LSC Use Only:
Number: ________
Submission Date: ________
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UWUCC Use Only:
Number: 00-38 c
Submission Date: ________
Action Date: UWUCC App 12/19/00
Senate App 1/30/01

CURRICULUM PROPOSAL COVER SHEET

University-Wide Undergraduate Curriculum Committee

I. CONTACT

Contact Person Keith Putirka Phone x5627
Department Geoscience

II. PROPOSAL TYPE (Check All Appropriate Lines)

X COURSE Ig and Met Petrol
Suggested 20 character title

____ New Course* ________
Course Number and Full Title

X Course Revision GEOS 320 , Igneous and Metamorphic Petrology
Course Number and Full Title

____ Liberal Studies Approval
for new or existing course ________
Course Number and Full Title

____ Course Deletion ________
Course Number and Full Title

Rev.

X Number and/or Title
Change GEOS 322 , Igneous and Metamorphic Petrology
Old Number and/or Full Old Title
GEOS 320 , Igneous and Metamorphic Petrology
New Number and/or Full New Title

____ Course or Catalog Description Change ________
Course Number and Full Title

____ PROGRAM: ____ Major ____ Minor _Track

____ New Program* ________
Program Name

____ Program Revision ________
Program Name

____ Program Deletion* ________
Program Name

____ Title Change ________
Old Program Name

____
New Program Name

III. Approvals (signatures and date)

Darlene Richardson
Department Curriculum Committee

Darlene Richardson
Department Chair

[signature]
College Curriculum Committee

[signature]
College Dean

____
Director of Liberal Studies (where applicable)

____
*Provost (where applicable)

Part II

1. Description of the Curriculum Change

A. Catalog Description

GEOS 320: Igneous and Metamorphic Petrology

2 lecture hours
3 lab hours
3 credits
(2c-3l-3sh)

Prerequisites: GEOS 220 and 131, or permission of instructor

An introduction to the origin and evolution of igneous and metamorphic rocks based upon a plate tectonic framework. Topics include the evolution of Earth, the Moon, Mars, and other terrestrial planetary objects. Planetary evolution will be examined through analysis of phase equilibria, and the physics of magma transport. Laboratory topics emphasize quantitative methods in petrology, and the identification and interpretation of rocks and rock textures in hand specimen and thin section. Includes field trips, which may occur on weekends.

B. Course Objectives
Students will be able to:

1. Relate the origin and evolution of the major igneous and metamorphic rock types to various plate tectonic environments.

2a. Use isotopic ratios, trace elements and heat flow data to develop models that explain the evolution of Earth's crust, mantle and core.
2b. Use spreadsheets to construct geochemical and petrologic models.

3. Deduce differences in evolutionary paths between Earth and other terrestrial planetary objects (which will include Venus, Mars, the Moon and the putative Eucrite parent body).

4. Apply elementary phase equilibria and thermodynamic principles to deduce petrologic history.

5. Identify rocks in hand specimen and thin section, and interpret mineral associations and textures to deduce igneous and metamorphic petrogenesis.

C. Course Outline

<u>I. Course Outline - Lecture</u>

1. **Introduction (1 hours)**
   Definitions
   Partition coefficients and magma genesis
   Models of Magma evolution

2. **Introduction to Quantitative Techniques in Igneous Petrology (3 hours)**
   Mass balance
   Equations for partial melting, equilibrium crystallization
   Equations for fractional melting, fractional crystallization
   Stable and radioactive isotopes, isotope mixing

3. **Phase equilibria (2 hours)**
   The equilibrium constant
   First and second laws of thermodynamics
   Phase diagrams (1-, 2- and 3-component systems; constant and variable P and/or T)

4. **Magma Genesis (2 hours)**
   Planetary heat sources (accretion, core formation, radioactive elements)
   The core formation problem; origin of the Moon
   Heat transfer and mantle convection
   Mantle adiabats and magma genesis

Exam (1 hour)

5. **Classification of Igneous Rocks (2 hours)**
   IUGS; CIPW norms
   Streckeisen's diagrams
   Geochemical approach (AFM, alkali-silica diagrams)
   Petrography

6. **The ocean basins (3 hours)**
   Mid-ocean ridges and MORB; transform fault effects
   Mantle plumes and ocean island basalts; Mars and Venus as extraterrestrial examples
   Ophiolites; structure of a MOR magma chamber
   Mantle xenoliths; composition of Earth's upper mantle
   Physics of magma transport form the mantle (Darcy's Law); magma transport on the Moon and Mars
   Mantle melting - phase diagrams

7. **Magma Chamber Processes (2 hour)**
   Fluid mechanics within magma chambers (Reynolds number)
   Nucleation and crystal growth
   Crystal settling (Stokes Law)
   Equilibrium and fractional crystallization - phase diagrams and liquid lines of descent
   Freezing point depression - quantitative aspects of phase diagrams
   Large layered igneous complexes; heat flow

