

Lunar Water

PTYS 595B – Spring Semester 2020 – Tu & Th, 2pm-315pm Kuiper 309

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Scope. This is a graduate research seminar on lunar water. Readings will range from impact evolution of planetary inventories, to chemical and petrological evidence for water in samples and meteorites, to orbital and landed exploration for water (e.g. caves, PSRs, sample return), to ideas (both mainstream and wild) about early lunar evolution. We will also evaluate LPSC abstracts and keep up with significant white papers as they come out in advance of the Decadal Survey. Students will prepare a 20-page academic research paper and present lectures. Some knowledge of terrestrial geochemistry is required.

Course Objectives. Students who engage with this course will develop a broad understanding of satellite formation and the mysterious aspects regarding their dynamics and geology, related to planet formation in general. They will gain an appreciation for the mathematics and observations behind the discoveries, and for the quantitative reasoning that leads to modern understanding. They will become adept at tracking reasoning through assigned papers, and papers or projects they have selected or developed, where one paper or idea is followed by another, and presented to the class as a series of short lectures and discussions. Students will gain experience compiling information from outside sources in a collection of papers relevant to an idea. They will go to the board once per lecture to demonstrate or develop a certain result or concept, and thereby demonstrate their proficiency in quantitative understanding.

Expected Learning Outcomes. Upon successful completion of this course, students will have gained a broad knowledge about modern problems in the origin, geology and discovery of lunar water, and will have increased their familiarity with accessing papers and conducting critical evaluations of published science for supporting fundamental concepts in quantitative (physical, chemical, astro-bio-geological) detail. They will communicate an understanding of these fundamental concepts to their peers by synthesizing the information behind the paper(s) they are presenting, thereby improving their ability to clearly articulate ideas in front of scientists. They will also have a good understanding of the Decadal Survey process, as it relates to White Papers that lead to survey recommendations.

Format. Seminar discussion based on a mix of assigned and volunteered papers. Students will regularly lead discussions, and will prepare two 40-minute lectures about two topics related to lunar volatiles, and one 15-minute focused research lecture that can be less formal.

Grading. Students are evaluated based on seminar performance, which includes reading and preparation; their demonstrated ability to field questions about the work they are presenting and discussing; and their ability to ask coherent questions when participating in a discussion. There is no final exam. Grading is as follows:

- 20%, attendance and prepared participation
- 40%, a 20-page research manuscript (topical review)
- 15% each, two 40-min lectures reviewing two major questions on lunar volatiles
- 10%, a 15-min lecture on a focus topic

Attendance and prepared participation grade includes allocating time to read and/or work on the required assignments ahead of the seminar. It is important to a research seminar, that everyone has done the reading. If students are generally unprepared, there will be a graded quiz.

Grading Scale. 90%-100% = A; 80%-89% = B; 70%-79% = C; 60%-69% = D; 59% and below = F.

Class Policies:

- Office hours after class or by appointment
- Regular attendance is vital. If you miss a class, it is your responsibility to get notes from fellow students and to schedule a brief meeting (even by email) to go over what was missed.
- For university-approved activities for which you have in advance a note of dean's approval, you will be excused, or other arrangements will be made. If you will be absent due to a religious holiday, please let me know by email one week in advance. Absences for other reasons will not be excused unless special dispensation was received in advance.

University Policies:

All university policies related to this syllabus are available at:

<https://academicaffairs.arizona.edu/syllabus-policies> .

Class Schedule: This is a readings-based seminar including documents that come online during the course, such as conference abstracts and white papers, and with specific readings based on the evolving research interests of the students. The first several readings are determined, and after that the students will engage in the selection of further readings. The general topics to be covered by the weekly readings are listed here, along with one trip to ASU (schedule TBD) and absences due to professional conferences and committees.

Th 1/16 Class introduction

Tu 1/21 Advancing science of the Moon (LEAG report 2018)

Th 1/23 Impact formation of the Moon (Asphaug 2014)

Tu 1/28 Delivery and removal of lunar water by the late veneer (Brasser et al. 2011)

Th 1/30 Delivery and removal of lunar water by comets and asteroids (Ong et al. 2011)

Tu 2/4 Water in lunar samples

Th 2/6 Water in lunar meteorites

Tu 2/11 Water and lunar volcanism

Th 2/13 Class visit to ASU/LROC (day trip either 2/12 or 2/13)

Tu 2/18 Permanently shadowed regions: physics

Th 2/20 Permanently shadowed regions: migration and archival of volatiles

Tu 2/25 Lunar polar and lava tube exploration

Th 2/27 Lunar volatiles and ISRU (in situ resource utilization)

Tu 3/3 Students present their first 45 minute lecture

Th 3/5 Pre-LPSC abstracts discussion

Tu 3/10 No class – Spring Break
Th 3/12 No class – Spring Break
Tu 3/17 No class – Lunar and Planetary Science Conference
Th 3/19 No class – Lunar and Planetary Science Conference
Tu 3/24 Post-LPSC conference review
Th 3/26 Students present their 15 minute talk
Tu 3/31 No class – CAPS meeting in DC
Th 4/2 No class – CAPS meeting in DC
Tu 4/7 Decadal Survey white paper review
Th 4/9 Decadal Survey white paper review
Tu 4/14 Ideas for a volatile-rich early Moon
Th 4/16 Lunar sample return missions: strategies
Tu 4/21 Lunar sampling return missions: sampling sites
Th 4/23 No class – Apophis conference in Nice
Tu 4/28 No class – Apophis conference in Nice
Th 4/30 Students present their second 45 minute lecture
Tu 5/5 Rethinking lunar origins; research manuscripts are due