UNIVERSITA' DEGLI STUDI DI MILANO
PROGRAMME DESCRIPTION - ACADEMIC YEAR 2020/21
MASTER DEGREE
Earth Sciences (Classe LM-74)
Enrolled from 2009/2010 academic year

HEADING

Degree classification - Denomination and code:	LM-74 Geology
Degree title:	Dottore Magistrale
Curricula currently available:	Sedimentary basins and energetic resources / Environmental Geology, Engineering Geology and Hydrogeology / Geophysics and structural geology with applications / Geology of mineral resources and geomaterials
Length of course:	2 years
Credits required for admission:	180
Total number of credits required to complete programme:	120
Years of course currently available:	1st , 2nd
Access procedures:	Open, subject to entry requirements
Course code:	F97

PERSONS/ROLES

Head of Study Programme

Prof. Massimo Tiepolo

Tutors - Faculty

Tutors per l'orientamento: Prof.ssa Tiziana Apuani, Prof. Fabrizio Berra, Prof.ssa Patrizia Fumagalli, Prof.ssa M. Iole Spalla, Prof.ssa Anna Maria Marotta.
Tutors piani di studio per il percorso "Bacini Sedimentari e Risorse Energetiche": Prof.ssa Elisabetta Erba, Prof. Riccardo Bersezio.
Tutors piani di studio per il percorso "Geologia Applicata al Territorio, all'Ambiente e alle Risorse Idriche": Prof. Giovanni Beretta, Prof.ssa Tiziana Apuani.
Tutors piani di studio per il percorso "Geofisica e Geologia Strutturale con Applicazioni": Prof.ssa Anna Maria Marotta, Prof.ssa M. Iole Spalla.
Tutors piani di studio per il percorso "Geologia delle Risorse Minerali e Geomateriali": Prof. Stefano Poli, Prof. Fernando Camara Artigas.

Degree Course website

https://scienzeterra.cdl.unimi.it/it

Ufficio per la Didattica, al momento solo via mail scrivendo a: cclsg@unimi.it https://www.unimi.it/it/corsi/corsi-di-laurea/scienze-della-terra

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https://www.unimi.it/it/studiare/biblioteche

CHARACTERISTICS OF DEGREE PROGRAMME

General and specific learning objectives

The Master's Degree Course aims to train Graduates with in-depth preparation in various branches of the Earth Sciences, offering opportunities of scientific development and of employment both in public and private fields. The Degree Course provides theoretical and practical preparation based also on participation in field and laboratory activities, internships and traineeships, research stages in public and private institutions including international ones.

Some of the thematic areas offering solid professional opportunities are: (1) Analysis, quantification and modeling of Earth processes interacting within the planet, on its surface, in atmosphere and hydrosphere, related to the origin of energy, water and mineral resources. (2) Evaluation and characterization of natural minerals for their role in geologic processes and with respect to industrial applications. (3) Basic field mapping and thematic mapping for the interpretation of geologic processes at various scales. (4) Analysis and interpretation of geologic processes interacting with human activities for a balanced use of natural resources and for protection of the environment and archeological and cultural sites. (5) Field surveys and direct/indirect prospecting for the parametrization of technical properties and behavior of soils and rocks for wide and small

scale engineering plans. (6) Exploration, exploitation, protection and reclamation of underground water resources, after local and diffuse pollution events. (7) Exploration, evaluation and management of natural resources, with particular reference to energy and mineral resources, also in relation to the environmental impact deriving from their exploitation. (8) Characterization and prevention deriving from natural risks affecting the territory, and their evaluation in the context of territorial planning.

