ECOLE LEMANIQUE DES SCIENCES DE LA TERRE
DES UNIVERSITES DE GENEVE ET DE LAUSANNE

Master of Science (Msc) in Earth Sciences

Rules and Regulations

Curriculum

Course Description

École Lémanique des Sciences de la Terre

2021/2022

UNIL | Université de Lausanne
Faculté des géosciences
et de l'environnement

UNIVERSITÉ DE GENÈVE
FACULTÉ DES SCIENCES

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

Master of Science (MSc) in Earth Sciences

Master ès Sciences en sciences de la Terre

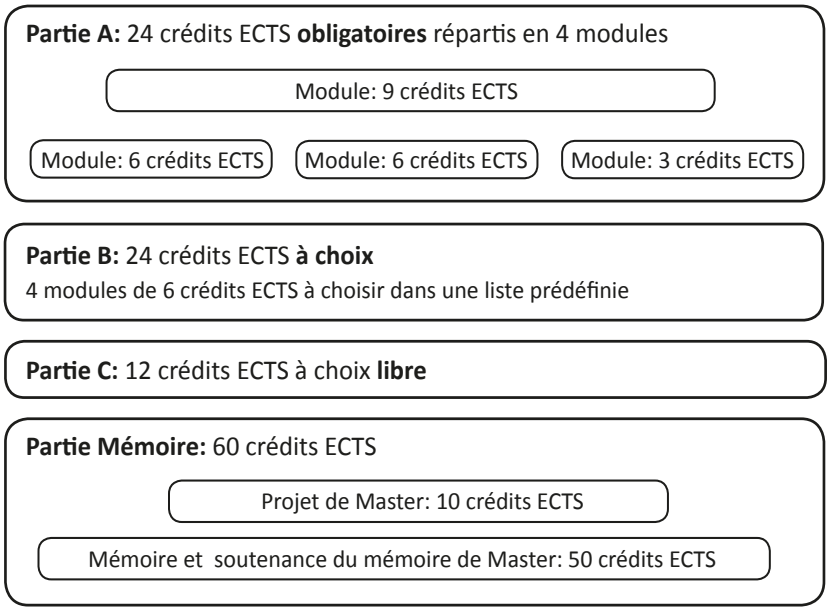
The Master of Science in Earth sciences is delivered jointly by the University of Geneva and the University of Lausanne, through the «Ecole Lémanique des Sciences de la Terre» (Lemanic School of Earth Sciences- ELSTE). This second level cycle of 120 ECTS credits program has a proposed period of four 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 concentrations :

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

At the beginning of the Master, each student choses a proposed concentration. The program of each concentration comprehends:

- 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 thesis is a personal research work under the responsability of an ELSTE teacher.



Whenever possible, courses must be taken during the first your 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.

Structure

Master of Science (MSc) in Earth sciences ELSTE - 2021/2022

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

the color of each module is to be found on sheets with schedules

	SERG	GATO	RGEOL
Part A : mandatory 24 ECTS credits	Sedimentary rock and processes from source-to-sink S. Castelltort	Petrological processes in geodynamic environments U. Schaltegger - O. Müntener	Petrological processes in geodynamic environments U. Schaltegger - O. Müntener
	Life evolving with Earth - A. Daley et E. Samankassou	Quantitative tectonics and rock deformation - S. Schmalholz	Fundamentals of numerical modelling and data analysis - Y. Podladchikov
	Basin Research G. Simpson	Field trips L. Caricchi et L. Baumgartner	Spatial analysis applied to geology and risk - M. Sartori
	Geophysics across scales for geologists G. Hetényi	Geophysics across scales for geologists G. Hetényi	Geophysics across scales for geologists G. Hetényi
Part B : choice of 4 modules - 24 ECTS credits	Pratique de la géologie environnementale	Pratique de la géologie environnementale	Pratique de la géologie environnementale
	Fluid flow for geologists M. Lupi	Fluid flow for geologists M. Lupi	Fluid flow for geologists M. Lupi
	Advanced structural geology JL Epard	Advanced structural geology JL Epard	Volcanic and seismic risks C. Bonadonna
	Fundamentals of numerical modelling and data analysis - Y. Podladchikov	Fundamentals of numerical modelling and data analysis - Y. Podladchikov	Hazard and risk of slope movements M. Jaboyedoff
	Spatial analysis applied to geology and risk - M. Sartori	Spatial analysis applied to geology and risk - M. Sartori	Advanced risk M. Jaboyedoff
	2D and 3D seismic interpretation A. Moscariello	Ore deposits K. Kouzmanov	2D and 3D seismic interpretation A. Moscariello
	Borehole logging and rock physics B. Quintal	Advanced petrology and volcanology L. Caricchi	Advanced petrology and volcanology L. Caricchi
	Integrated Basin analysis A. Moscariello	Applied and environmental mineralogy O. Müntener	Risk management S. Menoni
	Reservoir geology I A. Moscariello	Stable and radiogenic isotope geochemistry - M. Charadia	
	Reservoir geology II A. Moscariello	Petrology and fluids in the Earth's crust Z. Zajacz	
	Biostratigraphy and micropaleontology (R. Martini)	Mineral exploration R. Moritz	
Part C: free choice credits	Free choice credits 12 ECTS	Free choice credits 12 ECTS	Free choice credits 12 ECTS

60 ECTS credits

Master's Thesis
60 ECTS credits

Rules and Regulations

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Preamble

The Joint Geneva and Lausanne School of Earth Sciences (ELSTE) Agreement was signed on 7 July 1999, then renewed most recently on January, the 11, 2018. The Agreement applies to:

- the University of Geneva's Department of Earth Sciences, part of the Earth and Environmental Sciences Section of the University of Geneva's Faculty of Sciences;
- the University of Lausanne's Institute of Earth Sciences, part of the University of Lausanne's Faculty of Geosciences and Environment.

Chapter 1 – General Provisions

Article 1
Introduction

[1] The Universities of Geneva and Lausanne (hereinafter, "the partner universities") jointly award a Master of Science (MSc) in Earth sciences which constitutes a basic university program of study pursuant to the Framework agreement of 27 March 2009 on the creation of common Bachelor's and Master's programs between the Universities of Fribourg, Geneva, Lausanne, and Neuchâtel, and as stipulated in swissuniversities provisions.
[2] The academic units concerned (hereinafter, "the partner faculties") are:

- The University of Geneva's Faculty of Sciences
- The University of Lausanne's Faculty of Geosciences and Environment.

Article 2
Management and organization

[1] The course of study and management of the Master of Science in Earth sciences (hereinafter, "MSc in Earth sciences") are placed under the responsibility of the Executive Committee of the Joint Geneva and Lausanne School of Earth Sciences (hereinafter, "ELSTE"). ELSTE's competencies are defined in the Agreement cited in the Preamble.
[2] The Faculty in which a student is enrolled is defined as the Faculty responsible for the management of a student's course of study (hereinafter, the "Faculty responsible for managing the course of study").
[3] The Director of ELSTE is charged with the execution (dissemination) of committee recommendations to the competent bodies of the partner universities.
[4] The ELSTE Executive Committee's responsibilities include:

- Designing the rules and regulations and the curriculum for the MSc in Earth sciences such that they are compatible with the laws, rules, and regulations applicable to each university, and submitting them to the competent bodies of each of the partner universities;
- Providing recommendations for the competent bodies of each of the partner universities regarding admission of candidates and equivalencies;
- Coordinating courses and other activities called for by the curriculum, as well as the evaluation process;
- Encouraging the cooperative promotion of the MSc in Earth sciences;
- Designating an Academic Advisor at each of the two sites.

Article 3
Training objectives

The Master in Earth sciences offers a training that combines fundamental science and practical applications with a view to addressing geological problems of the planet. It aims to provide students with the tools necessary to manage fields governing Earth Sciences through a multidisciplinary approach: geodynamics of mountain chains and its underlying physical processes, the geochemistry of mantle and terrestrial crust, the evolution of life, oceans and paleoclimate through the study of sedimentary rocks, monitoring and modeling of surface geophysical processes, reservoir geology and basin analysis, mineral resources, and geological hazards. Students use analytical methods and laboratories and are involved in field studies, in collaboration with academic, research and industrial partners. The skills acquired during this program prepare concretely to professional duties and to very varied insertion areas in the sphere of Earth Sciences. In this context, at the end of the Master, students are able to:

- Analyze the challenges in the field of Earth Sciences.
- Develop critical thinking, capacity for analysis and synthesis in the management of contemporary issues related to Earth Sciences.
- Propose solutions to complex problems in geology on the basis of technical knowledge, of field measurements, of quantitative data processing and of modeling methods.
- Use sharp tools in Earth Sciences (equipment and analytical techniques, laboratories).
- Conduct an independent and innovative research by incorporating theoretical and experimental aspects, as well as practice acquired in the field at a national or international level.
- Work both independently and in groups.
- Be capable of effective oral and written communications, including in English.
- Argue from solid and consistent basis in the field of Earth Sciences; demonstrate logically a scientific argument and convince a varied audience while being open to new ideas.

Chapter 2 – Registration and Admission

Article 4
Admission

[1] The following are eligible for admission to the Master's program in Earth sciences:

a. holders of a Bachelor's Degree in Earth Sciences and Environment from the Faculty of Sciences of the University of Geneva
b. holders of a Bachelor's Degree in Geosciences and Environment with a Geology concentration from the Faculty of Geosciences and Environment of the University of Lausanne
c. holders of a Bachelor's Degree in the Earth Sciences field (swissuniversities category “sciences de la Terre”) from a Swiss university
d. holders of any degree deemed to be equivalent by the competent organs of each university, on recommendation of the Executive Committee.

[2] In addition, candidates for admission must meet all requirements for registration of the university with which they wish to register.

Article 5
Admission with conditions

[1] The Executive Committee may offer candidates with Bachelor’s Degrees in a field not mentioned in Article 3.1 above admission conditional upon requirements to be met after admission except as specified in Article 6 below. Conditions to be met after admission shall not exceed 18 ECTS credits.
[2] Specific conditions shall be specified in writing and agreed to by the student and the Faculty responsible for management of his curriculum.
[3] Failure to meet post-admission requirements by the specified deadline shall result in the student's elimination from the program pursuant to Article 18 below.

Article 6
Admission with pre-conditions

[1] The Executive Committee may offer candidates with Bachelor’s Degrees in a field not mentioned in Article 3.1 above admission conditional upon requirements to be met before admission. Conditions to be met before admission shall not exceed 60 ECTS credits.
[2] Specific conditions shall be specified in writing and agreed to by the student and the Faculty responsible for management of his curriculum
[3] Failure to meet pre-admission requirements by the specified deadline shall result in revocation of admission.

Article 7
Registration and Fees

[1] Registration and admission are processed by the competent bodies of the registering university, upon the recommendations of the competent science committee.
[2] Each student is registered at his choice of one of the partner universities and is recorded as a student of the corresponding Faculty. He shall pay fees for that university only.
[3] It is in principle not possible to change registration to another university during the course of studies.

[4] Students are subject to all laws, rules, and regulations of their university for all matters not addressed in these rules and regulations.

Article 8
Equivalencies

[1] A student who earned through prior studies a Master's-level degree in a field of study related to the MSc in Earth sciences curriculum, or holding a recognized university degree in another field of study, may be offered equivalencies.
[2] In all cases, at least 80 ECTS credits out of the 120 ECTS credits required must be earned in the framework of the course of study for the MSc in Earth sciences. The credits for the Master's thesis must be earned through the program.
[3] The ELSTE Executive Committee provides recommendations on equivalencies to the Faculty responsible for managing the course of study.

Article 9
Admission conditions following elimination

A student who has been eliminated from a Master's-level program at another faculty or higher education institution and who is admitted to the MSc in Geology is only permitted one attempt to successfully complete the module representing 12 ECTS credits in the part of required courses defined in the curriculum of the MSc in Earth sciences. Failing to successfully complete this module shall result in the student being eliminated from the program.

Chapter 3 – Curriculum

Article 10
Duration of studies and ECTS credits

[1] The curriculum is organized for 60 ECTS credits to be earned per year of full-time study.
[2] To obtain the MSc in Earth sciences, the student must earn a total of 120 ECTS credits as specified in the curriculum. The duration of studies is normally 4 semesters; the maximum duration of studies is 6 semesters, unless an extension is granted by the Dean's Office of the responsible Faculty due to exceptional or justified circumstances.
[3] The maximum duration of studies may be shortened proportionally for students granted equivalencies. It is extended proportionally if extra courses have been required of the student (Article 4).

Article 11
Leave of absence

Students wishing to temporarily interrupt their studies may request a leave of absence in the manner specified by the rules and regulations of the University at which they are registered.

Article 12
Curriculum

[1] The curriculum specifies the forms of instruction (courses, seminars, practicums, labs, etc.) as well as the forms of assessment (exams, continuing assessment, practical tests, etc.). The curriculum also specifies whether an internship is part of the course of studies.
[2] The curriculum differentiates between required courses and elective courses.
[3] The curriculum shall include instruction validated on its own as well as groups of related instruction (modules).
[4] The breakdown of ECTS credits for each course and for the Master's thesis shall be specified in the curriculum.
[5] Courses are organized into several concentrations. Each concentration comprises:

- A part of 24 required ECTS credits divided into 4 modules
- A part of 24 ECTS credits divided into 4 modules to be chosen from those in the selected concentration
- A part of 12 elective ECTS credits (student's choice, including courses, internships, etc.)
- A part that corresponds to the Master's thesis worth 60 ECTS credits. 10 ECTS credits are for the thesis project and 50 ECTS credits are for the written thesis and its defense.

[6] At the beginning of the Master's program, the student selects one concentration among those offered in the curriculum of the MSc in Earth sciences program. The director of the Master's thesis (or, alternatively, the Academic Advisor) approves, in writing, the list of courses chosen by the student.
[7] By the end of the first semester of Master's studies at the latest, the student must have chosen the director and the subject of his Master's thesis.
[8] The curriculum must be approved by the competent organs of each of the two partner universities.
[9] Instructors from other higher education institutions or institutes who teach courses in the framework of the curriculum of the MSc in Earth sciences are considered associate members of ELSTE.