8. **Subduction related volcanism (2 hours)**
   Magmatism and island arcs and continental margins
   Calc-alkaline and andesitic volcanism

Why Earth is distinct from other terrestrial planets, especially Venus, Mars and the Eucrite parent body

9. **Granitoids and the Evolution of Continental Crust (2 hours)**
   Classification; geochemical characteristics
   Physics of melt segregation
   Phase diagrams (feldspars; granite minimum)

Exam (1 hour)

10. **Overview of Magma Transport Phenomena (1 hours)**
    Porous flow
    Diapiric flow
    Fracture transport
    Clues from igneous thermobarometry
    Comparison of magma transport on Earth, Mars and the Moon

11. **Metamorphism (3 hours)**
    Types and conditions
    Mapping metamorphic rocks (metamorphic zones, isograds)
    Metamorphic rocks and plate tectonics
    Heat flow and contact metamorphism
    Metamorphism on other planetary objects

12. **Metamorphic Phase equilibria (3 hours)**
    Components; conditions required for equilibrium
    Mass transfer - diffusion (Fick's Law)
    Solid state thermodynamics; Gibbs-Duhem equation
    Metamorphic mineral facies; petrogenetic grids
    ACF, AKF diagrams

II. Course Outline - Laboratory

1. **Quantitative Labs (9 hours)**
   Developing crystallization and partial melting models
   Isotopic systems; mass balance calculations
   Sample experimental data set - calibrating igneous thermometers and barometers

2. **Hand Specimen and Thin Section Labs (27 hours)**
   Review Optical Mineral Properties
   Ultramafic Rocks
   Cumulate rocks, anorthosites
   Arc volcanics (andesites, dacites, and rhyolites)
   Granites and other intrusives
   Metamorphosed Sediments
   High-P metamorphic rocks

Contact metamorphic rocks

3. **Seminars -Student Presentations (6 hours)**
   Presentations of Individual Research Papers
   Presentations on focus topic

D. Evaluation Methods

The final grade for this course will be determined as follows:
20% Laboratory write-ups (includes seminar presentations, which count as one lab each)
20% Quizzes
40% Exams (Three exams total; two exams during the term, and a final exam, each equally weighted. Exams will cover both lecture and laboratory material)
20% Homework

Grading Scale: A = 90-100%; B = 80-89%; C = 70-79%; D = 60-69%; F = 0-59%.

E. Required Textbooks, Supplemental Books and Readings

Lecture Text:

Philpotts, A. R., 1990, Principles of igneous and metamorphic petrology: Prentice-Hall, Englewood Cliffs, NJ, 498 p.

Lab texts:

Philpotts, A. R., 1989, Petrography of igneous and metamorphic rocks: Prentice-Hall, Englewood Cliffs, NJ, 178 p.

Deer, W. A., Howie, R. A., and Zussman, J., 1997, The rock-forming minerals: Addison Wesley Longman Ltd., Essex, UK, 696p.

F. Special Resource Requirements

Mineral specimens and petrographic slides and microscopes are available in the Geoscience Department.

G. Bibliography

Anderson, G. M., 1996, Thermodynamics of natural systems: John Wiley and Sons, New York, NY, 382 p.

Cox, K. G., Bell, J. D., and Pankhurst, R. J., 1979, The interpretation of igneous rocks: Allen and Unwin Inc., Winchester, MA, 450 p.

Faure, G., 1986, Principles of isotope geology, 2nd ed.: John Wiley and

Sons, New York, NY, 589 p.

Hibbard, M. J., 1995, Petrography to petrogenesis: Prentice-Hall, Englewood Cliffs, NJ, 587 p.

Kerr, P. F., 1977, Optical mineralogy: McGraw-Hill, New York, NY, 492 p.

Klein, C., and Hurlbut Jr., C. S., 1999, Manual of mineralogy, 21st ed.: John Wiley and Sons, New York, NY, 681 p.

MacKenzie, W. S., Donaldson, C. H., and Guilford, C., 1980, Atlas of igneous rocks and their textures: John Wiley and Sons, New York, NY, 148 p.

Spear, F. S., 1993, Metamorphic phase equilibria and pressure-temperature-time paths: Mineralogical Society of America Monograph, Washington D. C., 799 p.

Yardley, B. W. D., MacKenzie, W. S., and Guilford, C., 1990, Atlas of metamorphic rocks and their textures: John Wiley and Sons, New York, NY, 120 p.

2. Summary of Proposed Revisions

A. Comparison of Catalog Descriptions

Current Catalog Description:

GEOS 322: Igneous and Metamorphic Petrology

2 lecture hours
3 lab hours
3 credits
(2c-3l-3sh)

Prerequisites: GEOS 321

Concerned with a description of igneous and metamorphic rock character based upon mineral components and physical relationship between mineral components of a rock. Includes field trips which may occur on weekends.

