Master of Science (MSc) in Earth Sciences

Maîtrise universitaire ès Sciences en sciences de la Terre

Study plan

Enter into force on the 18th September 2023

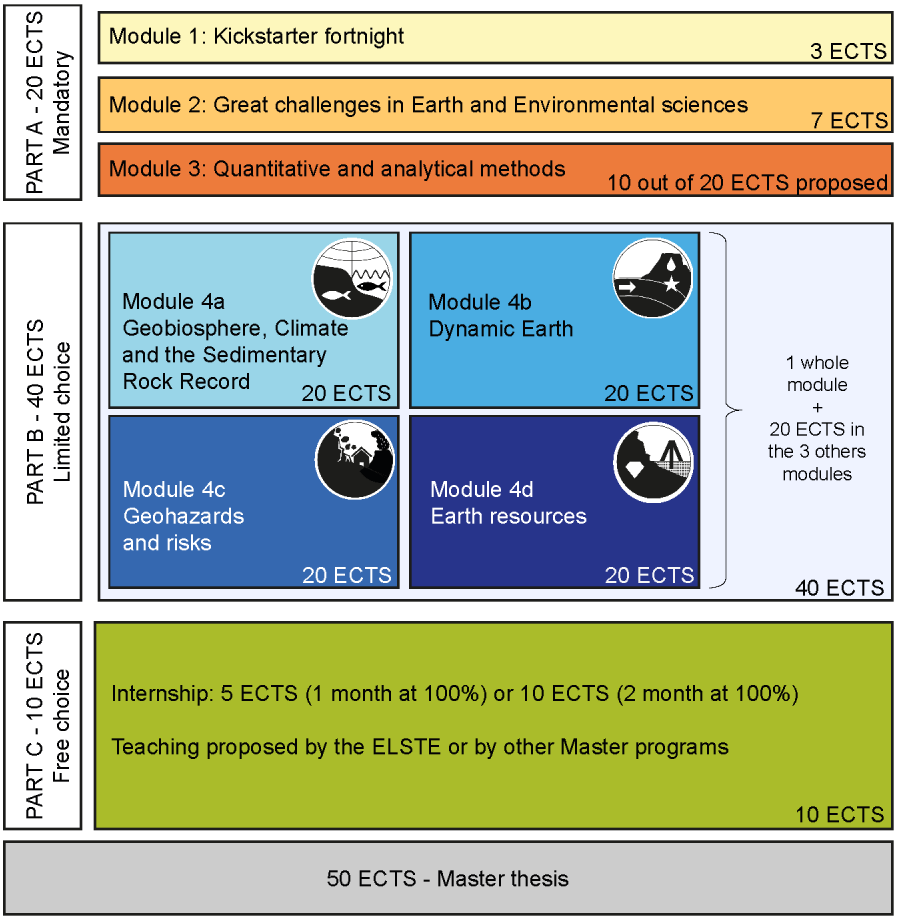
Could be modify by the competent. authorities

In this document, male pronouns are used indiscriminately for females and males.

The Master of Science in Earth Sciences is delivered jointly by the University of Geneva and the University of Lausanne, through the «Ecole Lémanique des Sciences de la Terre» (Lemanic School of Earth Sciences - ELSTE). This second level cycle of 120 ECTS credits program has a proposed period of four semesters. Courses are generally given in French and in English. However, the program can be entirely followed in English.

The Master in Earth sciences is composed by four parts :

- A joined and mandatory part of 20 ECTS credits;
- A limited choice part of 40 ECTS, with four modules of 20 ECTS credits ;
- A free choice part of 10 ECTS credits ;
- A Master thesis of 50 ECTS credits. This Master thesis is a personal research work under the responsibility of a ELSTE teacher



Whenever possible, courses must be taken during the first your of the Master. However, some courses are taught during the second year. During the first year of the Master, the student also starts to work on his master thesis in order to present his project of Master before the beginning of the second year of the program. The second year of the Master program is dedicated to the Master thesis.

An exhaustive description of the courses is availllable on the ELSTE website.

