Course Syllabus

Course Information
(course number, course title, term, any specific section title)

GEOS 3464 Mineralogy and Petrography

Professor Contact Information
(Professor's name, phone number, email, office location, office hours, other information)

Manton, W.; 972-883-2441; manton@utdallas.edu ; MW: 10a to 11a

Course Pre-requisites, Co-requisites, and/or Other Restrictions
(including required prior knowledge or skills)

Prerequisite: GEOS 2409 Rocks and Minerals
Corequisite: PHY 2326

Course Description Description of crystal morphology, symmetry, atomic structure and chemistry. Structure and classification of silicate minerals. Identification of minerals under the polarizing microscope. Crystallization of magma and classification of igneous rocks and their identification in thin section. Metamorphic reactions, facies and tectures. Examination of metamorphic rocks in thin section.

Student Learning Objectives/Outcomes

Understanding the relation between symmetry and crystal faces; optical properties of crystals; crystal identification under the polarizing microscope; interpretation of textures of igneous and metamorphic rocks

Required Textbooks and Materials

William D. Nesse. Introduction to Mineralogy. Oxford University Press 2000. ISBN 0-19-510691-1

Ron H. Vernon. A Practical Guide to Rock Microstructure. Cambridge University Press 2004. . ISBN 0-521-89133-7

Suggested Course Materials

Pencils, erasers and ruler

Assignments & Academic Calendar
(Topics, Reading Assignments, Due Dates, Exam Dates)

Basic Crystallography

Definition of space lattices, point, unit cell. The 14 Bravais lattices. Development of crystal systems from length and angular relationships of unit cells.

Indexing planes in the lattice. Miller indices of lattice planes. Crystal faces as planes in the lattice. Concept of symmetry.

Elements of symmetry. Centre. Mirror planes. One, two, three, and six fold rotation axes. Inversion of a face. One, two, three, four, and six fold rotation-inversion axes. Uniqueness and non-uniqueness of roto-inversion axes. The 32 crystal classes.

The stereographic projection. Projection of planes and lines. Representation of a plane by its pole.

Representation of symmetry of specific classes as stereographic projections, vi3 classes 1, 1, 2/m, mmm, 4/mmm, 6/mmm, 3m, 32, m3m, 43m, m3.

Crystal faces and crystal forms. Miller indices of individual faces. Principal forms as listed below.

Classes 1 and 1	- {hhl}
Class 2/m	- {001}, {010}, {001}, {110}, {111}
Class mmm	- {001}, {010}, {001}, {011}, {111}
Class 222	- {hkl}
Class 4/mmm	- {001}, {100}, {110}, {hko}, {111}, {hkl}
Class 6/mmm	- {0001}, {1010}, {1120}, {hkio}, {1011}, {1121}, {hkil}
Class 3m	- {0001}, {1010}, {1120}, {1011}, {0111}, {1121}
Class 32	- {hkil}
Class m3m	- {100}, {110}, {111}
Class 43m	- {111}, {111}
Class m3	- {100}, {h0l}, {0kl}

Above lead to discussion of 1st and 2nd order forms, positive and negative forms, and left and right handed forms.

Twinned crystals. Contact and penetration twins. Albite and pericline twinning.

Crystal Chemistry and Crystal Structure

Bonding

Coordination
Ionic radius
Solid solution

X-Ray Crystallography

X-ray generation
X-ray detection
Bragg's Law
Powder Method
Powder Diffraction file
Mixtures of minerals

Physical Properties of Minerals

Density
Magnetic properties
Mineral separation

Crystal Optics

Review of basic optics.

- Sinusoidal wave motion – definitions of wavelength, amplitude, period, and frequency.
- Light as an oscillating electric vector. Constancy of velocity in a vacuum.
- Units of wavelength – the Angstrom and nanometer. Wavelengths of visible spectrum.
- Concept of wave fronts and rays.
- Law of reflection of light. Definition of the normal to a surface.
- Law of refraction – Snell's law deduced from the glass block, pins, and board experiment. Nature of refractive index being a ration of velocities.
- Definition of absolute refractive index.
- Dispersion of refractive index.

Measurement of Refractive Index

- Apparent depth method
- Minimum deviation of a prism method
- Immersion oil method
- Relief of grain
- The Becke line

Behavior of Light in Crystals.

