Description of courses in English in third year

LU3TS501 - Geochemistry

Convenors :
Etienne Balan (Etienne.Balan@sorbonne-universite.fr)
Pierpaolo Zuddas (Pierpaolo.Zuddas@sorbonne-universite.fr)

Teaching team : Hélène Balcone-Boissard, Sylvain Huon, Erwan Martin, Mathieu Chassé, Etienne Balan, Pierpaolo Zuddas

GENERAL PRESENTATION AND OBJECTIVES OF THE TEACHING UNIT

This teaching unit will treat of basic notions of geochemistry, which make it possible to envision the Earth planet as a chemical system. It will be shown how the chemical and physical properties of elements, and related isotopes, control their distribution in Earth environments. The first part adresses the chemical equilibrium formalism in link with aqueous and low-temperature geochemistry, the second part is focused on fundamental physical and chemical mechanisms operating in natural systems, ranging from crystal growth to isotopic fractionation processes, the third part is devoted to element partitioning in high temperature environments and to the basics of isotopic geochronology.

TEACHING ORGANISATION

- 10 lectures (2h)
- 10 tutorials (2h)

DEVELOPED SKILLS (and expected level at the end of the teaching unit)

Disciplinary knowledges

- ✓ Acid-base equilibria in aqueous solution
- ✓ Solid formation from aqueous solutions
- ✓ Chemical bonding and chemical variability of minerals
- ✓ Basics of stable isotope geochemistry
- ✓ Petrogenetic use of trace elements and radiogenic isotopes
- ✓ Basics of geochronology

Transverse skills

- ✓ Litterature analysis
- ✓ Scientific writting, description and interpretation of scientific figures
- ✓ Basics of chemistry

EVALUATION

- ✓ 60% homework
- ✓ 40% exam

LU3ST058 – Mineralogy

Faculty members in charge: Laurence Galoisy (laurence.galoisy@sorbonne-universite.fr) and Mathieu Chassé (mathieu.chasse@sorbonne-universite.fr)
Teaching staff: Laurence Galoisy, Mathieu Chassé, Chrystèle Sanloup

GENERAL PRESENTATION AND OBJECTIVES OF THE TEACHING UNIT

Mineralogy is fundamental for geosciences as it confers a knowledge of the materials forming the Earth and the other planets. The composition, structure and physical properties of minerals control the physico-chemical processes at stake in all terrestrial compartments. These properties are also at the origin of their use by mankind as mineral resources. This teaching unit gives a first contact with the mineralogy as a tool to understand the Earth system through the diversity of the accessible information (geochemical, petrophysical, geochronological, geothermometric…). It offers a vision complimentary of the one provided by the magmatic petrology unit and gives the possibility to capture implicit information included in the mineralogical nomenclature used all along the Earth-sciences licence.
The objective is to get acquainted with the fundamental knowledge of the field (crystal, mineral, composition of the matter, structural formula, crystallographic structure, macroscopic and microscopic properties of the minerals and classification of minerals) and understand the most common characterisation techniques associated (optical microscopy, X-ray diffraction, electron microscopy, spectroscopies) in order to answer a variety of scientific questions (internal structure of the Earth, thermobarometry, geochronology, (paleo)environmental conditions, biogeochemical cycles of the elements, useful properties of mineral materials...).
This teaching unit will rely on a set of multidisciplinary prerequisites: (1) global structure and functioning of the Earth system (licence 2 level); (2) structure and organisation of the matter (chemistry, licence 1 level); (3) optics (physics, licence 1 level); (4) geometry (mathematics, high-school level).

Structure de la calcite | Biréfringence d'un spath d'Islande | Scalénoèdre de calcite hydrothermale | Calcite sableuse de Fontainebleau | Oeil de trilobite

Calcite: from the assembly of atoms to the geological and environmental context

TEACHING ORGANISATION

The 6 ECTS are divided into 12 teaching sessions, 6 tutorial session and 3 practical sessions, part of the time will be dedicated to an oral presentation. This is complemented by personal work in interaction with the teaching staff. The teaching unit is divided in four parts:
- Physico-chemical structure and crystallography of minerals: lecture/investigation, construction of a "toolkit of the mineralogist", applied exercises during tutorials.
- Application to the understanding of magmatic processes: lecture and tutorial.

- Systematic approach of the structure–properties relationships in minerals: lecture and tutorials.
- Mineralogical analyses: lecture followed by practical sessions on analytical facilities and oral report.

DEVELOPED SKILLS (and expected level at the end of the teaching unit)

Disciplinary knowledge

- ✓ Interpret a crystal structure and the organisation of the atoms in relation with the chemical composition and the environment of formation of a mineral.
- ✓ List, classify and describe the major terrestrial minerals, their characteristics, occurrences and uses.

Disciplinary know-how

- ✓ Analyse the results obtained using the most common techniques of mineralogical characterisation (optical and electron microscopy, X-ray diffraction, spectroscopy) to determine the nature and physico-chemical properties of minerals.

Transverse skills

- ✓ Deduce geochemical and geophysical information from mineralogical analyses to understand the physico-chemical processes at stake in the Earth system.

Bibliography

- To consolidate your skills:
Montel, J.-M. & Martin, F. *Minéralogie : Cours et exercices corrigés*. (Dunod, 2014).
Nesse, W. D. *Introduction to Mineralogy*. (Oxford University Press, 2016).
- For the mineralogical culture:
Cordier, P. & Leroux, H. *Ce que disent les minéraux*. (Belin, 2008).
Farges, F. *À la découverte des minéraux et pierres précieuses*. (Dunod, 2018).

EVALUATION

- ✓ 30 % final written examination.
- ✓ 20 % intermediate written examination.
- ✓ 30 % oral report following the practical sessions.
- ✓ 20 % synthesis (“toolkit of the mineralogist”) early in the teaching unit.

LU3ST057 – Earthquakes, waves and images

Professor in charge: Frédérique Rolandone

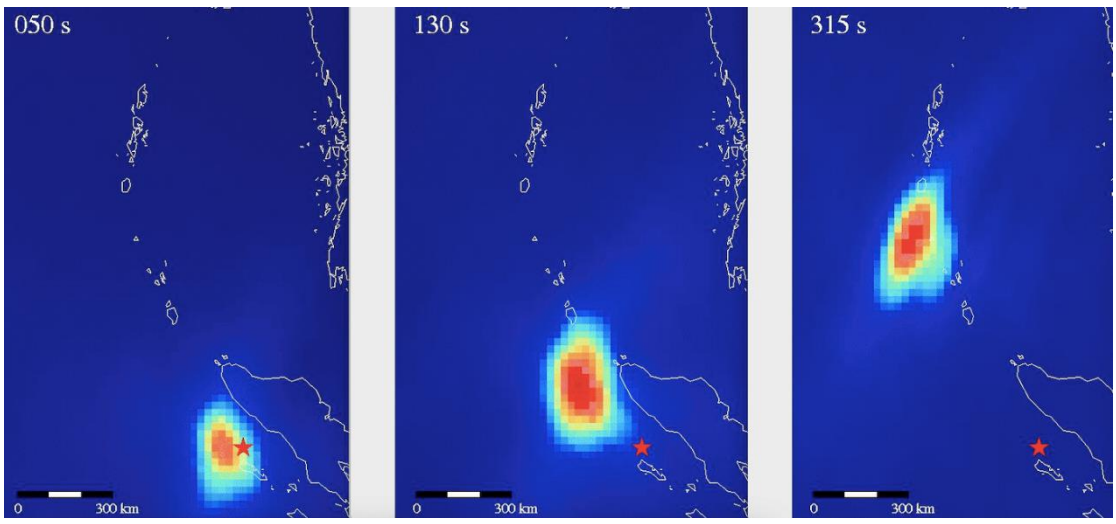
Speakers: Frédérique Rolandone & Elia d'Acremont

GENERAL PRESENTATION AND OBJECTIVES OF THE TEACHING UNIT

The study of earthquakes and seismological waves includes several items: the first part of this UE focuses on the earthquakes and source theory and the second part deals with the seismic waves propagation.

