Study Plan

School: School of Sciences and Technology
Degree: Master
Course: Geology (cód. 686)

1st Year - 1st Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
GEO13461M	Introduction to Scientific Research in Geology	Geology	3	Semester	78
GEO13473M	Industrial Mineral Resources	Geological Engineering	3	Semester	78
GEO13472M	Earth Materials Characterization	Geology	6	Semester	156
GEO13462M	Data analysis and treatment in Geology	Geology	6	Semester	156
GEO13701M	Metallogenic Models	Geology	6	Semester	156
GEO13474M	Hydrogeological Resources and Geoenergy	Geology	6	Semester	156

1st Year - 2nd Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
GEO13464M	Tectonics and sedimentary processes	Geology	6	Semester	156
GEO13467M	Tectonics and Orogenic Processes	Geology	6	Semester	156
GEO13477M	Petrogenetic Processes	Geology	6	Semester	156
GEO13465M	Mapping of Orogenic Belts	Geology	6	Semester	156

Options

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
GEO13468M	Quaternary Geology and Recent Processes	Geology	6	Semester	156
GEO13469M	Microtectonics	Geology	6	Semester	156
GEO13470M	Geology and Heritage	Geology	6	Semester	156
GEO13471M	Geologic Risks	Geology	6	Semester	156
GEO13475M	Environmental Passives and Regional Planing	Geology	6	Semester	156
GEO13478M	Applied Geochemistry	Geology	6	Semester	156

2nd Year - 3rd Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
GEO13466M	Digital Cartography Applied to Geology	Geology	6	Semester	156
GEO13476M	Geological and Mining Exploration	Geological Engineering	6	Semester	156

2nd Year - 3rd Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Options					

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
GEO13468M	Quaternary Geology and Recent Processes	Geology	6	Semester	156
GEO13469M	Microtectonics	Geology	6	Semester	156
GEO13470M	Geology and Heritage	Geology	6	Semester	156
GEO13471M	Geologic Risks	Geology	6	Semester	156
GEO13475M	Environmental Passives and Regional Planing	Geology	6	Semester	156
GEO13478M	Applied Geochemistry	Geology	6	Semester	156

Dissertation

2nd Year - 4th Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Dissertation					

Conditions for obtaining the Degree:

*** TRANSLATE ME: Para aprovação na componente curricular deste Mestrado, é necessário a aprovação (através de avaliação ou creditação) das seguintes unidades curriculares:

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1º Ano

1.º Semestre:

- 6 UC Obrigatórias num total de 30 ECTS{\}newline

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2.º Semestre:

- 4 UC Obrigatórias num total de 26 ECTS

- 1 UC Optativa num total de 6 ECTS

2.º Ano{\}newline

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3.º Semestre:

- 2 UC Obrigatórias num total de 12 ECTS

- 1 UC Optativa num total de 6 ECTS {\}newline

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Para obtenção do grau, é necessário também a aprovação em Dissertação/Relatório de Estágio, com o total de 42 ECTS, no 3.º e 4.º Semestre. ***

Program Contents

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Introduction to Scientific Research in Geology (GEO13461M)

- Bibliographic search: evaluate the credibility of bibliographical sources, databases construction;
- Research work plan – timetables. The ethical aspects of conducting scientific research.
- The object of research in Geology. History of science in Geology. The roll of Geology in the new societal challenges for 21st century.
- Research funding: cost / benefit (budgets), sources of funding, partnerships;
- Data analyses in Geology: diversity, multidimensionality, correlation, randomness, uncertainty, and temporal and spatial inhomogeneity. New information technology in Geology (e.g. Big data processing);
- Laboratory facilities and emerging issues in field of new technologies;
- Ethical aspects related to the elaboration of scientific articles in peer review journals;
- Critical analysis of a scientific text.
- Transmission of scientific knowledge: abstract, article, poster and oral presentation.

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Industrial Mineral Resources (GEO13473M)

THEORETICAL

1.Non-metallic mineral resources in the economy and society.
2.Geology of the main non-metallic mineral raw materials (industrial minerals, clays, ornamental rocks and industrial rocks).
3.Types of exploitations: cycle of quarry work in extractive units of ornamental rock; cycle of quarry work in extractive units of aggregates.
4.Characterization of mineral raw materials. Main properties of raw materials for industrial applications.
5.Ornamental rock processing units, aggregate production units and clay concentration units.

