

# **Geology 315 Syllabus (Fall, 2019): MINERALS AND EARTH SYSTEMS**

## **From the Core to the Surface: An Earth System Approach**

### **Overview**

Minerals are the fundamental building blocks of the solid Earth. Knowing when, where, and why they form is critical for understanding all aspects of geology. Minerals also influence many aspects of our lives: they make up the soil in which our food grows; they provide raw materials that we use for manufacturing (automobiles, paper, paint, pharmaceuticals, etc.); they help us remediate hazardous waste problems; biological systems produce minerals: they make up not just the carbonate shells we find as fossils, but many other structures including teeth, kidney stones, magnetite grains for orientation, etc. Minerals record clues that reveal information about formation and evolution of the Earth, and mineral structures are used in applications including more efficient solar cells (perovskite).

### **Course Description**

The course will begin with an overview of Earth Systems, followed by subjects that make up traditional mineralogy: mineral properties, discussions of the atom, chemical bonding, crystal structures, and instrumental techniques for mineral analysis. Subsequently, we will use an Earth Systems approach to explore the mineral phases of the core and deep mantle, working upward to Earth's surface. Discussions will include important phase changes, including core melting, the nature of the core-mantle boundary, and mineralogy of the upper mantle. Crustal mineralogy follows, including minerals produced during high temperature magmatic and metamorphic processes, those forming under moderate temperatures in hydrothermal settings, and those forming in low temperature surface environments including clays, carbonates and evaporites. Aspects of economic geology and instrumental analysis will be considered. The final topics focus on biogeochemical interactions, including biogenic minerals, life in extreme environments, and health hazards related to minerals and mining.

### **Learning Objectives**

Ability to recognize major rock-forming minerals and some common rocks  
Understanding the architecture of mineral structure and the underlying chemistry  
Understanding the geological environments that have led to formation of important minerals  
Appreciation of the uses of economically important minerals and reasons for their value

**Professors:** Emily Cooperdock, Email: cooperdo@usc.edu  
Room: ZHS 317; Phone 213-  
Office hours: By appointment (also open door)

Doug Hammond, Email: dhammond@usc.edu  
Room: ZHS 325E; Phone 213-740-5837  
Office hours: By appointment (also open door)

**Teaching Assistant:** Abigail Wesley, Email: awesley@usc.edu  
Room: ZHS 309  
Office hours: TBA

**Lecture:** TTh 11-12:20, ZHS 118

**Lab (Required time):** MF 12-1:50, ZHS B65

**Lab (TBA - independent):** About two additional hours

**Textbook:** After consulting with previous students, we decided to not require a text, as many students told us they did not use it. However, we still find a book quite helpful in providing an overview and a source for particular topics, so we recommend three books. You might wish to order one of these:

*Mineral Science*, by Cornelis Klein and Barbara Dutrow, 23rd ed. (but earlier editions are also good), Wiley, 2002. We have used this book in the past. It is the descendent of the classic *Dana's Manual of Mineralogy* and is rich in descriptive discussions of minerals, including extensive lists of minerals and their properties. This covers many details we will not have time to discuss.

*Earth Materials*, by Cornelis Klein and Anthony Philpotts, Cambridge Press, 2013. We have also used this previously. It has a good overview of geology, mineralogy and petrology, and lots of color pictures. This covers most (but not all) of the topics we will discuss. A 2nd edition is now out, but reading noted below is for 1st edition.

*Minerals: Their constitution and origin*, by H.R. Wenk and A. Bulakh, Cambridge Press, 2004. We like this book very much, as it is a bit more in-depth than the titles above. Illustrations are half-tone, but lots of good graphs and schematics. Less geology overview, but much more chemistry. We will not cover material quite as fully as this book presents it, but this will be an excellent future reference. A 2nd edition has been published in 2016.

