530 – Volcanology

Winter 2019

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Lectures and labs

Lectures: Monday-Wednesday, 1:30-2:30 PM, FDA 348

Labs: Wednesday, 2:30-5:30 PM, FDA 348

Course web site

<http://www.eps.mcgill.ca/~courses/c186-530/>

Grading

In-class presentations and writing assignments:	15%
Term paper:	30%
Laboratory assignments:	30%
Final exam:	25%
Total:	100%

Note: The in-class presentations, term paper, lab assignments, and final exam are all required for the course. Students must complete all these requirements.

Course schedule and assigned reading

<u>Week</u>	<u>Topic</u>
Week 1 (7 Jan):	Overview of volcanoes (read Encyclopedia of Volcanoes (EOV), Chapter 12: Earth's volcanoes and their eruptions: an overview)
Week 2 (14 Jan):	Deep magmatic systems (read EOV, Chapter 4: The composition and origin of magmas)
Week 3 (21 Jan):	Shallow magmatic systems (read EOV, Chapter 8: Magma chambers)
Week 4 (28 Jan):	Surface expressions of magmatic systems (read EOV, Chapter 25: Magmatic fragmentation)
Week 5 (4 Feb):	Calderas I (read EOV, Chapter 16: Calderas)
Week 6 (11 Feb):	Calderas II
Week 7 (18 Feb):	Pyroclastic falls and density currents I (read EOV, Chapter 29: Plinian and subplinian eruptions)
Week 8 (25 Feb):	Pyroclastic falls and density currents II (read EOV, Chapter 35: Pyroclastic density currents: processes and models)
Week 9 (4 Mar):	Optional field trip to western Costa Rica during reading week
Week 10 (11 Mar):	Volcano instability I: debris avalanches (read EOV, Chapter 38: landslides, debris avalanches, and volcanic gravitational deformation)
Week 11 (18 Mar):	Volcano instability II: lahars (read EOV, Chapter 37: Lahars and their deposits)
Week 12 (25 Mar):	Volcano instability III: lava domes and lava flows (read EOV, Chapter 18: Lava dome eruptions)
Week 13 (1 April):	Volcanic hazard and volcanic risk (read EOV, Chapter 70: Volcanic risk assessment)
Week 14 (8 April):	Summary

Laboratory schedule

16 Jan:	LAB 1: prepare analogue experiments
23 Jan:	prepare experiments
30 Jan:	run analogue experiments

6 Feb:	run, analyze analogue experiments
13 Feb:	analyze experiments
20 Feb:	analyze and write up experiments
27 Feb:	oral presentations, hand in lab report
13 March:	LAB 2: start analyzing MULTIGAS and mini-DOAS data
20 March:	analyze data
27 March:	interpret data
3 April:	finish interpreting data, write up report
10 April:	oral presentations, hand in lab report

Required materials for the course

Sigurdsson, H., B.F. Houghton, S.R. McNutt, H. Rymer, and J. Stix, editors, 2015. Encyclopedia of Volcanoes, 2nd Edition. Academic Press, 1,456 pp.

You can access this book at <http://www.sciencedirect.com/science/book/9780123859389>

Also, there are a set of cool new videos on various volcanic phenomena which we will explore during the course. Check out the videos here:

<https://vimeo.com/volfilm/>

In-class presentations and writing assignments

You will be asked once during the course to present a paper which we have read for the class that week. The oral presentation should summarize the key points and highlight the strengths and weaknesses of the paper. In certain instances, I may ask you to comment upon or interpret a diagram or diagrams from the paper.

Given the size of the class, we will probably do the above exercise as groups.

For each paper that we read for class, you also will be asked individually to write a one-page summary and critique (single spaced 12 point Times New Roman).

Laboratory assignments

The labs will be split into two parts. The first lab will examine magmatic processes beneath a volcano. The second lab will examine some stuff (in this case gas) which comes out of a volcano.

For the first half of the course, you will work in groups studying magma processes by means of analogue modeling. Each group will write a report and present their results to the class.

For the second half of the course, you will work in groups examining a set of real-life volcanic gas data from Yasur volcano in Vanuatu. Each group will write a report and present their results to the class.