In the source theory part, we study double-couple theory, stress drop, earthquake scaling laws, radiated energy, seismic moment, focal mechanisms and source functions. The objectives are to characterize large earthquakes and to map the time–space history of the slip distribution on faults during major earthquakes, and thus to image the rupture process. During this first part of the UE, the students gain knowledge on theoretical seismology and they study examples of recent major earthquakes.

In the second part, the seismic source is this time artificial. We study reflection and refraction seismic methods based on seismic waves propagations. The objectives are to understand the basic principle of seismic data acquisition and processing. These methods are used to illuminate sub-seafloor geological properties and processes. The students gain knowledge on seismic wave equations, seismic traces, impedance contrast, to better interpret the seismic data used for geophysical imaging.



Spatio-temporal evolution of the rupture of the 2004 Sumatra earthquake

TEACHING ORGANISATION

10 CM (lecture course) of 2h & 12 TP (practical work) of 2h

Source theory part: 6 CM and 7 TP
Seismic imaging part: 4 CM and 5 TP

DEVELOPED SKILLS (and expected level at the end of the teaching unit)

- ✓ Theory of elastic wave and wave types
- ✓ Seismic wave equation
- ✓ Reflection and refraction seismic methods
- ✓ Earthquake source function
- ✓ Rupture and directivity of earthquakes
- ✓ Intensity of earthquakes, magnitude and energy
- ✓ Moment tensor
- ✓ Calculation of seismic moments
- ✓ Critical sense of seismic data interpretation
- ✓ Analysis of seismic waves
- ✓ Analysis of earthquake source function
- ✓ Use of software SeiSee to visualize seismic data

EVALUATION

- ✓ 40 TP
- ✓ 20 CC
- ✓ 40 Courses

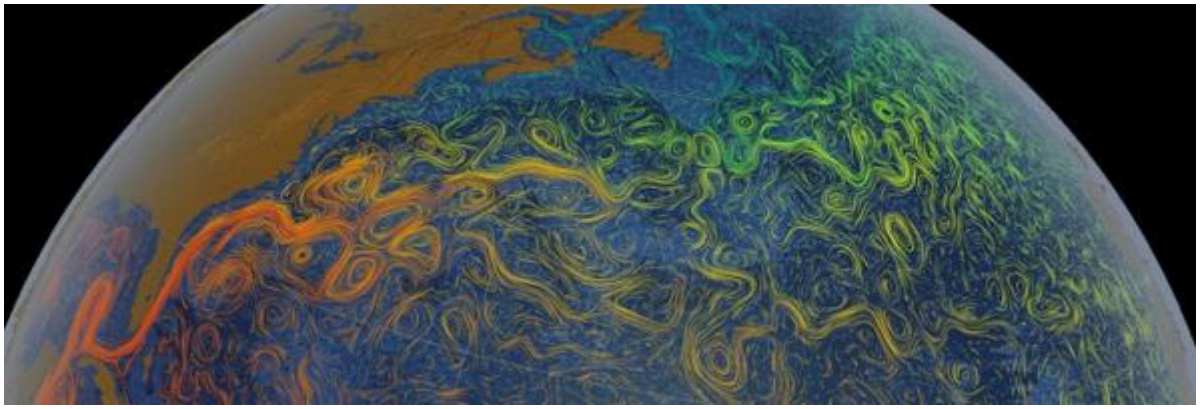
LU3ST059 – Oceanography

Convenors : Alban Lazar (alban.lazar@ sorbonne-universite.fr) Guillaume Gastineau (guillaume.gastineau@sorbonne-universite.fr)

Teaching team:: Alban Lazar, Guillaume Gastineau

GENERAL PRESENTATION AND OBJECTIVES OF THE TEACHING UNIT

Introduction to the organization, realization and analysis of an at-sea campaign on board the Sagitta III or other vessels of the French Coastal Oceanographic Fleet, dedicated to the measurement of key quantities in physics (temperature, salinity and density profiles), optics (scatterometry), biogeochemistry (oxygen and pH) and marine biology (chrorophyll and plankton)



TEACHING ORGANISATION

The 6 ECTS are divided into 10 teaching sessions, 10 tutorial session and 10practical sessions.

Bibliography

-Fieux, M. L'océan planétaire. Les Presses de l'ENSTA. 01/2020 (2ème édition).
-Trujillo, A.P, Thurman, H.V.. Essentials of Oceanography, 12th edition.

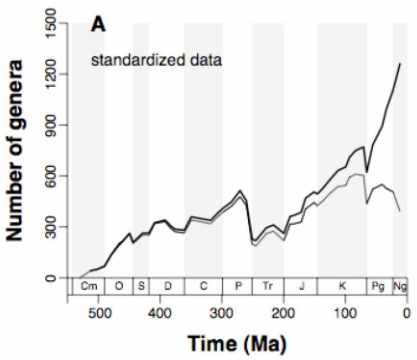
LU3ST056 – Palaeobiodiversity

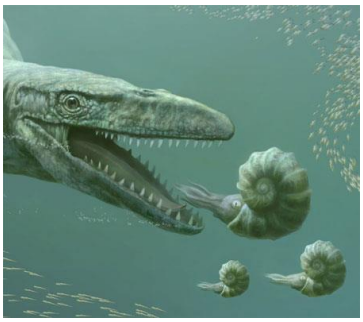
Coordonator : Carine RANDON (carine.randon@sorbonne-universite.fr)
Speakers : Carine Randon, Loic Villier, Anais Boura, Isabelle Kruta, Johan Schnyder (SU), Ronan Allain, Sylvain Charbonnier (MNHN)

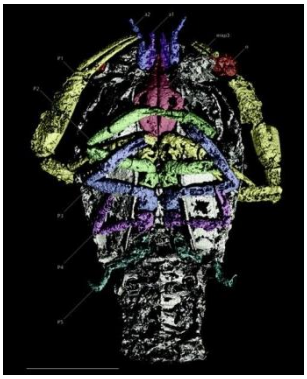
GENERAL PRESENTATION AND OBJECTIVES OF THE TEACHING UNIT

The aim of this EU is to give an overview of the fossil biodiversity and to follow its evolution through the different concepts and methods used in both biology and palaeontology. Students will also learn about the methods and tools used to rebuild past ecosystems.