Expected learning outcomes

In the Master's Degree Course in Earth Sciences, students will acquire in-depth knowledge in the different branches of geological sciences in their theoretical, experimental and practical aspects. They will have to address the analysis of complex problems inherent in natural processes, in the transformation of natural resources, and in the processes resulting from human activities, relying on solid skills regarding analytical-instrumental techniques, methodologies for data acquisition on the field, and construction of theoretical-interpretative models. They will properly transfer analytical results into interpretations, using modern software. The goal is to train geologists who are able to: (a) perform the analysis of geological systems and processes, their temporal evolution and modeling also for application purposes; (b) develop basic and applied geological research in different public and private areas, including academic and industrial fields; (c) recognize and predict, in the medium and long term, the effects of the interaction among geological processes of different nature, human impact, and global climate changes, as well as restore and preserve the quality of complex natural realities, identify the vulnerability of the sites, the danger of geological phenomena and the interactions with anthropic systems, providing for the management and mitigation of the risk; (d) operate both in industries that process natural materials (and synthetic analogues) and in public institutions, in order to manage instrumentation, organize and carry out measures to meet research/ development, quality control requirements in the framework of legislative regulations or processes manufacturing; (e) carry out their activity independently in a professional or subordinate context with public bodies or companies in the corporate world that have skills in the geological and geological application fields. Activities and knowledge can provide skills in planning actions on the environment, even in an interdisciplinary way.

Professional profile and employment opportunities

Earth Science Master graduates are formed to perform the Geologist authonomous professional activity. The role of Professional Geologist is officially attributed by Ordine Nazionale dei Geologi by means of insertion in Section A (Geologo senior), in accordance with law D.P.R. 5 Giugno 2001, n. 328; after passing a State Exam.

Otherwise, Master graduates may find employment opportuninties with research companies, public administrations, professional and consulting companies in Italy or abroad, companies and laboratories for treatment of natural materials.

Generally, the various sectors of the employment market, included in the intellectual, scientific and highly specialised professions are listed within category 2 ISTAT (2.1.1.5; geologists, geophysicists and other related professions) are the following:

- Field mapping, updating of geolgical, technical and thematic maps;
- Planning, performing and interpretation of geophysical and geological investigations for civil engineering; prospecting and carachterisation of mineral, water end energy resources, environmental monitoring;
- Modeling of geologic processes for the analysis of slope instability, underground water circulation and pollutors transport, tunneling, and related activities;
- Prospecting, evaluation and managing of geological resources, direction of mining and quarrying works;
- Coordination of protection systems in mobile and temporary yards;
- Direction of mineralogical, petrographical, sedimentological, geochemical and geotehcnical laboratories;
- Territorial planning of hazardous sites and hydrogeological protection systems;
- Environmental monitoring for protection of water resources, reclamation and de-pollutioning of acquifers and sites, waste management;
- Control of industrial quality, tecnological use of geomaterials for mecnanical, chemical and electronic industries, use of dimension stones; gemmology;
- Analysis, reclamation and managing of degraded sites, modeling of geoenvironmental processes and systems, managing, yard direction, testing and monitoring;
- Managing of Geographic Information Systems, particularly the ones oriented to geoenvironment;
- Protection of cultural and paleontological heritages, monuments conservation, geoarchaeology;
- Planning of civil engineering constructions and of environmental and soil protection, in collaboration with affine professionals;
- Evaluation of the environmental impact of wide engineering interventions (VIA) and strategic environmental evaluation (VAS);
- Scientific outreach and journalism;
- Didactics of Earth Sciences;
- Forensic Geology;

The Earth Science Master represents a preferential quality in PhD selections.

Notes

To obtain the degree, students are required to demonstrate an English language proficiency at level B2 within the Common European Framework of Reference for Languages (CEFR). This level can be assessed in the following ways:

- by submitting the language certificate achieved no more than three years prior to the submission, at level B2 or higher, recognised by the University (the list of recognised language certificates can be found at https://www.unimi.it/en/node/297/). The language certificate must be uploaded during the admission process;

- by taking the Placement Test, organised by SLAM exclusively during the first year, from October to January. Students who fail to reach level B2 will have to attend an English course organised by SLAM. The Placement Test is compulsory for all students who do not have a valid language certificate.

Students who do not take the Placement Test within the deadline and students who fail the SLAM end-of-course test within six attempts will have to obtain a language certificate within the year in which the language exam is scheduled.

LEVEL OF ENGLISH ASSESSED THROUGH A COMPUTER-BASED TEST DURING THE BACHELOR'S DEGREES OBTAINED AT THE UNIVERSITY OF MILAN. English levels B1 and B2 achieved no more than four years previously are deemed valid. The verification is automatic with no need to attach any certificate during the application phase.

