**Earth Science 3312b: Genesis of Meteorites and Planetary Materials Winter 2018**

## General information

**Instructor:** Roberta Flemming: B&GS 0172, <rflemmin@uwo.ca>

**Teaching Assistant:** Brendt Hyde <bhyde@uwo.ca>

**Lectures:** Tuesdays and Thursdays, 10:30 - 11:20 pm, STVH-3101

**Laboratory:** Tuesday 2:30-5:30 pm, B&GS 1069

**Office hours:** Thursdays 11:30-12:20. You can also drop by at any time (except the hour before class or lab!), but I cannot guarantee that I will be in my office, outside of office hours. You may also email me. Email Brendt at any time and meetings can be set up for a time that works for both the student and TA.

**Purpose:** In this course, we will review the origin of our solar system and formation of planets and other planetary bodies. We will examine meteorite mineralogy and textures, and use this evidence to understand their formation mechanisms and possible origins. We will also examine data from Earth impacts, the moon and Mars.

Laboratory exercises will enhance the students' understanding of concepts learned in class. In the laboratory students will become familiar with mineralogy, textures and classification of meteorites. Students will become familiar with methods used to analyze planetary materials and they will classify a meteorite. Students will also give a brief (15 minute) seminar presentation on the meteorite that they have been typing and compare it to one from the literature.

**Prerequisites:** Earth Sci 2200a/b, Earth Sci 2206a/b, and Earth Sci 2230a/b, or permission from the Department. Unless you have all of the requisites for this course or written special permission from your Dean to enroll in it, you may be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

## Course topics/themes - Tentative schedule

### Origin of the Solar System/Early Solar System

Week 1: Jan 9, 11 Organizational; Cosmochemical formation/distribution of elements

Week 2: Jan 16, 18 Solar System formation; CAI and chondrule formation

Week 3: Jan 23, 25 Planetary formation/differentiation; Age and evolution of the solar system

### Introduction to Asteroids/ Comets/ Meteorites

Week 4: Jan 30, Feb 1 Asteroids and classification by spectroscopy; Orbits and meteorite delivery (Guest Dr. Wiegert)

Week 5: Feb 6, 8 Meteorites: History and classification; Meteorite classification, cont'd: composition, rock types

### Chondrites and their Parent Bodies

Week 6: Feb 13, 15 Chondrites cont'd (H, L, LL, EC, Carbonaceous, Rumuruti); Stable Isotopes (Guest Dr. Webb)

********** Reading Week – February 19-23 **********

### Achondrites and their Parent Bodies

Week 7: Feb 27, Mar 1 Magmatic achondrites (4 Vesta HEDs, aubrite, ureilite, angrite, brachinite), Midterm (Mar 1)

Week 8: Mar 6, 8 Primative achondrites (winnonaite, acapolcoite, lodranite); Irons and pallasites – planetary cores

Week 9: Mar 13, 15 Microdiffraction of meteorites; Canadian meteorite falls

Week 10: Mar 20, 22 Guest Lectures: Exoplanets (Dr. Metchev) and Chelyabinsk Airburst (Dr. Brown) (LPSC week)

### The Earth, Moon, and Mars

Week 11: Mar 27, 29 Earth Impacts and Astrobiology (Chicxulub & mass extinction) (Guest Dr. Osinski)

Week 12: Apr 3, 5 Mars: Data from Mars Orbiters and Rovers; Martian meteorites (Guest Dr. Moser)

Week 13: Apr 10 The Moon: Apollo samples and meteorites

## Laboratory Exercises

| Labs | Date | Topic |
|---|---|---|
| Week 1: | Jan 9 | No Lab. |
| Week 2: | Jan 16 | Chemical origin of the Earth. |
| Week 3: | Jan 23 | Crater counting and relative age of Mars. |
| Week 4: | Jan 30 | Spectroscopy of meteorite minerals (NIR and Raman) and correlation to asteroids. |
| Week 5: | Feb 6 | Microscopy: mineralogy & textures of meteorites I. |
| Week 6: | Feb 13 | Microscopy: mineralogy & textures of meteorites II. |
| ********** | Conference Week – February 19-23 | ********** |
| Week 7: | Feb 27 | Typing of meteorites (using microscopy). |
| Week 8: | Mar 6 | Typing of meteorites (using microscopy) – continued. |
| Week 9: | Mar 13 | Micro X-ray Diffraction of meteorites: Phase ID, olivine unit cell, strain index. |
| Week 10: | Mar 20 | Open session to work on meteorite projects. (Flemming away at LPSC, Texas) |
| Week 11: | Mar 27 | Micro X-ray Diffraction of meteorites – continued. |
| Week 12: | Apr 3 | Seminar presentations. |
| Week 13: | Apr 10 | Seminar presentations. |

## Evaluation

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| **Marks:** | Midterm Exam*: (50 min) | March 1 | 20% |
| | Lab assignments: (5) | Due weekly (beginning of the next week's lab) | 25% |
| | Lab project (5 weeks) | Due April 10 | 10% |
| | Final presentation | April 3 or 10 | 5% |
| | Participation: | (Attendance, class discussion, and seminar participation) | 10% |
| | Final Exam*: (2 hr) | TBA | 30% |

* NOTE: Closed book. Calculators will be allowed during tests and exams. No makeup midterm test will be given. For students with a legitimate reason for not attending, this 20% will be added to the weight of the final exam.