The practical sessions will focus on (i) analysis of online databases, (ii) computer softwares and (iii) fossil material. Students will learn how (i) to construct diversity and morphological disparity curves (with applications to crises and radiations), (ii) to identify the quality of fossil registration and (iii) to rebuildt past ecosystems.







The Paleobiology Database
revealing the history of life

TEACHING ORGANISATION

20h course
26h practical
14h personal work

DEVELOPED SKILLS (and expected level at the end of the teaching unit)

Disciplinary knowledge

- Palaeoecology (population vs. settlement, ecological niche, biotic interactions,...)

- Reconstruction of a food webchain in the fossil record

- Characteristics of marine and continental palaeoecosystems and their constraints on populations

- To use the preservation of the organism to reconstruct its taphonomic history

- To know methods and biases for paleoenvironmental reconstructions

- To know the different indices to estimate palaeobiodiversity and to know how to use them wisely

- Study of Lagerstatten

Transverse skills

- PaleobiologyDatabase
- Biodiversity indices
- CLAMP Méthod

EVALUATION

- ✓ 30% practical
- ✓ 20% personal project
- ✓ 50% course

LU3ST055 – Ressources

Faculty members in charge : Laurence Galoisy (laurence.galoisy@sorbonne-universite.fr) – François Baudin (françois.baudin@ sorbonne-universite.fr)
Teaching staff : Laurence Galoisy – François Baudin – Valérie Plagnes – Georges Ona-Nguema

GENERAL PRESENTATION AND OBJECTIVES OF THE TEACHING UNIT

Mineral, energy and water resources are the basis of the development of our societies. They correspond to highly topical and expanding fields, at the crossroads of major fundamental and applied disciplines.
This course will thus present industrial ores and minerals, the diversity of the main types of mineral raw material deposits, the main types of energy resources as well as the specific problem of water resources, including aspects related to water treatment. The issues related to sustainable development and the management of environmental impacts will also be adressed.

Nickel mine– New Caledonia

TEACHING ORGANISATION

- ✓ 20 supervised works, "TD"
- ✓ 10 courses

DEVELOPED SKILLS (and expected level at the end of the teaching unit)

Petrology and mineralogy of deposits, Hydrogeology, Petroleum geology.
Use of resources in an environmental context: relation between resources and major geological processes, environmental impacts

Cross-disciplinary skills

Becoming familiar with technical expressions (in French and English), bibliographic research, oral presentations

EVALUATION

- ✓ Written examination 60%
- ✓ Supervised works and oral presentations 40%

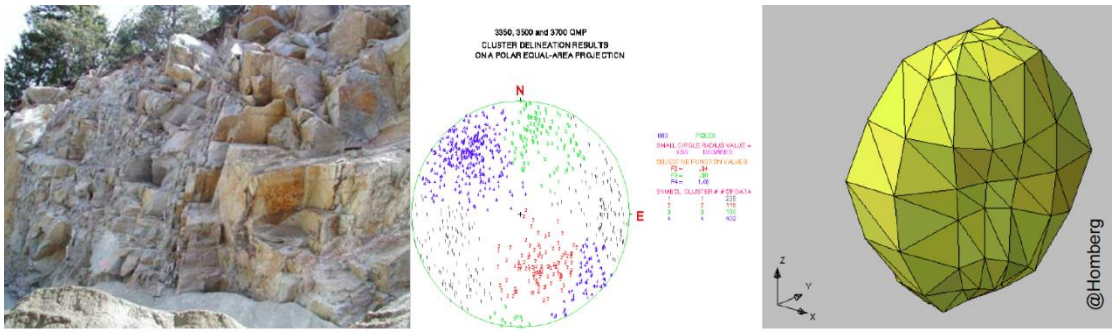
LU3ST602 – Integrated Approach to Geosciences

Academic Leader: Sophie Violette (sophie.violette@sorbonne-universite.fr)
Instructors: Catherine Homberg (catherine.homberg@sorbonne-universite.fr) &
Johann Schneider (johann.schnyder@sorbonne-universite.fr)

GENERAL PRESENTATION AND OBJECTIVES OF THE TEACHING UNIT

The Integrated Approach in Geosciences module is a methodological module that aims to teach you: multidisciplinary in geosciences, to comment on documents and to create new ones that are synthetic, to write a synthesis and to present your work orally.

The complementarity of the disciplines in geoscience is illustrated thanks to a geological object, the Paris Basin, and to a common thread represented by an operational theme, Water.



From left to right: Outcrop of a fractured geological formation where fracture planes are measured, transfer of the poles of the fracture planes on a canvas and ellipsoid of the hydraulic properties is calculated.

TEACHING ORGANISATION

At each session, the work is organized in sub-groups (3-5 students depending on the number of students). You will be asked to answer a scientific questionnaire allowing you to analyse and comment on the documents provided. Each session constitutes a step in the scientific progress of the theme. It will essentially be a matter of combining approaches/concepts/tools acquired during the modules of the License.

The theme will be broken down into 5 sub-thematic sessions of 2 x 2hours each, and one session of 2 hours to prepare you for the oral exam.

DEVELOPED SKILLS (and expected level at the end of the teaching unit)

- Valorise in an original way its knowledge in Geoscience (all disciplines)
- Acquire methodological knowledge based on various data
- Quantify physical processes in a simple way
- Develop an open mind, a critical mind and a spirit of synthesis
- Acquire mastery of the writing of a synthesis and oral presentation

EVALUATION

40% - Continuous assessment (session synthesis at each sub-thematic sessions)

Students will have to choose a theme related to the Paris basin and showing the contribution of multidisciplinary. This theme will be illustrated by a poster. The poster will be used as a support for an oral presentation in front of a jury of the theme and will give the opportunity for an exchange of questions and answers.

40% - Formatting, presentation and answering questions about the poster
20% - Writing of a summary of the poster and commentary of a synthesis figure from the poster (limited number of words).

LU3ST603 – Field courses 3

Field courses in volcanology

Location : Italy (7days) or Auvergne (France, 6 days)

Instructors H. Balcone-Boissard, C. Hontaas, E. Martin

Study of the recent volcanism from the Massif Central (Chaine des Puys and Sancy massif). From the observation of volcanic deposits on the field, we infer the main eruption dynamisms as well as the volcanic activity through time of the area.

Study of the Italian active volcanism (Phlegrean Fields, Mt Vesuvius and Stromboli). From the observation of the active volcanic systems, from their activity to their deposits, we discuss the diversity of volcanic dynamisms and the associated hazards.

Goal : integration of volcanic system dynamisms from their origin to their consequences

Field courses in sedimentology, stratigraphy and paleontology.

Location: Merry-sur-Yonne (Bourgundy , France ; 6 days)

Instructors: L. Riquier, L. Villier

This field camp focuses on the reconstruction of the structure and the geological evolution of a reef system from the Jurassic, integrating a wide paleontologic, sedimentary, stratigraphic and cartographic dataset. We study as well the carbonaceous rocks as exploitable reservoirs from the petroleum industry.