- Concept of isotropy and anisotropy
- Concept of polarization of a wave
- Anisotropy in crystals shown by the double refraction of calcite
- The apperant failure of Snell's law. The ordinary and the extraordinary rays.
- Path of extraordinary ray predicted by Poynting's vector.
- Snell's law redefined in terms of the wave normals. Proof that refractive index varies as inverse of wave velocity.
- Some ray paths in calcite by Huygens construction:

i) along c-axis
ii) normal to c-axis
iii) random

The Uniaxial Indicatrix

- Refractive index and polarization direction combined into a single vector leading to representation of unpolarised light as a circle and the polarized waves in a crystal as an ellipse. The circle and the ellipse shown to be sections through an ellipsoid of revolution. Proof that this ellipsoid and the extraordinary ray velocity surface are identical on shape.
- Definition of positive (prolate) and negative (oblate) indicatrices. Definitions of circular, principal and random sections.
- Birefringence and its dependence on orientation.

Origin of Interference Colors.

- Interference of waves. Conditions for reinforcement and annihilation.
- Interference of white light. Origin of color of soap film. Newton's rings.
- The design of the polarizing microscope. The polariser and the analyzer.
- Review of vector resolution. Resolution of plane polarized light into two waves of differing amplitude on entering crystal.
- Retardation. Proof retardation equals thickness times birefringence.
- Recombination by analyzer of light into two wave trains of equal emplitude polarized in the same plane but retarded with respect to one another.
- Production of light and dark bands by quartz wedge inserted into sodium light.
- Effect of retardation by mineral on white light. Equal retardation removes some wavelengths from spectrum, reinforces others. Result production of interference colors.
- Order of an interference color.

Examination of Uniaxial Minerals.

- Nicols uncrossed – pleochroism
- Nicols crossed – Extinction 4 times a revolution.
- Interference colors – Contours of equal retardation.
- Significance of minerals that remain dark on rotation of stage.
- Interference figures. Origin of isogyres and isochromes.
- The off-axis interference figure.
- Determination of sign – the gypsum plate.
- Orientation – length fast and length slow.

Examination of Biaxial Minerals.

- Biaxial indicatrix as a triaxial ellipsoid whose principal axes are parallel to the polarization directions of those three waves that travel with constant velocity in those planes and whose lengths are equal to the refractive indices of those same waves.
- Definitions of principal planes, circular sections optic axes, 2V, acute and obtuse bisectrices, optic plane.
- Definition of optic sign. The uniaxial indicatrix as a special case of the biaxial.
- Some polarsition directions and ray paths for different planes of incidence.
    i) light incident on a principal section

ii) on a plane containing a principal axis
iii) a random section
iv) a circular section. External conical refraction

The Biaxial Interference Figure.

- The Biot-Fresnel law. Use of law to deduce form of biaxial figure with optic plane east-west and in 45^{o} position. Origin of isochromes.
- Optic axis and optic normal figures.
- Effect of 2V on acute nisectrix figure.
- Estimation of 2V. From separation of isogyres. Effect of n_{β} 2V vs. 2E. Oil immersion objective. Wright's method.

Extinction Angles.

- Significance of straight extinction.
- Inclined extinction. Distinguishing aegirine and aegirine-angite.
- The extinction angles of the plagioclases.

How to Use Optical Descriptions in a Handbook.

- Review of terms: Color, Form, Cleavage, Relief, Birefringence, Extinction, Orientation, Interference Figure, Distinguishing Features, Related Minerals, Occurrence.

Review of principal rock forming minerals

- Crystal chemistry
- Crystal structure
- Exsolution, phase relationships where appropriate.

Review of petrogenesis

- Crystallization of magma
- Metamorphic reactions and metamorphic facies
- Dynamic metamorphism

Laboratory Exercises

- Assignment of crystal systems
- Extraction of symmetry elements
- Stereographic representations of lines and planes
- Deduction of forms from symmetry elements
- Ray paths in calcite
- Huygens construction
- Becke Line
- Fast and slow directions
- Finding interference figures

Minerals in Thin Section.

- Birefringence, cleavage habit.
- Properties in thin section of:
    + The potash felspars
    + The plagioclases
    + The olivines
    + The orthopyroxenes
    + The clinopyroxenes
    + The amphiboles
    +The spinels
    + The micas
    + Epidote, zoisite and clinozoisite
    + Andalusite, kyanite and sillimanite
    + Cordierite
    + Idocrase
    + Zircon
    + Allanite
    + Monazite
- Microstructures of igneous rocks
- Microstructures of metamorphic rocks
- Microstructures of deformed rocks

Examinations: There will be three examinations. One on crystallography; one on optics; one on petrology and petrography. The format will be essay type questions. No multiple choice, thus a wider grade scale.