One ECTS (European Credit Transfer and Accumulation System) credits corresponds to 25-30 hours of actual work

The following abbreviations are used: C: course – PW: Practical work – E: Exercises – CE: Courses/Exercises – S: Seminars – F : Field – d : days (block course) – h: hours (weekly course) – N.N. : teacher to be named

Part A joined and mandatory– 20 ECTS credits

The common and mandatory part A is composed of three modules: Module 1 – Kickstarter fortnight; Module 2: Great challenges in Earth sciences; Module 3: Quantitative and analytical methods. This part is validated if the student has passed all three modules. The conditions for success are specific to each of the modules and are specified below the description of each of them.

Module 1 includes refresher lessons and three field days. This module allows students to complete and balance their basic knowledge, and to create a first contact between them and the teachers of the Master.

Module 2 is designed so that students can apply geoscience concepts in order to respond to important scientific and societal issues in Earth sciences, such as the origin of Life or the energy transition, among others.

Module 3 addresses two main themes: the first theme focuses on the different methods used in Earth sciences to model geological processes numerically or in the laboratory and to analyze spatial and temporal databases. The objective of the second theme is to learn the analytical methods of geochemistry and imaging to study geological samples, ranging from macroscopic observation of the rock to the study of samples at the microscopic scale.

Module 1 : Kickstarter fortnight – 3 ECTS credits

« Kickstarter fortnight »

Coordinators : Guy Simpson, Sébastien Pilet, György Hetényi

Courses	Teacher(s) in charge	Semester Modality	Evaluation	ECTS credits
ELSTE introduction and organization Introduction à l'ELSTE et organisation **MANDATORY**	G. Hetényi S. Pilet G. Simpson	1d C + E Fall	-	-
Field - Discovery of local and regional geology Terrain - Découverte de la géologie locale et régionale **MANDATORY**	J.-L. Epard, G. Hetényi	3d F Fall	Validation without grade	1.5

Petrology Pétrologie	S. Pilet	1d C + E Fall		0.5
Mathematics for geosciences Mathématiques pour les géosciences	G. Hetényi	1d C + E Fall		0.5
Programming Programmation	G. Simpson	1d C + E Fall		0.5
Geochemistry Géochimie	J. Marin Carbonne M. Chiaradia	1d C + E Fall		0.5
Geophysics Géophysique	G. Hetényi	1d C + E Fall		0.5
History of Life Histoire de la Vie	A. Daley J. Marin Carbonne	1d C + E Fall		0.5
Fieldwork preparation and organization Préparation et organisation du travail sur le terrain	J.-L. Epard G. Hetényi	2d C + E Fall		1.5

"ELSTE introduction and organization" is mandatory, as well as "Field – Discovery of local and regional geology". In addition, the student chooses courses in this module for a total of 1.5 ECTS. For students with a Bachelor's degree from UNIL or UNIGE, the only course strongly recommended to follow is "**Fieldwork preparation and organization**".

This module is evaluated by a single assessment. This module is passed and the 3 ECTS credits awarded, if the student obtains the validation to the assessment.

Module 2 : Great challenges in Earth and environmental sciences – 7 ECTS

Les grands défis en sciences de la Terre et de l'environnement

Coordinators : Johanna Marin Carbonne and Luca Caricchi

Courses	Teacher(s) in charge	Semester Modality	Evaluation	ECTS credits
Great challenges in Earth and environmental sciences Les grands défis des sciences de la Terre et de l'environnement	J. Marin Carbonne L. Caricchi	42h C + personal work Spring	Practice	7
This module is passed and the 7 ECTS credits awarded, if the student obtains at least a mark of 4 in the teaching evaluation				

Module 3 : Quantitative and Analytical methods – 10 ECTS

Méthodes quantitatives et analytiques

Coordinators : Martin Robyr and Guy Simpson

Courses	Teacher(s) in charge	Semester Modality	Evaluation	ECTS credits
Data science Traitement quantitatif des données **MANDATORY**	T. Sheldrake J. Irving	36h C + PW Fall and Spring	Practice	4
Simulating geological processes on computers and in the laboratory Simulation de processus géologiques	Y. Podladchikov	27h C + PW Fall	Practice	3
From outcrop to 3D model De l'affleurement au modèle 3D	M.-H. Derron	9h C + 18h PW + T Fall	Practice	3