Field courses of structal geology

Location: Corbières et Cap Creus (France and Spain; 7 days)

Instructors N. Bellahsen, C. Rosenberg

The study of the deformation markers in brittle and ductile conditions is based on outcrop to regional scale structures. This field camp is complementary to the cartography field courses (L2 field courses) and the study of orogens (M1 and M2 field courses)

Goal: quantitative approach of the deformation at different scales, stereographic representation, 3D vision of the geological structures, observation of the links between mineralogy and deformation.

Field courses Environment and Heritage

Location: Bourgundy (France, 5 days)

Instructors: L. Galoisy (SU-S), S. Balcon Berry (SU-L), D. Sandron (SU-L)

This field camp is mix between students from sciences/ingineering and arts/humanities that are interested in the construction materials at different historical periods: from ornate caves to Roman through Gallo-Roman monuments. The historical aspects is completed by the presentation of deposit exploitation for the construction material, the visit of the main carbonate stone exploitation sites as well as an introduction to archaeological experiments

Field courses Geochemistry of soil and water

Location: Oise (France; 5 days)

Instructors: M. Alexis, M. Rouelle

This field camp is dedicated to characterise he soil diversity and to study the geochemical interactions between soil and water. This course is based on observation and sampling of soils (and water) and finally on their geochemical analyses on the field.

Field courses, oceanography (physics, chemistry, biology)

Location: Villefranche sur Mer (France; 6 days)

Instructors: A. Lazar, D. Ruiz-Pino

Introduction to planning, data acquisition and interpretation of a sea campaign onboard of the Sagitta III or an other boat from the French oceanographic fleet. These boats are dedicated to the measure of physical, optical, biogeochemical and biological parameters in the water column.

The evaluations are variable depending on the field courses.

LU3ST065 – Geochemistry

Convenors : Pierpaolo Zuddas (Pierpaolo.Zuddas@sorbonne-universite.fr)
Sylvan Huon (Sylvain. Huon@sorbonne-universite.fr

Teaching team: Sylvain Huon, Maryse Castrec-Rouelle, Pierpaolo Zuddas

GENERAL PRESENTATION AND OBJECTIVES OF THE TEACHING UNIT

This course treats the chemical functioning of natural systems and the impact of human activity on these systems. It develops the principles and methods applicable to understanding and solving environmental problems.
Concepts concerning chemical balances in natural waters (acid-base and redox reactions in waters and water-mineral reactions) are integrated in the context of a specific problem and environment. The properties of stable and radiogenic isotopes will also be presented. The processes and problems studied will be chosen from continental and / or marine environments. The analysis of historical records of pollution in sediments completes the teaching with the temporal notion of environmental dynamics.

TEACHING ORGANISATION

- 12 lectures (2h)
- 12 tutorials (2h)

DEVELOPED SKILLS (and expected level at the end of the teaching unit)

Disciplinary knowledge

Theoretical and practical geochemistry applied to natural waters to understand the processes of interaction with ecosystem components. Classification of natural waters and ability to assess their chemical quality in relation to the state of ecosystems.

Ability to process and assess the quality of analytical data: use of simple thermodynamic calculations (ionic strength, ionic activity, saturation index, interpretation of state diagrams). Interpretation and environmental significance of stable and radiogenic isotope fractionations.

Transverse skills

Analysis of scientific literature. Oral and written reports. Field and laboratory analysis.

EVALUATION

Continuous monitoring and final project

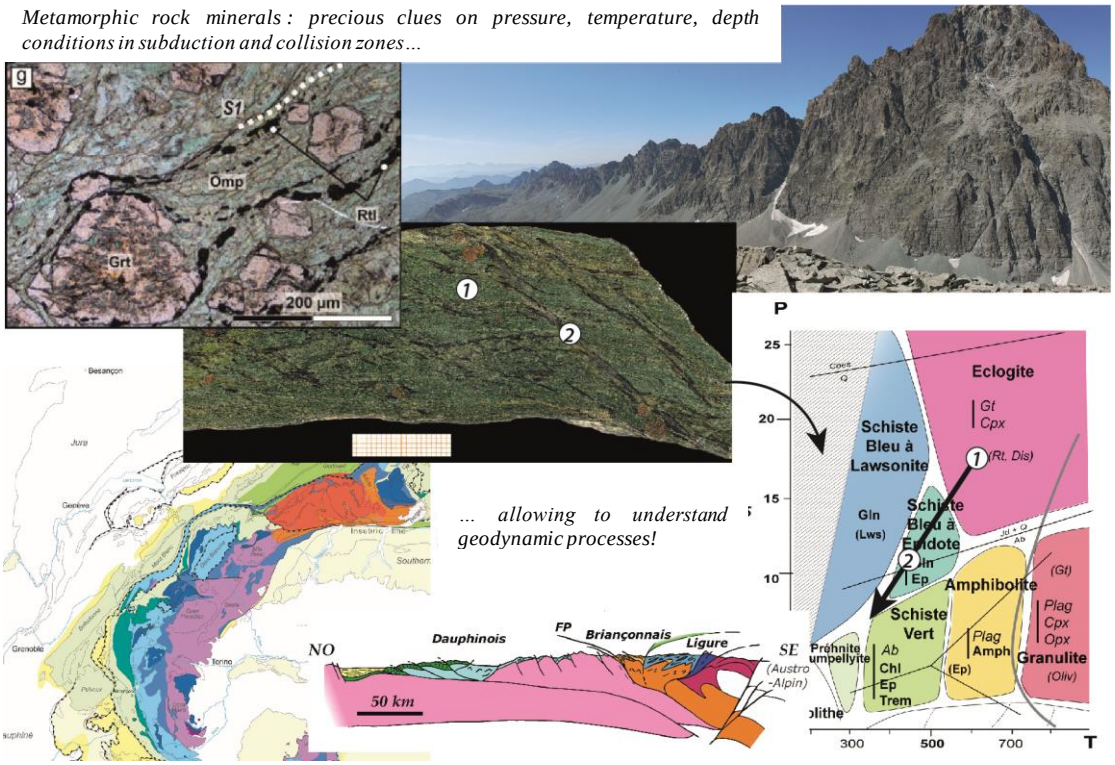
LU3ST605 – Metamorphic petrology

Professors in charge : Anne Verlaguet (anne.verlaguet@sorbonne-universite.fr) and Philippe Agard (philippe.agard@sorbonne-universite.fr)

GENERAL PRESENTATION AND OBJECTIVES OF THE TEACHING UNIT

Metamorphic rocks outcropping in mountain belts represent rock slices buried in a subduction or continental collision zone, and then exhumed to the surface. During rock burial, their mineralogy is regularly modified as a function of variations in pressure-temperature conditions. ***Metamorphic rock minerals are therefore precious clues of these P-T conditions and allow determining the maximal depth reached by rocks, their exhumation rate, the geodynamic context during burial… Many major data for better understanding geodynamic processes and constructing geodynamic scenarios!***

This course unit aims at training students (1) to identify metamorphic minerals (e.g. garnet, staurolite, kyanite…) and deformation structures in rocks, (2) to use these minerals to constrain pressure-temperature-time paths followed by rocks, and (3) to interpret them in terms of geodynamic scenarios.



