Petrologic Systems - 316L
Spring, 2020

Instructors:
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Time and Place
Lecture: Tuesdays, Thursdays 1:00PM – 2:20PM at ZHS118
Lab: Th, 2:30PM – 4:20PM, ZHS B65

Textbook:
Principles of Igneous and Metamorphic Petrology (2nd edition) John Winter. Prentice Hall, 2009.

Exams:
Exam 1 (Igneous midterm) – March 5, 2.30-4:20 pm
Exam 2 (Metamorphic midterm) – Thursday April 30, 2.30-4:20 pm

Field Trips:
Igneous Rocks: Feb. 21-23, Peninsular Ranges Batholith, we will leave at 9 am.
Metamorphic Rocks: April 9-12, Santa Catalina Island.

Basis of Grade:

Lecture midterms: (total 50%):	
Igneous Midterm	25 %
Metamorphic Midterm	25 %
Lab (total 50%):	
Lab assignments	30%
Field trip projects (total 20%):	
Igneous paper on arcs,	10%
Metamorphic paper on Catalina	10%

Schedule of Lectures

Jan. 14: Class Intro (Reading: Chapter 1)
Go over course and syllabus.
Differentiation of solar system+earth, crustal growth, heat sources, and plate tectonics

Igneous Petrology Module

Jan. 16: Magmatism and tectonics, (Readings: Chapters 1, 13-20)
Sources and styles of magmatism at different plate boundaries
Sources and styles of magmatism at intraplate settings

Jan. 21: Transcrustal magmatic-volcanic systems (Reading: Chapters 4, 16, 17)

Jan. 23: Introduction to igneous rocks (Reading: Chapters 2, 3, 18)
Review of common rock types and rocks as assemblages of minerals.
Modal and chemical compositions of rocks, common types of variation diagram.

Jan. 28-30: Properties and classifications of igneous rocks, (Readings: Chapter 2, 3, Appendix B)
Information about magmatic processes preserved by textures: Textural based classifications
Quartzofeldspathic, mafic, ultramafic rock classifications

Feb 4: Mantle melts (Readings: Chapter 10)

Feb. 6, 11, 13: Forming compositional diversity in magmas, (Readings: Chapters 4, 5, 6, 7, 11)
Crustal melting, fractional crystallization, magma mixing, assimilation, liquid immiscibility
Phase diagrams.
Case study: Forming compositionally defined magma structures.

Feb. 18: Volcanoes and eruptive processes (Readings: Chapters 4, 6, 7)

Feb. 20: Major, minor, trace and REE elements (Readings: Chapter 8)
Compatible versus incompatible elements
Mass balance equations
Case study 1: Tectonics and use of element ratios
Case study 2: Mineral chemistry and uses.

Feb 21-23: Field trip to Peninsular Ranges Batholith. Leave 9 am Friday.

Feb 25: Stable and radiogenic isotopic behavior (Readings: Chapter 9)
Case study: Temporal evolution of arcs.

Feb 27: Oceanic and Continental magmatism; (Readings: Chapter 12, 13, 14, 15, 16, 17, 18, 19, 20)

March 3-5: Catch-up lectures and review for midterm.

March 5, 2:30-4:20 pm. Igneous Petrology exam.

Metamorphic Petrology Module.

Introduction to metamorphic petrology Tuesday March 10
Metamorphism and the concept of metamorphic facies
Controls on metamorphic mineral assemblages by facies and rock composition
An outline of the principle metamorphic facies
Geologic settings of metamorphism and metamorphic facies sequences
Phase changes and metamorphic reactions

Reading: Ch 21, p. 446-458; Ch 22; Ch 25, p. 537-542

Thermodynamic concepts in metamorphic petrology Thursday March 12
Definitions of phase equilibria and thermodynamic variables
Examples of unstable, metastable, and stable conditions
The phase rule and its applications
Reading: Ch 24, p. 518-522 (see also p. 95-98)

Spring Break March 15-22

Progressive metamorphism in pelites Tuesday March 24
The onset of greenschist facies metamorphism
The chlorite isograd
Breakdown of pyrophyllite
The biotite isograd
The garnet isograd
AKF and AFM composition diagrams
Reading: Ch 24, p.522-535; Ch 28, p. 607-614

Progressive metamorphism in pelites continued Thursday March 26
The staurolite isograd and the onset of amphibolite facies metamorphism
The kyanite isograd and the breakdown of staurolite
Breakdown of muscovite and biotite
The first and second sillimanite isograds
Reading: Ch 28, sections 28.2.4, and 28.2.6 through 8.