Your term paper

Your paper will consist of a 10-20 page essay (double-spaced, Times New Roman 12 point) which examines a particular aspect of volcanology that you find interesting. The paper is due on **Wednesday, 10 April 2019**.

Possible research topics for the term paper

I have compiled a list of potential topics which you may find useful when choosing the subject of your term paper. You are, however, free to choose a topic which does not appear on the list below. Before embarking on a topic, please consult with me first so that I may steer you in the right direction, towards relevant references, etc.

Once you choose a topic, you can use search tools such as Geobase and GeoScienceWorld, which are available through the web, to identify relevant scientific articles.

Some useful sources of information

McGill library, <http://www.mcgill.ca/library/>

Compendex, <http://www.engineeringvillage2.org/controller/servlet/Controller?CID=quickSearch&database=1>

Geobase, <http://www.engineeringvillage2.org/controller/servlet/Controller?CID=quickSearch&database=8192>

GeoScienceWorld, <http://www.geoscienceworld.org/>

Web of Science,

http://apps.webofknowledge.com/WOS_GeneralSearch_input.do?product=WOS&search_mode=GeneralSearch&SID=4ACdEG8bbPPGg7alMNI&preferencesSaved=

Begin searching early in the term, in case you need inter-library loans, etc.

For your paper, you are expected to mostly use scientific articles in journals and books, with little or no reliance on web materials. However, feel free to use photos, maps, etc., from the web (with proper documentation). I strongly encourage you to download and read papers from scientific journals. You can access scientific journals at <https://www.mcgill.ca/library/find/articles>. To access these journals, you need to be connected to a McGill computer, VPN DAS, etc.

Term paper topics (you can also choose your own)

tectonic control of volcanoes

hot spots

ophiolites vs. modern ocean ridges
 kimberlites
 shield volcanoes
 flood basalts and rifting
 many different aspects of calderas
 geochemical zonation in ignimbrites
 lava domes
 explosive activity on lava domes
 generation of block and ash flows from lava domes
 edifice collapse
 volcanic submarine landslides
 lahars and lahar support mechanisms
 transformations from pyroclastic flows to lahars
 emplacement mechanisms of pyroclastic flows
 distinctions between surges and other pyroclastic flows
 fallout deposits
 phreatomagmatic volcanism
 subglacial volcanism
 subaqueous pyroclastic flows
 volcano degassing
 volcanic volatiles
 volcanoes and hydrothermal ore deposits
 rheology of magmatic liquids
 magma mixing
 crystallization in magma reservoirs
 alteration of volcanic glass
 classic volcanoes and eruptions (Parícutin, Pinatubo 1991, Krakatau 1883, Mt. St. Helens 1980, Mt. Pelée 1902, Unzen 1993-1995, Kilauea 2018, Mauna Loa, Soufrière Hills, Etna, Miyakejima 2000, Chaiten 2008, Eyjafjallajökull 2010, Bárðarbunga 2014, etc.)
 classic calderas: Valles, Long Valley, Toba, Cerro Galan, Rabaul (especially 1970's-1994), Thira (Santorini), Phlegrean fields (Campi Flegrei), Maule (Chile), Yellowstone, Kilauea, Fernandina 1968, Galapagos, etc.

References

I have compiled a list of references which you may find useful during the course. I have made a few comments beside each of the volcanology books.

Volcanology

General books

- Blong, R.J., 1984. *Volcanic Hazards: a Sourcebook on the Effects of Eruptions*. Sydney, Academic Press, 424 pp. *A comprehensive look at hazards from volcanoes from a number of viewpoints.*
- Cas, R.A.F., and J.V. Wright, 1987. *Volcanic Successions Modern and Ancient*. London, Allen & Unwin, 528 pp. *A modern treatment of volcanic deposits from a sedimentological perspective, with an emphasis on explosive volcanism.*
- Chester, D., 1993. *Volcanoes and Society*. London, Edward Arnold, 351 pp. *A general view of volcanism and volcanic deposits, with a nice section on the impact of volcanoes on society.*