**Hand Lens and Field Book:** You are strongly encouraged to buy a hand lens and field notebook.

**Field trips:** Fieldtrips are great for honing mineral ID skills, and are just plain fun. Attendance is required, so please inform others affected by this (coaches, profs in other classes, etc.) early in the semester about these trips. The first trip is to an area near the San Gabriel Mts, just north of LA. This trip will be very helpful for developing an appreciation for looking at geology in the field, rather than in ideal settings used in most pictures. This will occur early in the semester, **Sunday, Sept. 8**. Our big field trip, **an overnight weekend trip to the Mojave Desert (Oct. 25-27)**, is an excellent opportunity to look at minerals in diverse and beautiful settings! You will need to bring personal gear for camping.

#### **POLICIES & GUIDELINES:**

**Attendance:** is ESSENTIAL. Reading in the recommended texts or on line will augment, but not replace, class meetings and exercises—a missed class meeting is hard to make up. Please prearrange excused absences or let me know before class (via email) if you are going to be out with an illness. The same applies for exams. They cannot be made up if absence is not excused.

**Academic Honesty:** You are expected to observe the rules of academic conduct outlined in the Student Handbook. I encourage you to work together on labs and assignments; however, always turn in your own work (describe results in your own words). This helps you better learn the material and helps us see your individual progress.

**Quizzes:** There will be a 5-10 minute quiz at the beginning of each Thursday lecture, beginning Sept 5. Questions will emphasize material from the previous two lectures, but some may repeat earlier material not mastered. Make-ups will be given only in extraordinary circumstances. (the lowest two quizzes will be dropped, so a brief illness should not affect your final grade). **In lab, there will be a 5-10 minute quiz at the beginning of each Monday lab.**

**Grading:** Lab: 40%; Lecture: 60% (Weekly Quizzes: 18% -**Every Thursday:** lowest 2 will be dropped; Midterm: 18%, Final: 18%, Presentation: 6%)

## **Guidelines for Presentation**

Topic: Get it approved before **September 17!** You should choose a topic closely tied to mineralogy.

Products: 1) Prepare an 8 minute presentation (powerpoint or other demonstration) that you will give in class, accompanied by an abstract to be handed out. The abstract must include references, and must use at least 2 non-web based sources, in addition to any web-based resources used. The topic can be about anything related to minerals and mineralogy. Become an expert in something you really want to learn about! Past topics have included mineral characterizations for samples found on the first field trip, applications of mineralogy, unusual minerals, environmental issues, mining geology, or original research. New discoveries are made weekly, and these are excellent topics.

Presentation date: We will offer dates throughout the semester. Sign up when you submit your topic. You must submit a progress report a week in advance with a list of the slides you plan to include. Then turn in a digital copy of your project to us at least 2 days prior to your presentation. This will be reviewed and returned with recommendations for improvement.

References: **The source of text, figures, and pictures that you use, should be acknowledged, including the full address of any website.** This could be done at the end of your project, or turn in a separate sheet with your project for references (as convenient or appropriate). A brief citation should be on the slide, such as Smith et al. (2014).

Grading: The project and/or presentation will be judged on quality and quantity of research done, quality of presentation, adherence to time limit, and ability to answer questions after the presentation.

**Academic Accommodations:** Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me as early in the semester as possible. DSP can be reached at [ability@usc.edu](mailto:ability@usc.edu) and is open 8:30am-5:00pm Monday through Friday. The phone number for DSP is 213-740-0776.