Methods of isotope analysis Méthodes d'analyses isotopiques	P. Nuriel T. Vennemann	27h C + personal work Fall – 2nd year	Practice and oral exam	3
Chemical analyses and imaging techniques for major and trace elements Techniques d'analyses chimiques et d'imagerie électronique pour les éléments majeurs et traces	M. Robyr F. Bégué	49h C+ PW Fall	Practice	3
The "Data science" course is compulsory (4 ECTS). The student chooses from among the other courses offered in this module for a total of 6 ECTS credits. *This module is passed and the 10 ECTS credits awarded, if the student obtains at least a mark of 4 in the evaluations of each of the courses chosen.*				

The common and mandatory part A is validated if the student has passed each of the three modules.

Part B with limited choice - 40 ECTS

In part B with limited choice, the student chooses a module of 20 ECTS in its entirety and selects a choice of courses in the 3 other modules for an additional 20 ECTS, making a total of 40 ECTS. This part is validated if the student has passed one of the modules in its entirety (conditions for passing the modules specified below), as well as if he/she has passed each of the evaluations for the courses chosen separately in the three other modules for a total of 20 ECTS.

The purpose of this part is to allow the student to acquire specific skills in a field of Earth sciences while allowing him to develop his knowledge on complementary subjects. A description of each of these four modules is available below. The student chooses his or her main module at the beginning of the cursus and cannot change it thereafter.

Module 4a : Geobiosphere, Climate and the Sedimentary Rock Record – 20 ECTS

Géobiosphère, climat et enregistrements sédimentaires

Coordinators : Allison Daley and Sébastien Castelltort

This module examines the interactions between sedimentary geology, atmosphere, and life. We will focus on how processes occurring at the Earth's surface have helped shape the evolution of our planet, both in the modern-day and looking back at billions of years of geological history. With a strong practical component in every course, this module provides advanced training of techniques and analyses within the domains of sedimentology, paleontology, climate reconstruction, basin analysis, and biogeochemistry. Teaching activities include fieldwork, laboratory analyses, data interpretation, computer modelling, seminars and lectures.

Courses	Teacher(s) in charge	Semester Modality	Evaluation	ECTS credits
Life evolving with Earth La Vie évolue avec la Terre	A. Daley N.N. (Sucessor of R. Martini)	36h C + PW Fall	Practice and written exam	4
Climate and Paleoclimate: from deep time to the Anthropocene Climat et paléoclimat: des temps anciens à l'Anthropocène	S. Jaccard *N. Zeyen*	36h C + PW Spring	Practice and written exam	4
Surface processes and depositional environments from source to sink Processus de surface et environnements de dépôts sédimentaires des sources aux bassins	S. Castelltort E. Samankassou	36h C + E Fall	Practice and written exam	4
Sedimentology analytics - Collecting, Interpreting and Presenting Field Data Récolte - analyse, interprétation et présentation des données de terrain en sédimentologie *Prérequis: "Chemical analyses and imaging techniques for major and trace elements"*	T. Adatte N.N. (Sucessor of R. Martini)	28h PW + personal work Spring	Practice	4

Sedimentology, Climate, Paleontology and Geomorphology Field Camp* Camp de terrain de sédimentologie, climatologie, paléontologie et géomorphologie*	A. Daley S. Castelltort	12d F Spring	Practice	4
* « Sedimentology, Climate, Paleontology and Geomorphology Field Camp » cannot be taken separately, it must be chosen with another course in the module. *This module is successfully completed and the 20 ECTS credits awarded in bloc, if the student obtains an average of at least 4 (weighted by the credits) in the teaching evaluations.*				

Module 4b : Dynamic Earth – 20 ECTS

Terre dynamique

Coordinators : Luca Caricchi and György Hetényi

The Earth is constituted by rocks, magmas, fluids and the atmosphere. Its dynamic nature is expressed in the temporal evolution of the chemical and physical properties of these fundamental components, which all shape the structure of the Earth at different scales. Via a combination of supervised and independent learning the students will deepen their knowledge on how fieldwork, geophysics, geochemistry, petrology, and numerical modelling are essential to acquire data, to construct structural models, and to identify and quantify geological processes related to earthquakes, volcanic eruptions and mountain building, among others.