- Decker, R., and B. Decker, 1998. *Volcanoes*, 3rd Edition. New York, W.H. Freeman and Company, 321 pp. *A popular text.*
- Fisher, R.V., and H.-U. Schmincke, 1984. *Pyroclastic Rocks*. Berlin, Springer-Verlag, 472 pp. *A thorough treatment of rocks produced by explosive volcanism.*
- Fisher, R.V., G. Heiken, and J.B. Hulen, 1997. *Volcanoes, Crucibles of Change*. Princeton, Princeton University Press, 317 pp. *A popular account of volcanoes and volcanology by three experienced volcanologists. The illustrations are excellent.*
- Francis, P.W., and C. Oppenheimer, 2003. *Volcanoes*, 2nd Edition. Oxford, Oxford University Press, 536 pp. *A general, somewhat iconoclastic treatment of volcanoes and their deposits.*
- Grattan, J., and R. Torrence, editors, 2007. *Living Under the Shadow: Cultural Impacts of Volcanic Eruptions*. Walnut Creek, Left Coast Press, 307 pp. *A different perspective of the effects and impacts of volcanoes.*
- Lopes, R.M.C., and T.K.P. Gregg, 2004. *Volcanic Worlds, Exploring the Solar System's Volcanoes*. Berlin, Springer, 236 pp. *A good overview of planetary volcanism.*
- Macdonald, G.A., 1972. *Volcanoes*. Englewood Cliffs, Prentice-Hall, 510 pp. *An older but still useful text on volcanology.*
- McClelland, L., T. Simkin, M. Summers, E. Nielson, and T.C. Stein, 1989. *Global Volcanism 1975-1985*. Englewood Cliffs and Washington, Prentice Hall and American Geophysical Union, 655 pp. *A compilation of volcanic activity around the world during 1975-1985. A very useful source of basic information.*
- McGuire, W.J., A.P. Jones, and J. Neuberg, editors, 1996. *Volcano Instability on the Earth and Other Planets*. London, The Geological Society, 388 pp. *A collection of articles which view volcanoes as unstable landforms.*
- McPhee, J., M. Doyle, and R. Allen, 1993. *Volcanic Textures*. Hobart, Centre for Ore Deposit and Exploration Studies, University of Tasmania, 198 pp. *An excellent practical guide to volcanic textures and structures in the field, in hand sample, and under the microscope.*
- Parfitt, E.A., and L. Wilson, 2008. *Fundamentals of Physical Volcanology*. Malden, Blackwell, 230 pp. *A good introduction to the subject.*
- Scarth, A., 1994. *Volcanoes, an Introduction*. College Station, Texas A&M University Press, 273 pp. *A general introduction to volcanoes.*
- Schmincke, H.-U., 2004. *Volcanism*. Berlin, Springer, 324 pp. *An excellent up-to-date overview of volcanoes, with marvelous photographs.*
- Sigurdsson, H., 1999. *Melting the Earth: the History of Ideas on Volcanic Eruptions*. New York, Oxford University Press, 260 pp. *An historical look at the evolution of ideas in volcanology.*
- Sigurdsson, H., B.F. Houghton, S.R. McNutt, H. Rymer, and J. Stix, editors, 2015. *Encyclopedia of Volcanoes*, 2nd Edition. Amsterdam, Academic Press, 1,456 pp. *An exhaustive yet easy-to-read treatment of all aspects of volcanism.*