EXPERIENCE OF STUDY ABROAD AS PART OF THE TRAINING PROGRAM

The University of Milan supports international mobility by providing its students with the opportunity to spend study and internship periods abroad. It is a unique chance to enrich your educational path in a new exciting environment.

The agreements entered into by the University with over 300 universities from 30 different countries under the European Erasmus+ programme allow regularly enrolled students to carry out part of their studies at one of the partner universities or to undertake internships at companies, training and research centres and other organizations.

Similar international mobility opportunities are provided outside Europe, through agreements with a number of prestigious institutions.

Study and internships abroad

The department of Earth Sciences offers opportunities for spending time as guest students at European universities and research centres both for attending courses/exams and for research and apprentiships related to projects for graduate, post-graduate and PhD students. Studying and doing research in foreign universities is not only an important life experience and the occasion for thorough learning of a foreign language, but is also, and primarily, the opportunity for experiencing and acquiring different and more flexible learning approaches. Doing research and apprentiships abroad may allow the access to facilities not available here (e.g., highly specialized labs), the performance of applied research on specific fields as well as the first-hand interaction with wider, international research groups. At present our partner universities in official Erasmus exchange agreements devoted to course/exams and, where indicated, research activity, are located in France, Germany, Spain, Holland, Switzerland and Turkey. However the agreements for bursaries specifically devoted to applied research/apprentiships can be stipulated with any other university or research centre with which any members of our department have or may establish collaboration on common research interests. For these research bursaries and, in general, for the correct validation of the research activity done by our students abroad, the role and the active involvement of a local member of the department is of fundamental importance, as he/she will act as official, competent internal scientific tutor for the student hosted in the guest foreign university. Students may access to "normal" Erasmus bursarships, allowing course/exam in addition to research activities in partner universities, as well as Erasmus Student Placement bursaries exclusively devoted to research/apprentiship activities. The access to the different types of bursary is done by means of separate application procedures. The activity (course/exam or research) that the candidate will do in the guest foreign university has to be agreed with the local professors/tutors in both original and guest universities by means of the "Learning Agreement".This document is of prime importance for the final validation and official administrative registration of the activity done abroad.

How to participate in Erasmus mobility programs

How to participate in Erasmus+ mobility programmes

The students of the University of Milan can participate in mobility programmes, which last 3 to 12 months, through a public selection procedure.
Ad hoc commissions will evaluate:
• the candidate's proposed study programme abroad
• his/her foreign language proficiency
• the reasons behind his/her application
Call for applications and informative meetings
The public selection generally begins around February each year with the publication of a call for applications specifying the destinations, with the respective programme duration, requirements and online application deadline.

Every year, before the deadline for the call, the University organizes informative meetings to illustrate opportunities and rules for participation to students.

Erasmus+ scholarship
The European Union grants the winners of the Erasmus+ programme selection a scholarship to contribute to their mobility costs, which is supplemented by the University funding for disadvantaged students.

Language courses
Students who pass the selections for mobility programmes can benefit from intensive foreign language courses offered each year by the University.

Learn more at https://www.unimi.it/en/international/study-abroad/studying-abroad-erasmus

For assistance, please contact:
International Mobility Office
Via Santa Sofia 9 (second floor)
Tel. 02 503 13501-12589-13495-13502
E-mail: mobility.out@unimi.it
Desk opening hours: Monday to Friday 9 am - 12 noon

1st COURSE YEAR Core/compulsory courses/activities common to all curricula		
Learning activity	**Ects**	**Sector**
English proficiency B2 (3 ECTS)	3	ND
Geology	6	GEO/02, GEO/03
Mineral Resources and Geomaterials	6	GEO/07, GEO/09
Physics of Earth's Interior	6	GEO/10
Technical Geology	6	GEO/05
Total compulsory credits	27	

COURSE YEAR UNDEFINED Core/compulsory courses/activities common to all curricula		
Learning activity	**Ects**	**Sector**
Trainig Stage	6	NA
Total compulsory credits	6	

