

Geology 315 Syllabus (Fall, 2018): 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 conditions for 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 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 of the architecture of mineral structure and the underlying chemistry
Understanding the geological environment that has led to formation of important minerals
Appreciation of the uses of economically important minerals and reasons for their value

Professor: Doug Hammond
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Office hours: By appointment (also open door)

Teaching Assistant: Abigail Wesley
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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, I decided to not require a text, as many of them told me they did not use it. However, I still find a book quite helpful in providing an overview and a source for particular topics, so I 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. I 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. I 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, Aug. 26**. Our big field trip, **an overnight weekend trip to the Mojave Desert (Oct. 19-21)**, 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 Aug. 30. Questions will emphasize material from the previous two lectures, but some may repeat material not mastered. Make-ups will be given only in extraordinary circumstances. (the lowest two 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 15!** 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 3 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 trip, applications of mineralogy, unusual minerals, environmental issues, mining geology, or original research.

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 me 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 and is open 8:30am-5:00pm Monday through Friday. The phone number for DSP is 213-740-0776.

Lecture Schedule (reading from 1st ed. of Philpotts and Klein, if you chose this book; bold dates are quizzes)

Aug 21 1. Introduction: Minerals and Mineral Properties I (Ch. 2.1-2.7, 3.1, 3.2, 3.4-3.7)

Aug 23 2. Earth Systems and Formation of Rocks, and Minerals (Ch.1,2.8)

Aug. 26: Half day trip to San Gabriel Mts.

Aug. 28 3. Atoms, Valence, Periodic Table, Ionic Radius (Ch. 4)

Aug. 30 4. Bonding, Crystal Structures, Silicate Structures, and Crystal Habits (Ch. 5)

Sept 4 5. Mineral Properties II: Color, Magnetism, Radioactivity (Ch. 3.3)

Sept 6 6. Crystal Symmetry and Point Groups (Ch. 5),

Sept 11 7. Crystal axes, Systems and Forms (**presentation topic approval due**)

Sept 13 8. Crystallography Wrap-up

- Sept 18 9. Optical Mineralogy I (Ch. 6)
Sept 20 10. Optical Mineralogy II (Ch. 6)
- Sept 25 11. Phase Diagrams (Ch. 8.3-8.4)
Sept. 27 12. Phase Diagrams continued.
- Oct. 2 13. X-rays and X-ray Diffraction (Ch. 3.8)
Oct. 4 14. Methods of Mineral Analyses – Xrays and Electrons (XRF, SEM, TEM, STEM); Raman Spectroscopy (Ch.3.8)
- Oct. 9 Review
 Oct. 11 **Midterm Exam**
- Oct. 16 15. Earth Structure&Differentiation, Use of Seismic Waves, Core of Earth (Ch. 1)
Oct. 18 16. Deep Mantle: Bridgemanite, Olivine, Pyroxene; Transition Zone & D'' layer (Ch. 8)
- Oct 23 17. Upper Mantle: Melting, Asthenosphere, Bowen's Rx Series & Igneous Rocks (Ch. 7,8,9)
Oct 25 18. Diamonds & Crustal Silicates 1: Feldspars, Feldspathoids, Amphiboles
Field trip Oct 19-21 Viewing minerals in their habitat
- Oct. 30 19. Crustal Silicates 2: Metamorphism, Garnet, Phyllosilicates (Ch. 13,14)
Nov. 1 20. Crustal Silicates 3: Si Polymorphs and Wrap-up
- Nov. 6 21. Weathering, Clays and Zeolites: Engineering to Kitty Litter
Nov. 8 22. Sedimentary Systems: Solution Chemistry-Evaporites, Carbonates, Authigenic Silica (Ch. 10,15)
- Nov. 13 23. Hydrothermal Systems, Gold, Ore Deposits – Native Elem, Sulfides, Sulfates (Ch. 15)
Nov. 15 24. Economic Minerals including Ore Deposits, Oxides and Hydroxides (Ch. 15, 16)
- Nov 20 25. Mining, Economics, and Hazards (Ch 11, 16)
 Nov 22 **Thanksgiving**
- Nov. 27 26. Extreme Life, Minerals, and Mineral Health Issues (Ch. 17)
Nov. 29 Evals and Recap.
- Dec. 11 Final Exam, 8-10am**