Chapter 4–Assessment and Grading

Article 13
General information

[1] Assessment is by either exam or validation.
[2] Exams take place during exam sessions and always result in issuance of a grade. Exams may be oral or written, may combine several types of questions, and may require assimilation of the material of multiple courses.
[3] Validations take place during the semester and may result in a grade or simply be pass/fail. Validations are typically obtained after continuing assessment, a personal project (oral or written), or a test at the end of the semester.
[4] Details regarding assessment are specified in the curriculum.
[5] All graded assessments receive a grade from 1 to 6, where the minimum passing grade is 4 and the best grade possible is 6. Grading is to the quarter point. The grade of 0 is reserved for unexcused absences from exams and for cases of fraud or attempted fraud. A grade of 0 in any part of a module results in the failure of the entire module. For all other matters, the rules and regulations regarding fraud and plagiarism of the Faculty responsible for managing the course of study shall apply.
[6] Assessment results are communicated to students and to the deans of the partner Faculties by the ELSTE Administrator.

Article 14
Registration, withdrawal, and absence from assessments

[1] Each partner University has its own procedures and deadlines for course and assessment registration for the MSc program in Earth sciences. The ELSTE Executive Committee publishes these on the ELSTE website at the beginning of each academic year.
[2] Registration for exams may only be withdrawn due to exceptional circumstances. A written withdrawal request must be submitted to the ELSTE Executive Committee.
[3] Candidates absent from an assessment for which they are registered shall receive a grade of 0 unless their absence is duly justified. Illness and accidents are the most common justifications accepted. Students must inform the Dean of the Faculty responsible for managing the course of

study in writing immediately, in principle within 3 days of the absence. In cases of illness or accident, a relevant medical certificate must be submitted.

Article 15
Successful completion of assessments and modules

[1] Courses or other forms of instruction with individual grades are successfully completed with an assessment grade of at least 4, or, in the case of courses without grades, with a notification of successful completion. All ECTS credits associated with the course are earned at that time.
[2] Courses or other forms of instruction that are graded in groups (modules) are successfully completed, and credits earned in a block, if the credit-weighted grade average is at least 4 and if validations are earned for courses representing at least 80% of the total ECTS credits.

[3] If a student fails to successfully complete a module, the student may make a second attempt to successfully complete the failed assessments, as stipulated in point 4 below. All results of 4 or higher, and notifications of successful completion, remain in place for the module. For repeated assessments, only grades or validations obtained in second attempt are retained.

[4] For each assessment, the maximum number of attempts is two, with the second failure resulting in elimination from the program in the case of a required course or module.
[5] In case of a second failure for an elective course or module, students may take and validate another elective course or module. If students fail to successfully complete this new course or module after their second attempt, they are eliminated from the program.
[6] An internship lasting at least one month may be validated as part of a student's elective credits. This internship is evaluated by the Master's thesis advisor based on a written report produced by the student and a certification produced by the internship director at the host institution.

Article 16
Procedures for, and successful completion of, the Master's thesis

[1] The Master's thesis is a personal research project under the responsibility of an ELSTE instructor (Full Professor, Associate Professor, Adjunct Professor, Assistant Professor, Visiting Professor, Research and Teaching Associate, or, upon approval by the Executive Committee, *Privat-Docent*, Senior Lecturer, Lecturer, Senior Research and Teaching Assistant, or another qualified scientist.)
[2] An instructor from another higher education institution may direct a Master's thesis, upon approval of the ELSTE Executive Committee. In this case, an ELSTE Professor shall be named co-director by the Executive Committee.
[3] The Master's thesis comprises a thesis project, a written thesis, and an oral defense.
[4] Before the beginning of the second year of the program, students must draft and present their Master's thesis projects as stipulated in the curriculum.
[5] To be allowed to defend their theses, students must have successfully completed the assessments for all courses and other forms of instruction stipulated by the curriculum, except the part free choice of credits (12 ECTS credits) as well as the biannual courses of the spring semester, that can be validated during the same session than the Master thesis. Students must have also successfully presented their thesis projects.
[6] Assessment of the thesis project and written thesis is by a jury comprising at least the thesis director and another instructor (co-director, holder of a doctorate) from one of the ELSTE units. If necessary, a second instructor can be chosen outside of the ELSTE.
[7] Thesis defenses take place on days shared by the two sites, organized by the ELSTE Executive Committee during the examination sessions of June and January. The August examination session is reserved to the second attempts and to duly justified exceptional cases . All directors of theses being defended must be present on these days.
[8] Theses are evaluated based on the submitted manuscript and the quality of the oral defense. This evaluation, weighted according to stipulations in the “Guidelines on the Master thesis”, takes the form of a single grade. The Master thesis is passed and the ECTS credits for the thesis are earned when that grade is 4 or higher and that the evaluation of the manuscript is 4 or higher.
[9] In case of failure, students have a second chance to rework their manuscript (if required) and to once again defend it orally. This second attempt must take place before the end of the following semester.
[10] The modalities of the Master thesis validation and the details related to its realization are explained in the “Guidelines of the Master thesis” developed by the ELSTE executive Committee and published on the website dedicated to the formation.

Article 17
Ethics and safety

[1] Students enrolled in the MSc program in Earth sciences complete and sign, at the beginning of studies, a document on compliance with ethical standards regarding borrowing from, citing, and using various sources. This document is held in students' ELSTE files.
[2] At each university students also sign a document on safety in laboratories and in the field.

Chapter 5 – Final Provisions

Article 18
Granting of the degree and the Europass Diploma Supplement

[1] The Master of Science in Earth sciences degree is granted when the candidate has met all requirements of the rules and regulations and the curriculum.
[2] The Dean of the Faculty responsible for managing the course of study requests the issuance of the degree and the Europass Diploma Supplement from the administrative organs concerned.
[3] The diploma is signed by the Deans of the partner faculties and the Rectors of the partner universities.

Article 19
Elimination

[1] Students are eliminated from the program if they are no longer able to meet the requirements for earning credits as stipulated in the rules and regulations and in the curriculum. Common reasons for this include:

a) failure on the last allowed attempt at an assessment for a required course or module;
b) failure to meet the deadline for maximum duration of studies as stipulated in these rules and regulations.
c) Students failing to earn the credits (up to 30) required for a conditional enrollment (per Article 5) within the permitted timeframe are also eliminated from the program.

[2] The decision to eliminate a student is made by the Dean of the Faculty responsible for management of the student's course of study.
[3] The Dean of the Faculty responsible for management of a student's course of study may take into account exceptional circumstances.

Article 20
Objections and appeals procedures

[1] Decisions made through application of these rules and regulations come from the Dean of the Faculty responsible for managing the course of study unless otherwise specified.

[2] In all cases, decisions made through application of these rules and regulations clearly indicate the deadlines and procedures for objections and appeals in effect at the concerned university.

Article 21
Entry into force

[1] These rules and regulations shall enter into force on 16 September 2019.
[2] It applies to all new students from its entry into force
[3] These rules and regulations supersede and replace the rules and regulations for the MSc in Earth sciences of the Faculty of Sciences of the University of Geneva and the University of Lausanne Faculty of Geosciences and Environment dated 17 September 2018 except as specified below.
[4] The rules and regulations of 17 September 2018 remain temporarily applicable to students already enrolled in the program before the autumn semester of 2019, but only until their maximum allowed time of studies expires or until the expiry of the granted studies extension.

Curriculum

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Orientation SERG Sedimentary, Environmental and Reservoir Geology

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 evolving with Earth
- Basin research
- Geophysics across scales for geologists

Module Sedimentary Rocks and Processes from Source-to-Sink - 9 ECTS *Teacher in charge: S. Castelltort*

Courses	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Carbonates / Carbonates	E. Samankassou	Fall 2d F, 2.5 d C PW S	Report, Seminars, oral or written exam	2
Clastics / Clastiques	S. Castelltort, D. Ariztegui, A. Moscariello, T. Adatte	Fall -5d C PW S	Report, Seminars, oral or written exam	2
Sedimentary rocks in the field / Les roches sédimentaires sur le terrain	S. Castelltort	Spring 8d F	Practice, Report, Seminars, oral or written exam	4
Weathering processes and soils formation / Processus d'altération et formation des sols	E. Verrecchia	Fall 2d C PW	Practice	1
Prerequisite: sedimentology course (BSc)				
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 evolving with Earth – 6 ECTS

Teacher in charge : A. Daley and E. Samankassou

Courses	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Life evolving with Earth	A. Daley, E. Samankassou, T. Adatte, D. Ariztegui, J. Spangenberg, T. Vennemann	Fall 10d C PW S	Report, Seminars, oral or written exam	6

Module Basin research – 6ECTS

Teacher in charge: S. Castelltort

Courses	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Basin research / Dynamique sédimentaire	S. Castelltort, 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Geophysics across scales for geologists / Géophysique à différentes échelles pour géologues	G. Hetényi, 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 micropalentology
- 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Integrated basin analysis / Analyse de bassin intégrée	A. Moscariello, 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Biostratigraphy and micropaleontology / Biostratigraphie et Micropaléontologie	R. Martini, 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Introduction to data analysis with MATLAB / Introduction à l'analyse de données avec Matlab	G. Simpson	Fall 3d C	Practice (Report)	1
MATLAB as a language of scientific computing / Matlab comme langage de calcul scientifique	Y. Podladchikov	Fall 42h CE	Practice (Report)	3
Physics as a basis for modeling / 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 geology I – 6 ECTS

Teacher in charge : A. Moscariello

Courses	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Clastic reservoirs / Réservoirs clastiques	A. Moscariello	Spring 5d C PW S	Oral or written exam	3
Carbonate reservoirs / 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 2D and 3D seismic interpretation.				
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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
3D static and geological modelling - Petrel and Eclypse / Modélisation géologique statique et dynamique en 3D - Petrel et Eclypse	A. Moscariello et collaborateurs	Spring 5d C PW S	Oral or written exam	3
From play evaluation to field development / 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 2D and 3D seismic interpretation.				

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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Alpine Structural Geology / Géologie structurale alpine	JL. Epard	Fall 24h C PW	Practice	3
Alpine tectonics, field camp / 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	Teacher in charge/ Speaker(s)	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	Teacher in charge/ Speaker(s)	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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Sites contaminés: application géologique et environnementale	S. Girardclos, 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Fluid flow for geologists / L'écoulements des fluides pour géologues	M. Lupi	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
Cartographic data management and landslide susceptibility assessment / Structuration des données géologiques et analyses spa ales appliquées aux instabilités de versant	M. Sartori, C. Frischknecht	Spring 5d CE	Practice (Report)	3
Spatial risk assessment / L'Evaluation spatiale du risque	C. Frischknecht, 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 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Geology of clays / Géologie des argiles)	T. Adatte	Spring 3d CE	Practice	1.5
SPACE-GEOENERGY: Geomatics and geo-energy / Géomatique et géo-énergies	A. Moscariello, J. Simantov et collègues	Spring 5d C	Practice	3
Dates and Rates of Mountains Evolution	G. King	Fall 20h PW, 21h F	Pratique	3
Imperial Barrel Award (AAPG) *Réservé en priorité aux étudiants de deuxième année. Prérequis : From play evaluation to field development*	A. Moscariello (coordinateur)	Spring 6 weeks	Practice	6
Biomineralization / Biominéralisation	A. Meibom	Fall 42h C PW	Report / oral presentation	4
Introduction to geothermics / AND **Introduction to hydrogeology and hydrology**	S. Miller (UNINE), Ph. Brunner (UNINE)	Fall-10d CE	Practice	5
Scanning Electron Microscopy / Microscopie électronique à balayage, MEB	R. Martini pour l'UNIGE P. Vonlanthen pour l'UNIL	Fall 2d C PW	Validation without grade	1

Optical cathodoluminescence / Cathodoluminescence optique	R. Martini	Spring 1d C PW	Validation without grade	0.5
Initation to the ion probe / Initiation à la sonde ionique	A.S. Bouvier, A. Meibom	Spring 1d C PW	Validation without grade	0.5
Electron probe microanalyzer / Microsonde électronique	M. Robyr	Fall 2j C PW	Practice	1
PoroPerm and QemScan	A. Moscariello	Fall 1d C PW	Validation without grade	0.5
Inductively-coupled plasma mass-spectrometry / Spectrométrie de masse à source plasma à couplage inductif	A. Ulianov	Fall 2d C E	Validation without grade	1
Marine seismic acquisition, interpretation and data integration / Acquisition, interprétation et intégration de données sismiques marines)	D. Ariztegui	Spring 8d F S	Practice	3
Model parameter estimation and uncertainty quantification	N. Linde	Spring 56h C PW	Report / oral presentation	5
Organic geochemistry	J. Spangenberg (Master BGS)	Fall 30h C et E	Written exam	3
Geothermal Field trip	S. Miller (UNINE)	Fall 4d F	Validation	2
Advanced geothermics and earth energy resources	B. Valley and L. Gugliemetti (Prof. S. Miller) (UNINE)	Printemps 30h C	Practice	3
Internship in a company / 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	

Total credits to validate	12 ECTS credits
*: 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 deposed 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	60
Master project	Spring	*		Report (Master proposal) and oral exam	10
Master thesis	Spring		*	Manuscript and oral defense	50

Orientation GATO
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 thermome- chanical 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 mechan- ics, 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Petrological processes in geodynamic environments / Processus pétrologiques dans les environnements géodynamiques	U. Schaltegger, O. Müntener S. Pilet, L. Caricchi L. Baumgartner, S. Schmalholz, J. Marin-Carbonne, Z. Zajacz	Fall 70h C PW E S	Seminars, Report	9
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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Quantitative tectonics / Tectonique quantitative	S. Schmalholz	Fall 42h C PW	Practice	4
Microtectonics / 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Geophysics across scales for geologists / Géophysique à différentes échelles pour géologues	G. Hetényi, B. Quintal, M. Lupi, A. Moscariello	Fall 4d C PW	Practice	3