- Simkin, T., and L. Siebert, 1994. *Volcanoes of the World*, 2nd Edition. Tucson, Geoscience Press, 349 pp. *A compilation of the world's active volcanoes and their activity; an invaluable sourcebook.*
- Williams, H., and A.R. McBirney, 1979. *Volcanology*. San Francisco, Freeman, Cooper & Co., 397 pp. *A thorough review of volcanology, somewhat dated but still useful.*
- Wohletz, K., and G. Heiken, 1992. *Volcanology and Geothermal Energy*. Berkeley, University of California Press, 432 pp. *A book which places geothermal energy in a volcanologic-geologic context; a unique text.*
- Specialized books
- Aramaki, S., and I. Kushiro, editors, 1983. *Arc Volcanism*. Amsterdam, Elsevier, 652 pp. *A book dealing with subduction zone volcanoes.*
- Bignami, C., V. Bosi, L. Costantini, C. Cristiani, F. Lavigne, and P. Thierry, editors, 2012. *Handbook for Volcanic Risk Management*. Orleans, MIAVITA, 197 pp. *A book dealing with volcanic processes, hazards, and risk.*
- Branney, M.J., and P. Kokelaar, 2002. *Pyroclastic Density Currents and the Sedimentation of Ignimbrites*. Geological Society Memoir Number 27, 143 pp. *An excellent in-depth study of the sedimentology of pyroclastic flow and ignimbrite deposits.*
- Breitkreuz, C., and S. Rocchi, editors, 2018. *Physical Geology of Shallow Magmatic Systems: Dykes, Sills and Laccoliths*. Berlin, Springer Open, 409 pp. *A collection of papers providing good insight into magmatic plumbing systems beneath volcanoes.*
- Burchardt, S., editor, 2018. *Volcanic and Igneous Plumbing Systems, 1st Edition: Understanding Magma Transport, Storage, and Evolution in the Earth's Crust*. Amsterdam, Elsevier, 356 pp. *A modern look at volcanic-magmatic plumbing systems.*
- Crandell, D.R., B. Booth, K. Kusumadinata, D. Shimozuru, G.P.L. Walker, and D. Westercamp, 1984. *Source-Book for Volcano-Hazards Zonation*. Paris, UNESCO, 97 pp. *A volume dealing with methodologies of hazard zonation.*
- Dobran, F., 2001. *Volcanic Processes, Mechanisms in Material Transport*. New York, Kluwer, 590 pp. *A detailed theoretical look at volcanic processes.*
- Fearnley, C.J., D.K. Bird, K. Haynes, W.J. McGuire, and G. Jolly, G., editors, 2018. *Observing the Volcano World: Volcano Crisis Communication*. Berlin, Springer Open, 771 pp. *A modern look at how stakeholders communicate (or don't) during and between times of crisis.*
- Freundt, A., and M. Rosi, editors, 1998. *From Magma to Tephra, Modelling Physical Processes of Explosive Volcanic Eruptions*. Amsterdam, Elsevier, 318 pp. *A theoretical look at explosive volcanism.*
- Gasparini, P., and R. Scarpa, editors, 1992. *Volcanic Seismology*. Berlin, Springer-Verlag, 572 pp. *A volume dealing with various aspects of volcano seismicity.*