Courses	**Teacher(s) in charge**	**Semester Modality**	**Evaluation**	**ECTS credits**
Physical-chemical mechanisms of geological processes Mécanismes physico-chimiques des processus géologiques	S. Schmalholz N.N (Sucessor of L. Baumgartner)	36h C + PW Fall	Practice	4
Geophysics across scales Géophysique à différentes échelles	G. Hetényi	36h C + PW Spring	Practice	4

Minerals, rocks and magma Minéraux, roches et magma	L. Caricchi O. Müntener	36h C + PW Spring	Practice	4
Geochemical cycles and rates of geological processes Cycles géochimiques et taux des processus géologiques	M. Chiaradia P. Nuriel	36h C + PW Spring	Practice	4
Mountain belts in the field* Les chaînes de montagnes sur le terrain*	O. Müntener J.-L. Epard	2d C + PW + 8d F Spring	Practice	4
* « Mountain belts in the field » cannot be taken separately, it must be chosen with another course in the module. *This module is successfully completed and the 20 ECTS credits awarded in bloc, if the student obtains an average of at least 4 (weighted by the credits) in the teaching evaluations*.				

Module 4c : Geological Hazards and Risks – 20 ECTS

Dangers et risques géologiques

Coordinatos : Costanza Bonadonna and Michel Jaboyedoff

Volcanic eruptions, terrain instabilities and earthquakes are fascinating but complex phenomena with potentially significant impacts on society that can occur at different temporal and spatial scales. Through a combination of theoretical and practical courses, this module addresses the dynamics of volcanic eruptions, earthquakes, erosion and slope movements. It also introduces the concepts of vulnerability and risk and discuss the factors influencing decision making and warning messaging. In addition, this module encompasses a variety of analysis strategies involving field studies, numerical modeling and experimental investigations. The associated field trip represents an opportunity to integrate the knowledge acquired in the module by carrying out a multidisciplinary risk assessment including hazard, exposure and vulnerability analysis.

Courses	Teacher(s) in charge	Semester Modality	Evaluation	ECTS credits
Risk and decision making Le risque et le processus décisionnel	C. Gregg S. Menoni	35h C + E Spring	Practice and written exam	4
Physical volcanology and volcanic risk Volcanologie physique et risque volcanique	C. Bonadonna	36h C + E Fall and Spring	Practice and written exam	4
Volcanic risk field trip Evaluation du risque volcanique – camp de terrain *Prérequis: "Physical volcanology and volcanic risk" et "Risk and decision making"*	C. Bonadonna	7d F Spring	Seminar	4
Seismic risk Risque sismique	B. Duvernay D. Fäh	28h C + E + 1d T Spring	Written exam	3
Erosion and slope movement Erosion et mouvement de versant	M. Jaboyedoff	56h C + TP Spring	Practice and oral exam	5
The Field camp « Hazards and risks of slope mass movements » (5 ECTS credits– 10 days, in the par C – Free choice) is highly recommende. *This module is successfully completed and the 20 ECTS credits awarded in bloc, if the student obtains an average of at least 4 (weighted by the credits) in the teaching evaluations.*				

Module 4d : Earth Resources – 20 ECTS

Ressources de la Terre

Coordinators : Zoltan Zajacz and Andrea Moscariello

The Earth Resources module aims to provide fundamental and applied geological knowledge and skills required for modern mineral, hydrocarbon and geothermal energy resource targeting, exploration, exploitation and research. The module includes a set of compulsory courses, which cover exploration methods, the physics and chemistry of crustal fluids and major economic aspects of the resource and energy industry. All students will have to attend a field course covering the mineralizing and geothermal energy potential of hydrothermal systems, use of portable analytical devices and mineralization/alteration mapping, as well as the practical aspects of the oil and gas exploration. More specialized courses will individually focus on a variety of advanced concepts used to understand the generation of energy and mineral resources, and/or provide the students with a working knowledge of state-of-the-art methodologies used in resource exploration and for the purpose of academic research on Earth Resources.