Module Field trips - 6 ECTS

Teacher in charge : L. Baumgartner

Courses	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Field trips UNIGE / Camp de terrain UNIGE	L. Caricchi, Z. Zajacz	Spring 8d T	Pratique	6
Field trips UNIL / Camps de terrain UNIL	L. Baumgartner	Spring 8d T	Pratique	6
Ore deposit field camp / Camp des gîtes métallifères *Prerequist : Module « Ore deposit » or equivalent*	R. Moritz, K. Kouzmanov, Z. Zajacz	Spring 8d T	Pratique (rapport)	6
The student chooses one of the two courses. The course of this module is validated and the 6 ECTS credits given, 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Stable and radiogenic isotope geochemistry (bisannual)/ Géochimie des isotopes stables et radiogéniques	M. Chiaradia, E. Samankassou, U. Schaltegger, R. Spikings, T. Vennemann, J. Marin-Carbonne	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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Modelling volcanic processes/ Modélisation des processus volcaniques	C. Bonadonna, and collaborators	Fall 28h C	Seminar	2
Volcano petrology / Pétrologie volcanique	L. Caricchi, S. Pilet	Spring 28h C	Seminar	2
Volcano fieldtrip / Excursion volcanique	L. Caricchi, 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 : Z. Zajacz

Courses	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Fluids in the Earth crust / Fluides dans la croûte terrestre	L. Baumgartner	Spring 28h C PW	Validation without grade	2
Exprimental petrology and hydrothermal fluids / Pétrologie expérimentale et fluides hydrothermaux	Z. Zajacz	Spring 3d C TP	Validation sans note	1.5
Fluid inclusions / Inclusions de fluides	R. Moritz	Fall 3j C PW	Validation without grade	1.5
Reading rocks – Rock textures and fluids / 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Alpine Structural Geology / Géologie structurale alpine	JL. Epard	Fall 24h C PW	Practice	3
Alpine tectonics, field camp / 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Introduction to data analysis with MATLAB / Introduction à l'analyse de données avec Matlab	G. Simpson	Fall 3d C	Practice (Report)	1
MATLAB as a language of scientific computing / Matlab comme langage de calcul scientifique	Y. Podladchikov	Fall 42h CE	Practice (Report)	3
Physics as a basis for modeling / 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 : K. Kouzmanov*

Courses	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Advanced ore deposits / Gîtes métallifères - avancé *Pré-requis: cours «Ore microscopy» ou équivalent*	K. Kouzmanov, M. Chiaradia, R. Moritz, Z. Zajacz	Fall 10d C PW + personal work	Practice (report, seminar) written exam	4
Ore microscopy / 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 : R. Moritz

Courses	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Methods of exploration (bisannual) / Méthodes d'exploration Prererequis: basic geological and mineral deposit knowledge	G. Beaudoin	Every odd semesters, Fall 10d CE	Practice (Report)	4
Mining geophysics / Géophysique minière Pré-requis: Introduction à la géophysique	J. Irving	Spring 4d 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 Applied and environmental mineralogy – 6 ECTS *Teacher in charge : O. Müntener*

Courses	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Gemmology / Gemmologie	L. Cartier	Spring 6d CE PW	Practice (Exercices)	2
Gemmology - field / Gemmologie – terrain Pré - requis : Gemmology	L. Cartier	Fall 2d F	Validation without grade	1
Applied mineralogy / Minéralogie appliquée	T. Vennemann, B. Putlitz	Spring 4d C F	Practice (Report)	2
Physics and structure of minerals / Physique et structure des minéraux	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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Sites contaminés: application géologique et environnementale	S. Girardclos, J. Poté	Spring 5d C PW	Practice	3
Les déchets: gestion environnementale et contraintes géologiques	J. Poté, 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Fluid flow for geologists / L'écoulements des fluides pour géologues	M. Lupi	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
Cartographic data management and landslide susceptibility assessment / Structuration des données géologiques et analyses spatiales appliquées aux instabilités de versant	M. Sartori, C. Frischknecht	Spring 5d CE	Practice (Report)	3
Spatial risk assessment / L'Evaluation spatiale du risque	C. Frischknecht, P. Peduzzi	Spring	Pratique (Report)	3

5j CE
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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Syn-tectonic granite emplacement and vein formation – Cevennes, France (bisannual) / Mise en place de granites syn-tecto- niques et veines hydrothermales - Cévennes, France	K. Kouzmanov, A. Chauvet	Every odd semester, Spring 6j F	Practice	3
Environmental biogeochemistry / Biogéochimie environnementale. *Prerequis: general geochemistry, aqua c chemistry, introductory chemistry and physics*	N.N	Spring 30h C E	Written exam	3
Biomineralization / Biominéralisation	A. Meibom	Fall 42h C PW	Report / oral presentation	4
Scanning Electron Microscopy / Microscopie électronique à balayage,	R. Martini for UNIGE P. Vonlanthen for UNIL	Fall 2d C PW	Validation without grade	1
Optical cathodoluminescence / Cathodoluminescence optique	R. Martini	Spring 1d C PW	Validation without grade	0.5

Initation to the ion probe / Initiation à la sonde ionique	A.S. Bouvier, A. Meibom	Spring 1d C PW	Validation without grade	0.5
Electron probe microanalyzer / Microsonde électronique	M. Robyr	Fall 2d C PW	Practice (PW)	1
PoroPerm and QemScan	A. Moscariello	Fall 1d C PW	Validation without grade	0.5
Inductively-coupled plasma mass-spectrometry / Spectrométrie de masse à source plasma à couplage inductif	A. Ulianov	Fall 2d C E	Validation without grade	1
Microtomography / *Microtomographie*	L. Baumgartner	Spring 1d C PW	Validation without grade	0.5
Laboratory techniques in geochemistry / Techniques de laboratoire en géochimie	M. Ovtcharova	Fall 1d C PW	Validation without grade	0.5
Internship in a company / 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	
Total credits to validate			**12 ECTS credits**	
*: 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 deposed 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	60
Master project	Spring	*		Report (Master proposal) and oral exam	10
Master thesis	Spring		*	Manuscript and oral defense	50

Orientation RGEOL
Geological Risks

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 as- sessment 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Petrological processes in geodynamic environments / Processus pétrologiques dans les environnements géodynamiques	U. Schaltegger, O. Müntener S. Pilet, L. Caricchi L. Baumgartner, S. Schmalholz, J. Marin-Carbonne, Z. Zajacz	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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Introduction to data analysis with MATLAB / Introduction à l'analyse de données avec Matlab	G. Simpson	Fall 3d C	Practice (Report)	1
MATLAB as a language of scientific computing / Matlab comme langage de calcul scientifique	Y. Podladchikov	Fall 42h CE	Practice (Report)	3
Physics as a basis for modeling / 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Cartographic data management and landslide susceptibility assessment / Structuration des données géologiques et analyses spa ales appliquées aux instabilités de versant	M. Sartori, C. Frischknecht	Spring 5d CE	Practice (Report)	3
Spatial risk assessment / L'Evaluation spatiale du risque	C. Frischknecht, 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Geophysics across scales for geologists / Géophysique à différentes échelles pour géologues	G. Hetényi, 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Modelling volcanic processes/ Modélisation des processus volcaniques	C. Bonadonna and collaborators	Fall 28h C	Seminar	2
Volcano petrology / Pétrologie volcanique	L. Caricchi, S. Pilet	Spring 28h C	Seminar	2
Volcano fieldtrip / Excursion volcanique	L. Caricchi, 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Risk management / Gestion des risques	S. Menoni, 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Volcanic risk *Prérequis : Risk Management*	C. Bonadonna and teachers of CERG-C	Spring 6d C F	Written exam, practice (Report)	3
Seismic risk	D. Fäh, 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Erosion and slope movements / Erosion et mouvements de versants	M. Jaboyedoff	Spring 56h CE	Written exam	4
Hazards and risks of slope movements : field camp I / Risques et dangers liés aux mouvements de versants: terrain I - – Mandatory to follow « Hazards and risks of slope mass movements: field camp II » in the part C	MH Derron, 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.				

Module Advanced risks – 6 ECTS

Teacher in charge : M. Jaboyedoff

Courses	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Advanced quantitative risk and vulnerability / Risques avancés quantitatifs et la vulnérabilité	M. Jaboyedoff	Fall 28h C 14h E	Written exam, continuous assessment	3
Communication on environmental risks / 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Sites contaminés: application géologique et environnementale	S. Girardclos, J. Poté	Spring 5d C PW	Practice	3
Les déchets: gestion environnementale et contraintes géologiques	J. Poté, 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Fluid flow for geologists / L'écoulements des fluides pour géologues	M. Lupi	Spring 5d C 5d F	Practice	6

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 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	Teacher in charge/ Speaker(s)	Semester Modality	Evaluation	ECTS credits
Biomineralization / Biominéralisation	A. Meibom	Fall 42h C PW	Report / oral presentation	4
Hazards and risks of slope movements : field camp II *part I of the field of the module «Hazards and risks of slope movements» mandatory*	M. H. Derron, M. Jaboyedoff	Spring 5d F	Practice	3
Marine seismic acquisition, interpretation and data integration / Acquisition, interprétation et intégration de données sismiques marines	D. Ariztegui	Spring 8d F S	Practice	3
Model parameter estimation and uncertainty quantification	N. Linde	Spring 56h C PW	Report / oral presentation	5
Dates and Rates of Mountain evolution / Datation et taux d'évolution des montagne	G. King	Fall 20h PW, 21h F	Practice	3

Internship in a company / 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
Total credits to validate	**Total credits to validate**
*: 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.

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 deposed 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	60
Master project	Spring	*		Report (Master proposal) and oral exam	10
Master thesis	Spring		*	Manuscript and oral defense	50

Courses Description

2D and 3D sesimic interpretation / Interprétations sismiques 2D et 3D

Module 2D and 3D sesimic interpretation

Teacher(s): Moscariello A.
Course given in the following orientation(s): SERG - RGEOL
6 ECTS credits

Course taught at UNIGE
Autumn, 6j C TP & Personal work
Evaluation type: Pratique

Description: The course provides the knowledge to perform geological interpretation of 2D and 3D seismic reflection data, an essential tool for basin analysis and for the assessment of associated natural resources. During the course, an experience on the geological seismic interpretation of different data types (2D and 3D) , in a variety of geological settings using specific software such as Petrel and Kingdom will be acquired. For the completion of the program, participants will perform a geological interpretation of subsurface data using 3D seismic real data from the North Sea.

Prerequisite:

3D static geological modelling - Petrel and Eclypse/Modélisation géologique statique en 3D - Petrel et Eclypse

Module Reservoir geology II

Teacher(s): Moscariello A. et collaborateurs
Course given in the following orientation(s): SERG
3 ECTS credits

Course taught at UNIGE
Spring, 5j C TP S
Evaluation type: Oral or writen exam

Description: During this course students will apply the learnings acquired during the previous Basin Research and Reservoir Geology I courses by developing their own conceptual geological model starting from a real-case subsurface data set from industry. The course will provide an intense and realistic software hands-on experience where students will develop their own software-based 3D-geological model and will learn how to evaluate the reservoir characteristics of their own model.

Prerequisite: Priority to students having followed: Reservoir Geology I, Dynamique sédimentaire, Borehole logging and rock physics et 2D and 3D seismic interpretation

Advanced geothermics and earth energy ressources

Free choice credits

Teachers : B. Valley and L. Gugliemetti (Prof. S. Miller) (UNINE)
Course given in the following orientation(s): SERG
3 ECTS credits

Course taught at l'UNINE
Spring, 30h C
Evaluation type: Practice

Description : voir unine

Prerequisite :

Advanced ore deposits / Gîtes métallifères - avancé

Module Ore deposits

Teacher(s): K. Kouzmanov, M. Chiaradia, R. Moritz, Z. Zajacz
Course given in the following orientation(s): GATO
4 ECTS credits

Course taught at UNIGE
Autumn, 10j C TP + personnel work
Evaluation type: Practical and Writen exam

Description: The program includes
1) Deepening general metallogeny topics (mineralizing fluids, transport of fluids and ore forming componenens in fluids, precipitation mechanisms, retrieving transport and precipitaiton conditions through hydrothermal alteration and mineral assemblages, classifications)
2) Relatively detailed presentation of important ore deposit types, in particular the porphyry system
Each participant will orally present a topic on some basic aspect of point 1 and prepare a written report and an oral presentation on polished ± thin sections on a typical ore deposit
The evaluation will be based on the oral and written presentations (40%) and a written exam on the topics dealt with in the course (60%).

Prerequisite: "Ore microscopy" or similar knowledge

Advanced quantitative risk and vulnerability / Risques avancés quantitatifs et la vulnérabilité

Module Advanced risks

Teacher(s): Jaboyedoff M.
Course given in the following orientation(s): RGEOL
3 ECTS credits

Course taught at UNIL
Autumn, 28h C, 14h E
Evaluation type: Writen exam, ongoing assessment

Description: This course is dedicated to improve the concepts of risk. The calculation of risk to natural hazards is tackled in more details than in the previous courses. It includes, among others, the methods of the Swiss Confederation. It also provides an overview expert approaches through probability-impact matrices.
A thorough concept of vulnerability is given and integration curves of damage and vulnerability are discussed. This leads to probabilistic approaches in terms of risk, which ultimately leads to the notion of disaster simulation using stochastic models.
Several exercises related to risk calculations illustrate the purposes both in the field of natural hazards and for projects managements, and industrial risks. This includes:
• The probability that a target is reached in a borehole
• Individual risk along a road
• Risk due to a plume of smoke
• Global climate risks
• Etc ...
Finally the impact of the increasing complexity of society is presented as a source of risk.

Prerequisite: Risques environnementaux (BSc) or equivalent

Alpine Structural Geology / Géologie structurale alpine

Module Advanced structural geology

Teacher(s): Epard J.L.	Course taught at UNIL
Course given in the following orientation(s): SERG - GATO - RGEOL	Autumn, 24h C TP
3 ECTS credits	Evaluation type: Practice

Description: To be able to analyze and interpret complex tectonic structures frequently observed in collisional orogens and to deduce the possible tectonic consequences.
Lectures and exercises on:
- Analysis of complex patterns between several phases of folding;
- Advanced method to restore balanced cross-sections (excess surface , …); use of the requisite strain concept; kinematics of detachment folds;
- The effect of pre-existing structures (i.e. listric sysedimentary faults); their impact on the present day geometry for nappe structures;
- Drawing geological cross-sections in complex areas of the Alps;
- Other topics to be defined.