Proposed Catalog Description:

GEOS 320: Igneous and Metamorphic Petrology

2 lecture hours
3 lab hours
3 credits
(2c-3l-3sh)

Prerequisites: GEOS 220 and 131, or permission of instructor

An introduction to the origin and evolution of igneous and metamorphic rocks based upon a plate tectonic framework. Topics include the evolution of Earth, the Moon, Mars, and other terrestrial planetary objects. Planetary evolution will be examined through analysis of phase equilibria, and the physics of magma transport. Laboratory topics emphasize quantitative methods in petrology, and the identification and interpretation of rocks and rock textures in hand specimen and thin section. Includes field trips, which may occur on weekends.

B. Summary of revisions

The content of the course has been updated to meet the current needs of the Geoscience community. The course description has been revised to better reflect the nature and content of the course. The course number has been changed to better reflect course progression in the Geoscience program.

3. Justification for Revision:

The sciences of igneous and metamorphic petrology are rapidly changing. Our understanding of how igneous rocks can be used to understand the internal workings of planetary objects has advanced dramatically over the last several decades. Similarly, the techniques of metamorphic petrology have advanced considerably, with substantial progress toward understanding compositional and deformational history in the context of plate tectonics. GEOS 322, as originally designed, was largely descriptive in nature and lacked many of the quantitative elements and later advances in these fields. It is thus essential that this course be overhauled to reflect the modern study of these sciences.

The new syllabus emphasizes process over description, and is indeed more flexible than the prior syllabus. In each of the sections the topics are specific in regard to the quantitative and theoretical aspects of petrology. Topical aspects, though, are general enough for future adaptation, as our understanding of planetary evolution advances with continued research efforts.

A new twist to the existing course is the addition of several laboratory exercises that are specifically quantitative in nature, and the addition of two oral seminars. The seminars have been added because oral presentations are a common form of communication in the geosciences. In addition, a job in the geosciences may be won or lost depending upon the quality of an oral presentation during an interview. These seminars allow students to receive constructive criticism on presentation style. Moreover, seminar topics are literature-based and, hence, are a device for students to practice searching, reading and interpreting geologic journals. The addition of the quantitative labs is perhaps more urgently needed: While igneous and metamorphic petrology are fundamental to understanding planetary evolution, most students do not practice these sciences upon graduation. All students, though, need quantitative skills, regardless of their selected sub-discipline. The goal of these quantitative labs is not only to teach the principles of igneous and metamorphic petrology, but also to introduce students to the habit of looking for mathematical descriptions of nature, and to illustrate the role of mathematics as a tool for hypothesis testing. GEOS 320 is an ideal vehicle for teaching this material since many concepts in igneous and metamorphic petrology are mathematically straightforward, and can be grasped without advanced mathematics or geology. Finally, these changes are more appropriate for the listing of GEOS 320 as a dual level course (GEOS 320/520). With the addition of the seminars and quantitative labs, graduate students will have the opportunity to refine their quantitative modeling skills, and to perform focused research projects (or integrate ongoing research) into labs and seminars.

4. Old Syllabus of record

Attached

Part III - Letters of Support (in appendix)

Not applicable

Course Syllabus

Geoscience Department

Igneous and Metamorphic Petrology

Coure Title: Petrology
Course Number: GS 322
Credit Hours: 3 credits
Pre-requisite: General Geology I and Mineralogy or instructor approval.

A. Catalog Description: The various rock types composing the crust of the earth will be identified by origin, chemical and mineral composition and conditions of formation. Two hours lecture and one 3 hour lab per week.

B. Rationale: The classification of crustal rocks into igneous, sedimentary, and metamorphic is primarily based upon mineral composition and rock texture. The composition and texture are a reflection of the conditions of formation processes occurring within a limited chemical and physical environment. Although sedimentary rocks will be described as the most important precursor of metamorphic rocks, the emphasis in lecture and lab will be a descriptive terminology and the processes that model the origin of igneous and metamorphic rocks.

C. The lectures will be two one hour periods per week and the laboratory will be three hours per week. One extended field trip will be part of the course.

D. The text to be used is Igneous and Metamorphic Petrology by Myron Best published by W.H. Freeman and Company. Laboratory materials will be provided by the instructor.

E. Approximate time alloted to topics in lecture and laboratory.

Lecture:	Introduction, sources of information, and testing	2 hrs.
	Composition structure and properties of crust and earth structure models.	4 hrs.
	Pressure and temperature as controlling parameters in rock origins	3 hrs.
	Phase diagrams and plate tectonic processes used in modeling rock formation processes	4 hrs.
	Igneous rock processes, composition, textures and type locations	8 hrs.
	Metamorphic rock processes, compositions textures	5 hrs.
	Meteorites-moon rocks	1 hr.
Laboratory:	Normative Calculations, phase diagrams and triangular diagrams	5 labs
	Microscope techniques and mineral optics	2 labs
	Thin section preparations	1 lab
	Hand specimen rock identification and correlation with thin sections	7 labs
	Testing	1 lab

revised 11-20-87