GEOS 605 Geochronology - Fall 2006

Room: 235 NSCI MWF 1:00-2:00
Instructor: Paul Layer Office: 368 NSCI, x5514 Office hours: By appointment

Course Philosophy

This course is designed to briefly outline the major isotopic systems currently in use in geochronology and their specific applications. Some of the uses of radiogenic isotopes in geochemistry and some non-isotopic geochronologic techniques may be discussed. The principle goals of this course are to:

1. Introduce students to the principles of radioactivity and radioactive decay.
2. Demonstrate the applicability of radioactive isotopes to a variety of geologic problems.
3. Discuss the uses and limitations of the various isotopic dating systems.
4. Allow the student to critically evaluate isotopic data that they encounter in the literature.

Text

The text for this class is Radiogenic Isotope Geology by Alan P. Dickin, Cambridge Press, 1995. It is a fairly up-to-date book (but still 10 years old) and would make an excellent reference book.

Another recommended book is: Principles of Isotope Geology, Second Edition by Gunter Faure, published in 1986. There is a first edition published in 1977 floating around as well. This is actually a better textbook (it explains things in a simpler way and has problem sets), but as the 2nd edition is now 20 years old, it is hopelessly out of date.

A third book that we will refer to is Geochronology and Thermochronology by the 40Ar/39Ar Method by Ian McDougall and T. Mark Harrison, Oxford, 1999. I will distribute parts of this book as handouts.

Additional published papers will be distributed to expand on the information in the text. There are many other geochronology books and we will look at sections from some of them as well.

First assignment:

Prior to the first lecture (September 6!!, not September 1), students should read chapters 1 and 2 in Dickin and review their chemistry or geochemistry notes regarding atoms, isotopes and radioactivity. I will be back in town on September 2. Please try to meet with me on September 5 (before the first class).

Course Topic Summary

Week	Date	Topic
1	Sept 4	Atoms and Decay
2	Sept 11	Mass spectrometers and measurement
3	Sept 18	Rb-Sr and K-Ar
4	Sept 25	40Ar/39Ar dating
5	Oct 2	Diffusion and Thermochronometry
6	Oct 9	40Ar/39Ar dating revisited
7	Oct 16	U-Pb
8	Oct 23	Pb-Pb
9	Oct 30	Sm-Nd
10	Nov 6	Re-Os and other dating methods
11	Nov 13	Fission Track
12	Nov 20	U-Series
13	Nov 27	C-14 and other cosmogenic nuclides
14	Dec 4	Student Presentations

Grading Procedure

Literature discussion	15%	
Classroom lecture	15%	
Argon data analysis	10%	
Paper	35%	*First Draft (10%), Final Paper (20%), Abstract (5%)*
Oral Presentation	15%	
Problem Sets	10%	

Literature Review and Discussions

Each student or team of students will choose (or be assigned) papers to evaluate and lead the class in discussion each Friday. We may do this as a pro- and con- discussion. Grading will reflect the degree of preparation and ability to defend (or repudiate) the premises of the paper. We will also discuss or go over parts of the text. Near the end of the semester I will assign a 'big picture question' (i.e. given a particular geologic problem, what isotopic methods would you use to address the problems and why) for discussion on December 1.

Lecture

Each student will choose or be given one topic not covered in other lectures and present a ~30 minute lecture (depending on the number of students) to the rest of the class on that topic. Examples are: Lu-Hf, Re-Os, La-Ce /La-Ba, Nd-Sr-Pb isotopes, K-Ca, Age of the Earth (Pb. Isotopes), Shrimp (SIMS), AMS. This will be the only presentation of the topic in the class. You can have hand-outs and should cover the material in the text and provide a bibliography of current papers on the topic beyond what is in the text. There will be peer evaluation of this lecture.

Argon data analysis

Each student will participate in collection of data from one or two samples that the lab is working on for 40Ar/39Ar dating. You will work with me on data reduction, interpretation and presentation. The discussion will be done during one of the "Literature discussion" days. These data may be part of the paper. Please try to meet with me before the first class (September 6) to discuss options for this assignment.

