GEOL/PLANETSCI 9559b: Geochronology of Planetary and Resource Evolution

Winter 2015

Course Instructor: Dr. Desmond Moser (office: B&GS 1072; e-mail: desmond.moser@uwo.ca)
Lectures: Thursday, 9:30–11:30 AM, B&GS 1069
Office Hours: by appointment

Course description:

This course provides an overview of U-Th-Pb geochronology - now recognized as the benchmark method for the calibration of the geologic timescale. Students will be introduced to the principles underlying U-Th-Pb geochronology (e.g. the concordia curve) and the relative advantages of the numerous U-Th-Pb isotopic analysis techniques such as isotope dilution thermal ionization mass spectrometry (ID-TIMS), secondary ion mass spectrometry (SIMS), laser ablation multi-collector inductively coupled mass spectrometry (LA-MC-ICPMS) as well as elemental U-Pb geochronology by electron beam techniques. Complimentary geochemical information from geochronology minerals including radiogenic (e.g. Lutetium-Hafnium) and stable (e.g. Oxygen, Lithium) isotopic analyses, trace elements (e.g. Ti) will also be discussed, as well as growing interest in micro- and nano-structural analysis (CL, EBSD, atom probe). A range of U-Th-Pb geochronology phases and applications will be investigated through a problem set assignment as well as case study critiques and reports by students. The course is divided into several components; analytical techniques, common geochronology minerals, applications in planetary science, tectonics and economic geology. Microscopic examination of geochronology minerals in the Zircon and Accessory Phase laboratory will be conducted whenever possible to complement lecture material and discussions.

> **Prerequisites:** Permission of the instructor. *(Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you will be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.)*

Readings:

Most material is going to be covered by reviewing recent publications that will be assigned on a regular basis.

Reference Textbooks:

- **Zircon**, Reviews in Mineralogy and Chemistry (Mineralogical Society of America; Series editor Paul. H. Ribbe), *edited by: Hanchar, J.M. and Hoskin, P.W.O.*, v53, 2003
- Dickin, A.P., **Radiogenic Isotope Geology**, 2nd ed. Cambridge ; New York : Cambridge University Press, 2005
- Faure, G., and Mensing, T., **Isotopes: Principles and Applications,** 3rd ed., Hoboken, N.J.: Wiley, 2005.

Summary of Topics to be covered (*approximate and subject to change*!):

A) Principles and Techniques of (U-Pb) Geochronology

- Origins of geochronology, Decay schemes and half-lives of actinides
- The concordia curve, precision and accuracy
- Discordance; metamictization, causes of discordance, use of discordia lines

B) Techniques

- Mass spectrometry
- Isotope Dilution-Thermal Ionization Mass Spectrometry; high precision dating, chemical abrasion, timescale calibration
- Probe techniques; ion microprobe (SHRIMP, Cameca, NanoSIMS, electron)
- Probe techniques; laser (U-Pb and Hf isotopes) and electron (chemical dating)
- Probe techniques; stable isotope and trace element analysis

C) U-Pb geochronometers

- Dateable phases; zircon, monazite, baddeleyite, titanite, rutile, apatite etc.
- Crystallogenesis; Lattice and growth imaging techniques and crystal kinetics (e.g. growth, resorption, dissolution-reprecipitation)
- Diffusion

D) Applications 1: Tectonics and terrestrial processes

- Dating igneous events; age and duration of magmatism (e.g. magma residence time, dyke swarm dating)
- Dating sediment deposition
- Dating metamorphic events; age and conditions of metamorphic mineral growth (e.g. Ti-in –zircon thermometry, hydrothermal zircon)
- Dating deformation; age bracketing and direct strain chronometry

E) Applications 2: Solar system and planetary evolution

- Dating early solar system events, meteorite dating (chondrules, eucrite zircon)
- U-Pb geochronology and impact processes (crater, ejecta, dating impact events, shock features in geochronology minerals)
- Hadean zircons
- Lunar and martian U-Pb geochronology

F) Applications 3: Resource formation and low-temperature events

- Porphyry-copper systems; U-Pb, K-Ar and Ar-Ar dating of igneous and hydrothermal events
- Dating gold deposits
- Diamond exploration; kimberlite perovskite dating, kimberlite megacryst suite (e.g.zircon, rutile, phlogopite)
- Uranium mineralization

Method of Evaluation

Problem set (U-Pb data analysis)_____15%

Student-led Discussion and Critique_____25%

Final Term Paper _____50%

Overall Participation (preparation, readings, attendance etc.) _____10%

Course Work

Problem set Students will be given a data set of U-Pb mass spectrometry measurements with which they will reduce and interpret a date for the sample and present an age interpretation.

Discussion Following the introductory session individual students will lead a discussion on a refereed publication selected from the above topics in consultation with the instructor. Students will present a brief oral summary and critique of their paper to the class and then facilitate a discussion focusing on two questions: 1) What hypotheses are the author(s) aiming to test? and 2) What bearing (i.e. success, failure) do the results have on these hypotheses?. Class members are required to read all papers prior to discussion.

The FINAL TERM PAPER will involve a written review paper in which the student performs a full formal review of an area of U-Pb geochronology selected in consultation with the instructor. Review topics can be in any area covered during the course. The review must include references to the scientific literature, and assessment of raw data and interpretations. Papers are due at the end of term (April 8th).

*(**Plagiarism:** Students must write their essays and assignments in their own words. Whenever students take an idea, or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence (see Scholastic Offence Policy in the Western Academic Calendar).*

Statement on Academic Offences: "Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site: http://www.uwo.ca/univsec/handbook/appeals/scholoff.pdf ."

Statements on special circumstances:

If you are unable to meet a course requirement due to illness or other serious circumstances, you must provide valid medical or other supporting documentation to the Dean's office as soon as possible and contact your instructor immediately. It is the student's responsibility to make alternative arrangements with their instructor once the accommodation has been approved and the instructor has been informed. In the event of a missed final exam, a

"Recommendation of Special Examination" form must be obtained from the Dean's Office immediately. For further information please see:
http://www.uwo.ca/univsec/handbook/appeals/medical.pdf

A student requiring academic accommodation due to illness, should use the Student Medical Certificate when visiting an off-campus medical facility or request a Records Release Form (located in the Dean's Office) for visits to Student Health Services. The form can be found here: https://studentservices.uwo.ca/secure/medical_document.pdf

Graduate Course Health and Wellness

As part of a successful graduate student experience at Western, we encourage students to make their health and wellness a priority. Western provides several on campus health-related services to help you achieve optimum health and engage in healthy living while pursuing your graduate degree. For example, to support physical activity, all students, as part of their registration, receive membership in Western's Campus Recreation Centre. Numerous cultural events are offered throughout the year. for example, please check out the Faculty of Music web page http://www.music.uwo.ca/, and our own McIntosh Gallery http://www.mcintoshgallery.ca/. Information regarding health- and wellness-related services available to students may be found at http://www.health.uwo.ca/. Students seeking help regarding mental health concerns are advised to speak to someone they feel comfortable confiding in, such as their faculty supervisor, their program director (graduate chair), or other relevant administrators in their unit. Campus mental health resources may be found at http://www.health.uwo.ca/mental_health/resources.html.