Courses	**Teacher(s) in charge**	**Semester Modality**	**Evaluation**	**ECTS credits**
Exploration methods [1] Méthodes d'exploration [1] **MANDATORY**	B. Quintal	18h C + PW Fall	Practice	2
Fluids in the crust [1] Fluides dans la croûte terrestre [1] **MANDATORY**	M. Lupi	36h C Fall	Oral or written exam	4
Economics and Management of Earth Resources Exploration and Development [1] Économie et gestion de l'exploration et de l'exploitation des ressources de la Terre [1] **MANDATORY**	A. Moscariello	18h C + TP Fall	Oral or written exam	2

Field camp in Earth resources [1] * Camp de terrain en ressources de la Terre [1] * **MANDATORY**	A. Moscariello M. Lupi K. Kouzmanov	9d F Spring	Practice	3
Ore deposit models [2] Modèles de gisements métallifères [2] (Thème Mineral Resources)	K. Kouzmanov Z. Zajacz	36h C + PW Spring	Practice and written exam	4
Fluid and melt inclusions in minerals[2] Inclusions fluides et vitreuses dans les minéraux [2] (Thème Mineral Resources)	Z. Zajacz	27h C + PW Spring	Practice and written exam	3
Applied mineralogy in resource exploration and modern technologies [2] Minéralogie appliquée à l'exploration des ressources et aux hautes technologies [2] (Thème Mineral Resources)	K. Kouzmanov	18h C + PW + 1d F Spring	Practice and written exam	2
Integrated Geo-Energy Seismic Interpretation and 3D Modelling Workflows [2] Workflow pour l'interprétation sismique et modélisation 3D appliqués aux Géo-énergies [2] (Thème Geo-Energy)	A. Moscariello	27h C + PW Spring	Practice	3
Petrophysics and Reservoir Characterisation [2] Pétrophysique et caractérisation des réservoirs [2] (Thème Geo-Energy)	B. Quintal A. Moscariello	27h C + PW Spring	Practice	3

Geo-Energy Exploration and Development Workflow [2] Méthodes de développement des geo-energies [2] (Thème Geo-Energy)	L. Guglielmetti	27h C + PW Spring	Practice and oral exam	3

[1] The courses « Exploration methods », « Fluids in the crust », « Finance and PM » and « Field courses » are mandatory for the students choosing the whole module (11 ECTS). The student chooses from among the other courses offered in this module for a total of 9 ECTS credits.

[2] Attention the lessons of the theme of the "Mineral resources" part and the theme "Geo-Energy" can be programmed at the same time.

* « Field camp in Earth resources », it must be chosen with another course in the module.

This module is successfully completed and the 20 ECTS credits awarded in bloc, if the student obtains an average of at least 4 (weighted by the credits) in the teaching evaluations.

Part B with limited choice is validated if the student has passed one of the modules in its entirety (conditions for passing the modules specified above), as well as if he has passed each of the evaluations for the courses chosen separately in the other three modules for a total of 20 ECTS.

PART C Free choice – 10 ECTS credits

The student completes his course by choosing courses from among those offered in the Master's in Earth Sciences or in other Master's programs in Switzerland and abroad (for example: Master in Environmental Sciences from UNIGE, and from UNIL, Master in Biogeosciences, UNIL/UNINE).
The student can choose courses at Bachelor level for a maximum of 5 ECTS credits. An internship in a company can be validated within this part, as provided for by the regulations (Art. 15, al. 7).

