



UNIL | Université de Lausanne

Faculté des géosciences  
et de l'environnement



**UNIVERSITÉ  
DE GENÈVE**

**FACULTÉ DES SCIENCES**

## Master of Science (MSc) in Earth Sciences

# Study plan

*Enter to force, 16 Septembre 2019*

*This translation is for information purposes only.  
The language of the original document takes precedence.*



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

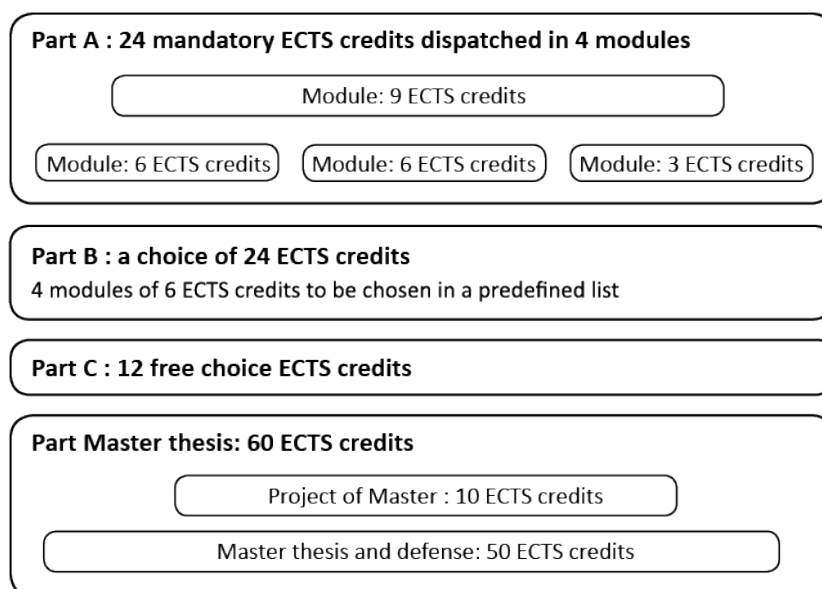
The Master of Science in Earth Sciences is delivered jointly by the University of Geneva and the University of Lausanne, through the «Ecole Lémanique des Sciences de la Terre» (Lemanic School of Earth Sciences - ELSTE). This second level cycle of 120 ECTS credits program has a proposed period of four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

The Master in Earth Sciences has three orientations:

- Sedimentary, Environmental, and Reservoir Geology → SERG
- Geochemistry, Alpine Tectonics, Ore Deposits → GATO
- Geological Risks → RGEOL

At the beginning of the Master, each student chooses a proposed orientation. The program of each orientation includes:

- A part of 4 mandatory modules (24 ECTS credits)
- A part of 4 modules to be chosen in a predefined list (24 ECTS credits)
- A part of free choice credits (12 ECTS credits)
- A Master thesis of 60 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 year of the Master. 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.

It is strongly recommended that students register to a course no later than two weeks before it begins. Otherwise the student could be denied access to the course due to lack of space or material.

## Orientation : Sedimentary, Environmental, and Reservoir Geology / SERG

### Coordinators: Rossana Martini –Thierry Adatte

The sedimentary cover of the Earth is the result of the interaction between tectonics, weathering and erosion, sediment transport and biological and geochemical processes. Sediments and sedimentary rocks therefore contain fundamental information on the history of the Earth, the environment, climate and life. In addition, sediments and sedimentary rocks are the largest reservoir of the main natural resources such as water, fossil fuels, metals and raw materials. The orientation Sedimentary, Environmental, and Reservoir geology offers a wide and extensive training focusing on sedimentology, stratigraphy, paleontology, basin analysis, reservoir geology, environmental geology and geophysics.

Instruction is provided in the form of ex-cathedra courses, seminars, field trips and independent research. This orientation is unique in Switzerland and Central Europe in general due to its focus on current and fossil surface processes, its interdisciplinary approach, access to a natural laboratory that is the Swiss Jura and the Alps, the number of experts involved, internal to the Universities of Geneva and Lausanne and external guests.

The program proposed in this Master is an ideal preparation to further academic training (PhD) as well as to environmental professions, to engineering geology and to industrial reservoirs and to geo-energy.

### PART A1 mandatory: 24 ECTS credits

The mandatory **part A1** includes four modules:

- Sedimentary Rocks and Processes from Source-to-Sink
- Life evolution
- Basin research
- Geophysics across scales for geologists

## Module Sedimentary Rocks and Processes from Source-to-Sink - 9 ECTS

Teacher in charge: S. Castelltort

Courses	<u>Teacher in charge/</u> Speaker(s)	Semester Modality	Evaluation	ECTS credits
<b>Carbonates</b> / Carbonates	E. Samankassou	Fall 2d F, 2.5 d C PW S	Report, Seminars, oral or written exam	2
<b>Clastics</b> / Clastiques	<u>S. Castelltort</u> , D. Ariztegui, A. Moscariello, T. Adatte	Fall -5d C PW S	Report, Seminars, oral or written exam	2
<b>Sedimentary rocks in the field</b> / Les roches sédimentaires sur le terrain	S. Castelltort	Spring 8d F	Practice, Report, Seminars, oral or written exam	4
<b>Weathering processes and soils formation</b> / Processus d'altération et formation des sols	E. Verrecchia	Fall 2d C PW	Practice	1
Prerequisite: sedimentology course (BSc)				
One ECTS credits corresponds to 25-30 hours of actual work				
C: course – PW: Practical work – E: Exercises – S: Seminars – F : Field – d : days (block course) – h: hours (weekly course)				
This module must be followed during the two first semesters of the Master and then validated during the following exam session.				
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained.				

