UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Geochemistry

2425-2-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. 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, where possible with a field excursion. Finally, basic knowledge on methods of visualization and processing of geochemical data will be imparted.
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.
Notes on nucleosynthesis and cosmochemistry. Evolution of the solar system and the Earth. Composition of the Earth. 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, in person, Delivered Didactics
3 of 2-hour lab activities, in person, Interactive Teaching
3 of 2-hour practical classes, in person, Interactive Teaching

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
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.
J. Hoefs, Stable isotope Geochemistry
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 exam consisting of an interview on the topics developed during the course. The exam consists of at least three open questions, the first of which is a topic of the program chosen by the student. The teacher will evaluate the knowledge and deepening of the concepts, the ability to connect the topics, the expository clarity, the use of a language appropriate to the subject, and the commitment made to prepare for the exam.

Vote out of thirty

Office hours

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

Sustainable Development Goals