PRACTICE

1.Characterization of clays: Atterberg limits.
2.Characterization of aggregates: granulometric analysis, shape index, flatness index, sand equivalent, methylene blue.
3.Characterization of ornamental rocks: mechanical resistance to compression, mechanical resistance to flexion, resistance to slipping.
4.Contact with the national extractive reality (technical visits to extractive and processing units).

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Earth Materials Characterization (GEO13472M)

Introduction: geological materials characterization (bulk analysis vs microanalysis), analytical chemistry concepts
Applied petrography: the petrographic microscope in the study of composite materials as ceramics, concrete and mortars
Diffraction techniques: interaction ray-x with matter, geometric conditions, intensities and structure determination
Spectroscopy techniques: interaction matter-radiation, X-ray absorption and emission spectroscopies, vibrational and mass spectroscopies
Microanalysis: introduction, interaction electron-matter, electron microscopy, electron, nuclear and photonic microprobe, ablation methods: detention limits, precision, spatial resolution and applications
Element and isotopic geochemistry: geochemical behaviour of the elements, sampling and preparation of samples, main analytical methods, treatment a presentation of the data
Physical properties of rocks in what concern to permeability vs. porosity and rock tension, strength and deformability

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Data analysis and treatment in Geology (GEO13462M)

Theoretical

1. Introduction
-Exploratory data analysis
-Anomalous and regional background
-Analysis of modeled data
2. Multivariate geochemical data
- Exploratory methods
-Limit elements and pathfinders
- Rejected data and acquisition problems
-Outliers; Robust estimation
-Transformation of data
3. Geochemical and geophysical data modeling
- Regression methods
-Classification analysis, principal component analysis
- D2 graphs: A multivariate extension of (qq) -plots
-Analysis of canonical variables
-Classifying unknown observations
4. Inversion problems
- Conceptualization
- Linear inverse problem
- Non-linear inverse problem
- Applications
5. Future Trends

Practice

1- Introduction to data analysis and processing software.
2- Data processing
3. Analysis and treatment of data applied to a case study

Preliminary data analysis
- Exploratory analysis of multivariate data
-Multivariate data modeling
-Inversion of data

Back

Metallogenic Models (GEO13701M)

Theoretical
1- Metallogenic models: Basic concepts, utility and examples of use
2- Types of metallogenic models:
3- Descriptive models and the classification of mineral deposits:
3.1- Models related to igneous and hydrothermal processes;
3.2- Models related to metamorphic processes;
3.3- Models related to sedimentary processes;
3.4- Other mineralizing processes
4- Application of grade-tonnage models to quantify deposits
5- Application of probability of occurrence models to geological-mining prospecting
6- Genetic models and their applications
7- Critical analysis and source of error of the metallogenic models
8- Geodynamic framework of the metallogenic models
Practice
1- Creation of a metallogenic model from a case study
1.1- Collection of relevant information and creation of database
1.2- Implementation of a descriptive and tonnage models
1.3- Error evaluation in the model created
2-Technical visit to Portuguese case studies

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Hydrogeological Resources and Geoenergy (GEO13474M)

Module 1 – Mineral and thermal groundwater
Mineral water and geological environments
Groundwater exploration projects for mineral, spring and thermal groundwater
Thermal waters; design of wells for mineral and thermal groundwater.

Module 2 - Geothermal
Geothermal environments; Lindal diagram.
Geothermal heat sources and transfer, quantifying resources;
Geophysics applied to geothermal resources;
Geothermal activity in Portugal.

Module 3 - Hydrogeology in the energy transition
Climate change and emission mitigation objectives
Geological storage of CO2
Geological reservoirs for energy storage
Heat pumps and thermal storage in aquifers.