Further elective courses common to all curricula		
Environmental Geochemistry	6	GEO/08
Geothermal Energy	6	(3) GEO/05, (3) GEO/09
Groundwater Modelling	6	GEO/05
Isotope Geochemistry and Geochronology	6	GEO/08
Mineral Physics	6	GEO/06

End of course requirements common to all curricula		
Final Dissertation	30	ND
Total compulsory credits	30	

ACTIVE CURRICULA LIST

Sedimentary basins and energetic resources Course years currently available: 1st , 2nd
Environmental Geology, Engineering Geology and Hydrogeology Course years currently available: 1st , 2nd
Geophysics and structural geology with applications Course years currently available: 1st , 2nd
Geology of mineral resources and geomaterials Course years currently available: 1st , 2nd

Procedure for choosing a curriculum

Curriculum selection

The selection of the curriculum will be performed through the compilation of the study plan during the first or second year.

CURRICULUM: [F97-A] Sedimentary basins and energetic resources

Qualifying Training Objectives

Qualifying Training Objectives:

The general purpose of the curriculum is the training of geologists with a detailed knowledge in the qualitative and quantitative characterization of sedimentary systems (sedimentary environments, depositional processes, sedimentary basins, ecosystems) from the geological record and in present-day settings, with attention to the geological, geodynamic and environmental context in which they form or where formed. Fundamentals of the methodological and qualitative-quantitative approach will be provided, with attention to field and laboratory analyses and to the elaboration of two- and three-dimensional models. Paleontological skills (taphonomy, systematics, biostratigraphy, paleobiology) are provided, with applications to the diverse aspects of paleontology, in particular regarding dating, facies analysis, (paleo) environmental-climatic-oceanographic reconstructions.

The curriculum provides a training focused on tools and methodological approaches for the study of the subsurface, for applications related to natural resources (e.g.; hydrocarbons, other fossil fuels, geothermal energy) and for environmental protection (e.g.; storage of methane gas, re-injection of harmful gases, identification of sites contaminated by hydrocarbons,

monitoring of subsidence).
The graduates in this curriculum own basic and specialistic preparation about advanced geological and geophysical investigation tools, with basic concepts about energy source economics and energy resource policy. The competences acquired develop skills in the multidisciplinary analysis of sedimentary processes, environmental evolution, biodiversity and energy sources of sedimentary basins.

Skills acquired

Expected learning outcomes
The graduates in this curriculum will acquire skills required to study and understand the processes ruling sedimentary basins and controlling the related resources, their origin, exploration, management, and use. The knowledge acquired provides the ability to reconstruct the distribution and 3D-4D spatial-temporal relationships among sedimentary bodies. The graduates will be also able to study the processes that affected in the past oceans and emerged lands in order to understand the evolution and climate and environmental changes in the past, to be used as a predictive tool for the present.

1st COURSE YEAR Core/compulsory courses/activities Curriculum-specific features Sedimentary basins and energetic resources			
Learning activity		**Ects**	**Sector**
Sedimentology and Laboratory		9	GEO/02
Stratigraphy and Laboratory		9	GEO/02
	Total compulsory credits	18	
2nd COURSE YEAR Elective courses Curriculum-specific elective courses for Sedimentary basins and energetic resources			
Basin Analysis, Hydrocarbon Geology and Practicals		9	GEO/02
Micropaleontology and Laboratory		9	GEO/01
Further elective courses Curriculum-specific features Sedimentary basins and energetic resources			
Biostratigraphy		6	GEO/01
Complements of Paleontology		6	GEO/01
Diagenesis and Sedimentary Rock Geochemistry		6	GEO/02
Marine Geology Exploration and Georesources		6	GEO/01
Regional Stratigraphy		6	GEO/02, GEO/01
Seismic Exploration		6	GEO/11