### Module Life evolution – 6 ECTS

*Teacher in charge : E. Samankassou*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Life evolution</b> / Évolution de la vie	<u>E. Samankassou</u> , T. Adatte, D. Ariztegui, J. Spangenberg, T. Vennemann, A. Daley	Fall 10d C PW S	Report, Seminars, oral or written exam	6

### Module Basin research – 6ECTS

*Teacher in charge: S. Castelltort*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Basin research</b> / Dynamique sédimentaire	<u>S. Castelltort</u> , G. Simpson, R. Spikings, et collaborateurs	Fall 10d C PW S	Report, Seminars, oral or written exam	6

### Module Geophysics across scales for geologists – 3 ECTS

*Teacher in charge : G. Hetényi*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Geophysics across scales for geologists</b> / Géophysique à différentes échelles pour géologues	<u>G. Hetényi</u> , B. Quintal, M. Lupi, A. Moscariello	Fall 4d C PW	Practice	3

The part A2 is validated if each of the four modules is validated.

## PART B1 : a choice of 24 ECTS credits

The student must select four modules among those proposed in the list below:

- Integrated basin analysis
- Reservoir geology I
- Reservoir geology II
- Biostratigraphy and micropaleontology
- 2D and 3D seismic interpretations
- Borehole logging and rock physics
- Fluid flow for geologists
- Spatial analysis applied to geology and risk
- Fundamentals of numerical modelling and data analysis
- Advanced structural geology
- Pratique de la géologie environnementale (in French)

### Module Integrated basin analysis – 6 ECTS

*Teacher in charge : A. Moscariello*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Integrated basin analysis /</b> Analyse de bassin intégrée	<u>A. Moscariello</u> , E. Samankassou, et collègues	Spring 10dj F S	Exercises Report	6
Prerequisite: "From play evaluation to field development"				

### Module Biostratigraphy and micropaleontology – 6 ECTS

*Teacher in charge : R. Martini et A. Daley*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Biostratigraphy and micropaleontology /</b> Biostratigraphie et Micropaléontologie	<u>R. Martini</u> , S. Fesit-Burkhardt, E. Samankassou,, et A. Daley	Fall 7d C E  Spring 7d F	Exercises Report	6

### Module Fundamentals of numerical modelling and data analysis – 6 ECTS

*Teacher in charge : Y. Podladchikov*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Introduction to data analysis with MATLAB</b> / Introduction à l'analyse de données avec Matlab	G. Simpson	Fall 3d C	Practice (Report)	1
<b>MATLAB as a language of scientific computing</b> / Matlab comme langage de calcul scientifique	Y. Podladchikov	Fall 42h CE	Practice (Report)	3
<b>Physics as a basis for modeling</b> / La physique comme base de modélisation	Y. Podladchikov	Fall 28h CE	Practice (Report)	3
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained.				

### Module Reservoir geology4 – 6 ECTS

*Teacher in charge : A. Moscariello*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Clastic reservoirs</b> / Réservoirs clastiques	A. Moscariello	Spring 5d C PW S	Oral or written exam	3
<b>Carbonate reservoirs</b> / Réservoirs carbonatés	A. Moscariello et collaborateurs	Spring 5d C PW S	Oral or written exam	3
Courses of this module cannot be taken individually.				
Prerequisite: modules Basin research, Borehole logging and rock physics, and Practical seismic reflection				
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained.				



## Module Reservoir geology II – 6 ECTS

*Teacher in charge : A. Moscariello*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>3D static and geological modelling - Petrel and Eclipse /</b> Modélisation géologique statique et dynamique en 3D - Petrel et Eclipse	A. Moscariello et collaborateurs	Spring 5d C PW S	Oral or written exam	3
<b>From play evaluation to field development /</b> De l'Evaluation du «play» au développement	A. Moscariello,	Spring 5d C PWP S	Oral or written exam	3
Courses of this module cannot be taken individually				
Prerequisite: priority will be given to students who have followed the modules Reservoir geology I, Basin research, Borehole logging and rock physics, and Practical seismic reflection				
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained..				

## Module Advanced structural geology - 6 ECTS

*Teacher in charge : JL Epard*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Alpine Structural Geology /</b> Géologie structurale alpine	JL. Epard	Fall 24h C PW	Practice	3
<b>Alpine tectonics, field camp /</b> Camp de tectonique alpine	JL. Epard	Spring 6j F	Practice (Report)	3
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained..				

### Module 2D and 3D seismic interpretation – 6 ECTS

*Teacher in charge : A. Moscariello*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
2D and 3D seismic interpretation / Interprétation sismique 2D et 3D	A. Moscariello	Fall 6d C PWP and personal work	Practice	6

### Module Borehole logging and rock physics - 6 ECTS

*Teacher in charge : B. Quintal*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
Borehole logging and rock physics / Diagraphie de puits et physique des roches	B. Quintal, A. Moscariello	Fall 6j C E + personal work	Practice	6

### Module Pratique de la géologie environnementale – 6 ECTS (in French)

*Teacher in charge : S. Girardclos*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
Sites contaminés: application géologique et environnementale	<u>S. Girardclos</u> , J. Poté	Spring 5d C PW	Practice	3
Les déchets: gestion environnementale et contraintes géologiques	J. Poté, S. Girardclos, G. Giu- liani, M. Patel.	Spring 5d C PW	Practice	3
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained.				