Prerequisite:

Alpine tectonics, field camp / Camp de tectonique alpine

Module Advanced structural geology

Teacher(s): Epard J.L.	Course taught at UNIL
Course given in the following orientation(s): SERG - GATO - RGEOL	Spring, 6j T
3 ECTS credits	Evaluation type: Practical (Report)

Description: The field work is intended to illustrate and discuss several concepts developed during the lectures and exercises such as: fold interference patterns, kinematic shear indicators, shear zones (ductile and brittle); boudins; etc.
Notes: the camp will probably take place in the area of the Simplon Pass (housing at the Hospice). A financial contribution of approximately CHF 20.-per day per person will be required from each student to partially cover the costs of the accommodation (dormitory, half-board).

Prerequisite:

Applied mineralogy / Minéralogie appliquée

Module Applied and environmental mineralogy

Teacher(s): Vennemann T., B. Putlitz	Course taught at UNIL
Course given in the following orientation(s): GATO	Spring, 4j C TP
2 ECTS credits	Evaluation type: Practical (Report)

Description: This course should provide a short introduction into the mineralogy and geology of technical respectively industrial materials.
We will cover diverse topics such as ceramics, cement & concrete, glass & melts, zeolithes, asbestos, construction & decoration stones. Economical, ecological and/or medical aspects can also be discussed. This course includes practical exercises using in-house equipment (e.g. SEM, tomography, XRD).
This course should provide a short introduction into the mineralogy and geology of technical respectively industrial materials.

Prerequisite:

Basin research / Dynamique sédimentaire

Module Basin research

Teacher(s): S. Castelltort, G. Simpson, R. Spiking et collaborateurs	Course taught at UNIGE
Course given in the following orientation(s): SERG	Autumn, 10j C TP S
6 ECTS credits	Evaluation type: Report, Seminars, Oral or writen exam

Description: In this course, students will be introduced to various aspects of basin research via the reading, analysis and discussion of various classic published papers. The aims of this course are (1) to introduce students to different fundamental aspects of basin analysis and/or modern controversies in this subject area and (2) to give students practice in analysing and discussing scientific manuscripts.
Basin analysis is the integrated study of sedimentary basins. It includes investigating the geodynamic processes responsible for forming sedimentary basins, mechanisms driving sediment supply, controls on stratigraphic patterns, and how one can study sedimentary sequences to derive information concerning the thermal and subsidence history of a basin.

Prerequisite:

Biomineralization / Biominéralisation

Free choice credits

Teacher(s): Meibom A.	Course taught at EPFL
Course given in the following orientation(s): SERG - GATO - RGEOL	Autumn, 42h C TP
4 ECTS credits	Evaluation type: Report, exposé oral

Description: Understanding process and role of biomineralization (minerals formed by living organisms) in context of Earth's evolution,global chemical cycles, climatic changes, remediation and as inspiration for new materials.
Biomineralization refers to the processes by which organisms form minerals. It is therefore, by definition, a highly multidisciplinary field that spans both the inorganic and the organic world. The phenomenon of biomineralization is relevant to the Earth, Environmental and Life Sciences on practically all length scales. From the immense scale of reef-systems and global ocean life-cycles to small bacterial communities, the impact of biominera–liza–tion spans length scales of at least 12 orders of magnitude and a large fraction of geological time! But despite the global environmental impact of biomineralization and its funda–mental scien–ti–fic importance, there is still no consensus about the basic biological mecha–nisms involved.
This class aims at giving the student an insight into the study of fundamental biological processes that shape biominerals and determine their chemical and isotopic composition. The physiology of biomineralization, matrix-mediated control of biominerals, cell-biomineralization interface will be discussed for a number of organisms, including bacteria, corals, foraminifera and sponges.
The occurrence of biominerals in the geologic record and their use as paleo-climate recorders will be discussed together with biomineralization induced by bacteria, with important implications for mineral ore formation and remediation of contaminated sites.

Prerequisite:

Biostratigraphy and micropaleontology / Biostratigraphie et Micropaléontologie

Module Biostratigraphy and Micropaleontology

Teacher(s): Martini R., E. Samankassou, S. Feist-Burkhardt, A. Daley.	Course taught at UNIGE
Course given in the following orientation(s): SERG	Autumn, 7j C E
6 ECTS credits	Evaluation type: Exercises, Report

Description: This course introduces the main group of micro-fossils demonstrating their biostratigraphic importance: benthic foraminifers and calcareous algae in relation to platform carbonates; radiolarians for basin sediments and palynomorphs and palynofacies for continental to pelagic deposits.
The course begins with the main group of Tethyan benthic foraminifers which are of stratigraphic interest and for the period from Lower Carboniferous to Upper Triassic (this does not include fusilines). It gives students the opportunity to acquire basic knowledge required for recognizing and giving a date to previously mentioned periods during the petrographic and biostratigraphic analyses of thin sections in order to characterize the depositional paleoenvironments.
The study follows on with calcareous algae which play an important determining role in the analysis of present day carbonate platforms and are also frequently found in fossil records. The module focuses on acquiring general determining criteria and includes practical work aimed at consolidating knowledge. The evolution of main groups in geological periods will also be included and the importance of algae in biostratigraphy and paleoecology as well as in paleogeographic reconstruction will be examined.
Then, “Fossil Lagerstätten” - fossil sites with exceptional preservation of quality or quantity - will be examined. These are important sources of information, owning to the preservation of an impressive abundance of fossils, or fossils with incredible preservation of soft tissues and anatomical features that do not normally preserve. We will explore the types of Lagerstätten, the different mode of preservation, and undertake several case studies examining the evolutionary and ecological importance of particular Lagerstätten, including the Burgess Shale, Fezouata Biota, Rhynie Chert, Solnhofen, Holzmaden, Crato Formation, Messel Oil Shale, and Dominican Amber.
The course finishes with a palynological approach: the composition and classification of palynological residue and the importance of organic matter (kerogene). A study of the morphology and biostratigraphy of pollen and spores, dinoflagelles, acritarches, green algae and chitonozoaires will be undertaken. The end of the course deals with the sedimentation of organic matter and palynofacies in relation to the importance of their role in the reconstruction of sedimentary paleoenvironments.
An on site practical training course (max 5 days fieldwork in spring semester) completes this course.

Prerequisite:

Borehole logging and rock physics / Diagraphie de puits et physique des roches

Module Borehole logging and rock physics

Teacher(s): Quintal B, A. Moscariello	Course taught at UNIL/UNIGE
Course given in the following orientation(s): SERG - GATO - RGEOL	Autumn, 6j C E & Personal work
6 ECTS credits	Evaluation type: Practical

Description: Advanced course covering the essential methods used in petroleum exploration and environmental geophysics; overview on rock physics; qualitative and quantitative interpretation to estimate lithology, porosity, and fluid saturation (water, oil, gas/air).

Prerequisite:

Carbonate reservoirs / Réservoirs carbonatés

Module Reservoir geology I

Teacher(s): Moscariello A. et collaborateurs	Course taught at UNIGE
Course given in the following orientation(s): SERG	Spring, 5j C TP S
3 ECTS credits	Evaluation type: Oral or writen exam

Description: This course will provide an overview of the key aspects of reservoirs formed in carbonate depositional environments ranging from carbonate platforms to reefs complexes, with their primary characteristics and secondary modifications such as karst processes. The course will focus on the key aspects which characterise the reservoirs development such as rock texture (e.g. primary, secondary porosity), composition, internal architecture, connectivity and reservoir property distribution. Specifically, the students will learn to identify and recognise the key parameters which determine the reservoir properties of a carbonate depositional sequence by using and integrating multiple data such as seismic, core data (e.g. sedimentology and petrophysical data), outcrops examples and wireline data.

Prerequisite: modules Basin research, Borehole logging and rock physics et 2D and 3D seismic interpretation.

Carbonates / Carbonates

Module Sedimentary rocks and processes from Source-to-Sink

Teacher(s): E. Samankassou	Course taught at UNIGE
Course given in the following orientation(s): SERG	Autumn, 2j T, 2.5j C TP S
2 ECTS credits	Evaluation type: Report, séminaire, Oral or writen exam

Description: The 2-days fieldtrip takes students to outcrops in the Jura Mountains (mainly carbonate platform deposits) and the Alps (slope and basinal deposits). The main aim of the course is to provide a general introduction to carbonate sedimentology. Topics will include a review carbonate grains, rock classification, facies models and depositional environments.
The in-room part of the course consists of lectures introducing fundamental concepts of carbonate sedimentology, covering depositional systems ranging from tidal flats to basinal settings. Case studies and oral presentations will help the students to develop a deep understanding of carbonates, along with a critical evaluation of the concepts and open questions.

Prerequisite:

Cartographic data management and landslide susceptibility assessment / Structuration des données géologiques et analyses spatiales appliquées aux instabilités de versant

Module Spatial analysis applied to geology
and risk

Teacher(s): Sartori M., C. Frischknecht	Course taught at UNIGE
Course given in the following orientation(s): SERG - GATO - RGEOL	Spring, 5j C E
3 ECTS credits	Evaluation type: Practical (Report)

Description: In a classical way, geological data are represented as paper maps. It is possible to implement this information into a GIS by developing a data model and a pseudo-3D multi-layer structure. The semantic and spatial richness of the data is revealed by this structuration.
Course content:
• Basic notions on GIS
• Geological maps translated into a "data model"
• The steps of developing a geological mapping project using GIS
• Example of data management according to the Swiss geological survey
• Construction techniques of a GIS using the “Sion-method”

Exercises:
1) Construction of a GIS project from a field map using ToolMap (open-source software). The « Sion-method » ensures the perfect topological matching of the layers.
2) Exploring the potential of GIS tools for susceptibility analysis on landslides using ArcGIS.

Prerequisite:

Clastic reservoirs / Réservoirs clastiques

Module Reservoir geology I

Teacher(s): Moscariello A.
Course given in the following orientation(s): SERG
3 ECTS credits

Course taught at UNIGE
Spring, 5j C TP S
Evaluation type: Oral or writen exam

Description: This course will provide an overview of the key aspects of reservoirs formed in clastic depositional environments ranging from alluvial fans, glacial, fluvial, marginal to deep marine. The course focuses on the key aspects characterizing the reservoirs development such as rock texture, composition, architecture, connectivity and reservoir property distribution. Specifically, the students will learn to identify and recognise the key parameters which determine the reservoir properties of a clastic depositional sequence by using and integrating multiple data such as seismic, core data (e.g. sedimentology and petrophysical data), wireline log data and outcrops. The course will provide software hands-on experience where students will learn how to handle 2D and 3D digital data sets and develop their own conceptual geological reservoir model.

Prerequisite: modules Basin research, Borehole logging and rock physics et 2D and 3D seismic interpretation.

Clastics / Clastiques

Module Sedimentary rocks and processes from Source-to-Sink

Teacher(s): S. Castelltort, D. Arztegui, A. Moscariello, T. Adatte
Course given in the following orientation(s): SERG
2 ECTS credits

Course taught at UNIL/UNIGE
Autumn, 5j C TP S
Evaluation type: Report, Seminars, Oral or writen exam

Description: Overview of the sedimentary environments and processes recorded in archives of clastic sedimentary rocks along the source-to-sink sedimentary system. The students get state-of-the-art knowledge of fundamental concepts and papers related to the different segments of the source-to-sink system, from proximal alluvial systems down to deep sea fan deposition, along with sequence stratigraphy.

Prerequisite:

Communication on environmental risks / Communication sur les risques environnementaux

Module Advanced risks

Teacher(s): Jaboyedoff M.	Course taught at UNIL
Course given in the following orientation(s): RGEOL	Autumn, 16h C, 16h E
3 ECTS credits	Evaluation type: Practical (Report)

Description: The primary objective of this course is to raise awareness of the problems of communication in general and which element governs it. This is achieved through examples coming from the studies of human behaviour. Which media for what purpose?
The L'Aquila example is discussed.
More specifically, the principles of risk communication pitfalls and biases are illustrated, particularly with regard to industrial risks. The impact of the representation of risk on people involved is analysed.
The relational aspect is emphasized; it is important to choose the right means of communication and understand what is expected by the interlocutors.
Students are invited to, firstly train themselves to understand the problem of transmitters and receivers, and secondly they are also asked to create documents of risk communication. This also represents the basis of the evaluation of the course.

Prerequisite:

Dates and rates of mountains evolution /datation et taux d'évolution des montagnes

Free choice of credits

Teacher(s): G. King	Course taught at UNIL
Course given in the following orientation(s): SERG -RGEOL	Autumn, 10h C, 20h TP, 21h T
3 ECTS credits	Evaluation type: Practical

Description: During this practical module students will gain experience of the complete research process, from project design to paper writing whilst addressing the research question "What drove ice retreat in Val d'Herens since the Little Ice Age". During a two-day field class, students will develop and execute a sampling strategy to constrain the timing of retreat. These samples will then be prepared and measured in the luminescence laboratories at UNIL within the practical class, before the data are analysed to derive ages. To explain the resulting sample ages, the students will develop a simple numerical model linking glacial extent to changes in precipitation and/or temperature. The assessment will be based on a 3000 word report, to be written in English in the style of a scientific paper.

Prerequisite: for 2nd year students

Electron probe microanalyzer / Microsonde électronique

Free choice of credits

Teacher(s): M. Robyr	Course taught at UNIL
Course given in the following orientation(s): SERG - GATO	Autumn, 2j C TP
1 ECTS credit	Evaluation type: Pratique

Description: The aim of this course is to provide the necessary theoretical and practical bases required to operate our electron microprobe. The program includes a description of the method and the instrument, analytical strategies, including the choice of appropriate standards, identification of potential error sources and

the way to minimize them. Exercises include raw data reduction, mineral normalization and petrologic interpretations. A lab tour is organized, but no practical work on the instrument, as students will be trained individually during their MSc work.