Module 4 - Groundwater beyond the “resource”
Environmental Hydrogeology; contamination and remediation of aquifers;
Definition of wellhead protection areas; Rational exploitation of aquifers.
Water regulation in Portugal and Europe

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Tectonics and sedimentary processes (GEO13464M)

Types of sedimentary basins and tectonic settings.
Analysis of sedimentary facies and deposition environments.
Sedimentary petrography and petrology of siliciclastic and carbonate rocks.
Geochemistry of total rock of siliciclastic rocks.
Sm-Nd and Rb-Sr isotopic chemistry of siliciclastic rocks.
U-Pb geochronology on zircon of siliciclastic rocks.
Sedimentary provenance and models of paleogeographic reconstruction.

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Tectonics and Orogenic Processes (GEO13467M)

THEORETICAL COMPONENT
1. Introduction
2 - Subduction zones, island arcs and active continental margins.
3 - Terranes
4 - General structure of orogenic belts.
5 – Young orogens
5.1 - Ocean-continent convergence, the example of the Andes.
5.2 - Continental collision, the example of the Himalayas.
5.3 – Arc-continent collision, the example of Timor.
6 – The variscan orogens based on Geology of the Iberian Peninsula.
7 - Structure and geodynamic evolution of the SW region of Iberia Peninsula - introduction to the field classes

FIELD COMPONENT
Geotraverse between the Ossa-Morena/Central-Iberian Zone boundary and the SW region of the South Portuguese Zone (4 days).

LABORATORY PRACTICE COMPONENT
Analysis and interpretation of selected geological maps, from the Iberian Peninsula and several other regions of the world.

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Petrogenetic Processes (GEO13477M)

1. Igneous processes associated with the genesis and evolution of oceanic crust
1.1 - Magmatism in divergent boundaries
1.2 - Magmatism in convergent boundaries
1.3 - Intraplate magmatism.
2. Metamorphic and metassomatic processes associated with the evolution of oceanic crust
2.1 - Hydrothermal vents
2.2 - Oceanic metamorphism
2.3 - Dynamic metamorphism
3. Igneous processes associate d with the genesis and evolution of continental crust
3.1 - Anorogenic magmatism
3.2 - Orogenic magmatism
4. Metamorphic processes associated with the evolution of continental crust
4.1 - Low-grade metamorphic belts
4.2 - High grade metamorphic belts
4.3 - Paired metamorphic belts

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Mapping of Orogenic Belts (GEO13465M)

1. Use of Geological Mapping for the understanding of fold Belts.
1.1. The importance of map scales.
1.2. The importance of thematic maps.
1.3. The importance of Fold Belt ages: old orogens versus young orogens.
1.4. Interpretation of geological maps of classical orogens (e.g. Alps, Andes e Himalayas).

2. Geological Mapping and Geodynamical Evolution of Portugal.
2.1. Cadomian and Varisca cycles; the mapping of metamorphic regions.
2.2. Atlantic and Alpine cycles; from the mapping of sedimentary basins to the mapping of the inversion processes.

3. Geological mapping in different geodynamical environments.
3.1. Geological mapping in low in situations of sedimentary basins inversions.
3.2. Geological mapping in low to moderate metamorphic regions.
3.3. Geological mapping in high metamorphic grade regions.

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Quaternary Geology and Recent Processes (GEO13468M)

Quaternary stratigraphy
Study Methods for the Quaternary
Climate Cycles: Effects and Forcing Mechanisms
Eustatic Cycles
Landscape Evolution and Continental Sedimentation
Coastal Dynamics
Neotectonics
Geological Hazards

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Microtectonics (GEO13469M)

Relationship between deformation and metamorphism.
Intra-crystalline deformation mechanisms.
Brittle deformation vs Ductile deformation.
Cataclasite and Mylonite.
Foliations, lineations and metamorphic mineral growth.
Practical application to shear zones and progressive deformation with different conditions of pressure and temperature.