TEACHING ORGANISATION

Theoretical courses and practical labs are tightly related and integrated.

<u>6 theoretical courses (2 hours each):</u>
Course 1 – Metamorphic rocks: definitions and basic notions
Course 2 – Deformation and recrystallization in rocks: structures and processes
Course 3 – Determining P-T conditions: building petrogenetic grids
Course 4 – Determining P-T conditions: divariant reactions and geothermobarometers

Course 5 – Metamorphic gradients and geodynamic contexts
Course 6 – Metamorphism and geodynamic evolution

6 labs of 3 hours for “majeures” or 9 labs of 2 hours for “mineures”
Lab sessions are mostly dedicated to observation of samples, thin sections at the microscope, and geological maps (about 15h/18h). Each session alternates macroscopic observation, microscopic study, map study and exercises.

- **Macroscopic and microscopic observation** of different rock types (metamafics and metasediments): identifying minerals and associated metamorphic facies, crystallization chronology and associated P-T paths (about 9h);

- **Study of geological maps and cross-sections** (and associated samples): indentifying metamorphic isograds, interpretation in terms of metamorphic gradient and geodynamic context; thermal evolution during orogenesis; P-T-t path and exhumation rate calculation; study of the hercynian and alpine chains in France (about 6h);

- **Exercises of P-T grid building and use of mineral composition as thermometers or barometers** (about 3h).

DEVELOPED SKILLS (and expected level at the end of the teaching unit)

Disciplinary knowledge
- ✓ Metamorphic facies and characteristic mineral associations
- ✓ Construction et interpretation of pressure-temperature-time paths
- ✓ Metamorphic gradients and interpretation in terms of geodynamic context

Disciplinary skills
- ✓ Identifying minerals both macroscopically and under optical microscope
- ✓ Reading and using compositional graphs of rocks and minerals
- ✓ Interpreting metamorphic isograds on geological maps and metamorphic gradient calculation
- ✓ Phase diagram reading and interpretation
- ✓ Use of thermobarometers and P-T grids
- ✓ Analysis of deformation structures and crystallization-deformation chronology

Transverse skills
- ✓ Presentation and analysis of documents
- ✓ Drawing and labelling samples and thin sections

EVALUATION

- ✓ 35% practical, lab exam
- ✓ 50% course exam
- ✓ 15% rocks-thin section drawing and QCMs in class.

LU3ST604 – Water: Resources and Risks

Responsable : Valérie PLAGNES (valerie.plagnes@sorbonne-universite.fr)
Intervenants : Agnès DUCHARNE, Anne JOST, Nicolas LE MOINE, Valérie PLAGNES, Ludovic OUDIN, Vincent THIEU, Danièle VALDES

GENERAL PRESENTATION AND OBJECTIVES OF THE TEACHING UNIT

The pressure on water resources is strong and will continue to increase in the coming years in response to sustained global economic growth and climate change, which increases tensions and makes extreme events more likely. Soil degradation and salinization, erosion phenomena, droughts and floods, pollution problems, as well as reduced water availability (surface and groundwater) are among the consequences of these pressures on water resources.

The Agenda 2030 adopted by the United Nations in 2015 proposes an action plan for humanity, the planet and prosperity. It includes 17 Sustainable Development Goals (SDGs), one of which, SDG 6, is dedicated to Water and entitled "Ensure availability and sustainable management of water and sanitation for all".

This course has a threefold objective:

1) Raising students' awareness of the context and current dynamics at the international level in the field of water through the study of the priorities defined in SDG 6.
2) Working on the various risks related to water and their evolution in the context of climate change (floods, exploitation and contamination of the resource).
3) Opening perspectives to help solve the many global challenges related to water.

Interactions between the different SDGs but also between society and the environment, as well as the ecological footprint of man himself on water resources will be discussed.
In addition, the different professions in the field of water will be presented for each topic.

Illustration of some Nature-based Solutions for Water Management

TEACHING ORGANISATION

This course includes 6 lectures and 4 practical exercises (2 hours each), as well as a project work realized individually or by group.

Class 1: Introduction to Sustainable Development Goals (SDGs) of the Agenda 2030 (UN). Presentation of the SDG 6 related to Water, and discussion on project works.

Class 2: Flood risks. Reminder of flood generation and propagation processes. Operational and regulatory aspects of flood forecasting and prevention.

TP 1: on the field - Gauging of the Mérantaise, a tributary of the Yvette river in small groups (9 to 12 students)

TP 2: Experimental hydraulic modeling in artificial canal

Class 3: Anthropogenic impacts on water resources 1/3 - quantitative aspects: impact of withdrawals (pumping) on the resource and on groundwater-river relations.

Cours 4 : Anthropogenic impacts on water resources 2/3 - qualitative aspects: impacts of human activities on water quality of. A focus will be made on the main contaminants found in surface and groundwater.

TP 3: Experimental modeling of contaminant transport in an aquifer through an alluvial groundwater analogic model.

Class 5: Anthropogenic impacts on water resources 3/3 - Impact of climate change on river flows and groundwater tables. Introduction to climate models and uncertainties in simulations.

Class 6: Water Management - Freshwater/Coastal Water Continuum: Examples at the Watershed and community level. Introduction of regulatory concepts.

TP 4 : Exercise around a role-playing game simulating a water management case.

TP 5: Oral presentation of the projects: Each group will prepare an oral synthesis of a case study related to the risks treated in the framework of this course and will evaluate its coherence with the SDG 6 priorities.

DEVELOPED SKILLS (and expected level at the end of the teaching unit)

Disciplinary knowledge

- ✓ Understanding of the physical mechanisms (river and torrential flow, flood wave propagation, transport of solute elements, climate modeling, groundwater abstraction) involved in the water cycle: surface and underground compartments
- ✓ Hydrological, climatic and anthropogenic risks, water contamination
- ✓ International context in the field of water

Disciplinary skills

- ✓ Measurement and calculation of balances, flows, physical and hydrodynamic properties
- ✓ Analysis of maps (topographic, geological, hydrogeological, piezometric) and synthesis documents
- ✓ Use of analogical models in hydrology and hydrogeology and water management

Interdisciplinary skills

- ✓ Valorization of the knowledge acquired in geosciences as well as in the UE of Hydrology-Hydrogeology of L2.

- ✓ Writing of reports on practical work, group work and oral presentation of a project based on analysis of documents in English and French. Crossing of multidisciplinary information. Modeling (notion of boundary conditions, optimization, permanent/transitory). Qualification and quantification of measurement and model uncertainties.

EVALUATION

30% TP, 30% Project, 40% Exam

LU3ST606 :Characterization of geotechnical and geophysical materials

Teaching team: Nicolas Florsch, Cyril Schamper and Pierre Théry.

GENERAL PRESENTATION AND OBJECTIVES OF THE TEACHING UNIT

This unit is meant to be practical and manual. It consists in handling some well-known concepts that are rarely dealt with through practice.