**Lecture Schedule (reading: Philpotts & Klein (1st ed), if you use this book; bold dates are quizzes)**

Aug 27	1. Introduction: Minerals and Mineral Properties I (Ch. 2.1-2.7, 3.1, 3.2, 3.4-3.7)	dh
Aug 29	2. Earth Systems and Formation of Rocks, and Minerals (Ch.1,2.8)	dh
Sept 3	3. Atoms, Valence, Periodic Table, Ionic Radius (Ch. 4)	dh
<b>Sept 5</b>	4. Bonding, Crystal Structures, Silicate Structures, and Crystal Habits (Ch. 5)	dh
Sept. 8:	<b>Half day trip to San Gabriel Mts.</b>	
Sept 10	5. Mineral Properties II: Color, Magnetism, Radioactivity (Ch. 3.3)	dh
<b>Sept 12</b>	6. Crystal Symmetry and Point Groups (Ch. 5),	dh
Sept 17	7. Crystal axes, Systems and Forms ( <b>presentation topic approval due</b> )	<b>dh</b>
<b>Sept 19</b>	8. Crystallography Wrap-up	dh
Sept 24	9. Optical Mineralogy I (Ch. 6)	ec
<b>Sept 26</b>	10. Optical Mineralogy II (Ch. 6)	ec
Oct 1	11. Phase Diagrams (Ch. 8.3-8.4)	dh
<b>Oct 3</b>	12. Phase Diagrams continued; Fluid Inclusions	<b>dh</b>
Oct. 8	13. X-rays and X-ray Diffraction (Ch. 3.8)	ec
<b>Oct 10</b>	14. Mineral Analyses – Photons, Xrays & Electrons (XRF, SEM, TEM, STEM, Raman) (Ch.3.8)	ec
Oct 15	<b>Midterm Exam</b>	
Oct 17	<b>Fall Recess</b>	
Oct 22	15. Earth Structure&Differentiation, Use of Seismic Waves, Core of Earth (Ch. 1)	dh
<b>Oct 24</b>	16. Deep Mantle: Bridgemanite, Olivine, Pyroxene; Transition Zone & D'' layer (Ch. 8)	dh
<b>Field trip Oct 25-27 Viewing minerals in their habitat</b>		
Oct 29	17. Upper Mantle: Melts, Bowen's Rx Series & Igneous Rocks (Ch. 7,8,9)	ec
<b>Oct 31</b>	18. Diamonds & Crustal Silicates 1: Feldspars, Feldspathoids, Amphiboles	ec
Nov 5	19. Crustal Silicates 2: Metamorphism, Garnet, Phyllosilicates (Ch. 13,14)	ec
<b>Nov 7</b>	20. Crustal Silicates 3: Si Polymorphs and Wrap-up	ec
Nov 12	21. Weathering, Clays and Zeolites: Engineering to Kitty Litter	dh
<b>Nov 14</b>	22. Sedimentary Systems: Solution Chemistry-Evaporites, Carbonates, Authigenic Silica (Ch. 10,15)	dh
Nov 19	23. Hydrothermal Systems, Gold, Ore Deposits – Native Elem, Sulfides, Sulfates (Ch. 15)	ec
<b>Nov 21</b>	24. Economic Minerals including Ore Deposits, Oxides and Hydroxides (Ch. 15, 16)	ec
Nov 26	25. Mining: Economics, and Hazards (Ch 11, 16)	ec
Nov 28	<b>Thanksgiving</b>	
Dec 3	26. Extreme Life, Minerals, and Mineral Health Issues (Ch. 17)	ec
<b>Dec 5</b>	Evals, Recap, Minerals as Archives	ec
<b>Dec 17 Final Exam, 8-10am (Tuesday)</b>		

## Geology 315: MINERALS AND EARTH SYSTEMS

### Lab Syllabus, Fall 2019

Teaching assistant: Abigail Wesley

Office: ZHS 309

Email: awesley@usc.edu

**OFFICE HOURS: 4-5pm Wednesdays in ZHS 309 or by appointment**

	<u>% of lab grade</u>
Weekly quizzes (3 pts each)	27% (best 9 count)
Lab assignments (2.5 pts each)	50% (best 20 count, exclude #1)
Mineral ID practical	23%

***Remember: lab is 40% of the total for the course***

*I will be keeping updated records of lab grades, and students may request to see their numerical grade in person at any time. University policy forbids me from sending grades via e-mail due to security issues.*

#### **LAB HOURS: MF, 12-1:50 pm in ZHS B65 (basement, NE corner)**

Expect to spend at least 2 additional hours beyond lab time working on exercises! You are responsible for finding available times to work in B65 when no other class is present – a class schedule is posted in the back of the lab room.