Prerequisite:

Environmental biogeochemistry / Biogéochimie environnementale

Free choice credits

Teacher(s): N. N.	Course taught at UNIL
Course given in the following orientation(s): GATO	Spring, 30h C E
3 ECTS credits	Evaluation type: Writen exam

Description: Reactions occurring at mineral and microbial surfaces govern the attenuation, release and cycling of the elements in aquatic and soil environments. This course draws on the fields of surface chemistry, mineralogy and environmental microbiology to develop an understanding of key (bio)geochemical reactions in natural environments, particularly those impacted by anthropogenic activities.
LEARNING OBJECTIVES
- To understand interfacial processes and the application of empirical and thermodynamic-based models to describe sorption processes
- To gain a molecular-scale perspective of chemical reactions occurring at water-mineral, water-microbe, and microbe-mineral interfaces
- To become familiar with microscopic and spectroscopic techniques used to characterize natural particles and detect surface species
- To gain experience with the critical reading of the scientific literature

Prerequisite: General Geochemistry, Aquatic Chemistry, Introductory Chemistry & Physics

Erosion and slope movements / Érosion et mouvements de versants

Module Hazards and risks of slope movements

Teacher(s): Jaboyedoff M.	Course taught at UNIL
Course given in the following orientation(s): RGEOL	Spring, 56h CE
4 ECTS credits	Evaluation type: Writen exam

Description: This course provides an overview of slope movements illustrated by examples. It introduces the landslide classification and their characterization. Then physics of each type of landslides, i.e. rockfalls, mudflows, debris-flows etc. are addressed. Some torrential floods are also tackled. The stability of landslides as well as the propagation are studied. An introduction to the modelling of each phenomenon is proposed.
Each part of the course is illustrated by practical examples. Throughout the course, the characterization of the hazard and mitigation principles are illustrated, which provides the elements necessary for risk management.

Prerequisite: Risques et dangers naturels (BSc), Modélisation numérique (BSc) ou équivalent

Exprimental petrology and hydrothermal fluids / Pétrologie expérimentale et fluides hydrothermaux

Module Petrology and Fluids in the Earth's Crust

Teacher(s): Zajacz, Z. Course given in the following orientation(s):: GATO 1.5 ECTS credits	Course taught at UNIGE Spring, 3d C PW Evaluation type: Validation without grade

Description -

Prerequisite :

Fieldtrips / Terrains principaux UNIGE

Module Field trips

Teacher(s) : Caricchi L., Zajacz, Z Course given in the following orientation(s): GATO 6 ECTS credits	Course taught at UNIGE Spring, 8d F Evaluation type : Practice

Description: -

Prerequisite :

Fieldtrips / Terrains principaux UNIL

Module Field trips

Teacher(s): Baumgartner L., T. Vennemann Course given in the following orientation(s): GATO 6 ECTS credits	Course taught at l'UNIL Spring, 8d F Evaluation type: Practice

Description : -

Prerequisite:

Fluid flow for geologists
L'écoulements fluides pour géologues

Module Fluid flow for geologists

Teacher(s): Lupi M. and collaborators Course given in the following orientation(s): SERG - GATO - RGEOL 6 ECTS credits	Course taught at UNIGE Spring, 5j C 5j T Evaluation type: Pratique

Description: Content:
1) Introduction to fluids in the crust
2) Darcy's law and groundwater flow
3) Heat transport
4) Regional scale flow and transport
5) Ore deposits and hydrocarbons
6) Geothermal systems
7) Earthquakes and fluid-driven seismic sequences
8) Numerical lab: academic and industrial softwares
9) Field trip

Prerequisite:

Fluid inclusions / Inclusions fluides

Module Petrology and Fluids in the Earth's Crust

Teacher(s): Moritz R.
Course given in the following orientation(s): GATO
1.5 ECTS credits

Course taught at UNIGE
Autumn, 3j C TP
Evaluation type: Validation without grade

Description: Basic principles – terminology: fluid inclusion types, fluid inclusion description, relationship among pressure – volume – temperature – composition (PVTX), isochores, etc.
Post-entrapment fluid inclusion modifications: reequilibration, stretching, necking down and leakage of fluid inclusions.
Introduction to the main analytical methods of fluid inclusions, including practice with the fluid inclusion microthermometric stage. Studies of fluid inclusions in opaque minerals using infrared microthermometry and identification of dissolved gases by Raman spectroscopy. Introduction to different fluid inclusion sofwares for isochore calculations.
Introduction to the main fluid types in different geological environments (sedimentary basins, various metamorphic facies, ore forming environments, etc.)
Relationship between fluid inclusion observations and microthermometric properties and different geological processes. Paleopressure and paleotemperature calculations based on fluid inclusion data.

Prerequisite:

Fluids in the Earth crust / Fluides dans la croûte terrestre

Module Petrology and Fluids in the Earth's Crust

Teacher(s): Baumgartner L.
Course given in the following orientation(s): GATO
2 ECTS credits

Course taught at UNIL
Spring, 28h C TP
Evaluation type: Validation without grade

Description: Fluids are the most efficient transport agent in the earth's crust. They interact with rocks on all levels of the crust, from the surface to the mantle. As such an in-depth understanding of the fluid phase is important to petrology, ore genesis, and large scale material cycles. The course reviews the basic thermodynamics of aqueous (supercritical) fluids, touches the basis of silicate melt-aqueous fluid interaction, and explores the importance of fluid-rock interaction in as diverse fields as ore genesis, metasomatism during metamorphism, as well as fixation of CO_2 in reacting fluid-rock systems.

Prerequisite:

From play evaluation to field development / De l'évaluation du "play" au développement

Module Reservoir geology II

Teacher(s): Moscariello A.
Course given in the following orientation(s): SERG
3 ECTS credits

Course taught at UNIGE
Spring, 5j C TP S
Evaluation type: Oral or writen exam

Description: This course will provide an overview of the key techniques for exploration and evaluation of subsurface reservoirs which may contain or can store natural resources (e.g. groundwater, hydrocarbons, gas

storage, carbon dioxide sequestration, etc.) . An overview of key principles of reservoir formation and natural resources accumulation will be presented and methods for the assessment of their potential using integrated exploration technology will be provided. The students will be confronted with practical examples of interpretation of a variety of data (e.g. geophysical, borehole, petrophysics outcrop, flow test, etc.) describing both large and microscopic aspects of the subsurface and learn how to identify prospects and calculate associated volumes of natural resources. Basic principle of economic evaluation of natural resources to will be also provided.

Prerequisite: Priority to students having followed: Reservoir Geology I, Dynamique sédimentaire, Borehole logging and rock physics et 2D and 3D seismic interpretation

Gemmology - Field / Gemmologie - terrain

Module Applied and environmental mineralogy

Teacher(s): Cartier L.
Course given in the following orientation(s): GATO
1 ECTS credit

Course taught at UNIL
Autumn, 2j T
Evaluation type: Validation without grade

Description: Excursions
Visit of gemstone trading and cutting centre (Idar Oberstein), visit of synthetic gemstone manufacturing company, visit of Basel jewellery & watch fair (Baselworld).

Prerequisite: Gemmology

Gemmology / Gemmologie

Module Applied and environmental mineralogy

Teacher(s): Cartier L.
Course given in the following orientation(s): GATO
2 ECTS credits

Course taught at UNIL
Spring, 6j CE T
Evaluation type: Practical (exercises)

Description: General gemmology
Gemstone deposits and formation of gemstones, production of synthetic gemstones. Gemstone cutting and polishing, identification methods in gemmology: simple instruments and scientific methods.
Gemmology of gemstones
The characteristics of diamonds, corundum, beryl, garnet, tourmaline, feldspar, spinel, chrysoberyl, quartz, opal, jadeite, nephrite, peridot, topaz, zircon, zoisite, organic gems including pearls.
Practical gemmology: use of gemmological instruments
Hands-on identification of different gemstones. Isotropic gemstones, birefringent gemstones, polariscope and conoscopy, refractometer, hydrostatic measurements, specific gravity, spectroscopy, use of loupe and gemmological micrscope, identification of natural, synthetic, treated gemstones and imitations. Application of gemmological tables and literature.

Prerequisite:

Geology of clays / Géologie des argiles

Free choice credits

Teacher(s): Adatte T.

Course taught at UNIL

Course given in the following orientation(s): SERG	Spring, 3j CE
1.5 ECTS credits	Evaluation type: Practical

Description: This course is devoted to geology of clays and is divided in three parts. The first part describes the clay minerals (chemical composition, structure, chemical and physical properties, as well as specific methods for identification. The second part concerns the study of clays in the geological cycle (origin, transportation, sedimentation and evolution during diagenesis.) Then the third part deals with application examples, both basic (pedogenesis, paleoclimate, geodynamics) and applied (soil, engineering, derived products, oil exploration).

Prerequisite:

Geophysics across scales for geologists / Géophysique à différentes échelles pour géologues

Module Geophysics across scales for geologists

Teacher(s): Hetényi G., B. Quintal, M. Lupi, A. Moscariello	Course taught at UNIL/UNIGE
Course given in the following orientation(s): SERG - GATO - RGEOL	Autumn, 4j C TP
3 ECTS credits	Evaluation type: Pratique

Description: Geophysical tools are inevitable in solving modern geological problems at all scales. This course gives an overview of geophysical methods going from global, through regional, to local scale investigations, and illustrates the use of geophysics in characterizing and constraining different geological structures and processes. The amount of equations in the course are limited to the (strict) minimum required to understand the approach, and the practicals focus on real examples taken from various fields of geosciences.
The course is given in English; questions can be asked in French.
Objectives:
- To know what kind of geophysical tools exist
- To know the use, advantage and limitations of the methods
- To know where to look for more details when applying geophysical tools

Contents:
- History of geophysics
- Reflection seismics – theory and practicals
- Structural seismology
- Geophysical characterization of reservoirs
- Earthquakes and related products
- Geophysics in geothermal exploration (incl. principles of heat flow)
- Potential field methods
- Nuclear waste disposal
- Remote sensing
- Borehole methods – theory and practicals
- Refraction seismics and wave propagation

Prerequisite:

Geothermal field trip

Free choice credits

Teacher(s): Miller, S.	Course taught at UNINE
Course given in the following orientation(s):: SERG	Fall, 4d T
2 ECTS credits	Evaluation : Validation

Description : voir unine

Prerequisite :

Hazards and risks of slope mass movements: field camp I / Risques et dangers liés aux mouvements de versants: terrain I

Module Hazards and risks of slope movements

Teacher(s): Derron M.H., M. Jaboyedoff	Course taught at UNIL
Course given in the following orientation(s): RGEOL	Spring, 5j T
2 ECTS credits	Evaluation type: Writen exam

Description: This course is based on field work in order to put into practice the teaching of the course "Risks and hazards of slope movements." A study site including one or more particular phenomena (landslides, rockfalls, landslides, mudflows, floods, etc…) or a region is chosen to conduct a comprehensive study which includes:

- The characterization of slope movements
- The characterization of the hazard
- Modelling
- The development of scenarios
- Risk analysis
- The proposition of solutions

Wherever possible, the phenomena will be based on the interests of students.

Prerequisite: Risques et dangers naturels (BSc), Modélisation numérique (BSc) or equivalent. Mandatory to follow « Hazards and risks of slope mass movements: field camp II » in the part C

Hazards and risks of slope mass movements: field camp II / Risques et dangers liés aux mouvements de versants: terrain II

Free choice credits

Teacher(s): Derron M.H., M. Jaboyedoff	Course taught at UNIL
Course given in the following orientation(s): RGEOL	Spring, 5j T
3 ECTS credits	Evaluation type: Practical

Description: This course is based on field work in order to put into practice the teaching of the course "Risks and hazards of slope movements." A study site including one or more particular phenomena (landslides, rockfalls, landslides, mudflows, floods, etc…) or a region is chosen to conduct a comprehensive study which includes:

- The characterization of slope movements
- The characterization of the hazard
- Modelling
- The development of scenarios
- Risk analysis
- The proposition of solutions

Wherever possible, the phenomena will be based on the interests of students.

Prerequisite: Risques et dangers naturels (BSc), Modélisation numérique (BSc), Mandatory to follow « Hazards and risks of slope mass movements: field camp I »

Imperial Barrel Award (AAPG)

Free choice credits

Teacher(s): Moscariello A. (coordinateur)	Course taught at UNIGE
Course given in the following orientation(s): SERG	Spring, 6 weeks
6 ECTS credits	Evaluation type: Practical

Description: AAPG's Imperial Barrel Award Program (IBA) is an annual prospective basin evaluation competition for geoscience graduate students from universities around the world. University teams compete to win scholarship funds for their geoscience department and the international recognition that comes from competing or winning in the competition. The program is rigorous and contributes to AAPG's mission of promoting petroleum geoscience training and advancing the careers of geoscience students.
In this global competition, university teams analyze a dataset (geology, geophysics, land, production infrastructure, and other relevant materials) in the eight weeks prior to their local competition. Each team delivers their results in a 25 minute presentation to a panel of industry experts. Students have the chance to use state of the art technology on a real dataset, receive feedback from an industry panel, impress potential employers in the audience, and win cash awards for their school. The judges will select the winning team on the basis of the technical quality, clarity and originality of presentation.
The IBA is a hands-on opportunity for students to experience the creative process and the high-tech science that is the foundation of the Energy Industry today.

Prerequisite: priority is given to second year students.

Inductively-coupled plasma mass-spectrometry / Spectrométrie de masse à source plasma à couplage inductif

Free choice of credits

Teacher(s): Ulyanov A.	Course taught at UNIL
Course given in the following orientation(s): GATO - SERG	Autumn, 2j C E
1 ECTS credit	Evaluation type: Validation without grade

Description: Methods of ion generation, mass separation and ion detection :
• Thermal ionisation and TIMS
• Secondary ion emission and SIMS
• Inductively coupled plasma ionisation and ICPMS
Construction of the mass spectrometer with an ICP ion source :
• The plasma torch, RF generators, interface
• Ion optics
• Quadrupole, sector-field, time-of-flight mass discriminators, resolution
• Detectors
Methods of sample introduction for ICP-MS :
• Nebulisers and Desolvators
• Solid-state and Excimer Lasers
Mass spectrum, calibration and data reduction in ICP-MS :
• Mass spectrums, resolution, abundance sensitivity
• Spectral overlaps and their handling
• Signal structure, uncertainties, detection limits
• Semi-quantitative elemental analysis
• Quantitative elemental analysis, external / internal standardisation
• Isotope ratios, (Th)-U-Pb geochronology
The course is accompanied by practical exercises with two instruments :
• Agilent 7700x quadrupole ICP-MS & GeoLas 200M laser ablation system
• Element XR sector field ICP-MS & UP-193 FX laser ablation system

Prerequisite:

Initiation to the ion probe / Initiation à la sonde ionique

Free choice of credits

Teacher(s): Bouvier A.S., A. Meibom
Course given in the following orientation(s): SERG - GATO
0.5 ECTS credit

Course taught at UNIL
Spring, 1j C TP
Evaluation type: Validation without grade

Description: Introduction to ion microprobe technology, with a focus on the two instruments (the IMS 1280 and the NanoSIMS) within the Center for Advanced Surface Analysis (CASA) at UNIL.