The student must establish the list of courses chosen in agreement with the supervisor of his Master's thesis. Here is a non-exhaustive list of additional lessons that are not included in the other parts of the study plan:

Courses	Teacher(s) in charge	Semester Modality	Evaluation	ECTS credits
Gemmology Gemmologie	L. Cartier	5d CE + PW + 2d F Spring – 2nd year	Validation without grade	3
Sites contaminés : application géologique et environnementale (en français)	S. Girardclos	5d C + PW Spring – 2nd year	Practice	3
Les déchets : gestion environnementale et contraintes géologiques (en français)	J. Poté	5d C + PW Spring – 2nd year	Practice	3
Construction and interpretation of cross-sections in complex deformed areas Construction et interprétation de coupes transversales dans des zones déformées complexes	J.-L. Epard	27h C + PW Fall – 2nd year	Practice	3

SwissSIMS winter School Ecole d'hiver SwissSIMS	J. Marin Carbonne	4.5d C + PW Spring – 2nd year (biannual)	Practice	2
SPACE-RISKS Géomatique appliquée à l'analyse du risque	C. Frischknecht	5d C + PW Spring – 2nd year	Practice	3
Microtectonics Microtectonique	M. Robyr	18h C + PW Fall– 2nd year	Practice	2
Model parameter estimation and uncertainty quantification Estimation des paramètres du modèle et quantification de l'incertitude	N. Linde	56h C + PW Spring – 2nd year	Practice	5
Hazards and risks of slope mass movements field camp Dangers et risques des mouvements de masse sur les pentes - camp de terrain	M.-H. Derron	80h F Spring – 2nd year	Practice	5
Biomineralization Biominéralisation	A. Meibom	42h C + PW Fall– 2nd year	Practice	4
What can we learn from melt inclusions?	A-S. Bouvier	21h C + PW Fall– 2nd year	Practice	2
Volcano Fieldtrip Camp de terrain en volcanologie	L. Caricchi S. Pilet	6d F Spring – 2nd year	Practice	2
Geology of clays Géologie des argiles	T. Adatte	3 d CE Spring – 2nd year	Practice	1.5

Company internship* Stage en entreprise * (validated by the Master thesis supervisor)	Validation without grade	5 or 10 function of duration
Modules or courses from the study plan of the Master in Earth sciences	**	**
Transversal courses offered by the UNIGE Rectorate	**	**
Courses proposed by : Master in environmental sciences – MUSE (UNIGE) ; Master in environmental geosciences (UNIL); Masterin Biogeosciences (UNIL-UNINE) **	**	**
Possibility of following courses offered by another university institution in Switzerland or abroad, subject to validation by the ELSTE Committee **	**	**
Courses from Bachelor	5 ECTS credits maximum	
Total credits to validate	**10 ECTS credits**	
* 5 ECTS credits are awarded to the internship if it lasts 1 month at 100%. 10 ECTS credits are awarded to the internship if it lasts 2 months at 100%		
** For these courses, the assessment and the number of ECTS credits allocated are those which appear in the study plan from which they come. Any costs are the responsibility of the student.		

In the free choice part C, the courses are validated individually if their mark is at least 4 or if the certificate is acquired.

Part Master Thesis in Earth sciences – 50 ECTS credits

The Master's thesis is an original and personal research work, placed under the responsibility of an ELSTE teacher.

At the end of the first semester of the Master, the student must choose a topic for the Master's thesis. Before the start of the 2nd year of the course, the student must write and present his Master's project. The ECTS credits of the Master's project are acquired when its grade is at least 4.

The Master's thesis is evaluated on the basis of the manuscript submitted and the quality of the oral defense. This evaluation, weighted according to the internal directive of the Master's thesis, is the subject of a single mark. The Master's thesis is passed and the ECTS credits of the Master's thesis acquired when this mark, as well as that of the written work submitted, are both at least 4. The procedure governing the completion of the Master's thesis is set out in the guidelines for the Master's thesis in Earth sciences available on the Master's website.

Master thesis	**Semester**	**Year 1**	**Year 2**	**Evaluation**	**50 ECTS credits**
Master project	Spring	•		Rapport and oral exam	5
Master Thesis	Spring		•	Manuscript and oral defense	45