## Module Fluid flow for geologists – 6 ECTS

*Teacher in charge : M. Lupi*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Fluid flow for geologists /</b> L'écoulements des fluides pour géologues	<u>M. Lupi</u>	Spring 5d C 5d F	Practice	6

## Module Spatial analysis applied to geology and risk - 6 ECTS

*Teacher in charge : M. Sartori*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Cartographic data management and landslide susceptibility assessment /</b> Structuration des données géologiques et analyses spa ales appliquées aux instabilités de versant	<u>M. Sartori</u> , C. Frischknecht	Spring 5d CE	Practice (Report)	3
<b>Spatial risk assessment /</b> L'Évaluation spatiale du risque	<u>C. Frischknecht</u> , P. Peduzzi	Spring 5d CE	Practice (Report)	3
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained.				
Courses of this module can be taken separately for the students not following the RGEOL orientation.				

### PART C1 : Free choice of 12 ECTS credits

The student completes his curriculum by selecting courses among those proposed in the Master in Earth Sciences or in other Master's programs (for example: Master in Environmental science, UNIGE; Master in Environmental geosciences, UNIL; Master in Biogeosciences, UNIL/UNINE).

The list of courses can contain courses of the Bachelor-level, for a maximum of 5 ECTS credits. An internship in a company can be validated in this part, as provided by the rules and regulations (art. 15, al. 6).

The student must draw up a list of courses selected in agreement with his Master's thesis supervisor. Here are some suggestions of additional courses that don't appear in the other parts of the study plan:

Courses	<u>Teacher in charge/</u> Speaker(s)	Semester Modality	Evaluation	ECTS credits
<b>Geology of clays</b> / Géologie des argiles)	T. Adatte	Spring 3d CE	Practice	1.5
<b>SPACE-GEOENERGY: Geomatics and geo-energy</b> / Géomatique et géo-énergies	A. Moscariello, J. Simantov et collègues	Spring 5d C	Practice	3
<b>Dates and rates of landscape evolution</b> / Datation et taux d'évolution du paysage de montagne	G. King	Spring 16h C, 10h PW, 40h F	Practice	3
<b>Imperial Barrel Award</b> (AAPG) <i>Réservé en priorité aux étudiants de deuxième année. Prérequis : From play evaluation to field development</i>	A. Moscariello (coordinateur)	Spring 6 weeks	Practice	6
<b>Biomineralization</b> / Biominéralisation	A. Meibom	Fall 42h C PW	Report / oral presentation	4
<b>Introduction to geothermics</b> / Introduction à la géothermie	S. Miller (UNINE)	Fall 4dj CE	Practice	2
<b>Introduction to hydrogeology and hydrology</b> / Introduction à l'hydrogéologie et à l'hydrologie	Ph. Brunner (UNINE)	Fall 6d CE	Practice	3
<b>Scanning Electron Microscopy</b> / Microscopie électronique à balayage, MEB	R. Martini pour l'UNIGE P. Vonlanthen pour l'UNIL	Fall 2d C PW	Validation without grade	1
<b>Optical cathodoluminescence</b> / Cathodoluminescence optique	R. Martini	Spring 1d C PW	Validation without grade	0.5
<b>Initiation to the ion probe</b> / Initiation à la sonde ionique	A.S. Bouvier, A. Meibom	Spring 1d C PW	Validation without grade	0.5
<b>Electron probe microanalyzer</b> / Microsonde électronique	M. Robyr	Fall 2j C PW	Practice	1
<b>Stable isotopes analysis</b> / Analyse des isotopes stables - <i>Cours sur mesure et sur demande</i>	T. Vennemann	Spring 1j C PW	Practice	0.5

<b>Organic geochemistry / Géochimie organique</b>	J. Spangenberg	Spring 6d C PW	Practice	3
<b>PorPerm and QemScan</b>	A. Moscariello	Fall 1d C PW	Validation without grade	0.5
<b>Inductively-coupled plasma mass-spectrometry / Spectrométrie de masse à source plasma à couplage inductif</b>	A. Ulianov	Fall 2d C E	Validation without grade	1
<b>Sedimentary laboratory techniques / Techniques de laboratoires sédimentaires</b>	N. N	Fall 1d C PW	Validation without grade	0.5
<b>Marine seismic acquisition, interpretation and data integration / Acquisition, interprétation et intégration de données sismiques marines)</b>	D. Ariztegui	Spring 8d F S	Practice	3
<b>Model parameter estimation and uncertainty quantification</b>	N. Linde	Spring 56h C PW	Report / oral presentation	5
<b>Internship in a company / Stage en entreprise (validated by the Master's thesis supervisor)</b>				6
Modules or courses of the curriculum of the Master in Earth Sciences*				
Courses proposed by the MUSE (UNIGE), Environment MSc (UNIL), Biogeosciences MSc (UNIL-UNINE)*				
Courses proposed by another academic institution*				
Courses of the Bachelor-level *			5 ECTS credits maximum	
<b>Total credits to validate</b>			<b>12 ECTS credits</b>	
*: for these courses, the evaluation and the number of attributed ECTS credits are those contained in the curriculum from which they are taken.				

In the part C1, courses are individually validated if their grade is equal of at least 4.0/6 or if the validation is obtained.

### Part Master thesis in Earth sciences – 60 ECTS credits

This Master's thesis is an individual research work under the responsibility of an ELSTE teacher.

By the end of the first semester of Master's studies at the latest, the student must have chosen the subject of his Master's thesis. Before the beginning of the second year of the program, the student must draft and present his Master's thesis project. The ECTS credits of the Master's thesis project are obtained when its grade is equal of at least 4.

