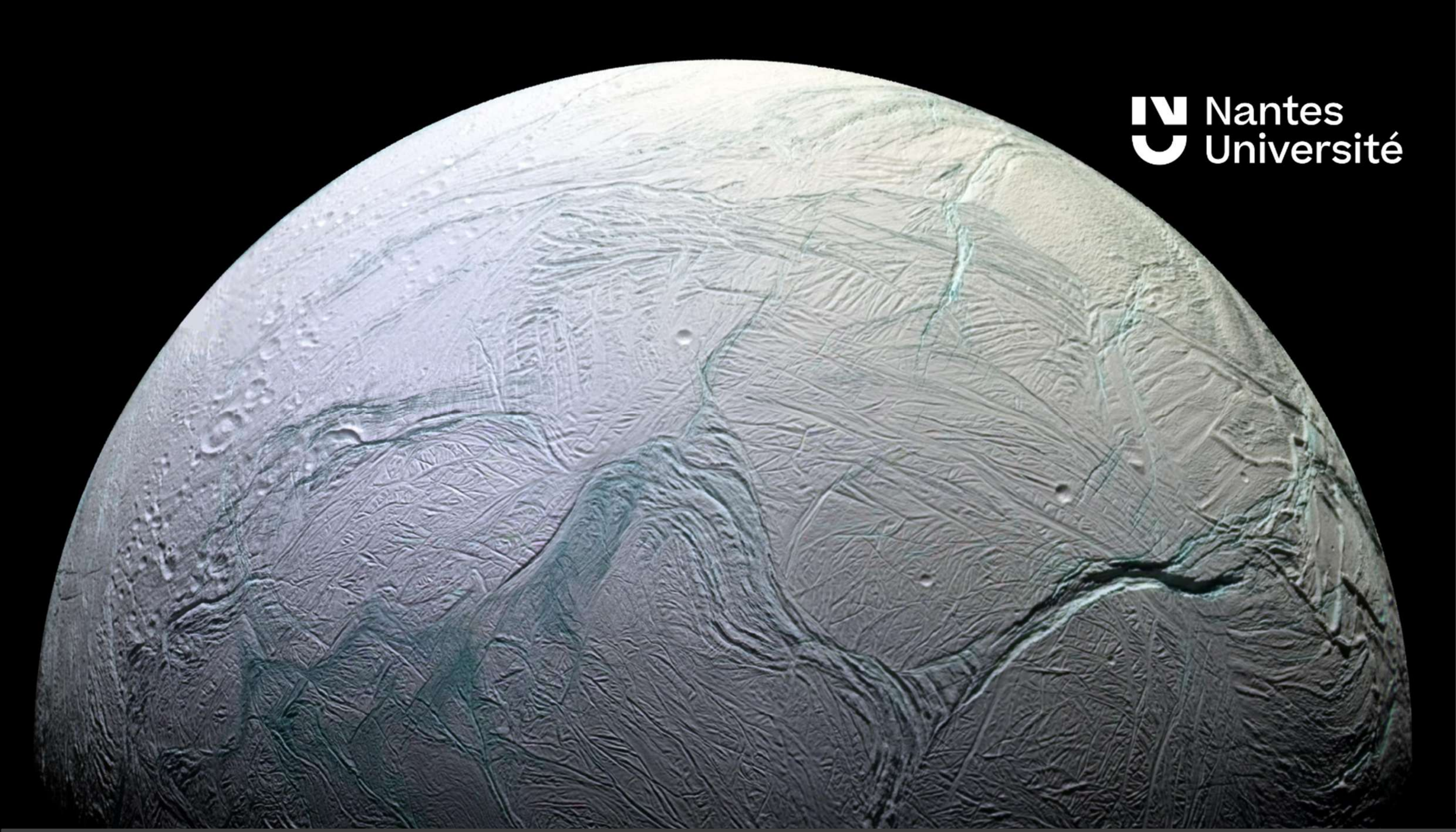
Nantes Université



Master

Earth and Planetary Sciences

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Graduate Programme EPS

Syllabus of the first year

Contents

General Overview

INTRODUCTION

Our Master's degree in Earth and Planetary Sciences aims to train the next generation of geologists, planetologists and space exploration mission experts by offering a cutting-edge teaching programme and the opportunity to study in an international environment. This course will offer you a unique learning experience combining a theoretical approach, field experience and project-based teaching at the Laboratoire de Planétologie et Géosciences (LPG). The LPG is involved in space exploration programmes as a member of the international research and training consortium GeoPlaNet, comprising more than 20 institutional research partners worldwide. Throughout your studies, you will work with students and researchers from different countries and be introduced to the major international programmes of NASA and ESA.

