Geol 619 Course Description and Goals, Spring 2009

Electron Beam Analysis is a laboratory course covering the theory and application of EPMA (electron probe micro analysis) and SEM (scanning electron microscopy) as an integrated and multi-disciplinary subject covering aspects of physics, chemistry, geology and statistics plus practical hands-on experience with the instruments themselves.

Students who have any intention of utilizing electron beam instruments for any part of their graduate research are strongly encouraged to enroll for this class. By providing theory and background for understanding what has now almost become a “black box” device, students will gain the ability to explain and defend their data and have a quantitative understanding of the confidence that they can assign to the numerical values that they obtain using these techniques.

Electron beam analysis is suited to a tremendous variety of sample types ranging from lithic (stone) fragments from archeological studies to chemical vapor deposited thin films in materials science to thin sections of igneous rocks for determining conditions of magma melting and mixing. Both conductive and non-conductive (when properly coated) samples can be utilized in these instruments and the only requirement is that for quantitative work the sample geometry must be accurately known. For this reasons flat and smooth samples will usually suffice.

Information can be obtained about the size, shape, chemical composition and distribution of single or multiple phases in almost any solid sample from cm to µm size scales. This process, coupled with the non-destructive nature of the analysis, ease of sample preparation and high levels of both accuracy and precision from major to trace concentrations for chemical composition and size determinations, results in fast and abundant data sets.

The course is designed to first provide a solid understanding of the theory behind the technique in order to provide students with the necessary intellectual tools to pursue their experimental goals. In doing so, the student will be able to better design a research project that is not only feasible but is clearly defined and produces data that is rigorous enough to hold up to critical review.

Class schedule:

Day	**Subject**
March 31	Introduction to the EPMA/SEM laboratory: A short tour of the facilities and discussion of lecture notes, suggested reading materials, grading methods, exams and current research projects followed by a short history of the instrument and related techniques. Discussion of alternative class meeting times or places? (1st lecture)
April 2	Electron beam instrumentation and electron solid interactions: A brief description of the major system components for both the electron microprobe and scanning electron microscope followed by an introduction to elastic and inelastic scattering of electrons and associated principles. (**Chapters 1 and 2**) (2nd lecture)

April 7 X-ray productions: The generation and emission of characteristic and continuum x-rays and their absorption and fluorescence interactions within the sample. (**Chapter 3**) (3rd lecture)

April 9 Electron Beam Columns: Formation, alignment, and choices for parameterization with regards to application and specimen interaction. (**Chapter 4**) (4th lecture)

April 14 Lab: Demonstration of electron beam parameters and sample interactions. (5th lecture)

April 16 WDS (wavelength dispersive spectrometer): A description of the Bragg spectrometer and associated principles. (**Chapter 5**) (6th lecture)

April 21 Lab: Demonstration of wavelength dispersive spectrometry technique and analysis. (7th lecture)

April 23 EDS (energy dispersive spectrometer): Spectral analysis using the EDS detector. (**Chapter 6**) (8th lecture)

April 28 Lab: Demonstration of energy dispersive spectrometry technique and analysis. (9th lecture)

April 30 Statistics: The essential key to scientific analysis. (**Chapter 7**) (10th lecture)

May 5 Lab: Examples of the application of statistical calculations to quantitative analysis. (11th lecture)

May 7 Quantitative matrix corrections: What goes on in the computer? An introduction to the corrections being applied to the intensity data in order to obtain elemental concentrations. Take home mid-term exam given out at the end of the lecture and due next class meeting. (**Chapter 9**) (12th lecture)

May 12 Lab or Discussion: A demonstration of various compositionally dependent data corrections (peak shape, interferences, carbon contamination, volatile element loss, etc.) or a discussion of the questions from the take home mid-term test. (13th lecture)

May 14 Imaging and mapping: An overview of electron and x-ray imaging and mapping techniques and the principles involved. (**Chapter 8**) (14th lecture)

May 19 Lab: a demonstration of the analog and digital mapping capabilities on the electron microprobe and SEM. (15th lecture)

Class Information: This format of this course will be somewhat open. There will be approximately eight weeks of lectures and 2-hour laboratories. Some lecture topics may receive increased emphasis depending upon specific student interests. Whenever possible, classroom material will be illustrated through laboratory exercises and demonstrations. Upon completion of this first part of the course, every student will do a class project which will require one day of individual microprobe usage. Classes on May 22, 27, 29 and June 3, 5, 10, 12 are reserved for this purpose, usually involving an area of interest selected by the student with the approval of the instructor.

The following criteria will be used to determine the grade that will be received:

> **Laboratory Notebook (40%) –** Students are expected to buy a small standard laboratory notebook and record all relevant and useful lecture and lab demonstration information, notes, questions, equations, ideas and thoughts. It is not necessary to write down every scrap of information, but it should be a useful record of your experience during the entire quarter. This notebook should be maintained and updated (permanent ink pen must be used) throughout the entire course and therefore obviously should be brought to each class and lecture. This notebook will be handed in along with the probe project report described below, at the end of the last class. The lab notebook should also contain all sample descriptions, experimental parameters, setup considerations and analytical notes utilized in the probe project report. Notebooks will be graded for neatness, legibility, clarity, accuracy, completeness, attention to detail, usefulness and individuality or uniqueness. Lab notebooks will be returned and left for students to pick up in the probe ante-room, after grades are posted.
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> **Mid Term (30%)** - There will be one take-home test at the end of the formal lecture period of the course. Students will be permitted to use all class notes and handouts to assist them during this test. The test will be due one week following its distribution at the specified time.
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> **Probe Project (30%)** - Students will perform analyses and interpret the results for a project chosen in consultation with the instructor. A short (3-5 page) report summarizing the analytical setup and results with a statistical evaluation will be due before the final day of class. Individual times on the microprobe with the instructor will be scheduled for this project.

The final grade will be determined by dividing the total number of points a student receives by the total possible points, weighting them according to the percentages above, and expressing the result as an overall percentage rounded to the nearest 1% (0.5% will be rounded up). Grades will be assigned as follows: <60% = F; 60-69% = D; 70-79% = C; 80-89% = B; and 90-100% = A. If the pass/fail option was selected for the grade, then a pass grade will be given if the student receives 70 points or more.

Course policies: Regular attendance is expected for both class and laboratory portion of this course. A substantial part of the course involves hands-on use of the microprobe during labs. An excessive number of absences, as determined by the instructor, will result in a grade of F. Plagiarism or any other form of cheating will result in an automatic grade of F. If there are exercises where students may cooperate, these will be specifically announced. There will be no “make-ups” on any tests or exercises, unless they are arranged with the instructor in advance. All materials submitted for evaluation (tests, exercises, projects) must be legible. Students should type their work.