UNIVERSITA' DEGLI STUDI DI MILANO
PROGRAMME DESCRIPTION - ACADEMIC YEAR 2023/24
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

Degree Course Coordinator

Prof Massimo Tiepolo

Tutors - Faculty

Tutors per l'orientamento: Dott.ssa Francesca Forni, Dott Mattia Marini, Prof Davide Zanoni, Prof Stefano Poli, Prof Francesco Cecinato.
Tutors Tirocini: Prof Riccardo Bersezio, Prof.ssa Tiziana Apuani.
Tutors Piani di Studio: Prof Fabrizio Berra, Prof Daniele Padretti, Prof G. Diego Gatta, Prof Federico Farina, Prof Alessandro Comunian, Prof Davide Zanoni,
Tutor Ammissione Laurea Magistrale: Prof G. Diego Gatta, Prof Massimo Tiepolo, Prof.ssa Paola Tartarotti, Prof Gabriele Cambiotti, Prof Fabrizio Felletti, Prof.ssa Maria Rose Petrizzo, Dott Daniele Pedretti, Prof Fernando Càmara Artigas.

Degree Course website

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

Via Botticelli, 23 Ricevimento: quando disponibile o su appuntamento via mail. Email: massimo.tiepolo@unimi.it

course management

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

Libraries

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

Student registrar

Via Celoria, 18 - 20133 Milano Phone 0250325032 https://www.unimi.it/it/node/360 https://www.unimi.it/it/node/359

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 archaeological 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 autonomous 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 opportunities 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 the following:

- Field mapping, updating of geological, 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, technological use of geomaterials for mechanical, 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.

Initial knowledge required

Applicants to the Master's Degree Programme in Earth Sciences must fall into one of the following categories:

- Geological Sciences graduates (L-34) from any Italian University;
- Graduates of other degree programmes and those who have obtained another qualification abroad recognized as suitable, provided they received adequate training in Earth Sciences core disciplines.

Access to the Master's degree programme in Earth Sciences is open to all graduates from Italian universities from degree class L-34 (Geological Sciences), subject to an interview.

Graduates from Bachelor's degree programmes from any Italian University and/or those holding a foreign qualification recognized as suitable are also eligible for admission, provided they demonstrate adequate knowledge of geology. In this case, for the purposes of admission to the Master's degree programme, the candidate's educational background is assessed by means of a selective test before the start of teaching activities. The test will focus on knowledge and skills in the geological field, particularly relating to the fundamentals of geology, geomorphology, petrology and geophysics.

Application for admission:

Bachelor's graduates and upcoming graduates may apply for admission to the Master's degree programme from 6 March 2023 to 25 August 2023. However, undergraduate applicants must graduate by 31 December 2023.

The admission application, which is required of all graduate and undergraduate students, must be submitted electronically within the deadlines provided on the Student Registrar's website at: https://www.unimi.it/en/study/bachelor-and-master-study/degree-programme-enrolment/enrolment-masters-programme/open-admission-master-programmes . The interviewing board will include faculty members appointed by the Academic Board of the study programme.

For the purposes of admission to the Master's degree programme, the candidate's educational background will be assessed by means of an interview on subjects covered by the fundamental courses of the aforementioned degree programme in Geological Sciences. Students from universities other than the University of Milan must show up for the interview with an ID and a photocopy of the same for identification and filing in the records of attendance.

For academic year 2023/2024, interviews have been scheduled on the following dates. Logistic details will be made available on the website (on the notice board) at least one week before the interviews, as well as in the programme description (“Manifesto degli Studi”).

- 2 pm on 6 July 2023 Via Botticelli, 23 Aula A;
- 2 pm on 14 September 2023 at 14.00 pm Via Botticelli, 23 Aula A.

Students must show up with a valid identity document and a copy of the same to be delivered to the examining board. Please check your email often for urgent communications, when the interview date is approaching.

The interview, aimed at assessing the candidate's educational background, may also take place before graduation. However, the candidate must obtain their degree by 31 December 2023.

Candidates who fail the interview, whether graduates or upcoming graduates, may not enrol on the Master's degree programme for the current year.

Compulsory attendance

Attendance is not compulsory, but highly recommended especially for all laboratories, field activities and many lectures of specialist courses with contents that are not easily available through textbooks.