Dates: Exam 1: Sept 19 Exam 2: Oct 24 Exam 3: Nov 26

Grading Policy
(including percentages for assignments, grade scale, etc.)

95-100 A+	**81-85 B+**	**66-70 C+**	**51-55 D+**
91-95 A	**76-80 B**	**61-65 C**	**46-50 D**
86-90 A-	**71-75 B-**	**56-60 C-**	**40-45 D-**

Laboratories will count 33% of final grade

Course & Instructor Policies
(make-up exams, extra credit, late work, special assignments, class attendance, classroom citizenship, etc.)

Students are expected to attend lectures and laboratories

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(make-up exams, extra credit, late work, special assignments, class attendance, classroom citizenship, etc.)

Technical Support

If you experience any problems with your UTD account you may send an email to: assist@utdallas.edu or call the UTD Computer Helpdesk at 972-883-2911.

Field Trip Policies
Off-campus Instruction and Course Activities

Off-campus, out-of-state, and foreign instruction and activities are subject to state law and University policies and procedures regarding travel and risk-related activities. Information regarding these rules and regulations may be found at the website address http://www.utdallas.edu/BusinessAffairs/Travel_Risk_Activities.htm. Additional information is available from the office of the school dean. Below is a description of any travel and/or risk-related activity associated with this course.

Student Conduct & Discipline

The University of Texas System and The University of Texas at Dallas have rules and regulations for the orderly and efficient conduct of their business. It is the responsibility of each student and each student organization to be knowledgeable about the rules and regulations which govern student conduct and activities. General information on student conduct and discipline is contained in the UTD printed publication, *A to Z Guide*, which is provided to all registered students each academic year.

The University of Texas at Dallas administers student discipline within the procedures of recognized and established due process. Procedures are defined and described in the *Rules and Regulations, Series 50000, Board of Regents, The University of Texas System*, and in Title V, Rules on Student Services and Activities of the university's *Handbook of Operating Procedures*. Copies of these rules and regulations are available to students in the Office of the Dean of Students, where staff members are available to assist students in interpreting the rules and regulations (SU 1.602, 972/883-6391) and online at http://www.utdallas.edu/judicialaffairs/UTDJudicialAffairs-HOPV.html

A student at the university neither loses the rights nor escapes the responsibilities of citizenship. He or she is expected to obey federal, state, and local laws as well as the Regents' Rules, university regulations, and administrative rules. Students are subject to discipline for violating the standards of conduct whether such conduct takes place on or off campus, or whether civil or criminal penalties are also imposed for such conduct.

The faculty expects from its students a high level of responsibility and academic honesty. Because the value of an academic degree depends upon the absolute integrity of the work done by the student for that degree, it is imperative that a student demonstrate a high standard of individual honor in his or her scholastic work.

Scholastic Dishonesty, any student who commits an act of scholastic dishonesty is subject to discipline. Scholastic dishonesty includes but is not limited to cheating, plagiarism, collusion, the submission for credit of any work or materials that are attributable in whole or in part to another person, taking an examination for another person, any act designed to give unfair advantage to a student or the attempt to commit such acts.

Plagiarism, especially from the web, from portions of papers for other classes, and from any other source is unacceptable and will be dealt with under the university's policy on plagiarism (see general catalog for details). This course will use the resources of turnitin.com, which searches the web for possible plagiarism and is over 90% effective.

Copyright Notice

The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted materials, including music and software. Copying, displaying, reproducing, or distributing copyrighted works may infringe the copyright owner's rights and such infringement is subject to appropriate disciplinary action as well as criminal penalties provided by federal law. Usage of such material is only appropriate when that usage constitutes "fair use" under the Copyright Act. As a UT Dallas student, you are required to follow the institution's copyright policy (Policy Memorandum 84-I.3-46). For more information about the fair use exemption, see http://www.utsystem.edu/ogc/intellectualproperty/copypol2.htm

Email Use

The University of Texas at Dallas recognizes the value and efficiency of communication between faculty/staff and students through electronic mail. At the same time, email raises some issues concerning security and the identity of each individual in an email exchange. The university encourages all official student email correspondence be sent only to a student's U.T. Dallas email address and that faculty and staff consider email from students official only if it originates from a UTD student account. This allows the university to maintain a high degree of confidence in the identity of all individual corresponding and the security of the transmitted information. UTD furnishes each student with a free email account that is to be used in all communication with university personnel. The Department of Information Resources at U.T. Dallas provides a method for students to have their U.T. Dallas mail forwarded to other accounts.