Prerequisite:

Integrated basin analysis / Analyse de bassin intégrée

Module Integrated basin analysis

Teacher(s): Moscariello A., E. Samankassou, M. Lupi and collaborators
Course given in the following orientation(s): SERG
6 ECTS credits

Course taught at UNIGE
Spring, 10j TS
Evaluation type: Exercises, Report

Description: The field-based course is aimed to examine the stratigraphy, tectonic and evolution of depositional environments occurred during the Late Mesozoic-Early Tertiary in the Tremp sedimentary basin (Eastern Spain). Students will work with a variety of data ranging from seismic scale outcrops, large number of stratigraphical sections across the basin and biostratigraphical data which will be integrated and used to reconstruct the full history of the sedimentary basin. Aspect of applied geology specifically associated with reservoir development and hydrocarbon play evaluation, will be also examined in this course.

Prerequisite: Modules Reservoir geology I et II, Borehole logging and rock physics et Practical seismic reflection

Internship in a company / Stage en entreprise

Free choice credits

Teacher(s): Directeur du travail de Master
Course given in the following orientation(s): SERG - GATO - RGEOL
6 ECTS credits

Spring, Autumn
Evaluation type: Validation without grades

Description: This internship should have duration of at least one month. It is the responsability of the student to find a place in a firm of her/his choice.
It will be validated by the host institution and the director of the Master thesis.
At the end of the internship, the student will have to provide a detailed certificate (length of the internship, type of work done, ...) signed by the internship supervisor in the firm and countersigned by the director of the Master thesis. This certificate will be delivered to the ELSTE administrator..

Prerequisite:

Introduction to data analysis with Matlab / Introduction à l'analyse de données avec Matlab

Module Fundamentals of numerical modelling and data analysis

Teacher(s): Simpson G.	Course taught at UNIGE
Course given in the following orientation(s): SERG - GATO - RGEOL	Autumn, 3j C
1 ECTS credit	Evaluation type: Practical (Report)

Description: The aim of this course is to familiarize students with several common techniques used to analyze numerical data sets commonly encountered in Earth Science. The course is based entirely around two one-day projects that the students will undertake independently. The first project involves multivariate data analysis with spatial data, while the second involves analysis of a time series and data modeling.
The techniques treated in this course include basic graphics, principal component and cluster analysis, autocorrelation, Fourier analysis and basic programming, all done with MATLAB.
Evaluation will be based on independent written reports based on the two projects, handed in after course has finished.
The number of participants is limited to 20 people.

Prerequisite:

Introduction to geothermics / Introduction à la géothermie and Introduction to hydrogeology and hydrology / Introduction à l'hydrogéologie et à l'hydrologie

Free choice credits

Teachers : Miller S. et Brunner Ph.	Course taught at l'UNINE
Course given in the following orientation(s):: SERG	Fall, 10d CE
2 ECTS credits	Evaluation : Practice

Introduction to geothermics : The objective of this course is to present global and local geothermal resources, how best to extract and utilize these resources, and the physics and thermodynamics that control these systems.
Contenu: Global and local heat flow, the heat equation, fluid flow, geothermal power plants, district heating, enhanced geothermal systems.
Introduction to hydrogeology and hydrology : The course will provide an overview of basic hydrological and hydrogeological processes and methods and discusses the importance of groundwater in the hydrologic cycle.
Contenu:
- Introduction to hydrology : Water balance approaches, rainfall runoff relations, measurement approaches for the key components of the hydrologic cycle
- Introduction to hydrogeology: Groundwater systems, hydraulic heads, porosity, groundwater flow equation

Prerequisite :

Laboratory techniques in geochemistry / Techniques de laboratoires en géochimie

Free choice of credit

Teacher(s): M. Ovtcharova	Course taught at UNIGE
Course given in the following orientation(s): SERG - GATO	Autumn, 1j C TP
0.5 ECTS credit	Evaluation type: Validation without grade

Description: This course offers insights into theoretical and practical aspects of laboratory techniques needed to acquire geochemical and isotopic data: sample selection in the field, sample preparation, mineral separation, laboratory techniques for dissolution, element separation by column-based ion chromatography, distillations, clean-air laboratory techniques, manipulation of acids, elemental and isotopic analysis, data treatment, precision and accuracy.

Prerequisite:

Les déchets: Gestion environnementale et contraintes géologiques – en français

Module Practicalde la géologie environnementale

Teacher(s): Poté-Wembonyama J., S. Girardclos, M. Patel, G. Giuliani	Course taught at UNIGE
Course given in the following orientation(s): SERG - GATO - RGEOL	Spring, 5j C TP
3 ECTS credits	Evaluation type: Practical

Description: Goal

This 5-days block course (given in French) addresses the topic of waste management, treatment and storage in an interdisciplinary manner with the following objectives :

- Understand waste management as an integrated concept for the management of natural resources and the protection of the environment.
- Discover the historical, economic and social context of waste management through time.
- Acquire knowledge on the legal framework of waste management and waste disposal.
- Understand technologies and practices of waste recovery and energy optimization.
- Apply current concepts in 'real-size' practical exercises.

This course includes various visits to waste management facilities in Geneva.

Program

- History of waste in the Western society.
- Legislation for waste management in Switzerland and in the EU.
- Development of organic waste and energy optimization. Compost & biogas.
- Integrated waste management "Life cycle and life cycle assessment."
- Management of municipal solid waste in the developing countries.
- Visit of the 'Voirie'. Waste management concept for the City of Geneva.
- Visit of the Cheneviers plant. Waste sorting, incineration and energy optimization.
- Visit of Châtillon site. Waste sorting, anaerobic digestion, composting, landfill disposal and leachates treatment.
- Spatial waste management and land use. Practical exercise with the selection of landfill sites in the Canton of Geneva based on georeferenced data.

Limitation

Ce cours multidisciplinaire, axé sur la pratique et le travail de groupe, est limité à 20 places. Pour des raisons d'organisation, il est **obligatoire de s'inscrire au préalable dans un formulaire en ligne** pour avoir accès au cours (choisir le cours concerné dans l'onglet)
https://www.unige.ch/sciences/terre/fr/education/bachelor/formulaires-dinscription-aux-cours-sites-contamines-cours-dechets/
Les personnes seront acceptées selon leur ordre d'inscription. Après réception de l'inscription, l'enseignante confirmera votre participation par un email. Cette procédure effectuée, vous pourrez inscrire ce cours auprès de votre programme de master selon l'usage administratif habituel

Prerequisite: This course is also open to Environment Sciences and Geography students, etc.

Life evolving with Earth

Module Life evolving with Earth

Teacher(s): A. Daley, E. Samankassou, T. Adatte, D. Ariztegui, J. Spangenberg, T. Vennemann	Course taught at UNIL/UNIGE
Course given in the following orientation(s): SERG	Autumn, 1j C TP S
6 ECTS credits	Evaluation type: Report, Seminars, Oral or writen exam

Description: This course covers a selection of topics and various tools currently used in palaeoenvironmental geology. The focus is on geochemical tracers, sedimentological proxies and palaeontontological data applied to reconstruct past changes of global implication. Selected case studies and time slides are presented, along with a particular focus on mass extinctions, the palaeoclimatology of the Cenozoic and examples in palaeoecology. By cutting across the boundaries of established sciences, the course provides an interdisciplinary forum where issues of general interest will be discussed.

Content

T. Vennemann: An overview of C- and O-isotope geochemistry, as well as Sr- and Nd-isotopes as tracers of palaeoenvironmental and/or palaeo-oceanographic conditions is given, based on some classic case studies that are using these tracers. These lectures also serve as a basic introduction to the use of isotope geochemistry in palaeoecological, -environmental and -climatic studies and their use will often be revisited in other parts of this course.

J. Spangenberg: Stable isotopes of carbon and nitrogen in sedimentary organic matter, and the distribution and nature of biological markers (biomarkers), which are molecular fossils derived from cells in once-living organisms contribute to the reconstruction of modern and fossil environments. Biomarkers (eg, alkanes, alcohols, alkenones branched isoprenoid, sterols and diglycerol tetraether) are used as proxies to estimate the temperature and salinity of ocean surface waters, wind direction, type of vegetation and the partial pressure of CO2 in ancient times.

K. Föllmi: The study of the history of the Earth's climate, environment and life allows us to trace the interactions and feedback mechanisms between the litho-, hydro-, cryo-, atmo- and biospheres and their importance in shaping our planet. At the same time its shows the boundaries within which life and the environment co-evolved during the last four billion years.

T. Adatte: Major extinction events and their documentation in sedimentary archives to better understand the interactions between life and environment. Case studies: end Ordovician, end-Devonian, Permian-Triassic, Triassic-Jurassic, Cretaceous-Paleogene mass extinctions and Paleocene-Eocene events).

D. Ariztegui: Diverse aspects of the climate of the Cenozoic including the Eocene-Oligocene transition, the Miocene, the salinity crisis as well as the starting of the Pliocene and Pleistocene glaciations. Case studies throughout the different analyzed intervals.

E. Samankassou: Basics of Palaeoecology: biological, physical and chemical factors. Interactions of organisms and relationships organisms-environment. Case studies throughout the Phanerezoic.

Prerequisite:

Marine seismic acquisition, interpretation and data integration / Acquisition, interprétation et intégration de données sismiques marines

Free choice of credits

Teacher(s): Ariztegui D.	Course taught at UNIGE
Course given in the following orientation(s): SERG - RGEOL	Spring, 8j T S
3 ECTS credits	Evaluation type: Pratique

Description: The goal of this "hands-on" course is to get students acquainted with geophysical and sediment sampling techniques in the field. This field acquisition section is complemented with the processing and interpretation of the produced geophysical dataset. Eventually, students might work on their own dataset.

Prerequisite:

MATLAB as a language of scientific computing / MATLAB comme langage de calcul scientifique

Module Fundamentals of Numerical Modelling and Data analysis

Teacher(s): Podladchikov Y.	Course taught at UNIL
Course given in the following orientation(s): SERG - GATO - RGEOL	Autumn, 42h C E
3 ECTS credits	Evaluation type: Practical (Report)

Description: To be able to model Earth processes on a computer using Matlab if equations are given. Philosophy: using simplest possible (intuitive) numerical approaches, emphasis on similarity of coding for very different processes (e.g. groundwater flow compared to pollutant diffusion and heat conduction), minimizing differences in coding for very different processes (such as wave propagation versus diffusion). To be able to model Earth processes on a computer using Matlab if equations are given. Philosophy: using simplest possible (intuitive) numerical approaches, emphasis on similarity of coding for very different processes (e.g. groundwater flow compared to pollutant diffusion and heat conduction), minimizing differences in coding for very different processes (such as wave propagation versus diffusion).

Prerequisite:

Methods of exploration / Méthodes d'exploration

Module Mineral exploration

Teacher(s): Beaudoin G., Fontboté L.	Course taught at UNIGE
Course given in the following orientation(s): GATO	Autumn, 10j CE
3 ECTS credits	Evaluation type: Practical (Report)

Description: Aim of course: Practical understanding of the procedure of exploring a mineral prospect, based on geological analysis, exploration by drilling, resource calculation of tonnage and grade as a basis for economic evaluation for reporting to investors.
Program and course structure: This practical course in mineral exploration will comprise 4 half-day lectures and a series of practical exercises from selection of a mineral property to discovery of mineral resources and their valuation. Teams are formed as Limited Partnership companies that have to select and bid for a mineral property offered during an auction. Each company has the same nominal budget. The highest bidder purchases the selected property, others need to purchase the remaining properties during an auction. Justification for selecting the property is justified in a report. The companies must interpret the geology of their mineral property to prepare a diamond drill program to discover and, eventually, delineate the mineral resources. This drill program is presented in a report prior to drilling. Drilling in the tri-dimensional matrix of the property is simulated using the software FOREUR, until budget lapse. The companies must select drill intervals for chemical analysis to document the extent and composition of the discovered mineralization. Portions of the mineral rights can be traded for capital between the companies. An estimate of the tonnage and grade of the discovered resource is prepared using geometric methods and GIS software (ex. Arc GIS). The ground value of the resource is estimated by a computation of the Net Smelter Return at current metal prices. The results of the exploration program are presented in a comprehensive report.

Prerequisite: Knowledge of mineral deposit-type characteristics is useful (orogenic gold, Cu-Zn VMS, Ni-Cu-PGE; at least Ressourcen der Erde at ETH or Gîtes Métallifères at ELSTE), but adequate knowledge of mineral deposits for the purpose of the course can be acquired by preparatory reading. Basic knowledge of ArcGIS software is important to produce maps and sections required in reports. Training exercises and tutorials will be provided in advance to prepare for the course.

Prerequisite: basic geological and mineral deposit knowledge

Microtectonics / Microtectonique

Module Quantitative Tectonics and rock deformation

Teacher(s): Robyr M., S. Schmalholz
Course given in the following orientation(s): GATO
2 ECTS credits

Course taught at UNIL
Spring, 27h C T
Evaluation type: Practical

Description: Objectives:
- Understanding the fundamental processes that occur during rock deformation on the mineral and crystal scale.
- Ability to describe microstructures in thin sections and to relate the observed structures to the responsible deformation process.

Program:
- Introduction to rock rheology: Diffusion creep, dislocation creep, low temperature plasticity
- Flow laws and deformation mechanism maps
- Description of deformation structures in thin sections
- Brittle microstructures.
- Ductile microstructures.