#### Labs, Late Policy

You will have a total of 21 graded laboratory exercises – 13 are topical exercises and 8 are hands-on mineral properties exercises. You will be assigned a new exercise each lab period and are expected to complete each exercise in full within one week from assignment (for example, if lab is assigned on Monday, it must be finished by the following Monday before the start of the next lab). Many of the labs will require more time than the lab period to complete them, and you are responsible for arranging any additional time necessary in the lab room. For lab exercises, you are allowed to work together with your classmates, but must submit individual work and individual labs or risk penalty according to University integrity guidelines. Each will be worth 2.5%, and we will drop the lowest score. The first exercise is not graded but must be submitted.

At the due date/time, I will post an answer key inside the lab room. You will be responsible for grading your lab exercises (in a different colour pen) and submitting your graded lab to me by the beginning of the next period. For example, Lab 2 is assigned on Aug. 30, is due on Sept 6, and must be graded and turned in by Sept 9. Graded labs must be turned in at the beginning of the lab period; **any late submissions will be penalized by subtracting 20% of the total possible points each day.**

#### Weekly Quizzes

Rather than overload you with midterms, we will have **short quizzes each Monday** at the beginning of the lab (10 total). These quizzes will test you on the material from the previous weeks – the 3 lab exercises prior to the quiz. You can expect the format of these to generally be a few questions including multiple-choice, short-answer, sketching, etc. No material explicitly from the lecture will be included (although lecture and lab will have overlap in topics). Each quiz will be worth 3% of your lab grade; quizzes missed cannot be made-up except with valid excuse. **We will drop the lowest quiz score at the end of the semester.**

#### Mineral Identification Practical

Throughout the semester, 8 of your 20 labs (referred to as “Mineral Labs”) will be focused on mineral identification of different groups of minerals. These will culminate in a mineral ID practical exam at the end of the semester in which you will have the full lab period to identify minerals and answer questions about their properties, groups, chemical formulae, and crystal structure. Of all the minerals we discuss this semester, you will only be expected to know the chemical formulae of **bold** minerals on the lab exercises.

#### Conflict and Make-up Quizzes/Practical

Available only if you have valid excuses. If you have a valid reason to request a make-up quiz, please see me a *minimum* of one class period before the scheduled quiz. Personal travel, work, interviews, exams or assignments in other courses, etc. are NOT acceptable excuses except under sanctioned circumstances. If you have a medical or family emergency immediately

before a quiz or the practical, please contact me as soon as possible. Any unexcused absence will result in a 0 on that quiz (but we will drop the lowest score).

#### Extra Credit, Lab Grades, and Other Concerns

There will be **no opportunities for extra credit** in any part of the class. Lab scores will be submitted to Profs. Cooperdock and Hammond at the end of the course for grade calculation, so I will not be able to give you accurate letter grade estimations at any point in the semester.

### **Tentative Lab Schedule**

Remember: Quizzes take place at the beginning of each Monday class, unless noted below.