Some things that will be studied are :

- Density (how to measure bulk density of irregular objects in the lab)
- Measuring the specific surface area (for instance when considering a chunk of sandstone)
- Measuring the amount of clay in a sample by using a methylene blue test
- Rock bulk electrical resistivity measurements in the lab and on the field
- Rock bulk porosity and permeability measurements (Darcy's law)
- Magnetic prospection

SESSION CONTENT

Each topic is tackled through a practical approach, which facilitates the understanding of the notion and how to measure it. Practicums are held in the department FAB LAB and on the campus field.

Like Archimedes : know how to measure the density of an irregular object and shout " Eureka!" (However we shall not use a bathtub).

TARGETED SKILLS

The practicums lead to assimilate the notions through practice and will facilitate the understanding of more complex concepts based on the familiarization of the more basic ones.

EVALUATION

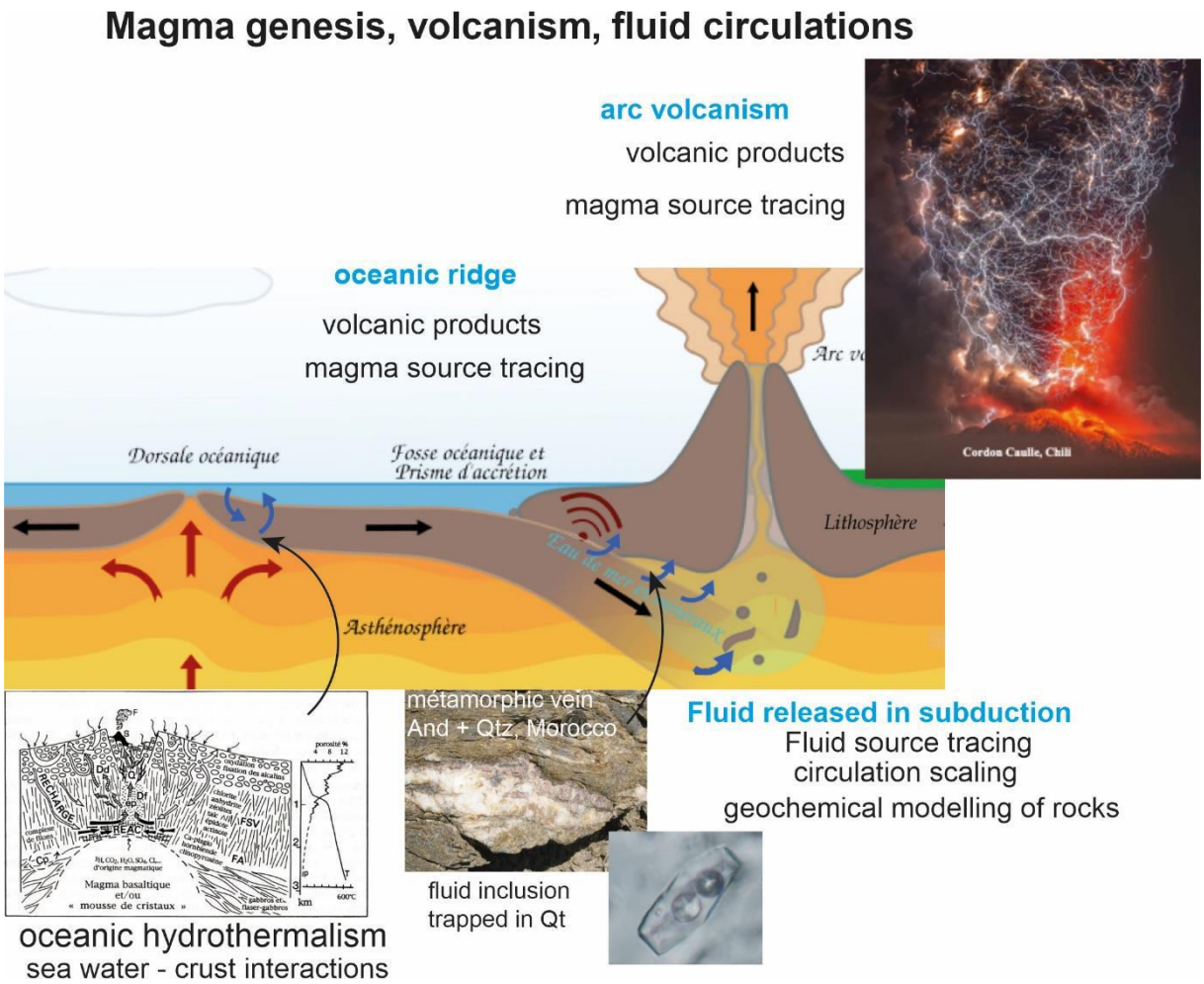
It is only based on written reports that follow the parcticums. The latter are based on the understanding of the concept and the style of the document.

LU3ST611– Magmas, Fluids and Volcanoes

Teachers : Hélène Balcone-Boissard (helene.balcone_boissard@sorbonne-universite.fr), Christian Honthaas (christian.honthaas@sorbonne-universite.fr), Erwan Martin (erwan.martin@sorbonne-universite.fr), Anne Verlaguet (anne.verlaguet@sorbonne-universite.fr)

GENERAL PRESENTATION AND OBJECTIVES OF THE TEACHING UNIT

The objective of this course is to study magmas in volcanic contexts, and the circulation of fluids responsible for the formation of these magmas. We will use petrological and geochemical tools to study the sources of magmas, the types of volcanic products and the eruptive dynamisms according to the different geodynamical contexts. We will also study fluid-rock interactions in hydrothermal and subduction contexts in order to characterize the sources of these fluids, the scale of their circulation in the rocks, and the chemical modifications they generate.



TEACHING ORGANISATION

The course will start with lectures on magmatic processes (fluid transfers, origin and differentiation of magmas) and volcanic processes (eruptive dynamics and impacts on climate), as well as on fluid circulation in rocks, in order to lay down theoretical foundations. Then, the main part of the course will be built on case studies around key geodynamic contexts (such as Iceland, Indonesia, West Indies, Mid-Atlantic ridge, Alps...) which will allow to explore the diversity of the processes of genesis and emplacement of magmas as well as the tracing of fluid flows. An analogical modeling session will also allow to discuss the physical processes involved in the emplacement of lava on the surface (example: strombolian dynamism, lava flow etc.)

SKILLS DEVELOPED (and expected level at the end of the teaching unit)

Disciplinary knowledge

- ✓ Processes of magma genesis
- ✓ Processes at the origin of the diversity of magmas
- ✓ Magma emplacement processes (eruptive dynamics, morphology of the edifices and products emitted)
- ✓ Source of fluids, fluid-rock interactions in the crust, circulation scales
- ✓ Geochemical tracing of fluids

How to do it ?