Recommended books:
- Passchier and Trouw: Microtectonics

Prerequisite:

Microtomography / Microtomographie

Free choice of credits

Teacher(s): Baumgartner L.
Course given in the following orientation(s): SERG - GATO

0.5 ECTS credit

Course taught at UNIL
Spring, 1j C TP

Evaluation type: Validation without grade

Description: X-ray microtomography provides 3-D images of rocks, composite materials like concrete or soils, as well as technical gadgets. It is used in material sciences and earth sciences to “map” the interior of solid samples. It is based on the fact, that different minerals attenuate X-ray differently, mainly based on their density and chemistry. This course will teach the principles of X-ray tomography, its use and limits. It will allow the participants to actually use the X-ray tomography laboratory. Some specific examples from etrology, sedimentology, and material sciences will be used.

Prerequisite:

Mining geophysics / Géophysique minière

Module Mineral exploration

Teacher(s): Irving J.
Course given in the following orientation(s): GATO
1 ECTS credit

Course taught at UNIL
Spring, 4j C TP
Evaluation type: Practical

Description: Geophysical surveying provides a powerful means of estimating the spatial distribution of physical properties inside the earth in a non-invasive manner. This course will focus on a number of geophysical techniques commonly used by the mining industry in exploring for new ore deposits. The techniques include gravity, magnetic, resistivity, induced polarization, electromagnetic, and radiometric surveying. Airborne, surface-based, and borehole survey configurations will be discussed. For each geophysical method, lectures will address (i) the underlying physical theory, (ii) the physical properties that can be resolved from the corresponding data and their relationship to properties of economic interest, (iii) instrumentation and survey methodologies used to acquire the geophysical data, and (iv) data processing, inversion, and interpretation strategies. Emphasis will be placed on building further quantitative understanding of the various methods past what has already been learned at the undergraduate level. The course will combine lectures with a series of practical exercises involving each of the studied techniques.

Prerequisite: Avoir suivi et validé un cours d'introduction à la géophysique

Model parameter estimation and uncertainty quantification

Free choice of credits

Teacher(s): N. Linde
Course given in the following orientation(s): SERG -RGEOL
5 ECTS credits

Course taught at UNIL
Spring, 56h C TP
Evaluation type: Report, oral presentation

Description: Many geoscientific problems consist of inferring system properties or to predict its response from a limited amount of noisy data. For example, what is the most likely permeability distribution of an aquifer or reservoir given a series of pumping tests? What is the maximum lateral extent of a geological body given geophysical data and surface observations? All such problems can be phrased as so-called inverse problem in which the data and its associated uncertainty is merged with a physical model that describes the relation between the model and its response under the constraint that any prior constraints about subsurface properties are honoured. This courses starts by reviewing basic probability theory before introducing classical solutions to the inverse problem, such as least-squares and maximum likelihood, as well as probabilistic formulations. Through a series of examples from the geosciences, we review the main components of an inverse problem and investigate how different solutions affect the resulting models and model uncertainty assessments. The students will work with existing data sets and software to gain an intuitive and practical understanding of how to obtain models that bring the most out of the data without resorting to interpretation of noise and artefacts. The course also considers both pragmatic and more theoretically based approaches to assess the reliability of the models obtained.

Prerequisite: A course in exploration or environmental geophysics / A course on scientific modeling
Working knowledge with Matlab

Modelling volcanic processes / Modélisation des processus volcaniques

Module Advanced petrology and volcanology

Teacher(s): C. Bonadonna, P. Jarvis, E. Rossi
Course given in the following orientation(s): GATO - RGEOL

Course taught at UNIGE
Autumn, 28h C

2 ECTS credits | Evaluation type: Seminars

Description: This course covers physical volcanology, from the physical and chemical properties of magma, to the dynamics of both effusive and explosive eruptions. Starting with the characterisation of magma as a multi-component, three-phase medium, we will develop a framework for understanding how its properties control processes of conduit flow and magma fragmentation, which govern eruption style. Then, using case studies and practical exercises, we will explore how theoretical, numerical and experimental modeling can be used to describe different eruptive process including volcanic plumes, tephra sedimentation, pyroclastic density currents and lava flow emplacement. A framework for the characterisation of eruptive parameters of explosive eruptions will also be discussed.

Prerequisite:

Optical cathodoluminescence / Cathodoluminescence optique

Free choice of credits

Teacher(s): Martini R.
Course given in the following orientation(s): SERG - GATO

Course taught at UNIGE
Spring, 1j C TP S

0.5 ECTS credit | Evaluation type: Validation without grade

Description: The content includes an explanation of physical phenomena required for understanding optic microscopy in cathodoluminescence (CL). Concrete examples taken from the study of carbonate sediments will be dealt with as well as the different methods used when preparing samples.
The main objective is to enable students to interpret the different facies of CL (i.e. colours) and to establish the chronology of diagenetic phases.
The course is given in French but may also be given in English as required.
Note
This course is compulsory for students studying for a Master's and who will be using CL during their research work in sedimentary geology, geochemistry, petrology and ore deposits; structural and alpine geology, as well as for PhD students.

Prerequisite:

Ore deposit fiel camp

Module Field trips

Teacher(s) : R. Moritz, K. Kouzmanov, Z. Zajacz
Course given in the following orientation(s):: GATO
6 ECTS credits

Course taught at l'UNIGE
Spring, 8d F
Evaluation : Practice

Description: -

Prerequisite : Module « Ore deposit » or equivalent

Ore microscopy / Microscopie des minerais

Module Ore deposits

Teacher(s): K.Kouzmanov
Course given in the following orientation(s): GATO

Course taught at UNIGE
Autumn, 6j C TP

2 ECTS credits | Evaluation type: Writen exam

Description: Part I (Learning the method, days 1 and 2): Introduction to Ore Microscopy. Properties: Reflectivity, hardness, color, anisotropy effects (//N, and +N), internal reflections, textures. Use of determination tables.
Part II: Mineral systematics (days 3 to 6): Native elements. Oxides. Sulfides and arsenides. Sulfosalts. Typical fabrics. Opaque minerals in "normal" magmatic and metamorphic rocks
Evaluation: Theoretical (20%) and practical test (80%).

Prerequisite:

Petrological processes in geodynamic environments / Processus pétrologiques dans les environnements géodynamiques

Module Petrological processes in geodynamic environments

Teacher(s): Schaltegger U., O. Müntener, S. Pilet, L. Caricchi, L. Baumgartner, S. Schmalholz, J. Marine-Carbonne, Z. Zajacz | Course taught at UNIL/UNIGE

Course given in the following orientation(s): GATO - RGEOL | Autumn, 70h C TP E S

9 ECTS credits | Evaluation type: Seminars, Report

Description: This course presents a synthesis of the petrologic and tectonic processes that occur during plate tectonics, and it will cover both the Phanerozoic and the Precambrian. The course is sub-divided into five parts:
1) Evolution of the early Earth: The very early stages of development of planet Earth were characterized by unique geological conditions, which differed from those during the Phanerozoic. These differences had profound consequences for the thermal regime of the Earth, the atmosphere, the nature of the Earth's crust, and many other aspects of evolution of the Earth. We will review several proposed mechanisms for the formation of the Earth (accretion), formation of the proto-crust, the development of the atmosphere and hydrosphere, the initiation of plate tectonics, and also other events such as episodic global glaciation (snowball Earth). The afternoons will be used for exercises and personal reading. First seminar (1 day): Each student presents a seminar about a scientific paper.
2) Mantle: Structure, composition and evolution of the mantle.
3) Subduction: Mornings will be devoted to aspects of metamorphism, magmatism, geophysics, thermo-mechanical processes and experimental petrology. Students will carry out individual work during the afternoon periods. Second seminar talk (1 day): Each student presents a seminar about a scientific paper.
4) Rifting and oceanic crust: We will study the processes linked to the movements of continents, the development of passive margins and the structure and composition of the oceanic crust. Different tectonic models for rifting and lithospheric extension (examples from geology and quantitative models) will be discussed and explained.
5) Collision: This chapter will cover crustal magmatism, transport of magma and its emplacement into the middle and upper crust, rheology of the lithosphere, and the formation of structures that typically form during collision. We will discuss the tectonic processes that occur during collision, and these will be applied to the Alpine Orogeny.
Presentation of the Main Seminar: This seminar will be presented by each student. Students can who can select a topic from a list provided by the responsible teachers. The seminar work will include a literature search, an oral presentation and a written report.
The course will be evaluated on the basis of the oral presentations, and the written report of the main seminar.

Prerequisite:

Physics and structure of minerals / Physique et structure des minéraux

Module Applied and environmental mineralogy

Teacher(s): Müntener O.	Course taught at UNIL
Course given in the following orientation(s): GATO	Spring, 14h C
1 ECTS credit	Evaluation type: Pratique

Description: This course addresses the fundamental chemical and physical properties (composition, chemical exchanges, electrical and elastic properties) of major rock forming silicates and oxides. Practical methods are discussed of how mineral analysis can be used to extract petrological and geophysical information.This course addresses the fundamental chemical and physical properties (composition, chemical exchanges, electrical and elastic properties) of major rock forming silicates and oxides. Practical methods are discussed of how mineral analysis can be used to extract petrological and geophysical information.

Prerequisite:

Physics as a basis for modeling / La physique comme base de modélisation

Module Fundamentals of numerical modelling and data analysis

Teacher(s): Podladchikov Y.	Course taught at UNIL
Course given in the following orientation(s): SERG - GATO - RGEOL	Autumn, 28h C E
2 ECTS credits	Evaluation type: Practical (Report)

Description: To be able to convert equations for Earth processes from a text book to Matlab and solve them numerically in 1 dimension. Philosophy: learning continuum physics by solving numerically in Matlab a set of classical one-dimensional problems having analytical solutions, skipping lengthy analytical derivations, but comparing the final results.

Prerequisite:

PoroPerm and QemScan

Free choice of credits

Teacher(s): Moscariello A.	Course taught at UNIGE
Course given in the following orientation(s): SERG - GATO	Autumn, 1j C TP
0.5 ECTS credit	Evaluation type: Validation without grade

Description: During this module students will learn how to describe the reservoir properties of rocks including quantitative mineralogical and textural aspects, and measured 3D porosity and permeability. The course will offer practical hands-on experience on both Coretest and QEMSCAN QUANTA 650F equipments and a number of exercises aimed to learn how to use and interpret those data e.g. for sedimentological, reservoir geology and palaeo-environmental purposes. Applications to ore-geology and volcanology will be also demonstrated.

Prerequisite:

Quantitative tectonics / Tectonique quantitative

Module Quantitative Tectonics and rock deformation

Teacher(s): Schmalholz S.	Course taught at UNIL
Course given in the following orientation(s): GATO	Autumn, 42h C TP
4 ECTS credits	Evaluation type: Practical

Description: Objectives:
- Understanding the fundamental concept of continuum mechanics, that is, concept of conservation of mass, concept of force balance and concept of conservation of energy.
- Ability to apply mechanical concepts to quantify tectonic processes.
- Ability to perform basic quantifications of tectonic processes on a piece of paper and with the help of scientific programming (using Matlab).

Content:
- Introduction to continuum mechanics
- Dimensional analysis and dimensionless solutions
- Overthrusting
- Folding
- Boudinage and necking
- Ductile shear zones
- Flexure
- Introduction to fracture mechanics

Recommended books:
- Turcotte and Schubert: Geodynamics
- Pollard and Fletcher: Fundamentals of Structural

Prerequisite:

Reading rocks - Rock textures and fluids / Lecture des roches - textures de roches et fluides

Module Petrology and Fluids in the Earth's Crust

Teacher(s): Kouzmanov K.
Course given in the following orientation(s): GATO
1 ECTS credit

Course taught at UNIGE
Spring, 2j C TP
Evaluation type: Validation without grade

Description: The course is focused on the analysis of textures resulting from the interaction of hydrothermal fluids with magmatic, sedimentary and metamorphic rocks. Correct textural description and interpretation of hydrothermally altered/mineralized rocks is fundamental for understanding the role of crustal fluids, in particular for ore-forming processes, and their time evolution. The course (lectures and practicals) provides an overview of applications of analytical methods allowing macro- to microscale sample observation/description.

Prerequisite:

Risk management / Gestion des risques

Module Risk Management

Teacher(s): Menoni S., C. Gregg, F. Romerio et enseignants du CERG-C
Course given in the following orientation(s): RGEOL
6 ECTS credits

Course taught at UNIGE
Spring, 84h C
Evaluation type: Writen exam

Description:
Objectives
At the end of the module participants should be able to:
• explain concepts around vulnerability, resilience, damage, event scenarios;
• describe main problems concerning socio-economic of disasters;
• apprehend economic and insurance aspects related to the field of risk mitigation;

• interact with journalists in case of post-disaster media communication;
• explain the functioning and dynamics of effective early warning systems; and
• recognize the role of public perception and education regarding hazard and risk

Content

The Risk Management module is the most multidisciplinary module of the CERG-C course. It includes several aspects of risk analysis. In particular, this module is focused on the best ways, according to literature, past experiences and lessons learnt, to make sound decisions in order to reduce damages and to mitigate the impact of hazards on society. Significant time and effort is devoted to understand risk assessment and risk management tools and methods used in a range of disciplines. The Risk Management module brings together a multidisciplinary team of experts representing fields such as physical and social sciences, communication, geography, land-use planning, statistics, modeling, insurance and economics. The module culminates in a one-week field trip to Vulcano Island, Italy, where participants are engaged in assessment of factors related to volcanic risk and its management.

Prerequisite:

Scanning Electron Microscopy , MEB_UNIGE / Microscopie électronique à balayage

Free choice of credits

Teacher(s): Martini R.	Course taught at UNIGE
Course given in the following orientation(s): SERG - GATO	Autumn, 2j C TP
1 ECTS credit	Evaluation type: Validation without grade

Description: This course provides an introduction to the functioning and the basic principles required for the use of a scanning electron microscope (SEM). Emphasis will be on the main imaging techniques, such as secondary and backscattered electron imaging, as well as on chemical analysis through energy dispersive spectroscopy (EDS), and cathodoluminescence. Preparation of both geological and biological samples for scanning electron microscopy will be treated as well. The course comprises a theoretical part complemented by hands-on practical exercises.

At the end of the course, the students should be able to interpret secondary and backscattered SEM images, as well as images on cathodoluminescence and spectra obtained from EDS analyses.

