UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Scienze della Terra e del Mare
ACADEMIC YEAR	2022/2023
MASTER'S DEGREE (MSC)	GEORISK AND GEORESOURCES
SUBJECT	INLAND AND MARINE WATERS GEOCHEMISTRY
TYPE OF EDUCATIONAL ACTIVITY	C
AMBIT	21015-Attività formative affini o integrative
CODE	22461
SCIENTIFIC SECTOR(S)	GEO/08
HEAD PROFESSOR(S)	CALABRESE SERGIO Professore Associato Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	86
COURSE ACTIVITY (Hrs)	64
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	2° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**CALABRESE SERGIO** Tuesday 10:00 13:00 Via Archirafi 36, terzo piano, stanza III-8 Thursday 10:00 13:00 Via Archirafi 36, terzo piano, stanza III-8

DOCENTE: Prof. SERGIO CALABRESE

PREREQUISITES	Prerequisites include basic knowledge of inorganic chemistry, and familiarity with basic concepts of geochemistry and mineralogy.
LEARNING OUTCOMES	Knowledge and comprehension skills; the acquisition of the necessary knowledge for understanding the laws governing the abundance and distribution of elements in the hydrosphere; the ability to apply the acquired knowledge in the modelling of natural phenomena and processes, according to the thermodynamic approach to equilibrium, concerning water-rock interaction phenomena in relation to the mobility of elements. At the same time, students are expected to acquire communication and dissemination skills; the ability to expound geochemical issues also to a non-expert audience; to be able to clearly highlight the possible scientific implications of geochemical applications; the ability to study and understand scientific articles in the field, as well as texts; the ability to attend thematic seminars and interact with professional researchers, using the knowledge acquired during the course.
ASSESSMENT METHODS	The assessment of learning will be based on an intermediate test and a final oral test, in order to verify the expected learning outcomes, and at the same time to evaluate the knowledge acquired; a project on the topics of the course will be assessed, which will include the elaboration of geochemical data concerning the hydrosphere and case studies. Assessment criteria include the adoption of appropriate technical language, the ability to reason critically and independently, the aptitude to work and solve problems in groups, and the ability to identify conceptual connections between the various course topics.
EDUCATIONAL OBJECTIVES	The central objective of the course is to study and understand the laws and processes that govern the abundance of elements in the hydrosphere, and how they interact with other geochemical spheres. The composition and evolution of the hydrosphere in relation to the history of planet Earth will be discussed. Specific applications of geochemistry and isotopic geochemistry to environmental problems and the study of the planet's water resources will be analyzed. The main geochemical cycles of the hydrosphere will be discussed. The legislation governing the protection of inland, transitional and marine-coastal waters will be outlined. Elements will be provided to frame the problem of water as a resource necessary for human survival, and in particular its quality; in particular, the perturbations induced by human activities will be discussed, trying to grasp the short- and long-term effects on the natural cycles. Particular attention will be paid to the study and understanding of possible causes of degradation of natural waters and to the preparation of appropriate remedies. To supplement and complete the course, laboratory activities will be proposed: in the classroom (processing and interpretation of analytical data and interpretation of results; use of software for water modelling), in the field (Thermal waters of Alcamo; the waters of the Conca d'Oro), and at analysis laboratories (DiSTeM, INGV, ARPA Sicilia); the didactic-experiential course will allow participants to experiment and familiarize themselves with the main sampling techniques and analytical methodologies for analyzing natural waters.
TEACHING METHODS	Classroom lectures and practical exercises, working tables and active learning methodologies (problem-based learning and flipped classroom); analysis and discussion of specific educational case studies; activities will take place in the classroom, in the laboratory and in the field. The course will be enriched by thematic meetings with specially invited specialists in the field (face-to-face and/ or online).
SUGGESTED BIBLIOGRAPHY	•Appelo C.A.J., Postma D. (2007) Geochemistry, Groundwater and Pollution. Balkema; •Clark I (2015) Groundwater Geochemistry and Isotopes. CRC Press. •Stumm, W. and Morgan, J.J. (1996) Aquatic Chemistry, Chemical Equilibria and Rates in Natural Waters. 3rd Edition, John Wiley & Sons, Inc., New York; •Ottonello G. (1991) Principi di Geochimica. Zanichelli Editore •Analytical methods for water APAT-ISPRA; •Ulteriori articoli e testi di consultazione e gli appunti del corso forniti dal docente