Internship criteria

The internship is a period of training in the actual world of work. It completes scientific-technological training with professional technical-practical skills in the field of geology. The internship is a form of training with a view to orientation, employability and integration into the labour market. The internship awards 6 CFU and can be carried out in companies, professional firms or other organizations outside the University, as well as within the University.

Learn more on internship procedures at

https://scienzeterra.cdl.unimi.it/it/studiare/stage-e-tirocini

https://www.unimi.it/en/study/traineeships-and-work/traineeships-and-internships/activating-curricular-internship

Degree programme final exams

Upcoming graduates are required to conduct an original experimental work, including individually or with a multidisciplinary bent, and writing a degree thesis. This thesis consists of an original work addressing an Earth Sciences topic with a scientifically rigorous approach.

The final exam will award 30 credits. The thesis application must be submitted by the end of the first year of the programme, during which thesis work can already begin.

The thesis subject may also involve topics covered by similar curricula. The students must work under the guidance of a supervisor, who will be a lecturer from the Master's Degree Programme in Earth Sciences. Thesis work may be conducted, in whole or in part, at external research institutions.

The degree thesis must be submitted to a co-examiner appointed by the Chair of the Academic Board for the study programme, after hearing the opinion of the supervisor, at least one month before the final exam. The co-examiner will submit their written opinion to the Degree Board, which will take it into account when assessing the candidate's following thesis presentation and defence. The co-examiner may be a member of the Degree Board.

Upcoming graduates must:

1) have earned 90 credits, including: 81 CFU for curricular exams; 3 CFU for English language proficiency (English II); 6 CFU for the internship;

2) have written the final paper awarding the remaining 30 credits.

https://www.unimi.it/en/study/bachelor-and-master-study/graduation

Campus

Teaching infrastructures for the Bachelor's degree programme in Earth Sciences are located in the three structures of the Department of Earth Sciences "A. Desio". The main teaching areas are: Geology and Paleontology (via Mangiagalli, 34); Mineralogy, Petrography, Geochemistry and Mineral Fields (via Botticelli, 23); Geophysics (via Cicognara, 7).

Laboratories

Teaching laboratories take place both in departmental structures, equipped with technical-scientific instruments and collections, and on-field, using customised logistics solutions.
Educational collections for the recognition and study of fossils, minerals and rocks are available in classrooms and ad-hoc teaching laboratories. Computerized classrooms offer software for data processing and for the simulation of geological processes.
Scientific instruments available at the Department of Earth Sciences (http://www.dipterra.unimi.it/ecm/home/laboratori) offer learning and application tools for optical, chemical and physical-mechanical characterization of minerals, fossils, rocks, soils, other natural or synthetic materials, as well as water and other terrestrial fluids. Practical exercises are carried out in laboratories of optical microscopy, scanning electron microscopy, transmission electron microscopy, X-ray diffraction, X-ray spectrometry, micro-Raman spectroscopy, mass spectrometry and experimental petrology, mechanics of rocks and sedimentology.
Field laboratories take place in areas where students can learn geological cartography, process geological data and reconstruct the genetic processes of terrestrial materials (e.g. Valchiavenna Station).

Notes

In order to obtain their degree, students must be proficient in English at a B2 level. This proficiency level may be certified as follows:
- By submitting a language certificate attesting B2 or higher level in English and issued no more than three years before the date of submission. You will find the list of language certificates recognized by the University at: https://www.unimi.it/en/node/297/). The certificate must be uploaded during the enrolment procedure, or subsequently to the portal http://studente.unimi.it/uploadCertificazioniLingue;
- B2 or higher level achieved during a University of Milan degree programme and certified by the University Language Centre (SLAM) no more than four years before the date of admission application. In this case the process is automatic, the applicant does not have to attach any certificates to the application
- Through a placement test administrated by the SLAM between October and January of year 1. Applicants who fail the test will be required to take a SLAM course.
The placement test is mandatory for all those who do not hold a valid certificate.
Those who do not take the placement test by January or do not pass the end-of-course exam after six attempts must obtain the necessary certification privately before graduating.