Through our multidisciplinary approach, which draws on the latest knowledge in geosciences and planetary sciences, you will acquire cutting-edge knowledge and develop research skills from the Master's level onwards:
- Working in an international collaborative environment
- Analysing and interpreting multidisciplinary data using advanced techniques and digital tools.
- Communicating the latest advances in the field in a concise, academic manner.

Mastering these advanced techniques will give you a range of opportunities to pursue a career in academic or private entities linked to the geosciences and space exploration.

CAREERS OPPORTUNITY

Nearly half of the Master's students go on to study for a PhD, while the other half enter the job market directly in the R&D departments of large organisations or in research consultancies. They occupy positions such as :

- Data analysis engineer (remote sensing, mapping, simulation, etc.)
- Geophysics/geology engineer
- R&D engineer in space/laboratory instrumentation

After studying for a doctorate, they can also go on to positions such as :

- Researcher or teacher-researcher
- Scientific manager
- Project manager

PROGRAM LEADER ON MASTER 1 LEVEL

Stéphane POCHAT stephane.pochat@univ-nantes.fr

Gabriel TOBIE gabriel.tobie@univ-nantes.fr

SKILLS BASED APPROACH

At the end of the course, students should be able to :

- ✓ Define and collect a corpus of geological or geophysical data in the field, in the laboratory, or through numerical simulations
- ✓ Contextualise the sample within its environment and test its representativeness
- ✓ Analyse, exploit and structure data from field observations, laboratory experiments or simulations, using descriptive statistical tools, taking into account uncertainties and biases
- ✓ Design a geological, theoretical or predictive model and test it
- ✓ Report one's results by positioning oneself in relation to a shared state of the art
- ✓ Promote scientific results and the proposed strategy, in writing and orally, in several languages, to a specialist audience, as well as to the general public
- ✓ Position oneself in a professional environment and collaborate within international and multidisciplinary teams
- ✓ Design and develop a project in Earth and planetary sciences.

TEACHING LOCATIONS

UFR Sciences et Techniques
Campus Lombarderie
2, rue de la Houssinière
BP 92208
44322 Nantes Cedex 3

HOW TO APPLY FOR JOINING MASTER 1 EPS

Requirements:

Master 1 level is intended for students with a degree preferentially in Earth and Planetary Science, and possibly Physics; Chemistry, Material Sciences or Mathematics.
Language requirement :

- TOIEC minimum 800
- IELTS : 6.0
- TOEFL : 80

Or equivalent Graduate of a university in an English-speaking country

Application procedure :

The application procedure varies depending on several criteria, primarily your nationality and whether or not there is a partnership with your home university. All procedures are detailed on our website:
https://english.univ-nantes.fr/education/admissions/regular-admissions

For our selection, applicants will have to submit documents (and pass an interview if needed).

Basic documents are required :

- A CV written in English/French
- A cover letter written in English/French
- A recommendation letter if possible
- Transcripts

Scholarship and financial facilities

The French government covers a large part of the cost of higher education at university. While a year of university study costs an average of around €10,500 per year, the **tuition fees** payable by the student are **€254 for a year of a Master's degree** and €397 for a year of a PhD, to which must be added a student life contribution of around **€100**. Exchange students are **exempt from paying tuition fees**.

International students are given priority for a room or studio in a student residence during their first year of study. The cost of accommodation varies **from €260 for a room to €370 for a studio.**

A welcome grant of **1 500€** is available to foreign students enrolling at Nantes Université.

The internship lasts 5 to 6 months during the second year. Students doing internships in France are paid approximately €650 per month. Students who wish to do their internship abroad can receive a grant of €550 to €700 per month (depending on the destination country).

Students can also apply to excellence Eiffel scholarships (or other scholarships proposed by their ambassy to finance their study.