Withdrawal from Class

The administration of this institution has set deadlines for withdrawal of any college-level courses. These dates and times are published in that semester's course catalog. Administration procedures must be followed. It is the student's responsibility to handle withdrawal requirements from any class. In other words, I cannot drop or withdraw any student. You must do the proper paperwork to ensure that you will not receive a final grade of "F" in a course if you choose not to attend the class once you are enrolled.

Student Grievance Procedures

Procedures for student grievances are found in Title V, Rules on Student Services and Activities, of the university's *Handbook of Operating Procedures*.

In attempting to resolve any student grievance regarding grades, evaluations, or other fulfillments of academic responsibility, it is the obligation of the student first to make a serious effort to resolve the matter with the instructor, supervisor, administrator, or committee with whom the grievance originates (hereafter called "the respondent"). Individual faculty members retain primary responsibility for assigning grades and evaluations. If the matter cannot be resolved at that level, the grievance must be submitted in writing to the respondent with a copy of the respondent's School Dean. If the matter is not resolved by the written response provided by the respondent, the student may submit a written appeal to the School Dean. If the grievance is not resolved by the School Dean's decision, the student may make a written appeal to the Dean of Graduate or Undergraduate Education, and the deal will appoint and convene an Academic Appeals Panel. The decision of the Academic Appeals Panel is final. The results of the academic appeals process will be distributed to all involved parties.

Copies of these rules and regulations are available to students in the Office of the Dean of Students, where staff members are available to assist students in interpreting the rules and regulations.

Incomplete Grade Policy

As per university policy, incomplete grades will be granted only for work unavoidably missed at the semester's end and only if 70% of the course work has been completed. An incomplete grade must be resolved within eight (8) weeks from the first day of the subsequent long semester. If the required work to complete the course and to remove the incomplete grade is not submitted by the specified deadline, the incomplete grade is changed automatically to a grade of **F**.

Disability Services

The goal of Disability Services is to provide students with disabilities educational opportunities equal to those of their non-disabled peers. Disability Services is located in room 1.610 in the Student Union. Office hours are Monday and Thursday, 8:30 a.m. to 6:30 p.m.; Tuesday and Wednesday, 8:30 a.m. to 7:30 p.m.; and Friday, 8:30 a.m. to 5:30 p.m.

The contact information for the Office of Disability Services is:
The University of Texas at Dallas, SU 22
PO Box 830688
Richardson, Texas 75083-0688
(972) 883-2098 (voice or TTY)
disabilityservice@utdallas.edu

If you anticipate issues related to the format or requirements of this course, please meet with the Coordinator of Disability Services. The Coordinator is available to discuss ways to ensure your full participation in the course. If you determine that formal, disability-related accommodations are necessary, it is very important that you be registered with Disability Services to notify them of your eligibility for reasonable accommodations. Disability Services can then plan how best to coordinate your accommodations.

It is the student's responsibility to notify his or her professors of the need for such an accommodation. Disability Services provides students with letters to present to faculty members to verify that the student has a disability and needs accommodations. Individuals requiring special accommodation should contact the professor after class or during office hours.

Religious Holy Days

The University of Texas at Dallas will excuse a student from class or other required activities for the travel to and observance of a religious holy day for a religion whose places of worship are exempt from property tax under Section 11.20, Tax Code, Texas Code Annotated.

The student is encouraged to notify the instructor or activity sponsor as soon as possible regarding the absence, preferably in advance of the assignment. The student, so excused, will be allowed to take the exam or complete the assignment within a reasonable time after the absence: a period equal to the length of the absence, up to a maximum of one week. A student who notifies the instructor and completes any missed exam or assignment may not be penalized for the absence. A student who fails to complete the exam or assignment within the prescribed period may receive a failing grade for that exam or assignment.

If a student or an instructor disagrees about the nature of the absence [i.e., for the purpose of observing a religious holy day] or if there is similar disagreement about whether the student has been given a reasonable time to complete any missed assignments or examinations, either the student or the instructor may request a ruling from the chief executive officer of the institution, or his or her designee. The chief executive officer or designee must take into account the legislative intent of TEC 51.911(b), and the student and instructor will abide by the decision of the chief executive officer or designee.

These descriptions and timelines are subject to change at the discretion of the Professor.