Paper

The paper is recommended to be about 10-15 pages of text and contain at least 8 references. The topic should be discussed with me by September 20. The paper will be due on November 24. It will be evaluated and graded and handed back for revision (Hopefully by December 1). The final draft is due during finals week. A 15-20 minute oral presentation accompanies the report, abstracts (AGU style) will be distributed to the class and are due on December 1. There are two options for this paper.

Option 1:

Choose one or two different isotopic systems. Outline the principles of the methods and how they can be applied to a problem such as your thesis or research area or another area of interest to you. Discuss the information that you hope to be able to get from the use of isotopes. Pay special attention to the limitations of the method (i.e. is the method precise enough to resolve your problem and what are the fundamental assumptions in the methodology). The best form for this paper would be as a proposal to a funding agency with focus on why you need to use the methods you propose.

Option 2:

From your thesis or research area, choose 3 – 5 samples, prepare them for irradiation and 40Ar/39Ar analysis. It is doubtful that we will be able to analyze them this semester, but you never know. Write up the geologic background for the project, the geologic problem that you hope these will address, the rationale for selecting the samples that you did, the methodology that you used to prepare the samples and how you might interpret the data that you will obtain. This will ultimately lead to a chapter in your thesis.

Problem sets/assignments

During the first few weeks of the semester, I will assign problems to allow students to practice manipulating the equations used in geochronology.

People "just sitting in" will be asked to give a brief presentation on the use of isotopes in their field or lead one of the discussion topics.

Tentative Course Schedule

		Sept.	1	**No Class** (reschedule as part of mass spectrometer demonstration)
	Week 1		4	**Labor Day No Class**
1.			6	Introduction. What is the age of a rock? The Atom; Isotopes and Isobars (ch. 1)
2.			8	Radioactive Decay (ch. 1.3, 1.4)
3.	Week 2		11	Mass Spectrometry (ch. 2)
4.			13	Isochrons and errors (ch 2.3)
5.			15	**Discussion about decay constants and geochronology or Mass Spectrometry**
6.	Week 3		18	Rb-Sr dating (ch 3)
7.			20	Rb-Sr and K-Ar dating *****PAPER TOPIC DUE*****
8.			22	**Literature Discussion**
9.	Week 4		25	K-Ar Methodology (ch. 10)
10.			27	$^{40}Ar/^{39}Ar$ Methodology (ch. 10) **Lecture topic assigned**
11.			29	**Literature Discussion**
12.	Week 5	**Oct.**	2	Step Heating and comparison to K-Ar
13.			4	Thermochronometry and Diffusion
14.			6	**Diffusion "Lab"**
15.	Week 6		9	Thermochronometry and Diffusion Discussion
16.			11	Applications and New Techniques
17.			13	**Literature Discussion**
18.	Week 7		16	The U, Th - Pb methods of dating (ch 5) ****Paper outline and bib due****
19.			18	U, Th - Pb dating
20.			20	**Literature Discussion**
21.	Week 8		23	New Methods: SHRIMP and single grain dating
22.			25	Pb isotopes
23.			27	**Literature Discussion**
24.	Week 9		30	Sm-Nd dating ch 4
25.		**Nov.**	1	Isotopes of Nd and Sr (ch 6, 7)
26.			3	**Literature Discussion**
27.	Week 10		6	**Student Lecture**
28.			8	**Student Lecture**
29.			10	**Student Lecture**
30.	Week 11		13	Fission Track dating (ch 16)
31.			15	U-He, Thermoluminescence, Pleochroic Haloes, etc.
32.			17	**Literature Discussion**
33.	Week 12		20	U-Series (ch 12)
34.			22	U-Series (ch 13) ******** First Draft Due
35.			24	*THANKSGIVING – No Class*
	Week 13		27	C-14 dating (ch 14) ******** First Draft Returned
36.			29	Cosmogenic Nuclides
37.		**Dec.**	1	**Literature Discussion** ******** Abstract Due
38.	Week 14		4	**Student Presentations**
39.			6	**Student Presentations**
40.			8	**Student Presentations**
41.	15		11	AGU No class -- reschedule
			16	Final exam time: AGU No class -- reschedule
				Final Paper Due on Monday, Dec 18 (but preferably before AGU)

Let me know if there are topics that you want to see covered in the class. This is a flexible schedule