These are evaluated based on the submitted manuscript and the quality of the oral defense. This evaluation, weighted according to the internal guidelines of the Master thesis in Earth sciences, takes the form of a single grade. The Master thesis is passed and the ECTS credits of the Master thesis obtained when the grade as well as the one of the deposited manuscript are both equal or higher to 4. The protocol regulating the achievement of the Master thesis are in the Guidelines of the Master thesis in Earth sciences.

Master thesis	Semester	Year 1	Year 2	Evaluation	6
Master project	Spring	*		Report (Master proposal) and oral exam	10
Master thesis	Spring		*	Manuscript and oral defense	50

## Orientation Geochemistry - Alpine Tectonics - Ore Deposits /

**Coordinators : Othmar Müntener, Robert Moritz, Stefan Schmalholz**

Terrestrial lithosphere is constantly reshaped by the igneous, metamorphic and tectonic processes strongly generated by heat and mass transfer. The mountain ranges are places of intense volcanic, tectonic and/or seismic activity, sometimes located in densely populated and heavily industrialized areas of the world. The study of the phenomena that shape our planet is also crucial for social and economic issues. It has long been established that the Alps constitute the ideal place to test revolutionary ideas in geodynamics such as the theory of nappes , the geometry of continental passive margins, plate tectonics, regional or contact metamorphism, until the recent debate on the exhumation of rocks formed under ultrahigh pressures. The Alps also allow to study the relationship between climate, erosion and orogenies.

The fieldwork and data analyses are the first step in understanding the formation of mountain chains and the physical and chemical processes that accompany them. It is then necessary to develop models that confront the petrological and thermomechanical processes with the acquired data.

Acquired during the two years of Master study in the orientation Geochemistry, Alpine Tectonics, Ore Deposits, the training provides the tools needed to elucidate the sequence of events recorded in the rocks of our planet, locate areas suitable for the exploitation of raw materials, or examine and explain the dynamic processes affecting the outer parts of our Earth, such as the formation and destruction of mountain ranges, volcanic eruptions or magma genesis. The theoretical and practical courses cover areas such as petrology, isotope geochemistry, tectonics, geodynamics, structural geology, ore deposits, the continuum mechanics, numerical modeling, and analytical methods in laboratory and of course work in the field. Throughout their curriculum in the Master in Earth sciences, students gain theoretical knowledge but also the opportunity to work in a series of state-of-the-art analytical laboratories. Lectures are held in the form of courses, practicals, seminars, field camp. The orientation Geochemistry, Alpine Tectonics, Ore Deposits offers unique courses in Switzerland and Europe through its interdisciplinary approach and the nearby natural laboratory that is the Swiss Jura and the Alps, the number of experts involved, internal to the Universities of Geneva and Lausanne and external guests. The vast and eclectic course offering of this orientation allows students to make a personal university curriculum to meet their needs for guidance, according to their career plan, both to an academic path, as to the professional world, allowing them to focus on jobs in the mining industry, in geological and environmental impact offices or in governmental agencies.

## PART A2 mandatory: 24 ECTS credits

The mandatory **part A2** includes four modules:

- Petrological processes in geodynamic environments
- Quantitative tectonics and rocks deformation
- Geophysics across scales for geologists
- Field trips

### Module Petrological processes in geodynamic environments – 9 ECTS

*Teacher in charge : U. Schaltegger et O. Müntener*

Courses	<u>Teacher in charge/</u> Speaker(s)	Semester Modality	Evaluation	ECTS credits
<b>Petrological processes in geodynamic environments</b> / Processus pétrologiques dans les environnements géodynamiques	<u>U. Schaltegger, O. Müntener</u> S. Pilet, L. Caricchi L. Baumgartner, S. Schmalholz, N.N, J. Marin-Carbonne	Fall 70h C PW E S	Seminars, Report	9
One ECTS credits corresponds to 25-30 hours of actual work				
C: course – PW: Practical work – E: Exercises – S: Seminars – F : Field – d : days (block course) – h: hours (weekly course)				
This module must be followed during the two first semesters of the Master and then validated during the following exam session. It is validated and the 9 ECTS credits earned if the grade is at least 4.				

### Module Quantitative tectonics and rock deformation – 6 ECTS

*Teacher in charge : S: Schmalholz*

Courses	<u>Teacher in charge/</u> Speaker(s)	Semester Modality	Evaluation	ECTS credits
<b>Quantitative tectonics</b> / Tectonique quantitative	S. Schmalholz	Fall 42h C PW	Practice	4
<b>Microtectonics</b> / Microtectonique	M. Robyr, S. Schmalholz	Spring 27h C PW	Practice	2
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained.				



### Module Geophysics across scales for geologists – 3 ECTS

*Teacher in charge : G. Hetényi*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Geophysics across scales for geologists</b> / Géophysique à différentes échelles pour géologues	<u>G. Hetényi</u> , B. Quintal, M. Lupi, A. Moscariello	Fall 4d C PW	Practice	3

### Module Field trips - 6 ECTS

*Teacher in charge : L. Baumgartner*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Field trips UNIGE / Camp de terrain UNIGE</b>	<u>L. Caricchi</u> , N.N	Spring 8j T	Pratique	6
<b>Field trips UNIL / Camps de terrain UNIL</b>	<u>L. Baumgartner</u>	Spring 8j T	Pratique	6
The student chooses one of the two courses. The courses of this module are validated and the 6 ECTS credits given in bloc, if the student have a grade equal or higher than 4 to the chosen course.				

The part A2 is validated if each of the four modules is validated.