Aug 26	M	Lab 1: Field Trip to Natural History Museum (not graded; no quiz)
Aug 30	F	Lab 2: Introduction to physical properties of minerals
Sept. 2	M	<b>Labor Day: NO LAB</b> (no quiz)
Sept. 6	F	Lab 3: Introduction to rocks ( <b>quiz 1</b> )
<b>Sept. 8</b>	<b>Su</b>	<b>Half day trip to San Gabriel Mts.</b>
Sept 9	M	Lab 4: Elements of crystal chemistry
Sept 13	F	Lab 5: Crystal coordination and structures
Sept 16	M	Lab 6: Symmetry in crystal models (I) ( <b>quiz 2</b> )
Sept 20	F	Lab 7: Crystal forms, crystal systems, crystallographic axes... (II)
Sept 23	W	Lab 8: (Mineral Lab 1): Native elements, sulfides, sulfates ( <b>quiz 3</b> )
Sept 27	F	Lab 9: Intro to Microscopy and Optics (I)
Sept 30	M	Lab 10 (Mineral Lab 2): Oxides and hydroxides ( <b>quiz 4</b> )
Oct 4	F	Lab 11: Phase Diagrams
Oct 7	M	Lab 12: (Mineral Lab 3): Carbonates, halides, phosphates, borates ( <b>quiz 5</b> )
Oct 11	F	Lab 13: Fluid and Melt inclusions in minerals
Oct 14	M	<b>Review for Lecture Midterm (quiz 6)</b>
Oct 18	F	Lab 14: (Mineral Lab 4): Nesosilicates
Oct 21	M	Lab 15: (Mineral Lab 5): Soro-, cyclo-, single-, double-chain inosilicates ( <b>quiz 7</b> )
<b>Oct 25-27</b>	<b>F-Su</b>	<b>Field trip to Mojave</b>
Oct 28	M	Lab 16: (Mineral Lab 6): Phyllosilicates
Nov 1	F	Lab 17: Optics (II); Mojave Thin Sections
Nov 4	M	Lab 18: (Mineral Lab 7): Tectosilicates ( <b>quiz 8</b> )
Nov 8	F	Lab 20: Analytical Mineralogy I: XRD & Raman
Nov 11	M	Lab 21: The mining process ( <b>quiz 9</b> )
Nov 15	F	Lab 22: Analytical Mineralogy II? Raman?

Nov 18	M	Lab 23: From Mineralogy to Petrology (not graded; <b>quiz 10</b> )
Nov 22	F	Study period for mineral ID practical
Nov 25	M	<i>Mineral ID Practical</i>
Nov 29	F	<b>NO LAB - Thanksgiving</b>

The lab component of this course is completed with the Mineral ID practical. No further labs are scheduled beyond this.

This syllabus and the order of labs are subject to revision. Updated 05/06/19

### **Due dates for Lab! (may need revision)**

Aug 26	M	Meet, but No Lab to turn in!
Aug 30	F	Meet, but No Lab to turn in!
Sept 2	M	Hand in Lab 1 (not graded)
Sept 6	F	Will post answer key to Lab 2
Sept 9	M	<b>Labor Day: NO LAB</b> (no quiz); Will post answer key for Lab 3
Sept 13	F	Submit graded Lab 2&3; Will post answer key for Lab 4
Sept 16	M	Will post answer key for Lab 4
Sept 20	F	Submit graded Lab 4; will post answer key for Lab 5
Sept 23	M	Submit graded Lab 5; will post answer key for Lab 6
Sept 27	F	Submit graded Lab 6; will post answer key for Lab 7
Sept 30	M	Submit graded Lab 7; will post answer key for Lab 8
Oct 4	F	Submit graded Lab 8; will post answer key for Lab 9
Oct 7	M	Submit graded Lab 9; will post answer key for Lab 10
Oct 11	F	Submit graded Lab 10; will post answer key for Lab 11
Oct 14	M	Submit graded Lab 11, will post answer key for Lab 12
Oct 18	F	Submit graded Lab 12; will post answer key for Lab 13 <b>(Review for Lecture Midterm)</b>
Oct 21	M	Submit graded Lab 13; will post answer key for Lab 14
Oct 25	F	Submit graded Lab 14;
Oct 28	M	Will post answer key to Lab 15
Nov 1	F	Submit graded Lab 15; Will post answer key to Lab 16
Nov 4	M	Submit graded Lab 16; Will post answer key to Lab 17

Nov 8	F	Submit graded Lab 17; will post answer key for Lab 18
Nov 11	M	Submit graded Lab 18; will post answer key for Lab 19
Nov 15	F	Submit graded Lab 19; will post answer key for Lab 20
Nov 18	M	Submit graded Lab 20; will post answer key for Lab 21
Nov 22	F	Submit graded Lab 21; will post answer key for Lab 22 <b>(Study period for mineral ID practical)</b>
Nov 25	M	Submit graded Lab 22; <i>Mineral ID Practical</i>
Nov 29	F	<b>NO LAB - Thanksgiving</b>