Progressive metamorphism in metamafic rocks Tuesday March 31
The greenschist - amphibolite transition in metamafic rocks
Comparison of assemblages among different rock types at different grades
ACF composition diagrams
Reading: Ch 25, p. 542-6

Melting, migmatites and granulites Thursday April 2
Fluid-absent and fluid-present melting
Crustal melting and the generation of migmatites
Granulite facies assemblages in metapelitic rocks
Granulite facies assemblages in metamafic rocks
Fluid composition during granulite facies metamorphism
Distribution of granulite facies rocks in space and time.
Reading: Ch 28, sections 28.4 and 28.5

Subduction zone metamorphism Tuesday April 7
Thermal conditions in subduction zone environments
Very low-grade metamorphism in subduction zone environments
Blueschist-facies metamorphism
Eclogite-facies metamorphism

Ultra-high pressure metamorphism
Reading: Ch 25, sections 25.3.4

Contact metamorphism; metamorphism of carbonates Thursday April 9
Contact aureoles around plutons
Model of conductive heat transfer
Metamorphic grades / facies during contact metamorphism
Metamorphic reactions in carbonate rocks
T-X diagrams
Critical reactions in quartz-calcite-dolomite assemblages
Reading: Ch 6, section 26.4; Ch 29, p. 635-641; Ch 21, sections 21.3.1 and 21.6.5

Field trip to Santa Catalina Island, April 9-12
The field trip will provide an introduction to metamorphic facies in a subduction zone environment; controls on metamorphic mineral assemblages by facies and rock composition; the effect of fluid flow and deformation on metasomatism, metamorphic reaction rates, and grain growth, and styles of ductile deformation in metamorphic environments. Students will be expected to write a full report on the field trip and the accompanying lab project.

Metamorphic processes and textures Tuesday April 14
Controls on metamorphism
Neomineralization, metasomatism, and grain-growth
Metamorphic textures
Deformational processes during metamorphism
Effect of fluids on metamorphic reactions, rates, and textures

Thermobarometry Thursday April 16
Motivation for geothermobarometry
Review of thermodynamic principles
  Distribution coefficient
  Clausius-Clapeyron equation
Geothermometry
  Exchange reactions
  Solvus thermometry
Geobarometry
Net transfer reactions
Gibbs method
Reading: Ch 27, p. 579-595.

Application of thermobarometry to a tectonic problem: the Snake Range metamorphic core complex, Nevada. Tuesday April 21

P-T paths during metamorphism Thursday April 23
The Franciscan Complex
The Alps
The Himalayas

The Betic Cordillera
Exhumation of high-pressure metamorphic rocks

Review Session	Tuesday April 28
Metamorphic petrology mid-term:	Thursday April 30, or by arrangement.

Student Support Services:

Disability Services and Programs (DSP): Students requesting academic accommodations based on a disability are required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP when adequate documentation is filed. Please be sure the letter is delivered to me as early in the semester as possible. All DSP students are expected to remind me in advance regarding special arrangements needed for midterm exams. DSP is open Monday-Friday, 8:30-5:00. The office is in 3601 Watt Way, Grace Ford Salvatori Hall, 120, the phone number is (213) 740-0776, and email is ability@usc.edu.

Academic Conduct: Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

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Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. engemannshc.usc.edu/counseling

National Suicide Prevention Lifeline – 1 (800) 273-8255: Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. www.suicidepreventionlifeline.org

Relationship and Sexual Violence Prevention Services (RSVP) – (213) 740-4900 – 24/7 on call. Free and confidential therapy services, workshops, and training for situations related to gender-based harm. engemannshc.usc.edu/rsvp

Sexual Assault Resource Center: For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: sarc.usc.edu

Office of Equity and Diversity (OED)/Title IX Compliance – (213) 740-5086: Works with faculty, staff, visitors, applicants, and students around issues of protected class. equity.usc.edu

*Bias Assessment Response and Support:*Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. studentaffairs.usc.edu/bias-assessment-response-support

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Student Support and Advocacy – (213) 821-4710: Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. studentaffairs.usc.edu/ssa

Diversity at USC: Information on events, programs and training, the Diversity Task Force (including representatives for each school), chronology, participation, and various resources for students. diversity.usc.edu

USC Emergency Information: Provides safety and other updates, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible. emergency.usc.edu

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