

GEOLOGY 465/839--EXPLORATION GEOCHEMISTRY

Kurt Kyser, Instructor

PURPOSE OF THE CLASS: The purpose of this course is to learn basic concepts of geochemistry that can be used effectively in both pure and applied aspects of earth science, particularly in tracing the flow of specific fluids associated with ore deposits. To this end, we will examine rather diverse topics, but each will address the geochemical consequences of fluids interacting with rocks and minerals. Many of you may have already had more classical courses in exploration geochemistry. Although some of these concepts will be part of this course, the emphasis will be on more “unorthodox” techniques and understanding basic concepts to give you the tools to develop and use future exploration techniques.

WEB-BASED MATERIAL: The diagrams used in the lectures and the problem sets (not including some of the handouts that go with them) will be available as pdf files on a web site located from the Geology Dept. web page. That includes this document on the Outline of the class.

The problem sets and due dates are as follows:

- (1) **Geochem1 due Jan 14, 2003.**
- (2) **Geochem2 due Jan 21.**
- (3) **Analytical geochem due Feb 11.**
- (4) **Clay minerals due March 4.**
- (5) **Phase equilibria due March 18.**
- (6) **Fluid inclusions due April 1.**

SUBJECT MATTER: Lectures and labs will be given by Kurt Kyser (410 Miller), Post-doctoral Fellows Paul Alexandre and Paul Polito and the TA, Esteban Urqueta. There will be labs that involve analytical geochemistry and problem solving. In addition, group seminar presentations on geochemical topics will be presented near the end of this class. Some the labs will require working in groups on specific problems centred on alteration and ore deposits. The subjects to be discussed and the tentative schedule include the following:

Geochemical behaviour of the elements--Why do elements behave the way they do, where are the major sources of most elements, what kinds of bonds really form, can some elements be used to trace others. **(Jan 6-8).**

Mobile ions and compounds—How metals, gases and compounds move in the near surface environment. **(Jan 13-16).**

Litho geochemistry and alteration minerals—loss of major elements, classifications, trace element mobility. **(Jan 16-22).**

Biogeochemistry--how organisms sample metals, plants as a guide to exploration and what the problems are. **(Jan 23).**

Analytical techniques—a review of the various techniques used in exploration geochemistry and discussion of the problems. **(Jan 28-Lab lecture).**

Soils—What are they, how do they form, what controls their formation their use in exploration geochemistry. **(Jan 27-30).**

Streams and lakes—How exploration geochemistry is done in an aqueous medium and what the data really reflect. **(Feb 3-6).**

Data presentation—Various methods for presenting and deciphering geochemical data, how to use but not

abuse statistics, how to correctly weigh data. (**Feb 4-Lab lecture**).

Clay minerals—The form and composition of clay minerals and why they are critical for exploration geochemistry. (**Feb 24-26**).

Thermodynamics and equilibrium--Equilibrium and the myth, K-G-S-H-A-pH and Eh, how do reactions really happen, the effect of temperature and pressure. (**March 3-6**).

Kinetics, pH and Eh—How fast things react, what redox really is and what is the role of pH in geochemistry. (**March 10-12**).

Surface chemistry--How cations and anions move in fluids, the complexities of complexes, what is saturation, how monomineralic veins form. (**March 13**).

Fluid inclusions--phase relations in the systems H₂O-NaCl, H₂O-CO₂, H₂O-CO₂-NaCl, H₂O-CO₂-salts, H₂O-CO₂-CH₄, how fluids are trapped, estimates of pressure, temperature, and chemistry. (**March 17-19**).

Stable isotope geochemistry--the hydrologic cycle, water/rock interactions, geothermometers and their use in exploration, use of stable isotopes in defining the character of alteration. (**March 20-26**).

Radiogenic isotope geochemistry--U-Pb, K-Ar, Ar-Ar, Sm-Nd, Rb-Sr, U-Th and cosmogenic isotope systems for tracing specific fluid flow (i.e. mineralizing, nonmineralizing, and environmental) and determining the timing of fluid events. (**March 27-31**).

New techniques—Where exploration geochemistry is headed and what new techniques are on the horizon. (**April 1-3, including lab lecture**).

SEMINARS--these will also be group presentations, the subjects to be discussed. Each group will be required to write an extended abstract (<3 pages) with an appropriate reference list attached and present this at the end of the semester but prior to the seminar so that the class can come prepared with penetrating questions. The seminars will be presented in the week following the end of classes. All materials presented in the seminars must be submitted for evaluation.

BOOK-KEEPING--The grade will be determined as follows: Labs (35%), seminar (20%), final (45%). There are few text books in Exploration Geochemistry and the only one for a reasonable cost (and therefore required) is **Geochemistry in Mineral Exploration** by Rose, Hawkes and Webb. Although somewhat out of date, much of the basic knowledge required is in this book and it will be supplemented by articles from the current literature. A few other books you may wish to consult include **Handbook of Exploration Geochemistry**—**Geochemical Remote Sensing of the Sub-surface** by Hale, which is a collection of the newest thinking on how to detect “blind” deposits using geochemical remote sensing. **Modern Analytical Geochemistry** by Gill is on modern analytical geochemical techniques and will serve as a source for several of the labs in this class. Other books of use for background preparation are:

Introduction to Geochemistry by K. Krauskopf and D. Bird

Geothermal Fluids-Chemistry and Exploration Techniques by K. Nicholson

Equilibrium Activity Diagrams by T.S. Bowers, K.J. Jackson, and H.C. Helgeson

Eh-pH Diagrams for Geochemistry by D.G. Brookins

Fluids in Basins MAC Vol. 28 by K. Kyser

Practical Problems in Exploration Geochemistry by AA. Levinson, P.M.D. Bradshaw, and I. Thomsom

Chemical Thermodynamics by D.K. Nordstrom and J.L. Munoz

Geochemistry of Natural Waters by J.I. Drever

Principles of Isotope Geochemistry by G. Faure

Stable Isotope Geochemistry of Low Temperature Fluids MAC Vol. 13 by K. Kyser

Applications of Radiogenic Isotope Systems to Problems in Geology MAC Vol. 19 by L. Heaman and J. Ludden

In addition, there are 3 volumes in the Minex room containing articles from recent publications that you should read.