



UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Geochemistry

2526-2-E3401Q017

Aims

The course introduces to the fundamental principles of Geochemistry and aims to explain the mechanisms and chemical principles underlying the main geological processes, and the interconnections with other disciplines of Earth Sciences. Students acquire the knowledge to characterize and classify the origin of elements and isotopes, their distribution in the main geochemical reservoirs and geospheres. The course allows understanding and interpreting chemical and isotopic fractionation processes, and use isotopic elements and ratios as tracers of geological, hydrogeological, petrogenetic, volcanological and geodynamic processes. Students will be able to assess the origin of a fluid or a geological process based on geochemical tracers. Knowledge of radioactivity, methods of radioactive decay of radionuclides, the main implications on geochronology and some dating methods used will be imparted. Students are able to reconstruct the geochemical cycles of the elements in different environments and geospheres. A mention will be given of analytical methodologies and techniques in the laboratory, with a visit to 1-2 analytical laboratories; furthermore, an overview of fluid and rock sampling techniques will be provided. Finally, basic knowledge on methods of visualization and processing of geochemical data will be imparted. At the end of the practical sessions, students will be able to model a mixing process involving the concentration and isotopic composition of a naturally occurring element. The course provides the basic quantitative and modeling knowledge for subsequent applications to natural and industrial processes.

Contents

Basic notions of Geochemistry. Notes on nucleosynthesis and cosmochemistry. Evolution of the Earth. Geochemical affinity of the elements. Geochemical spheres. Geochemistry of the atmosphere. Geochemistry of the Lithosphere. Geochemistry of magmatic volatiles. Solubility of volatiles. Magmatic degassing. Geochemistry of the Hydrosphere. Mechanical and chemical weathering. Geochemical cycles. Stable isotope geochemistry. Geochemistry of unstable isotopes: radioactive decay and notes on geochronology. Geochemistry of radiogenic isotopes. Geochemistry of noble gases. Notes on some applications of Geochemistry. Main water, gas and rock sampling methodologies and analytical techniques. Methods of visualization and processing of geochemical data.

Detailed program

Presentation of the course. Basic notions of Geochemistry. Review of the main properties of the elements in relation to their position in the periodic table. The internal structure of atoms. Geochemical spheres.

Outline of nucleosynthesis and cosmochemistry: big bang theory. Red shift. Hertzsprung–Russell diagram and stellar evolution. Formation and evolution of the solar system. Fraunhofer lines and chemical composition of the sun. Nucleosynthesis: hydrogen and helium fusion, carbon cycle. Exothermic reactions and the concept of nuclear binding energy. Endothermic reactions (neutron capture) from Iron onwards. Geochemical affinity of the elements, their influence on geochemical behavior.

Geochemistry of the atmosphere: the primordial atmosphere, genesis and evolution, concept of oxygen fugacity, the post-differentiation atmosphere of the Earth; chemical-physical properties, composition and current structure.

Geochemistry of the lithosphere. Chemical composition of the solid Earth: Core, Mantle and Crust. Genesis and properties of magmas. Magmatic differentiation. Classification of elements. Major and trace elements. Classification diagrams. Partition coefficients. Notes on experimental petrology.

Geochemistry of magmatic volatiles. Classification of magmatic, volcanic and hydrothermal gases. Solubility of volatiles in silicate melts. Magmatic degassing. Composition of volcanic gases in relation to geodynamic contexts and different mantle conditions. Volcanic gas sampling and analysis techniques. Volcanic gas sampling and analysis techniques.

Geochemistry of the hydrosphere, geochemistry of water. Chemical-physical properties of water. Unit of concentration of aqueous species. Langelier-Ludwig classification diagram. Ionic potential, residence time, conservative elements and removal mechanisms. Carbonate species in sea water. Chemical equilibria in the aqueous phase. Partition coefficients.

Weathering processes. Weathering of carbonates and aluminosilicates. Origin and structure of clays. Activity diagrams. Oxidation-reduction reactions. Eh-pH diagrams. Water sampling techniques and measurement of chemical-physical parameters.

Geochemistry of stable isotopes (H, O, C, N, S). Delta notation, fractionation and enrichment factor. International standards. Isotope fractionations. Evaporation and condensation process: the example of oceans and rain. Isotopic composition of precipitation, global meteoric line. Notes on the geochemical cycles of some elements. Use of isotopes in Paleoclimatology. Isotopic geothermometry. Composition of nitrogen within its (bio)geochemical cycle. Stable isotopes in the mantle and magmatic systems.

Geochemistry of unstable isotopes. Definition of radioactivity. Nuclide map. Radioactive decay mechanisms and main decay chains. Law of radioactive decay and basic equation of geochronology. The half-life. Main geochronological methods. The isochrone method. Geochemistry of radiogenic isotopes as petrogenetic tracers.

Geochemistry of noble gases. Properties of noble gases and historical notes. Noble gases in the atmosphere. Partition coefficients. Sampling methods for various matrices that can be analyzed for noble gases and analytical techniques. Classification into the main geochemical reservoirs and geospheres.

Methods of visualization and processing of geochemical data.

Prerequisites

Chemistry

Teaching form

Total hours: 68

28 two-hour lectures delivered in person

2 three-hour laboratory activities conducted interactively in person

2 three-hour practical sessions conducted interactively in person

Textbook and teaching resource

Slides provided during the lessons

BOOKS

W.M. White, Geochemistry

McSween H.Y., Richardson S.M. Jr., Uhle M.E., Geochemistry (Pathways and Processes)

Longinelli A., Deganello S., Introduzione alla Geochimica

J. Hoefs, Stable isotope Geochemistry

Walker M., Quaternary Dating Methods, Wiley

Porcelli, D., Ballentine, C.J. and Wieler, R. (2002). An introduction to noble gas geochemistry and cosmochemistry.

Reviews in Mineralogy and Geochemistry, 47: 1-18.

FURTHER INSIGHTS

Faure G. (1998), Principles and Applications of Geochemistry

Krauskopf K.B. & Bird, D. K., Introduction to Geochemistry, 1995. McGraw-Hill International Editions.

Ozima M. & Podosek F.A. (2002), Noble Gas Geochemistry, Cambridge University

Burnard P., The Noble Gases as geochemical tracers, Springer

Dongarrà G. & Varrica D. (2004) "Geochimica e ambiente" EDISES

C.J. Allègre, Isotope Geology

Semester

II year, II semester

Assessment method

Oral examination consisting of a discussion on the topics covered during the course. The exam includes no fewer than three open-ended questions, through which the instructor will assess the student's knowledge and depth of understanding, ability to make connections between topics, clarity of expression, use of subject-appropriate terminology, effort put into exam preparation, and attendance of the course.

Vote out of thirty

Office hours

To make an appointment, please write to andrealuca.rizzo@unimib.it

Sustainable Development Goals