### PART B2 : a choice of 24 ECTS credits

The student must select four modules among those proposed in the list below:

- Stable and radiogenic isotope geochemistry
- Petrology and fluids in the Earth's crust
- Advanced petrology and volcanology
- Advanced structural geology
- Fundamentals of numerical modelling and data analysis
- Ore deposits
- Mineral exploration
- Applied and environmental mineralogy
- Pratique de la géologie environnementale (in French)

- Fluid flow for geologists
- Spatial analysis applied to geology and risk

### Module Stable and radiogenic isotope geochemistry – 6 ECTS

*Teacher in charge : M. Chiaradia*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Stable and radiogenic isotope geochemistry (bisannual)/</b> Géochimie des isotopes stables et radiogéniques	<u>M. Chiaradia</u> , E. Samankassou, U. Schaltegger, R. Spikings, T. Vennemann	Every odd semester, Spring 84h C PW S	Written exam	6

### Module Advanced petrology and volcanology – 6 ECTS

*Teacher in charge : L. Caricchi, C. Bonadonna, S. Pilet*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
Modelling volcanic processes/ Modélisation des processus volcaniques	<u>C. Bonadonna</u> , Paul Jarvis, Eduardo Rossi	Fall 28h C	Seminar	2
<b>Volcano petrology /</b> Pétrologie volcanique	<u>L. Caricchi</u> , S. Pilet	Spring 28h C	Seminar	2
<b>Volcano fieldtrip /</b> Excursion volcanique	<u>L. Caricchi</u> , C. Bonadonna, S. Pilet	Spring 5j F	Practice (Report)	2
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained.				
Courses of this module cannot be taken separately.				

### Module Petrology and fluids in the Earth's crust - 6 ECTS

*Teacher in charge : R. Moritz*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
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<b>Fluids in the Earth crust /</b> Fluides dans la croûte terrestre	L. Baumgartner	Spring 28h C PW	Validation without grade	2
<b>Low-temperature alteration in the Upper Crust</b> (bisannuel) / Altérations de basse température sur la croûte supérieure	S. Schmidt	Every even semester, Fall 3j C TP	Validation without grade	1.5
<b>Fluid inclusions /</b> Inclusions de fluides	R. Moritz	Fall 3j C PW	Validation without grade	1.5
<b>Reading rocks – Rock textures and fluids /</b> Lecture des roches - textures de roches et fluides	K. Kouzmanov	Spring 2j C PW	Validation without grade	1
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained.				

### Module Advanced structural geology - 6 ECTS

*Teacher in charge : JL Epard*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Alpine Structural Geology /</b> Géologie structurale alpine	JL. Epard	Fall 24h C PW	Practice	3
<b>Alpine tectonics, field camp</b> / Camp de tectonique alpine	JL. Epard	Spring 6j F	Practice (Report)	3
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained.				

## Module Fundamentals of numerical modelling and data analysis – 6 ECTS

Teacher in charge : Y. Podladchikov

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Introduction to data analysis with MATLAB</b> / Introduction à l'analyse de données avec Matlab	G. Simpson	Fall 3d C	Practice (Report)	1
<b>MATLAB as a language of scientific computing</b> / Matlab comme langage de calcul scientifique	Y. Podladchikov	Fall 42h CE	Practice (Report)	3
<b>Physics as a basis for modeling</b> / La physique comme base de modélisation	Y. Podladchikov	Fall 28h CE	Practice (Report)	3
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained.				

## Module Ore deposits – 6ECTS

Teacher in charge : N. N

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Advanced ore deposits</b> / Gîtes métallifères - avancé <i>Pré-requis: cours «Ore microscopy» ou équivalent</i>	<u>N. N.</u> , K. Kouzmanov, M. Chiaradia, R. Moritz	Fall 10d C PW + personal work	Practice (report, seminar) written exam	4
<b>Ore microscopy</b> / Microscopie des minerais	K. Kouzmanov	Fall 6d C PW	written exam	2
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained.				

## Module Mineral exploration – 6 ECTS

*Teacher in charge : N.N*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Methods of exploration</b> (bisannual) / Méthodes d'exploration Prerequis: basic geological and mineral deposit knowledge	G. Beaudoin	Every odd semesters, Fall 10d CE	Practice (Report)	3
<b>Advanced ore deposits II /</b> Gîtes métallifères - avancé II Pré-requis: Advanced ore deposits et Ore microscopy ou équivalent	<u>N. N</u> , K. Kouzmanov, M. Chiaradia, R. Moritz	Spring 3d CE	Seminar, Exam oral	2
<b>Mining geophysics /</b> Géophysique minière Pré- requis: Introduction à la géophysique	J. Irving	Spring 4d C PW	Practice	1
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained.				

## Module Applied and environmental mineralogy – 6 ECTS

*Teacher in charge : O. Müntener*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Gemmology / Gemmologie</b>	L. Cartier	Spring 6d CE PW	Practice (Exercices)	2
<b>Gemmology - field /</b> Gemmologie – terrain Pré - requis : Gemmology	L. Cartier	Fall 2d F	Validation without grade	1
<b>Applied mineralogy /</b> Minéralogie appliquée	<u>T. Vennemann</u> , B. Putlitz	Spring 4d C F	Practice (Report)	2
<b>Physics and structure of minerals / Physique et structure des minéraux</b>	O. Müntener	Spring 14d C	Practice	1

The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained.

### Module Pratique de la géologie environnementale – 6 ECTS (en français)

*Teacher in charge : S. Girardclos*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
Sites contaminés: application géologique et environnementale	<u>S. Girardclos</u> , J. Poté	Spring 5d C PW	Practice	3
Les déchets: gestion environnementale et contraintes géologiques	<u>J. Poté</u> , S. Girardclos, G. Giuliani, M. Patel.	Spring 5d C PWP	Practice	3
Les enseignements de ce module sont validés et les 6 ECTS credits attribués en bloc, si la moyenne (pondérée par les crédits) de leurs notes est de 4 au moins et si les attestations sont obtenues.				