- Gottsmann, J., J. Neuberg, and B. Scheu, editors, 2019. *Volcanic Unrest: From Science to Society*. Berlin, Springer Open, 313 pp. *A potpourri of papers on volcanic unrest*.
- Harris, A., 2013. *Thermal Remote Sensing of Active Volcanoes*. Cambridge, Cambridge University Press, 736 pp. *All you ever needed to know about thermal properties of volcanoes*.
- Kilburn, C.R.J., and G. Luongo, editors, 1993. *Active Lavas*. London, UCL Press, 374 pp. *A synthesis of work done on lava flows*.
- Lane, S.J., and J.S. Gilbert, editors, 2008. *Fluid Motions in Volcanic Conduits: A Source of Seismic and Acoustic Signals*. Geological Society of London Special Publication 307, 252 pp. *A variety of papers from a number of angles examining processes in conduits*.
- Mader, H.M., S.G. Coles, C.B. Connor, and L.J. Connor, editors, 2006. *Statistics in Volcanology*. IAVCEI Special Publication Number 1, 285 pp. *Statistical treatments of volcano behaviour and eruptions*.
- Mouginis-Mark, P.J., J. A. Crisp, and J.H. Fink (eds.), 2000. *Remote Sensing of Active Volcanism*. American Geophysical Union Geophysical Monograph 116, 272 pp. *Interesting papers on remote sensing applied to volcanoes*.
- Newhall, C.G., and D. Dzurisin, 1988. *Historical Unrest at Large Calderas of the World*. U.S. Geological Survey Bulletin, 1855: 1-1108. *A compilation of historic activity at the world's calderas; another invaluable source of information*.
- Pyle, D.M., T.A. Mather, and J. Biggs, editors, 2014. *Remote Sensing of Volcanoes and Volcanic Processes: Integrating Observation and Modelling*. Geological Society of London Special Publication 380, 362 pp. *A collection of papers on remote sensing aspects of volcanoes*.
- Rouwet, D., B. Christenson, F. Tassi, and J. Vandemeulebrouck, J., editors, 2015. *Volcanic Lakes*. Berlin, Springer Open, 533 pp. *Everything you need to know about volcanic lakes*.
- Scarpa, R., and R.I. Tilling, editors, 1996. *Monitoring and Mitigation of Volcano Hazards*. Berlin, Springer-Verlag, 841 pp. *Methods used in volcano monitoring*.
- Smith, R.L., 1960. *Ash-Flow Tuffs: Their Origin, Geologic Relations, and Identification*. U.S. Geological Survey Professional Paper, 366: 1-81. *A comprehensive look at ignimbrites, somewhat dated but with excellent observations, photos, and photomicrographs of thin sections*.
- Sparks, R.S.J., M.I. Bursik, S.N. Carey, J.S. Gilbert, L.S. Glaze, H. Sigurdsson, and A.W. Woods, 1997. *Volcanic Plumes*. Chichester, John Wiley & Sons, 574 pp. *A theoretical look at the various types of plumes generated by volcanic and associated activity*.
- White, J.D.L., J.L. Smellie, and D.A. Clague (eds.), 2003. *Explosive Subaqueous Volcanism*. American Geophysical Union Geophysical Monograph 140, 379 pp. *A modern treatment of explosive subaqueous volcanism and associated processes*.
- Wood, G.D., 2014. *Tambora, the Eruption that Changed the World*. Princeton, Princeton University Press, 312 pp. *Events and impacts of a small supervolcano eruption in 1815*.

Igneous petrology

- Cox, K.G., J.D. Bell, and R.J. Pankhurst, 1979. *The Interpretation of Igneous Rocks*. London, Allen & Unwin, 450 pp.
- Faure, G., 1986. *Principles of Isotope Geology*, 2nd Ed. New York, Wiley, 589 pp.
- Hargraves, R.B., ed., 1980. *Physics of Magmatic Processes*. Princeton, Princeton Univ. Press, 585 pp.
- Hess, P.C., 1989. *Origins of Igneous Rocks*. Cambridge, Harvard Univ. Press, 336 pp.
- Philpotts, A.R., 1990. *Principles of Igneous and Metamorphic Petrology*. Englewood Cliffs, Prentice Hall, 498 pp.
- Wilson, M., 1989. *Igneous Petrogenesis - A Global Tectonic Approach*. London, Unwin Hyman, 466 pp.
- Williams, H., F.J. Turner, and C.M. Gilbert, 1982. *Petrography, An Introduction to the Study of Rocks in Thin Sections*. San Francisco, W.H. Freeman, 626 pp.

Sedimentology

- Allen, J.R.L., 1984. *Sedimentary Structures: Their Character and Physical Basis*, Vols. 1-2. Amsterdam, Elsevier, 1256 pp.
- Folk, 1980. *Petrology of Sedimentary Rocks*. Austin, Hemphill Publishing Co., 182 pp.
- Middleton, G.V., and J.B. Southard, 1984. *Mechanics of Sediment Movement*. Tulsa, Soc. Econ. Paleontol. Mineral., Short Course No. 3, 401 pp.
- Middleton, G.V., and P.R. Wilcock, 1994. *Mechanics in the Earth and Environmental Sciences*. Cambridge, Cambridge Univ. Press, 459 pp.

Plagiarism

STUDENT GUIDE TO AVOID PLAGIARISM

<http://www.mcgill.ca/students/srr/honest/>

McGill University values academic integrity. Therefore all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures (see <http://www.mcgill.ca/students/srr/honest/> for more information).

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Language of written work

In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded. (approved by Senate on 21 January 2009.)

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