Note

This course is strongly recommended for the students who will use this type of facilities during their master. For practical reasons, the course will be given on both sites (UNIGE: R. Martini; UNIL: P. Vonlanthen).

Prerequisite:

Scanning Electron Microscopy, MEB_UNIL / Microscopie électronique à balayage

Free choice of credits

Teacher(s): Vonlanthen P.	Course taught at UNIL
Course given in the following orientation(s): SERG - GATO	Autumn, 2j C TP
1 ECTS credit	Evaluation type: Validation without grade

Description: This course provides an introduction to the functioning and the basic principles required for the use of a scanning electron microscope (SEM). Emphasis will be on the main imaging techniques, such as secondary and backscattered electron imaging, as well as on chemical analysis through energy dispersive spectroscopy (EDS), and cathodoluminescence. Preparation of both geological and biological samples for scanning electron microscopy will be treated as well. The course comprises a theoretical part complemented by hands-on practical exercises.

At the end of the course, the students should be able to interpret secondary and backscattered SEM images, as well as images on cathodoluminescence and spectra obtained from EDS analyses.
Note: This course is strongly recommended for the students who will use this type of facilities during their master. For practical reasons, the course will be given on both sites (UNIGE: R. Martini; UNIL: P. Vonlanthen).

Prerequisite:

Sedimentary laboratory techniques / Techniques de laboratoires sédimentaires

Free choice of credit

Teacher(s): N.N	Course taught at UNIGE
Course given in the following orientation(s): SERG- GATO	Autumn, 1j C TP
0.5 ECTS credit	Evaluation type: Validation without grade

Description: Objectives:
This course aims to teach theoretical and practical aspects of various laboratory techniques for analyzing sedimentary rocks and their fossil content while learning the proper use of laboratory equipment. This equipment includes centrifuge, ultrasound, oven, distilled water device and other standard laboratory facilities. After the actual preparation of the samples in the laboratory, they are studied under both binocular and optic microscopes. Students are offered the possibility to work on their own samples.
Content:
1. Staining of carbonate minerals in thin sections.
2. Preparation of acetate peels for studying sedimentary rocks.
3. Microfossils preparation in sedimentary rocks.
4. Calcareous nannofossils preparation.

Prerequisite:

Seismic risk / Risque sismique

Module Volcanic and seismic risk

Teacher(s): Fäh D., B. Duvernay	Course taught at UNIGE
Course given in the following orientation(s): RGEOL	Spring, 6j CE
3 ECTS credits	Evaluation type: Writen exam

Description: At the end participants should be able to :
• understand seismic hazard products
• describe the required input data and the related uncertainties
• distinguish the main principles of good practice in seismic conceptual design
• develop an overview over seismic risk mitigation strategies
• communicate with experts from the fields of seismology and construction
This course is divided into seismic hazard assessment and seismic vulnerability and loss modelling. The seismic hazard assessment part is a general introduction to the methods of seismic hazard analysis. It provides an overview of the input data and the tools in deterministic and probabilistic seismic hazard assessment, and discusses the related uncertainties. It includes the discussion related to Intensity and macroseismic scales, historical seismicity and earthquake catalogues, ground motion parameters used in earthquake engineering, definitions of the seismic source, magnitude scales, ground motion prediction equations, site effects and microzonation, and the use of numerical tools to estimate ground motion parameters, both in a deterministic and probabilistic sense. Secondary effects such as liquefaction of soils, the triggering of landslides and tsunami generation will be discussed as well. The Seismic Vulnerability & Loss Modeling part provides an overview of the different factors affecting the seismic vulnerability of buildings and infrastructures and gives an insight in

how earthquake loss models work. General principles for a good seismic design of buildings and examples of what happens if these principles are not followed will be discussed. Students will put their knowledge into practice through the evaluation of the seismic vulnerability of existing buildings based on architectural plans. They will also learn about the structure of earthquake loss models and use a simple generic earthquake loss model.

Prerequisite:

Sites contaminés: application géologiques et environnementale – en français

Module Practical de la Géologie environnementale

Teacher(s): Girardclos S., J. Poté-Wembonyama
Course given in the following orientation(s): SERG - GATO - RGEOL
3 ECTS credits

Course taught at UNIGE
Spring, 5j C TP

Evaluation type: Practical

Descriptif : Objectives

This 5-day block course aims to understand contaminated site management as an integral concept of natural resource management and environmental protection as part of the Sustainable Development Goals. It is :

• Knowing the different sources of the most important and dangerous contaminants, their persistence and their diffusion in the environmental compartments.
• Acquiring in-depth knowledge of physicochemical and biological techniques (bioremediation) for remediation of contaminated sites.
• Developping an investigation program for polluted sites and assess the risks associated with pollution using geological and hydrogeological data.
• Putting concepts into practice with a technology implementation plan to reduce burdens, risks and remedying pollution.

This course includes a visit to a contaminated site management facilities

Program :

• Typology of pollution and family of micropollutants and macropollutants: mining, urban, industrial pollution related to the associated environmental compartments.
• Laws and procedures related to the management of contaminated sites in Switzerland and the EU.
• Preventive technical measures and site remediation; physicochemical and bioremediation approaches.
• Field visit of a contaminated site in the canton of Geneva that illustrates the concepts and techniques presented in the course.
• Management of a contaminated site from an industrial landfill of national importance.
• Exercises resulting from the practice in engineering office.

Limitation:

Ce cours multidisciplinaire, axé sur la pratique et le travail de groupe, est limité à 20 places. Pour des raisons d'organisation, il est **obligatoire de s'inscrire au préalable dans un formulaire en ligne** pour avoir accès au cours (choisir le cours concerné dans l'onglet)
https://www.unige.ch/sciences/terre/fr/education/bachelor/formulaires-dinscription-aux-cours-sites-contamines-cours-dechets/
Les personnes seront acceptées selon leur ordre d'inscription. Après réception de l'inscription, l'enseignante confirmera votre participation par un email. Cette procédure effectuée, vous pourrez inscrire ce cours auprès de votre programme de master selon l'usage administratif habituel

Prerequisite:

SPACE-GEOENERGY: Geomatics and geo-energy / Géomatique et géo-énergies

Free choice credits

Teacher(s): Moscariello A., J. Simantov et collègues	Course taught at UNIGE
Course given in the following orientation(s): SERG	Spring, 5j C
3 ECTS credits	Evaluation type: Pratique

Description: Learn a set of tools , techniques and methodologies that enable to assess the subsoil potential of energy resources.
Application to geothermy and to the Play Fairway Analysis process: data compilation, integration and interpretation , definition of zones of interest , probability maps construction, integration of maps and highlighting prospects.

Prerequisite: Notions de base en SIG, expérience utilisateur ArcGIS

Spatial risk assessment / L'évaluation spatiale du risque

Module Spatial analysis applied to geology and risk

Teacher(s): Frischknecht C., P. Peduzzi, B. Chatenoux	Course taught at UNIGE
Course given in the following orientation(s): SERG - GATO - RGEOL	Spring, 5j C E
3 ECTS credits	Evaluation type: Practical (Report)

Description: Objectives:
- understand various ways of assessing exposure and vulnerability
- apply GIS and mathematical tools for risk assessment

Description:
This course focuses on risk assessment. Natural hazards (earthquakes, floods, tsunamis, hurricanes), exposure, physical and human vulnerability as well as adaptation capacities and the role of ecosystem to mitigate risk will be considered. Tools such as ArcGIS, QGIS and Statistica will be used to assess risk either semi-qualitatively or quantitatively.
This course is based on theory and practicals using ArcGIS, QGIS and Statistica.

Prerequisite:

Stable and radiogenic isotope geochemistry / Géochimie des isotopes stables et radiogéniques

Module Stable and radiogenic isotope geochemistry

Teacher(s): Chiaradia M., E. Samankassou, U. Schaltegger, R. Spikings, T. Vennemann, J. Marin-Carbonne	Course taught at UNIL/UNIGE
Course given in the following orientation(s): GATO	Spring, 84h C TP S, biannual, odd semester
6 ECTS credits	Evaluation type: Writen exam

Description: This module illustrates the wide range of applicability of stable (light and heavy) and radiogenic isotopes to an advanced understanding of magmatic, metamorphic, surface, tectonic and ore-forming processes. The course will consist of both lectures (50%) and practical exercises (50%).
Contents
1. Magmatic systems.
a. Stable isotopes for source fingerprinting and reconstructions of magmatic processes
b. Radiogenic isotopes for source fingerprinting and magmatic processes reconstruction
c. Dating magmatic rocks and magma chamber processes

2. Metamorphic systems.
a. Metamorphic reactions and stable isotope compositions
b. Dating of metamorphic events
3. Thermochronology.
a. Low temperature thermochronology (FT, U-Th-He)
b. The Ar/Ar thermochronometer
c. High temperatute thermochronology (U-Pb)
4. Sedimentary systems
a. Clastic systems: provenance through radiogenic and stable isotopes and zircon dating
b. Carbonate systems: C- and Sr-isotope chronostratigraphy, reconstruction of paleo-chemical and physical parameters and processes (e.g., B, Ca, Zn isotopes), U-series dating
5. Surface systems
a. Tracing sources of pollutants in the environment and reconstructing surface processes with stable and radiogenic isotopes
6. Ore systems
a. Signatures of stable light and heavy isotopes in ore systems
b. Tracing fluid and metal sources with radiogenic isotopes
c. Dating ore deposits

Prerequisite: solid background in the basic principles of isotope geology acquired through the courses of the second and third years or equivalent.

Syn-tectonic granite emplacement and vein formation - Cévennes, France / Mise en place de granites syn-tectoniques et veines hydrothermales - Cévennes, France

Free choice of credits

Teacher(s): Kouzmanov K., A. Chauvet
Course given in the following orientation(s): GATO
3 ECTS credits

Course taught at UNIGE
Spring, 6j T, bianual, odd semester
Evaluation type: Practical

Description: The field camp is focused on the characterization of the structural context of formation of Au vein mineralization associated with the emplacement of the late-Hercynian Mont-Lozère granite in the Cevennes (France). Topics discussed during the field camp include: i) structural analysis of magmatic bodies and hydrothermal veins; ii) fluid-rock interaction; and iii) processes at the magmatic-hydrothermal transition. Participants, working in groups of 2-3 people, will perform exercises on: outcrop-scale detailed mapping, geological cross-section, and micro-structural analysis. Work to be submitted for evaluation includes interpretative group reports and individual notebooks.

Prerequisite:

Volcanic risk / Risque volcanique

Module Volcanic and seismic risk

Teacher(s): Bonadonna C. et enseignants du CERG-C
Course given in the following orientation(s): RGEOL
3 ECTS credits

Course taught at UNIGE
Spring, 6j C T
Evaluation type: Writen exam, Practical (Report)

Description: The objectives related to volcanic risk area :
- characterize different eruptive styles and volcanic phenomena
- distinguish main features of pyroclastic deposits

- describe key parameters of volcanic activity
- assess main volcanic hazards
- combine the evaluation of both volcanic hazard and vulnerability for the development of comprehensive models of risk assessment

This course presents an introduction to physical volcanology and volcanic risk. In particular, some basic concepts of main types of volcanoes, eruptive styles and associated deposits are discussed. Main volcanic hazards and examples of hazard assessment are described in greater detail. Main issues associated with the evaluation of volcanic risk and the management of volcanic crisis are also discussed.
Estimated expenses for the excursion: CHF 1'300.-

Prerequisite: Havoing followed the master's course "Risk management".

Volcano fieldtrip / Excursion volcanique

Module Advanced petrology
and volcanology

Teacher(s): Caricchi L., C. Bonadonna, S. Pilet
Course given in the following orientation(s): GATO - RGEOL

Course taught at UNIL/UNIGE
Spring, 5j T

2 ECTS credits

Evaluation type: Pratique

Description: During this advanced course of Volcanology we will show how petrology can be applied to unravel the processes of magma transfer, accumulation and evolution in the Earth's crust and how these processes affect the eruptive dynamics of volcanoes. Petrology will be combined with the quantitative study of pyroclastic deposits to demonstrate how the chemical and physical characterization of volcanic products can be used to characterize the processes leading to the variety of volcanic eruptions we observe on our planet. We will apply theoretical concepts of petrology and physical volcanology performing exercises to uncover the sequence of events leading to some of the best studied eruptions.
Estimation for the costs of the fieldtrip: travel expense to Catania (around 300 CHF) + food and lodging (300 Euros)

Prerequisite:

Volcano petrology / Pétrologie volcanique

Module Advanced petrology
and volcanology

Teacher(s): Caricchi L., S. Pilet
Course given in the following orientation(s): GATO - RGEOL
2 ECTS credits

Course taught at UNIL/UNIGE
Spring, 28h C
Evaluation type: Séminaire

Description: During this advanced course of Volcanology we will show how petrology can be applied to unravel the processes of magma transfer, accumulation and evolution in the Earth's crust and how these processes affect the eruptive dynamics of volcanoes. Petrology will be combined with the quantitative study of pyroclastic deposits to demonstrate how the chemical and physical characterization of volcanic products can be used to characterize the processes leading to the variety of volcanic eruptions we observe on our planet. We will apply theoretical concepts of petrology and physical volcanology performing exercises to uncover the sequence of events leading to some of the best studied eruptions.

Prerequisite:

Weathering processes and soils formation / Processus d'altération et formation des sols

Module Sedimentary rocks and processes from Source-to-Sink

Teacher(s): E. Verrechia	Course taught at UNIL
Course given in the following orientation(s): SERG	Autumn, 2j C TP
1 ECTS credit	Evaluation type: Pratique

Description: This course deals with the relationship between weathering processes and soil formation over geological times. After a large introduction on the processes of weathering at the surface of continents and a presentation of the main types of pedogenesis at work, the course will introduce the diversity of paleosols, show how paleosols can be used for palaeogeographic reconstructions, and how weathering and paleosols are keys to the understanding of elemental biogeochemical cycles at the surface of continents during Earth's history.
This mainly ex-cathedra course will also be illustrated by observations of thin sections of paleo-alterites and paleosols.

Prerequisite:

CONTACT

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et de l'environnement

UNIVERSITÉ
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FACULTÉ DES SCIENCES