### Module Fluid flow for geologists – 6 ECTS

*Teacher in charge : M. Lupi*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
Fluid flow for geologists / L'écoulements des fluides pour géologues	<u>M. Lupi</u>	Spring 5d C 5d F	Practice	6

## Module Spatial analysis applied to geology and risk - 6 ECTS

Teacher in charge : M. Sartori

Courses	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
<b>Cartographic data management and landslide susceptibility assessment /</b> Structuration des données géologiques et analyses spatiales appliquées aux instabilités de versant	<u>M. Sartori</u> , C. Frischknecht	Spring 5d CE	Practice (Report)	3
<b>Spatial risk assessment /</b> L'Évaluation spatiale du risque	<u>C. Frischknecht</u> , P. Peduzzi	Spring 5j CE	Pratique (Report)	3
Les enseignements de ce module sont validés et les 6 ECTS credits attribués en bloc, si la moyenne (pondérée par les crédits) de leurs notes est de 4 au moins et si les attestations sont obtenues.				
Les cours de ce module peuvent être pris séparément pour les étudiants hors de l'orientation RGEOL				

### PART C2 : Free choice of 12 ECTS credits

The student completes his curriculum by selecting courses among those proposed in the Master in Earth Sciences or in other Master's programs (for example: Master in Environmental science, UNIGE; Master in Environmental geosciences, UNIL; Master in Biogeosciences, UNIL/UNINE).

The list of courses can contain courses of the Bachelor-level, for a maximum of 5 ECTS credits. An internship in an company can be validated in this part, as provided by the rules and regulations (art. 15, al. 6).

The student must draw up a list of courses selected in agreement with his Master's thesis supervisor. Here are some suggestions of additional courses that don't appear in the other parts of the study plan:

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Syn-tectonic granite emplacement and vein formation</b> – Cévennes, France (bisannual) / Mise en place de granites syn-tecto- niques et veines hydrothermales - Cévennes, France	<u>K. Kouzmanov</u> , A. Chauvet	Every odd semester, Spring 6J F	Practice	3
<b>Environmental biogeochemistry /</b> Biogéochimie environnementale. <i>Prerequis: general geochemistry, aqua c chemistry, introductory chemistry and physics</i>	J. Peña	Spring 30h C E	Written exam	3
<b>Biominerzation /</b> Biominéralisation	A. Meibom	Fall 42h C PW	Report / oral presentation	4
<b>Scanning Electron Microscopy /</b> Microscopie électronique à balayage, MEB	R. Martini for UNIGE P. Vonlanthen for UNIL	Fall 2d C PW	Validation without grade	1
<b>Optical cathodoluminescence /</b> Cathodoluminescence optique	R. Martini	Spring 1d C PW	Validation without grade	0.5
<b>Initiation to the ion probe /</b> Initiation à la sonde ionique	<u>A.S. Bouvier</u> , A. Meibom	Spring 1d C PW	Validation without grade	0.5
<b>Electron probe microanalyzer /</b> Microsonde électronique	M. Robyr	Fall 2d C PW	Practice (PW)	1
<b>Stable isotopes analysis /</b> Analyse des isotopes stables Cours sur mesure et sur demande	T. Vennemann	Spring 1d C PW	Practice	0.5
<b>PorPerm and QemScan</b>	A. Moscariello	Fall 1d C PW	Validation without grade	0.5
<b>Inductively-coupled plasma mass-spectrometry /</b> Spectrométrie de masse à source plasma à couplage inductif	A. Ulianov	Fall 2d C E	Validation without grade	1
<b>Microtomography /</b> <i>Microtomographie</i>	L. Baumgartner	Spring 1d C PW	Validation without grade	0.5
<b>Laboratory techniques in geochemistry /</b> Techniques de laboratoire en géochimie	U. Schaltegger	Fall 1d C PW	Validation without grade	0.5



<b>Internship in a company</b> / Stage en entreprise (validated by the Master's thesis supervisor)	6
Modules or courses of the curriculum of the Master in Earth Sciences*	
Courses proposed by the MUSE (UNIGE), Environment MSc (UNIL), Biogeosciences MSc (UNIL-UNINE)*	
Courses proposed by another academic institution*	
Courses of the Bachelor-level *	5 ECTS credits maximum
<b>Total credits to validate</b>	<b>12 ECTS credits</b>
*: for these courses, the evaluation and the number of attributed ECTS credits are those contained in the curriculum from which they are taken.	

In the part C2, courses are individually validated if their grade is equal of at least 4.0/6 or if the validation is obtained.

### Part Master thesis in Earth sciences – 60 ECTS credits

This Master's thesis is an individual research work under the responsibility of an ELSTE teacher.

By the end of the first semester of Master's studies at the latest, the student must have chosen the subject of his Master's thesis. Before the beginning of the second year of the program, the student must draft and present his Master's thesis project. The ECTS credits of the Master's thesis project are obtained when its grade is equal of at least 4.

These are evaluated based on the submitted manuscript and the quality of the oral defense. This evaluation, weighted according to the internal guidelines of the Master thesis in Earth sciences, takes the form of a single grade. The Master thesis is passed and the ECTS credits of the Master thesis obtained when the grade as well as the one of the deposited manuscript are both equal or higher to 4. The protocol regulating the achievement of the Master thesis are in the Guidelines of the Master thesis in Earth sciences.