CURRICULUM: [F97-B] Environmental Geology, Engineering Geology and Hydrogeology

Qualifying Training Objectives

Educational Objectives:
One of the key sub-disciplines of Geology is Engineering Geology, i.e. the application of Geology to civil and infrastructure engineering works of any size and importance.
To this aim, the measurement or estimation of rock and soil properties (strength, deformability and permeability), in relation with geological properties, is of paramount importance. Measurement techniques include site surveying and investigation, adopting both direct and indirect exploration techniques, and laboratory experiments, also aimed at producing thematic maps.
Identifying the relevant parameters of the geologic medium serves the scope of designing engineering works such as dams, tunnels, roads, bridges, landfills, and assessing the ground-structure interactions. To support the design of engineering works, both theoretical and numerical modelling techniques are employed, aimed at optimizing their performance from the technical and economical point of view, as well as minimizing their environmental impact, in agreement with relevant design standards.
Among problems related to land and environment protection, hydrogeological instability phenomena (e.g. landslides and floods) issues are quantitatively addressed, by means of empirical, analytical and numerical methods, aimed at monitoring and preventing unwanted events as well as designing remediation measures.

Skills acquired

The graduate will have the knowledge to plan and carry out the investigations and participate to the design of the above mentioned engineering works. She/He will be able to plan and carry out investigations for the assessment of slope instabilities and suggest remediation and protection measures.
Concerning the sustainable use of the resources, the Engineering Geology curriculum trains geologists for the quantitative investigation, qualitative evaluation, intelligent management, and overall protection of water resources, providing for their restoration in case of contamination. The curriculum will furnish an advanced training on aquifer, aquitard, and aquiclude parameterization, as well as on groundwater flow in both porous and fissured materials. Groundwater flow modelling oriented at an optimal use of the resource, including its relationships with superficial waters and climatic forcing, will be a key topic of the degree. The behavior of organic compounds in groundwater will be investigated, too. Regarding contamination, problems related to both point and non-point sources will be addressed, considering their specificities, through state-of-the-art identification and remediation techniques, including numerical modelling. All these instruments are essential to design groundwater protection and remediation measures at different scales, and to perform environmental risk analyses. The curriculum will provide the know-how for designing groundwater collection and abstraction systems, and organizing optimal groundwater monitoring networks, in respect of the existing legislation.

The graduate will have the knowledge to plan and carry out the appropriate investigations to assess quantity and quality of water resources, to map with modern information technology instruments their distribution and vulnerability to contamination, to design groundwater collection and abstraction systems, and to set-up groundwater monitoring networks with special attention

1st COURSE YEAR Core/compulsory courses/activities Curriculum-specific features Environmental Geology, Engineering Geology and Hydrogeology			
Learning activity		**Ects**	**Sector**
Applied Geomorphology		6	GEO/04
Geotechnical and Hydrogeological Survey and Laboratory		9	GEO/05
Groundwater Exploration and Management with Laboratory		9	GEO/05
	Total compulsory credits	24	

Further elective courses Curriculum-specific features Environmental Geology, Engineering Geology and Hydrogeology		
Geotechnics and Laboratory	9	ICAR/07
Hydrostratigraphy and Aquifer Sedimentology and Laboratory	9	GEO/02
Geographical Information Systems	6	GEO/05, ICAR/06
Rock Mechanics and Slope Stability	6	GEO/05, ICAR/07
Shallow Depth Geophysics	6	GEO/11
Water Quality and Remediaton Techniques	6	GEO/05

CURRICULUM: [F97-C] Geophysics and structural geology with applications

Qualifying Training Objectives

Qualifying Training Objectives:

This curriculum results from the integration of geophysics and structural geology for the study of Earth dynamics. Analytical and synthesis tools of multiscale data will be provided, starting from the methodologies that allow to monitor, model and interpret the geodynamic processes, up to the rock granular structure.

The goal of the geophysical part is to provide methodological tools aimed at studying the fundamental physical processes that control the dynamics of the Earth System at all spatial and temporal scales, including geodetic methodologies finalized to territory monitoring.

The objective of the structural geology part is focused on the interpretation of large-scale structures in subduction systems, orogenic belts, rifting, oceanic ridges and transcurrent systems, by integrating multiscale structural analysis with other geological methods, to locate geological events of economic or scientific interest in the unifying framework of the New Global Tectonics.