- ✓ Observation of samples (magmatic and metamorphic)
- ✓ Processing of geochemical and petrological data
- ✓ Use of geochemical tools for tracing magma and fluid sources
- ✓ Reading and synthesis of articles concerning petrology, geochemistry, fluids
- ✓ Interpretation of data and documents from research work
- ✓ Design of an analogical model

Transversal skills

- ✓ Data processing (Excel) of major, trace and isotopic element composition
- ✓ Reading and presentation of articles in English
- ✓ Bibliographic research/synthesis

EVALUATION

The evaluation by continuous assessment will include :

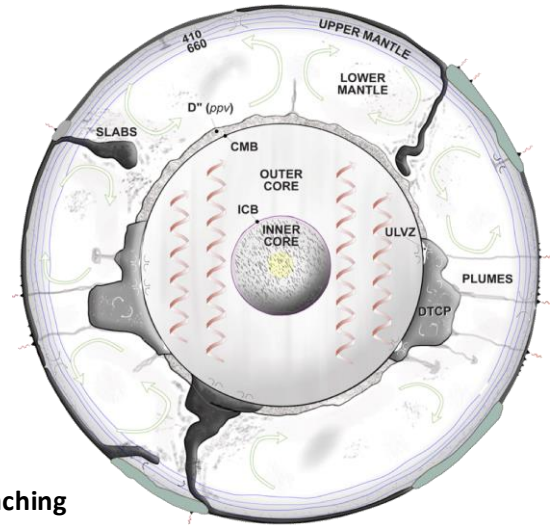
- ✓ Homework assignments or lab reports
- ✓ A written exam in the classroom
- ✓ An oral exam at the end of the course, closing a tutored project on a chosen theme, worked on alone or in pairs throughout the semester.

LU3ST621 - Physics of Earth's interiors

Responsable : Chrystèle Sanloup (chrystele.sanloup@sorbonne-universite.fr)
Intervenants : Déborah Bardet, Alice Jacob, Laurent Jolivet, Frédérique Rolandone, Chrystèle Sanloup

GENERAL PRESENTATION AND OBJECTIVES OF THE TEACHING UNIT

This course describes our current understanding of Earth's interiors, its internal structure and dynamics. The approaches rely mainly on geophysical techniques (seismology, geodesy, magnetism), experimental mineralogy, coupled with isotopic geochemistry data.



Teaching organisation

5 lectures (2h), 9 tutorials (2h), 1 lab session on convection (2h)

DEVELOPED SKILLS (and expected level at the end of the teaching unit)

Disciplinary skills

- ✓ Being able to present and explain the seismological PREM model and the geotherm
- ✓ Good knowledge of mantle mineralogy and core composition
- ✓ Being able to discuss models of mantle convection based on geophysical arguments
- ✓ Being able to define the lithosphere and its mechanical properties

Know-hows

- ✓ Mastering caracteristic values and orders of magnitude for the Earth
- ✓ Being able to describe scientific figures and provide interpretation of data

Transverse skills

bibliography (articles from generic science magazines)

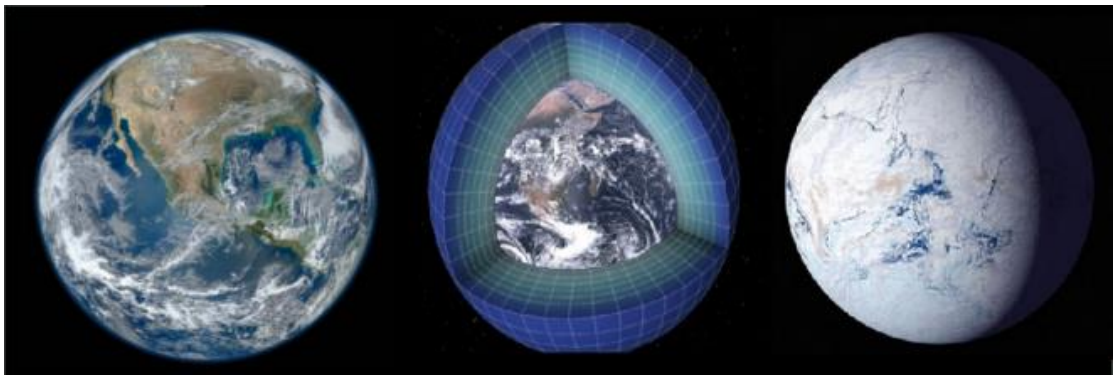
EVALUATION

- ✓ 50% final examen
- ✓ 25% oral presentation
- ✓ 25% lab report

LU3ST054 – Current and past climates

Course Instructors : Jean-Baptiste Madeleine (jean-baptiste.madeleine@sorbonne-universite.fr), Sylvain Huon

GENERAL PRESENTATION AND OBJECTIVES OF THE TEACHING UNIT



The goal of this course is to understand what controls the Earth's climate, its variability on short and long time scales, and its interactions with the biosphere, lithosphere, and hydrosphere. To do this, we will first lay the physical foundations for understanding the circulation of the atmosphere, the greenhouse effect, and the water cycle (cloud formation, precipitation). We will then explore the Earth's paleoclimate data to arrive at current satellite observations, and address the recent issue of climate change. To conclude, we will take a step back and look more closely at the notions of global energy balance and stability of the Earth's climate system. A large part of the course will be devoted to lab sessions, where students will learn how to use research tools. They will explore in-situ or satellite data, paleoclimate proxies, and perform their own climate simulations to reconstruct the Earth's climate, and conduct their own investigation on a topic of their choice.

TEACHING ORGANISATION

22h courses - **22h** labs - **16h** homework

Courses :

I. **Physics fundamentals**
   - The climate of the Earth and other planets, and climatology today
   - Solar illumination, the source of energy for climate
   - The atmospheric circulation
   - The greenhouse effect and radiation in the atmosphere
II. **Current and past climate data**
   - Geological markers and archives of past climates and variations on various time scales
   - The Quaternary example : time series reconstruction of climate and links to human activity
   - Observing the current climate : cycles and variability
III. **Advanced courses**
   - Water vapor, clouds and precipitation
   - Energy transport and the global energy balance
   - Climate sensitivity and climate stability
IV. **Concluding session**

We will assign problems on material we cover in class, so that you can apply the key concepts after it is been covered in lectures.

Labs :

- Labs 1 to 4: Reconstructing the Earth with a 3D climate model
- Labs 5 to 6: Exploration of paleoclimate data
- Lab 7: Current data (satellite observations, climate simulations)
- Lab 8 to 11 : Personal project (past, present, future climate, or other planets)

The lab uses an easy-to-use JupyterLab interface that can be accessed online from your computer, regardless of your operating system (Windows, macOS, Linux).