## Readings

**Text:**
McSween, H. Y. (2000) *Meteorites and Their Parent Planets. 2nd Ed.* Cambridge University Press, UK

**Additional readings:**
You will be responsible for additional readings, assigned in lectures. This material will be made available online.

**Resource texts:**
McSween, H. Y. and Huss, G. R. (2010) *Cosmochemistry.* Cambridge University Press, UK
Norton, O. R. and Chitwood, L. A. (2008) *Field Guide to Meteors and Meteorites*, Springer. USA (useful laboratory guide)
Lauretta, D. S. and McSween, H. Y. Eds. (2006) *Meteorites and the Early Solar System II* (Taylor: QB755.M4854x 2006)
Lauretta, D. S. and Kilgore, M. (2005) *A Colour Atlas of Meteorites in Thin Section*, Southwest Meteorite Press, Payson, AZ
Hutchison, R. (2004) *Meteorites: A petrologic, chemical and isotopic synthesis.* Cambridge Planetary Science, UK
Papike, J. J. Ed. (1998) *Planetary Materials*, Reviews in Mineralogy Vol. 36: Mineralogical Society of America. Washington

**Learning Outcomes:** Upon successful completion of this course the student will be able to:
1. Identify meteorites by their mineralogy & textures, using optical microscopy (polarizing & reflected light microscopes).
2. Determine the petrologic type, shock stage and weathering stage of meteorites by their mineralogy, using microXRD.
3. Use olivine unit cell (as determined by microXRD) to determine olivine composition, as an aid to classifying meteorites.
4. Classify meteorites using optical and X-ray diffraction information, and communicate their classification to the class.
5. Relate meteorites to asteroidal parent bodies using NIR spectroscopy. Become familiar with Raman Spectroscopy.
6. Develop an understanding of the age and evolution of the solar system.

**Note:** It is Faculty of Science policy that a student who chooses to write a test or exam deems themselves fit enough to do so. Claims of medical, physical, or emotional distress after the fact will not be considered. However, if a student improves their grade in their final exam by 10% over their grade in the midterm test, the student may opt to have the final exam given full weight (50%) and the midterm grade discounted. [This does not apply if the student fails to write the midterm exam.] If a student should miss the midterm test for any reason, there will not be a makeup test. Instead the final exam will be reweighted at 50%.

**Course Website:**
Students should check OWL (http://owl.uwo.ca) on a regular basis for news and updates. This is the primary method by which information will be disseminated to all students in the class. Students are responsible for checking OWL on a regular basis.

**Ethical Conduct:** Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site: http:// www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf.

**Plagiarism:** Students must write their assignments in their own words. Whenever you take an idea, or a passage from another author, you must acknowledge this both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence.
All required papers may be subject to submission for textual similarity review to the commercial plagiarism detection software under license to the University for the detection of plagiarism. All papers submitted for such checking will be included as source documents in the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between The University of Western Ontario and Turnitin.com (http://www.turnitin.com).

**Missed Course Components:**
If you are unable to meet a course requirement due to illness or other serious circumstances, you must provide valid medical or supporting documentation to the Academic Counselling Office of your home faculty as soon as possible.
If you are a Science student, the Academic Counselling Office of the Faculty of Science is located in WSC 140, and can be contacted at 519-661-3040 or scibmsac@uwo.ca
Their website is http://www.uwo.ca/sci/undergrad/academic_counselling/index.html

A student requiring academic accommodation due to illness must use the Student Medical Certificate (https://studentservices.uwo.ca/secure/medical_document.pdf) when visiting an off-campus medical facility. For further information, please consult the university's medical illness policy at
http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf

If you miss the Final Exam, please contact your faculty's Academic Counselling Office as soon as you are able to do so. They will assess your eligibility to write the Special Exam.
You may also be eligible to write the Special Exam if you are in a "Multiple Exam Situation" (see http://www.registrar.uwo.ca/examinations/exam_schedule.html).

**Accessibility:**
Please contact the course instructor if you require material in an alternate format or if you require any other arrangements to make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 x.82147 for any specific question regarding an accommodation.

**Support Services:**
Please contact the course instructor if you require lecture or printed material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 ext. 82147 if you have questions regarding accommodation.

Learning-skills counsellors at the Student Development Centre (http://www.sdc.uwo.ca) are ready to help you improve your learning skills. They offer presentations on strategies for improving time management, multiple-choice exam preparation/writing, textbook reading, and more. Individual support is offered throughout the Fall/Winter terms in the drop-in Learning Help Centre, and year-round through individual counselling.

Students who are in emotional/mental distress should refer to Mental Health@Western (http://www.health.uwo.ca/mental_health) for a complete list of options about how to obtain help.

Additional student-run support services are offered by the USC, http://westernusc.ca/services

The website for Registrarial Services is http://www.registrar.uwo.ca

The policy on Accommodation for Students with Disabilities can be found here:
www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_disabilities.pdf

The policy on Accommodation for Religious Holidays can be found here:
http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf

**Academic Policies**

The website for Registrarial Services is http://www.registrar.uwo.ca

In accordance with policy, http://www.uwo.ca/its/identity/activatenonstudent.html , the centrally administered e-mail account provided to students will be considered the individual's official university e-mail address. It is the responsibility of the account holder to ensure that e-mail received from the University at his/her official university address is attended to in a timely manner.