Skills acquired

Geophysics provides the physical-mathematical basis to dealing large-scale geophysical processes such as the convection of the mantle, the propagation of seismic waves in the most superficial portion of the Earth's crust and underground fluids circulation. Particular attention is also paid to the processing of geophysical data for a modern control of the territory and for the research, management and protection of natural resources. Used methodologies therefore range from satellite techniques to measure the displacements of the earth's surface, to seismic exploration techniques to identify reservoirs, up to those useful in the management and protection of groundwater and for more superficial investigations.

Structural Geology practices to unravel the complexity of tectonic structures and the syn-deformational rock-forming processes, at different depths in the tectonically active zones of the lithosphere, from rock mechanical behaviour. Acquired knowledges: (1) geological-structural field mapping techniques to analyse crust and mantle structures at different structural level and deduce deformation modes; (2) microstructural analysis to reveal deformation mechanisms at the granular and intracrystalline scale in any tectonic regime; (3) individuation of dominant deformation mechanisms at different P/T conditions and of geothermal regimes related to different geodynamic contexts.

The students who will instead want to fully integrate geophysics and structural geology will learn the use of multi-scale structural analysis, combined with geophysical investigation techniques and modeling, for: (a) geological prospection of natural resources; (b) analysis of tectonic structures supporting geological planning of major engineering works; (c) use of structural data and geophysical modeling for risk evaluation and prediction; (d) reconstruction and interpretation of geo-tectonic histories supported by numerical models in different geodynamic settings.

Further elective courses Curriculum-specific features Geophysics and structural geology with applications		
Basement Geology and Laboratory	9	GEO/03
Geodynamics and Laboratory	9	GEO/03
Geophysical Fluid Dynamics and Laboratory	9	GEO/12
Seismic Exploration	6	GEO/11
Seismology and Laboratory	9	GEO/10
Structural Analysis II and Laboratory	9	GEO/03
Numerical Modelling of Geodynamic Processes	6	GEO/10
Regional Geology	6	GEO/03
Shallow Depth Geophysics	6	GEO/11

Qualifying Training Objectives

Learning Objectives

The main objectives of the curriculum are the education and training of graduates in managing projects dealing with: 1) geological mapping of crystalline basement s.l., with particular interest on the evaluation of the economic resources and related geological risks; 2) determination of the properties of minerals and rocks and the applications in civil engineering; 3) evaluation of the environmental effects of the extraction and transformation processes of mineral georesources; 4) the supply of mineral resources and waste disposals, including radioactive ones; 5) the use of mineral resources in the industrial world bearing in mind the fast technological evolution and the needs of new materials; 6) research and development of new lithoid materials in the ceramic field; 7) fundamental and basic research on processes acting within the Earth's interior and planetary evolution.

Skills acquired

Expected Learning Outcomes

The curriculum aims to provide an effective study method and tools for understanding the geological, chemical and physical properties of minerals and rocks, as well as complex transformation processes involving natural materials during their use in industrial production cycles.

The curriculum is based on three fundamental teachings on the methodological bases and analytical techniques peculiar to the study of minerals, rocks and geological fluids, which are then connected to a wide range of geological disciplines, starting from the collection of field data to laboratory research. Particular attention is paid to the learning of instrumental and experimental methods, profiting of the wide laboratory facilities, which includes scanning and transmission electron microscopes, X-ray diffractometers, spectrometers for chemical and micro-chemical determinations, high pressure and/or high temperature experimental laboratory and apparatus for the determination of the petrophysical characteristics of rocks. The quantitative study approach is completed by the application of analytical and numerical models for solving both fundamental and applied problems.

1st COURSE YEAR Core/compulsory courses/activities Curriculum-specific features Geology of mineral resources and geomaterials

Learning activity		Ects	Sector
Crystallography and Laboratory		9	GEO/06
Petrology and Laboratory		9	GEO/07
Rocks, Minerals and Fluids Analysis and Laboratory		9	GEO/08
	Total compulsory credits	27	

Further elective courses Curriculum-specific features Geology of mineral resources and geomaterials

Applied Mineralogy	6	GEO/09
Applied Petrography	6	GEO/09
Ore Geology and Mineral Prospecting	6	GEO/09
Ore Petrography and Evvironmental Evaluation of ore Minerals	6	GEO/09