Master thesis	Semester	Year 1	Year 2	Evaluation	6
Master project	Spring	*		Report (Master proposal) and oral exam	10

*Study plan - Master in Earth sciences - 2019/2020*

Master thesis	Spring	*	Manuscript and oral defense	50
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## Orientation Geological Risks / RGEOL

**Coordinators : Costanza Bonadonna**

Geological processes such as landslides , earthquakes and volcanic eruptions are fascinating but complex phenomena with potentially significant impacts on society. These impacts may occur at different levels, local, regional and global .

The geological hazards concentration focuses on the dynamic challenges facing societies worldwide when developing risk reduction measures. This concentration forms on the deep and surface processes that generate geological hazards and on assessment methods of exposure and vulnerability of people and the built environment. Hazard and vulnerability assessments are then combined to conduct the analysis of impacts and associated risks. Through this concentration, students have access to teachers at the forefront of research, to acquisition tools of specific data, as well as to different approaches for modeling and risk analysis. Field works enable to integrate various aspects of risk management. This multidisciplinary concentration offers students the opportunity to acquire skills that make them employable in geological and geotechnical consulting firms, international and nongovernmental organizations, and federal offices.

### **PART A3 mandatory: 24 ECTS credits**

The mandatory **part A3** includes four modules:

- Petrological processes in geodynamic environments
- Fundamentals of numerical modelling and data analysis
- Spatial analysis applied to geology and risk
- Geophysics across scales for geologists

### Module Petrological processes in geodynamic environments – 9 ECTS

Teacher in charge : U. Schaltegger et O. Müntener

Courses	<u>Teacher in charge/</u> Speaker(s)	Semester Modality	Evaluation	ECTS credits
<b>Petrological processes in geodynamic environments</b> / Processus pétrologiques dans les environnements géodynamiques	<u>U. Schaltegger, O. Müntener</u> S. Pilet, L. Caricchi L. Baumgartner, S. Schmalholz, N. N, J. Marin-Carbone	Fall 70h C PW E S	Seminars	9
One ECTS credits corresponds to 25-30 hours of actual work				
C: course – PW: Practical work – E: Exercises – S: Seminars – F : Field – d : days (block course) – h: hours (weekly course)				
This module must be followed during the two first semesters of the Master and then validated during the following exam session. It is validated and the 9 ECTS credits earned if the grade is at least 4.				

### Module Fundamentals of numerical modelling and data analysis – 6 ECTS

Teacher in charge : Y. Podladchikov

Courses	<u>Teacher in charge/</u> Speaker(s)	Semester Modality	Evaluation	ECTS credits
<b>Introduction to data analysis with MATLAB</b> / Introduction à l'analyse de données avec Matlab	G. Simpson	Fall 3d C	Practice (Report)	1
<b>MATLAB as a language of scientific computing</b> / Matlab comme langage de calcul scientifique	Y. Podladchikov	Fall 42h CE	Practice (Report)	3
<b>Physics as a basis for modeling</b> / La physique comme base de modélisation	Y. Podladchikov	Fall 28h CE	Practice (Report)	3
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained.				

## Module Spatial analysis applied to geology and risk - 6 ECTS

*Teacher in charge : M. Sartori*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Cartographic data management and landslide susceptibility assessment /</b> Structuration des données géologiques et analyses spatiales appliquées aux instabilités de versant	<u>M. Sartori</u> , C. Frischknecht	Spring 5d CE	Practice (Report)	3
<b>Spatial risk assessment /</b> L'Évaluation spatiale du risque	<u>C. Frischknecht</u> , P. Peduzzi	Spring 5d CE	Practice (Report)	3
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained..				

## Module Geophysics across scales for geologists – 3 ECTS

*Teacher in charge : G. Hetényi*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Geophysics across scales for geologists</b> / Géophysique à différentes échelles pour géologues	<u>G. Hetényi</u> , B. Quintal, M. Lupi, A. Moscariello	Fall 4d C PW	Practice	3

The part A3 is validated if each of the four modules is validated.

## PART B3 : a choice of 24 ECTS credits

The student must select four modules among those proposed in the list below

- Advanced petrology and volcanology
- Risk Management
- Volcanic and seismic risk
- Hazards and risks of slope movements
- Advanced risks

- Pratique de la géologie environnementale
- Fluid flow for geologists

### Module Advanced petrology and volcanology – 6 ECTS

*Teacher in charge : L. Caricchi, C. Bonadonna, S. Pilet*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Modelling volcanic processes/</b> Modélisation des processus volcaniques	<u>C. Bonadonna</u> , Paul Jarvis, Eduardo Rossi	Fall 28h C	Seminar	2
<b>Volcano petrology /</b> Pétrologie volcanique	<u>L. Caricchi</u> , S. Pilet	Spring 28h C	Seminar	2
<b>Volcano fieldtrip /</b> Excursion volcanique	<u>L. Caricchi</u> , C. Bonadonna, S. Pilet	Spring 5j F	Practice (Report)	2
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained.				
Courses of this module cannot be taken separately				

### Module Risk Management – 6 ECTS

*Teacher in charge : S. Menoni*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Risk management /</b> Gestion des risques	<u>S. Menoni</u> , C. Gregg, and teachers of CERG-C	Spring 84h C	Written exam	6
In this module, courses are in English.				

## Module Volcanic and seismic risk – 6 ECTS

*Teacher in charge : C. Bonadonna*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Volcanic risk</b> <i>Préquis : Risk Management</i>	<u>C. Bonadonna</u> and teachers of CERG-C	Spring 6d C F	Written exam, practice (Report)	3
<b>Seismic risk</b>	<u>D. Fäh</u> , B. Duvernay	Spring 6d CE	Written exam	3
In this module, courses are in English.				