SYLLABUS

Hrs	Frontal teaching
3	Presentation and Introduction to the course. Historical background; water, a precious georisosa; natural waters and the hydrogeochemical cycle; distribution and concentration of elements in natural waters (groundwater, surface waters, meteoric waters, marine waters);
4	Basic chemistry concepts - atomic structure, chemical bonds, units of concentration and conversion of chemical data, estimation of error in charge balance calculations. Introduction to some graphical representations to explain the chemical composition of natural waters. Classification of waters according to Piper, Langelier-Ludwig, Giggenbach diagrams; triangular diagrams.
4	Stable isotopes of H and O. Isotopic size of the Periodic Table. Stable isotopes of greatest interest for hydrogeochemistry: H, O. Reference standards (SMOW, V-SMOW). Isotopic fractionation: why, where and under what conditions it occurs. Fractionation factor. World Meteoric Isotopic Line (MWML) and local. Temperature, altitude, precipitation and 'continental' effects on fractionation.

SYLLABUS

Hrs	Frontal teaching
4	Some concepts and simple tools of thermodynamics. Main concepts relating to equilibrium and equilibrium constants. Definition of the concept of activity and activity coefficients; calculation and use of IAP and SI. Calculation of the variation of the equilibrium constant with temperature. Calculation of the effect of activity coefficients on mineral solubility. Calculation of the effect of complexation on mineral solubility;
4	Study of the concepts of absorption, adsorption and ion exchange. Definition of the concept of oxidation and reduction. Examples of redox reactions in water geochemistry. Balancing of redox reactions. Definition of Eh and pe variables. Calculation of Eh from redox pairs. Measurement of Eh in the field and fallout from such measurements. Construction and use of pe-pH (Eh-pH) diagrams.
3	Introduction to some basic concepts of chemical kinetics; order of a reaction and fundamental laws of kinetics. Use of the Arrhenius equation. Study of factors controlling mineral precipitation and study of dissolution kinetics.
4	Study of factors influencing the resistance of primary minerals to weathering. Study of the nature of weathering products (clays, oxides and hydroxides). Study of the principles governing the solubility of quartz. Study of the principles governing the solubility of Al and Fe hydroxides. Study of the incongruent dissolution processes of silicates. Calculations and use of activity diagrams.
3	Contamination of natural waters; anthropogenic (urban and industrial) and natural sources (volcanoes, geogenic); notes on the composition of the main organic compounds in natural waters and the main contamination processes;
3	Regulatory overviews on the protection of natural waters; Italian water legislation, historical background and elements on the Consolidated Environment Act (Legislative Decree 152/2006); the protection of water bodies from pollution. The roles of institutions, the scientific community and citizenship; River Contracts, Citizen Science and examples of active citizenship.

Hrs	Workshops
12	Teaching workshop on the use of instrumentation for sampling and analysis of natural waters: pH-meter and conductivity meter, Eh-meter and dissolved oxygen; volumetric titration of carbonates and bicarbonates; ion chromatography; spectrophotometry; ICP-MS and ICP-OES; isotopic analysis; sampling of dissolved gases in natural waters. Geochemical data processing and statistical analysis using spreadsheets and dedicated software. Construction of graphs for the representation of geochemical data and realisation of process curves using calculation codes. Interpretation of analytical results for the understanding of natural phenomena in hydrogeochemical systems.
20	Outdoor activities. Excursions and educational field exercises on sampling natural waters and dissolved gases (Alcamo thermal waters; Conca d'Oro waters). Educational visits to the laboratories of the DiSTeM, the National Institute of Geophysics and Volcanology (INGV) Palermo section, and the ARPA). These activities will be modulated and agreed upon with the participants, and may vary depending on weather conditions, availability of means of transport and financial availability of the CDS.