DEVELOPED SKILLS (and expected level at the end of the course)

Specific skills

- ✓ Basics of climate physics: dynamics, thermodynamics, radiation, water cycle
- ✓ Data analysis, statistics, geological markers
- ✓ Climate of the Earth and other planets
- ✓ 3D climate modeling and numerical sciences
- ✓ Global energy flows
- ✓ System dynamics, feedbacks

General skills

- ✓ Usual mathematical tools: algebra, analytical calculation
- ✓ Physical calculations: temperature, pressure, velocities, energy flow
- ✓ 3D climate simulations, research software
- ✓ Data processing (observations/simulations), Python codes

Cross-cutting skills

Use of numerical tools (Fortran and Python scientific computing, no prior knowledge of programming required), learning of the experimental approach (hypothesis → experiment → confirmation / refutation), analysis and interpretation of numerical simulations, joint analysis of models and observations, represent ideas in written reports and oral presentations, ability to critically read, analyze, and interpret the scientific literature

EVALUATION

- ✓ Homework : 20 %
- ✓ Final exam : 40 %
- ✓ Labs : 40 % (written report 20 % and oral presentation 20 %)

LU3ST054 – Geophysics : Tools & Applications

Coordinators: Ludovic Bodet (ludovic.bodet@sorbonne-universite.fr) et Cyril Schamper (cyril.schamper@sorbonne-universite.fr)
Instructors: Ludovic Bodet, Cyril Schamper et Julien Thiesson

GENERAL PRESENTATION AND OBJECTIVES OF THE TEACHING UNIT

The aim of this course is to introduce students to the basic principles of **applied geophysics**, i.e. all the methods that call upon the laws, theories and techniques of physics, in order to **prospect** the first tens of meters of the Earth by carrying out measurements from its surface, without damaging it. In « near-surface » or « environmental geophysics », prospecting means **exploring, investigating, measuring and analyzing** all the natural or artificial signals available at the surface, in order to **discover, image or model** objects, structures, resources, properties and hidden processes of the subsurface. The fields of application are varied and include: **soil development** in relation to geotechnics and civil engineering (foundations, large structures, network detection); **preservation** and **rehabilitation** (detection and monitoring of pollution, control of remediation techniques); **hydrogeology** (for research, characterization, monitoring, management and protection of water resources); or **exploration**; **natural hazards**; **agronomy**; **archaeology**...

Prospecting techniques call upon **many scientific fields** in order to target physical properties of the subsoil that are both distinct and complementary, in order to better image and understand the processes that take place there. The different disciplines of applied geophysics cover the following methods: **electromagnetic**, **seismic**, **electric**, **magnetic** and **gravimetric**. This course does not aim at teaching these methods in detail all, but rather at **providing students with the main concepts**, principles and approaches they imply. It will also expose and **put into practice some the most important tools** usually used in geophysical prospecting. Theoretical aspects will be restricted to the strict minimum necessary for the students to deploy measurement tecchniques & instruments use data processing tools and interpretation and modeling techniques.

Data, processing and models will thus be the key themes addressed during this course, which is intended for future geophysicists as well as for students interested in other disciplines that use geophysics (future geologists, hydrogeologists, geotechnical engineers soil scientists, archaeologists, geochemists...). Some of the datasets will be acquired by the students **in the field**, in order to understand, through experimentation, the **objective**, the **theoretical context** and the **practical implementation** associated with different methods of near-surface geophysical prospection. The students will then discover, through their applications, the **processing** workflows (statistical, frequency analysis, etc.) and **interpretations** (modeling, inversion, machine learning, *etc.*) adapted to the different methods.

N.B. For those who wish to pursue a Master's degree in Geophysics-Geotechnics (where the theory of the different methods will be discussed in more detail), this course is not compulsory, but strongly recommended.

TEACHING ORGANIZATION

6 ECTS

20h courses, 28h tutorials/practicals, 12h field works

The field works will consist in the implementation of geophysical methods in the field after a quick introduction in class. The practical sessions will be used to «have a look at» the data by starting to process them and to put in place the main theoretical concepts on which these methods are based. The tutorials will also allow for more advanced analysis and interpretation of the data using numerical tools that will be provided and/or developed.

DEVELOPED SKILLS (and expected level at the end of the teaching unit)

Disciplinary knowledge

- ✓ Know which subsurface properties can be determined with which prospecting methods (learned)
- ✓ Know in broad terms the contributions and limitations of the different prospecting methods (learned)
- ✓ Know the concepts of direct imaging, inverse modeling and interpretation (learned)

Disciplinary know-how

- ✓ Know which prospecting techniques are best suited to targets of interest (being acquired)
- ✓ Implement near-surface geophysical prospecting in the field (being acquired)
- ✓ Implement the appropriate processing and interpretation tools (being acquired)

Transverse skills

- ✓ Measurements, uncertainties, and associated statistical tools (acquired)
- ✓ Data analysis and signal processing (being acquired)
- ✓ Modeling and inversion/optimization problems (being acquired)
- ✓ Team and/or project work (being acquired)
- ✓ Presentation of scientific results and reports (being acquired)

EVALUATION

- ✓ Systematic evaluation of practical works (reports, presentations, computer codes *etc.*), projects in groups throughout the course, short exams, online evaluations *etc.*

LU3STOIP-Teaching unit sheet of "Orientation and Professional Integration"

Teaching team
Damien DO COUTO (ISTeP lab.), damien.do_couto@sorbonne-universite.fr
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Roger GUÉRIN (METIS lab.), roger.guerin@sorbonne-universite.fr
Isabelle KRUTA (CR2P lab.), isabelle.kruta@sorbonne-universite.fr
Librarians : Julie ARROS, Maud DE TOLLENAERE, Sophie GAUDARD, Camille MOULIS, Laëtitia RAIMBAULT, Noreddine ZEGHOUD

GENERAL PRESENTATION AND OBJECTIVES OF THE TEACHING UNIT

- **Construction of the professional project**

The student is asked to perform an analysis of the various professions accessible after studies in Geosciences in the chosen sub-discipline and identify the different functions related to the career in private company and/or in the academic world.
Choosing a profession that is potentially of interest.
Discovery of sectors of activity.
Construction of a digital identity in line with the student's professional project.
Development of a potential academic careers allowing access to the professional project.

- **Implementation of tools**

Implementation of internship and job search tools, and master's application:

- ✓ CV
- ✓ Cover letter

- **Interview with a professional**

Interview of one (or two) professional(s) with information about training, career, interest, difficulties, a typical day.

Prerequisites to follow this teaching unit

No prerequisites are necessary. However, the program is a continuation of the teaching unit "Orientation and Professional Integration 1" (OIP1) followed during L1S1 (1st year/1st semester) by all students of Sorbonne Université.

TEACHING ORGANISATION

Global hourly volumes:	**24h + personal work**
Number of credits:	**3 ECTS**
Total scale/100:	distributed assessment /100

EVALUATION

The teaching unit will be rated out of 100.

Continuous assessment	**/30**
CV	**/10**
Progress and final result	
First version to be submitted in session 2, corrected version in session 7	
Digital identity	**/20**

Oral defense	**/30**
Oral presentation of the report (job + professional project) in pairs at the last session.	

Written assessment	**/40**
The report (job + professional project) must be given to the teacher one week before the oral defense.	
Report (job/sector/interview/training)	**/20**
Report not returned by the set date	-2 points per day of delay
Professional project	**/10**
Bibliography in the report	**/10**

2nd session

If the semester is not validated, a second session is offered to students who obtain less than 50/100 in this teaching unit.

They must take several evaluations: Written assessment (/40) and Oral defense (/30). The other notes are kept: CV (/10), Digital identity (/20).