## Module Hazards and risks of slope movements - 6 ECTS

*Teacher in charge : M. Jaboyedoff*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Erosion and slope movements</b> / Erosion et mouvements de versants	M. Jaboyedoff	Spring 56h CE	Written exam	4
<b>Hazards and risks of slope movements : field camp I</b> / Risques et dangers liés aux mouvements de versants: terrain I	<u>MH Derron</u> , M. Jaboyedoff	Spring 5d F	Written exam	2
Prerequisite: Natural risks and hazards (BSc) – Numerical modelling (BSc) or equivalent				
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained. 3 supplementary credits can be obtained in the student's elective part by taking the course «Hazards and risks of slope mass movements: field camp II »				

### Module Advanced risks – 6 ECTS

*Teacher in charge : M. Jaboyedoff*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Advanced quantitative risk and vulnerability</b> / Risques avancés quantitatifs et la vulnérabilité	M. Jaboyedoff	Fall 28h C 14h E	Written exam, continuous assessment	3
<b>Communication on environmental risks</b> / Communication sur les risques environnementaux	M. Jaboyedoff, K. Südmeier-Rieux, S. Rondic	Fall 16h C 16h E	Practice (Report)	3
Prerequisite: Environmental hazards (BSc) or equivalent				
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained.				

### Module Pratique de la géologie environnementale – 6 ECTS (en français)

*Teacher in charge : S. Girardclos*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
<b>Sites contaminés: application géologique et environnementale</b>	<u>S. Girardclos</u> , J. Poté	Spring 5d C PW	Practice	3
<b>Les déchets: gestion environnementale et contraintes géologiques</b>	J. <u>Poté</u> , S. Girardclos, G. Giuliani, M. Patel.	Spring 5d C PW	Practice	3
The courses of this module are validated and the 6 ECTS credits earned in a block if the credit-weighted grade average is at least 4 and if the validations are obtained.				

### Module Fluid flow for geologists – 6 ECTS

*Teacher in charge : M. Lupi*

Courses	<u>Teacher in charge/ Speaker(s)</u>	Semester Modality	Evaluation	ECTS credits
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<b>Fluid flow for geologists /</b> L'écoulements des fluides pour géologues	<u>M. Lupi</u>	Spring 5d C 5d F	Practice	6
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### PART C3 : Free choice of 12 ECTS credits

The student completes his curriculum by selecting courses among those proposed in the Master in Earth Sciences or in other Master's programs (for example: Master in Environmental science, UNIGE; Master in Environmental geosciences, UNIL; Master in Biogeosciences, UNIL/UNINE).

The list of courses can contain courses of the Bachelor-level, for a maximum of 5 ECTS credits. An internship in a company can be validated in this part, as provided by the rules and regulations (art. 15, al. 6).

The student must draw up a list of courses selected in agreement with his Master's thesis supervisor. Here are some suggestions of additional courses that don't appear in the other parts of the study plan:

<b>Courses</b>	<b><u>Teacher in charge/</u></b> <b>Speaker(s)</b>	<b>Semester</b> <b>Modality</b>	<b>Evaluation</b>	<b>ECTS</b> <b>credits</b>
<b>Biom mineralization /</b> Biominéralisation	A. Meibom	Fall 42h C PW	Report / oral presentation	4
<b>Hazards and risks of slope</b> <b>movements : field camp II</b> <i>part I of the</i> <i>field of the module «Hazards and risks of slope</i> <i>movements» mandatory</i>	M. H. Derron, M. Jaboyedoff	Spring 5d F	Practice	3
<b>Marine seismic acquisition,</b> <b>interpretation and data integration /</b> Acquisition, interprétation et intégration de données sismiques marines	D. Ariztegui	Spring 8d F  S	Practice	3
<b>Model parameter estimation and</b> <b>uncertainty quantification</b>	N. Linde	Spring 56h C PW	Report / oral presentation	5
<b>Dates and rates of landscape</b> <b>evolution /</b> Datation et taux d'évolution du paysage de montagne	G. Kling	Spring 16h C, 10h PW, 40h F	Practice	3
<b>Internship in a company /</b> Stage en entreprise (validated by the Master's thesis supervisor)				6

Modules or courses of the curriculum of the Master in Earth Sciences*	
Courses proposed by the MUSE (UNIGE), Environment MSc (UNIL), Biogeosciences MSc (UNIL-UNINE)*	
Courses proposed by another academic institution*	
Courses of the Bachelor-level *	5 ECTS credits maximum
<b>Total credits to validate</b>	<b>Total credits to validate</b>
*: for these courses, the evaluation and the number of attributed ECTS credits are those contained in the curriculum from which they are taken.	

In the part C3, courses are individually validated if their grade is equal of at least 4.0/6 or if the validation is obtained

### Part Master thesis in Earth sciences – 60 ECTS credits

This Master's thesis is an individual research work under the responsibility of an ELSTE teacher.

By the end of the first semester of Master's studies at the latest, the student must have chosen the subject of his Master's thesis. Before the beginning of the second year of the program, the student must draft and present his Master's thesis project. The ECTS credits of the Master's thesis project are obtained when its grade is equal of at least 4.

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Master thesis	Semester	Year 1	Year 2	Evaluation	6
Master project	Spring	*		Report (Master proposal) and oral exam	10
Master thesis	Spring		*	Manuscript and oral defense	50

**The original document in French carries these signatures**

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Adopté par le Conseil de Faculté du

Adopté par le Conseil de Faculté du

Frédéric Herman

Jérôme Lacour

Doyen de la Faculté des géosciences de  
l'environnement de l'UNIL

Doyen de la Faculté des sciences de l'UNIGE

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