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 the 27 EU member 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 internship 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 internship 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, Greece, Spain, Holland and Switzerland. However the agreements for bursaries specifically devoted to applied research/internship 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/internship 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

The students of the University of Milan can participate in mobility programmes, through a public selection procedure.
Ad hoc commissions will evaluate:
Academic career
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 for Erasmus+ mobility for study generally begins around February each year with the publication of a call for applications specifying destinations and requirements. Regarding the Erasmus+ Mobility for Traineeship, the University of Milan usually publishes two calls a year enabling students to choose a destination defined by an inter-institutional agreement or to find a traineeship position on their own.
The University organizes informative meetings to illustrate mobility opportunities and rules for participation.
Erasmus+ scholarship
The European Union grants the winners of the Erasmus+ programme selection a scholarship to contribute to their mobility costs, which may be 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 Language Centre (SLAM).
https://www.unimi.it/en/node/8/
Learn more at https://www.unimi.it/en/node/274/
For assistance, please contact:
International Mobility Office
Via Santa Sofia 9 (second floor)
Tel. 02 503 13501-12589-13495-13502
Contacts: InformaStudenti; mobility.out@unimi.it
Student Desk booking through InformaStudenti

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

The student must acquire 18 ECTS by freely choosing among all the courses activated by the University as long as they are culturally consistent with his educational path and cannot be superimposed, in terms of content, on the fundamental and elective courses already used in the study plan.
Therefore, all the teachings and/or modules present in this Study Manifesto that meet these criteria are included in the choice of the 18 credits.
The Academic Board of the course of study in the academic year 2023-2024 will also make available the following courses:

Environmental Geochemistry	6	GEO/08
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

The student will have to choose one of the following courses:

Basin Analysis, Hydrocarbon Geology and Practicals	9	GEO/02
Micropaleontology and Laboratory *course active in alternate years, not active for the a.y. 2023-24*	9	GEO/01

Further elective courses Curriculum-specific features Sedimentary basins and energetic resources

The student will have to choose two of the courses in the table below (total 12 credits).
Any credits acquired for the "Sismic Exploration Laboratory" module may be recognized as free-choice credits.

Biostratigraphy *course active in alternate years, not active for the a.y. 2023-24*	6	GEO/01
Complements of Paleontology *course active in alternate years, active for the a.y. 2023-24*	6	GEO/01
Diagenesis and Sedimentary Rock Geochemistry *course active in alternate years, not active for the a.y. 2023-24*	6	GEO/02
Marine Geology Exploration and Georesources *course active in alternate years, not active for the a.y. 2023-24*	6	GEO/01
Regional Stratigraphy *course active in alternate years, active for the a.y. 2023-24*	6	GEO/02, GEO/01
Seismic Exploration and Laboratory *course active in alternate years, not active for the a.y. 2023-24*	9	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

The student will have to choose one of the following courses:

Geotechnics and Laboratory	9	ICAR/07
Hydrostratigraphy and Aquifer Sedimentology and Laboratory *course active in alternate years, active for the a.y. 2023-24*	9	GEO/02

The student will have to choose one of the following courses:

Geographical Information Systems	6	GEO/05, ICAR/06
Rock Mechanics and Slope Stability	6	GEO/05, ICAR/07
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		
The student will have to acquire 27 credits by choosing 3 courses among those in the following table:		
Basement Geology and Laboratory	9	GEO/03
Geodynamics and Laboratory *course active in alternate years, active for the a.y. 2023-24*	9	GEO/03
Geophysical Fluid Dynamics and Laboratory	9	GEO/12
Seismic Exploration and Laboratory *course active in alternate years, not active for the a.y. 2023-24*	9	GEO/11
Seismology and Laboratory *course active in alternate years, not active for the a.y. 2023-24*	9	GEO/10
Structural Analysis II and Laboratory *course active in alternate years, active for the a.y. 2023-24*	9	GEO/03
The student must acquire 12 credits by choosing 2 courses among those below and among the 6 credits modules in the previous table, provided that the 9 credits courses that include them have not already been chosen. It is also possible to choose the 12 credits from the related and supplementary courses present in the other curricula.		
Mathematical Methods in Geophysics	6	GEO/10
Numerical Modelling of Geodynamic Processes	6	GEO/10
Regional Geology *course active in alternate years, not active for the a.y. 2023-24*	6	GEO/03

CURRICULUM: [F97-D] Geology of mineral resources and geomaterials

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			
The student will have to choose two of the following courses:			
Applied Mineralogy		6	GEO/09
Applied Petrography *teaching activated in alternate years, active in the a.y. 2023-24.*		6	GEO/09
Metallogenesis and Ore Minerals *teaching available for second year students*		6	GEO/09
Ore Deposits and Sustainability *teaching available for first year students*		6	GEO/09

COURSE PROGRESSION REQUIREMENTS

The four characterizing courses common to all curricula are preparatory.