

## **GEOLOGY 466/866—ISOTOPES AND THE ENVIRONMENT**

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This course is designed to expose those from a variety of disciplines to the use of naturally occurring isotopes in deciphering the complexities of processes. Both stable isotopes (and selected time-dependent isotope systems) will be examined in natural processes including formation of the elements, structure of the universe, origin and evolution of the atmosphere, the hydrologic cycle, biological systems, recent and past climates, isotopes in biological systems and the search for minerals and energy sources.

Practical experience will be gained through problem sets and laboratory assignments that will require the actual measurement of isotopic compositions in materials and the interpretation of sets of isotopic data. The course is designed to consist of 80% lectures by the instructor and 20% seminar presentation by the participants. Figures from the lecture, problem sets and additional material are available on the web under the login geol866 and the password given to you in lecture. The general subjects and preliminary schedule include:

**Introduction to isotopes**--what are the isotopic compositions of major elements, how are isotopic compositions expressed, what happens when isotopically distinct reservoirs mix? **(Jan 6-17)**

**Techniques**—how are isotopic compositions determined? **(Jan 6-Lab)**

**Isotopic fractionations**--why do isotopes of elements behave the way they do, where are the major mechanisms of isotopic disproportionation in isotopic substances, how are isotopic compositions expressed, can some elements be used to trace others? **(Jan 6-17); Problem set#1 due Jan 13, 2003.**

**Isotopic composition of the cosmos**—how are isotopes made, what do isotopes have to tell us about the solar system and beyond, is the earth unique? **(Jan 20-24); Problem set#2 due Jan 20, 2003.**

**Isotopic composition of the atmosphere**—what controls the isotopic composition of atmospheric gases, what are the major problems, what is the evidence that things have changed with time? **(Jan 27-31).**

**Basics of isotopes in the hydrologic cycle**—what determines the isotopic composition of atmospheric moisture, meteoric waters, seawater? **(Feb 3 & Lab lecture).**

**Results from isotope hydrology**-- what are the H and O isotopic compositions of various fluids associated with the meteoric water cycle and how do they get that way? **(Feb 5-7).**

**Isotope geochemistry of groundwater**—what determines the isotopic composition of groundwaters? **(Feb 10-14); Problem set#3 due Feb 10, 2003.**

**Isotope geochemistry of seawater**—what determines the isotopic composition of seawater? **(Feb 24-28).**

**High temperature systems**--the isotope geochemistry of hi-T systems. **(Mar 3-7).**

**Hydrothermal fluids**--the isotope geochemistry of natural geothermal systems, geothermometers for both ancient and modern systems, what do isotopes tell us about fluids associated with ore and petroleum deposits? **(Mar 10-14); Problem set#4 due Mar 10, 2003.**

**Paleoenvironments and isotopes**—what are the most recent isotopic studies of past climates, how has this changed during the evolution of the earth, what determines the isotopic composition of elements in

ancient systems? (**Mar 17-21**).

**Stable isotope of organisms, birds and trees**—what are the problems with isotopic tracing in organisms, how do fractionation factors differ in biological systems and why, what are some of the applications of isotope tracing in natural biological systems, what do isotopes say about birds, and trees-plants? (**Mar 23-31**).

**Other isotope systems**—what are the latest fads in isotope systems? (**April 2-4**).

**Seminars**--there will also be seminar presentations, the subjects to be discussed (usually tailored to your interests or thesis). Each person and group of up to three people will be required to write an extended abstract (<3 pages) with an appropriate reference list to be given at the time of the seminar. The seminars will be presented near the end of classes during the lab period.

The grade will be determined as follows: Labs & problems (30%), seminar (30%), final (40%). The labs will include 4 problem sets designed to introduce you to using basic concepts and labs involving measuring the isotopic composition of materials and interpreting the data. The text books for this class are listed on the web. One is a collection of isotope tracing of processes in hydrologic systems and the other is on detailed use of isotopes in earth science. Other books of use for background preparation are:

Attendorf H-G and Bowen R N C (1997) Radioactive and Stable Isotope Geology. Chapman and Hall, London, 522pp

Barnes H L (ed) (1997) Geochemistry of Hydrothermal Ore Deposits. 3rd Edition, John Wiley and Sons, New York, 972pp.

Bowen R N C (1988) Isotopes in Earth Sciences. Elsevier Appl. Sci., London, 647pp.

Bowen R N C (1991) Isotopes and Climates. Elsevier Appl. Sci., London, 483pp.

Clauer N and Chaudhuri S (eds) (1992) Isotopic Signatures and Sedimentary Records. Lecture Notes in Earth Sciences Vol.43. Springer-Verlag, Berlin Heidelberg New York, 529pp.

Faure G (1986) Principles of Isotope Geology. 2nd Edition, John Wiley and Sons, New York, 589pp.

Frenzel B, Stauffer B and Weiss M M (eds) (1995) Problems of Stable Isotopes in Tree-rings, Lake Sediments and Peat-bogs as Climatic Evidence for the Holocene. Gustav Fischer Verlag, Stuttgart, 189pp.

Fritz P and Foutter J C (eds) (1980) Handbook of Environmental Isotope Geochemistry. Vol.1, The Terrestrial Environment A. Elsevier, Amsterdam, 545pp.

Fritz P and Foutter J C (eds) (1986) Handbook of Environmental Isotope Geochemistry. Vol.2, The Terrestrial Environment B. Elsevier, Amsterdam, 557pp.

Fritz P and Foutter J C (eds) (1989) Handbook of Environmental Isotope Geochemistry. Vol.3, The Marine Environment A. Elsevier, Amsterdam, 428pp.

Gat J R and Gonfiantini R (eds) (1981) Stable Isotope Hydrology: Deuterium and Oxygen-18 in the Water Cycle. IAEA Technical Reports Series No.210, 337pp.

Griffiths H (ed) (1997) Stable Isotopes: The Integration of Biological, Ecological and Geological Processes. Bios Scientific Publishers, 448pp.

Hoefs J (1997) Stable Isotope Geochemistry. 4th Edition, Springer-Verlag, Berlin. 214pp.

Jaeger E and Hunziker J C (eds) (1979) Lectures in Isotope Geology. Springer-Verlag, Berlin Heidelberg New York, 329pp.

Kendall C and McDonnell J J (eds) (1998) Isotope Tracers in Catchment Hydrology. Elsevier, Amsterdam, 839pp.

Krouse H R and Grinenko V A (eds) (1991) *Stable Isotopes: Natural and Anthropogenic Sulphur in the Environment*. John Wiley and Sons, New York, 440pp.

Kyser T K (ed) (1987) *Stable Isotopes in Low Temperature Fluids*. MAC Short Course Series Vol.13, Mineralogical Society of Canada, 452pp.

Lajtha K and Michener R H (eds) (1994) *Stable Isotopes in Ecology and Environmental Sciences*. Blackwell Scientific Publications, Oxford, 316pp.

Rundel P W, Ehleringer J R and Nagy K A (eds) (1989) *Stable Isotopes in Ecological Research*. Springer-Verlag, Berlin Heidelberg New York, 525pp.

Valley J W, Taylor J R Jr, O'Neil J R (eds) (1986) *Stable Isotopes in High Temperature Geological Processes*. *Reviews in Mineralogy*, Vol.16, Mineralogical Society of America, 570pp.