Back

Geology and Heritage (GEO13470M)

1. The Big History; the importance of Geology in the development of the Societies during the historical times.
2. Geological heritage; what it is? The great diversity of the subjects related to Geology led to a strong heterogeneity of the Geological heritage that includes the use of geological materials by the Man.
3. Geological heritage; to whom disseminate? The different kinds of geoheritage could interest different audiences.
4. Geological heritage; how to disseminate? The strategy of science communication to use will depend, not only of the characteristics of the geoheritage, but also of the public that is intended to be achieved.
5. Geological heritage; how to preserve? The use of the geoheritage by the people, usually led to some risks in its preservation. It is important, not only to preserve/mitigate such risks, but also to recuperate the geoheritage, sometimes using sophisticate technologies.
6. Geological heritage; case studies (field trip to geosites, museums and/or geopar

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Geologic Risks (GEO13471M)

Theoretical:
1.Definition of Risk
Danger
Vulnerability
Mitigation
2.Earthquakes
Seismic microzoning
Seismic forecasting and prevention
Tsunamis
3.Flood plains
Mechanisms for quantification and flow control
Factors and effects of floods
Prevention
Mitigation Measures
4.Movements of soil and rock masses
Types of movement
Inducing mechanisms and factors
Landslides
Rock Movements
Stabilization of slopes
5.Coastal hazards
6.Volcanic eruptions
Forecasting and Monitoring
Security and prevention actions
7.Soils
Erosion of soils
Erosion Factors
Subsidence and solos
8.Radioactivity
Theoretical foundations
Natural decay of rocks.
Consequences of radioactivity, risks associated and mitigation measures

Practice:
Analysis of selected articles and sets of geological, topographic, satellite images, charts of slopes, soil occupation, climatic, with a view to the identification and characterization of natural hazards.

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Environmental Passives and Regional Planing (GEO13475M)

1. Environmental Challenges of the 21st Century; Role of geology.
2.Great history & geological contingency.
3.Portugal in the international context regarding the environmental liabilities, spatial planning; state of art.
4.Legislation, directives and standards relevant to environmental liabilities and land use planning.
5.Benchmarking
6.Characterization and territorial project.
7.Field study visit

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Applied Geochemistry (GEO13478M)

1- Principles and methods of Surficial Geochemical Processes
Weathering environments
Stream and lake sediments
Surface properties of solid constituents
Sampling methods
2- Principles of fluid and aquatic Geochemistry
Surface and interstitial water
Physical-chemical processes
Interactions with minerals and among dissolved species
3- High temperature Geochemistry
Behaviour of trace elements and geological controls in igneous processes
Geochemical composition of the mantle, continental and oceanic crust
4- Using geochemical data of rare earth elements (REEs) on surficial geochemistry
The chemistry of REEs
Interpreting REEs patterns
Multi-element diagrams
5- Environmental Geochemistry
Biogeochemistry of TE in surface environments
Environmental aspects of mine wastes
Ex-situ and in-situ strategies for remediation of contaminated soils and sediments
6- Analytical Geochemistry and data quality
7- Case studies

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Digital Cartography Applied to Geology (GEO13466M)

Theoretical:
1- Formation of geological images (multispectral images, radar, satellites and drones).
2- Software and algorithms of analysis and treatment of images.
3- Extraction of elements of an image (topography, slopes, hillshading).
4- Classification of images with indices and thresholds
5- Extraction of characteristics of an image (supervised and unsupervised methods, introduction to machine learning applied to geological images).
6- Remote information integration (Creation of thematic maps).
7- Crossing geological field information with digital information.

Practice:
1- Introduction to image processing software.
2- Sources of free and proprietary information.
3- Creation of thematic maps from satellite and drone data.
4- Creation of images from indexes and maps of characteristics.
4- Examples of image classification algorithms applied to geology.
5- Creation of thematic maps.
6- Research project.

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Geological and Mining Exploration (GEO13476M)

- Objectives and scope of the prospection: Concepts of resources and reserves, general notes of mineral economy and mining legislation.
- Phases and planning of a survey project: Strategic exploration, tactical exploration and mineral deposit evaluation.
- Remote analysis: Remote detection and multispectral images analysis. Acquisition and image processing with drone.
- Geological prospection: Mineralometric studies. Thematic cartography. Guide levels and geological models. Survey trenches.
- Geophysical prospection: Geophysical methods and their applications. Meaning of geophysical data.
- Geochemical prospection: Objective and planning of a geochemical survey. Concepts of geochemical mobility and dispersion. Background and anomalies.
- Computer graphics: Analysis, data interpretation and construction of 3D geological models.
- Drilling and evaluation: Drilling analysis and log construction. Calculation of contents and volumes.
- Case studies of exploration/exploitation in Portugal.