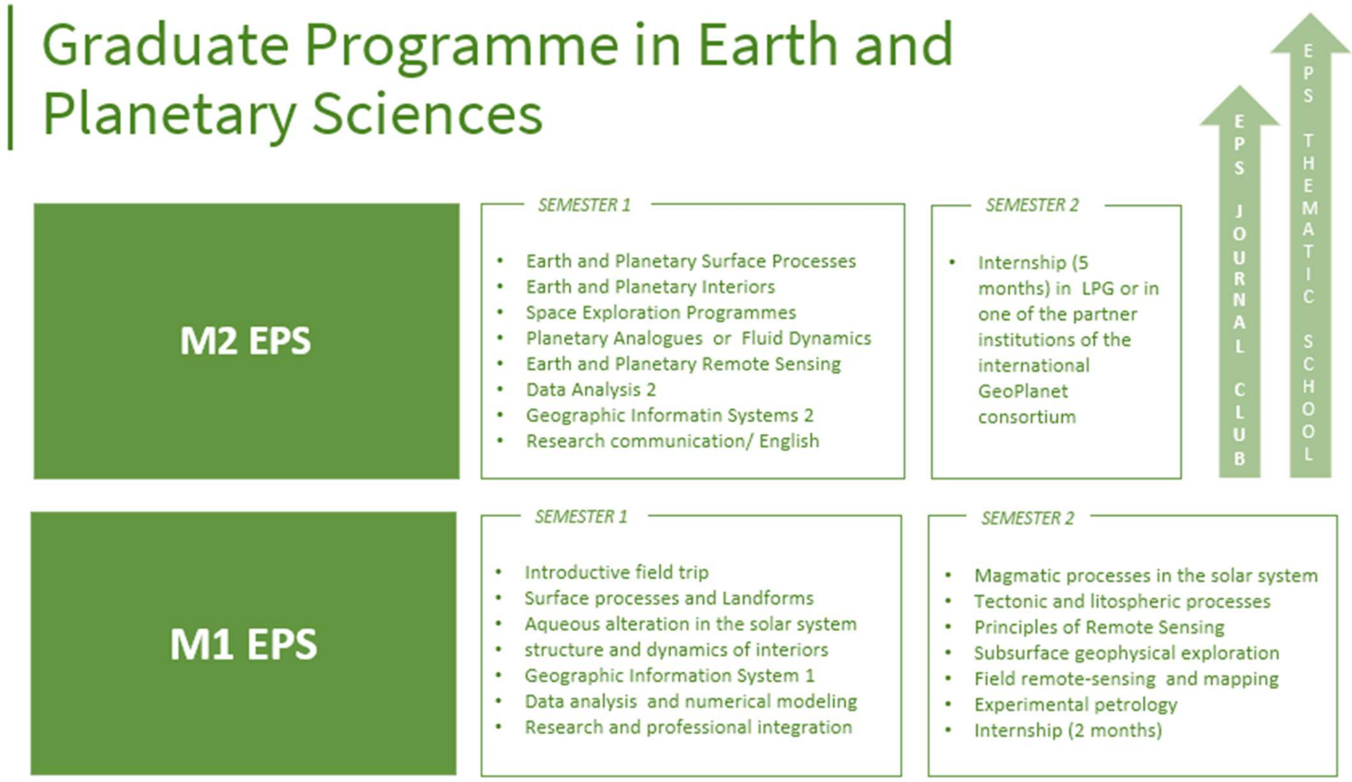
COURSE SCHEDULING

From September to April:	From April to June :
Lectures and practical training	2-month Internship (possibility of extension)

NB : Students enrolled in a foreign university may do an internship in one of our laboratories at any time of the year, subject to the constraints of their home institution.µ

PROGRAM STRUCTURE

The teaching program is organized in five teaching units detailed in next sections:



Structure and dynamics of Earth and planetary interiors

Affiliated TU: M1 EPS-S1	
Duration: 48h	Number of ECTS: 6
Year/semester: M1/S1	Language: English
Coordinator	Caroline DUMOULIN
Learning objectives	• Understand the formation, structure, dynamics and evolution of the interior of the Earth and other planets. • Be able to apply thermodynamic and geophysical tools to the study of the structure and dynamics of terrestrial planets and icy satellites. • Understand and model the various geophysical quantities that characterise a planet, such as mantle convection. • Collaborate within a research team to produce a joint modelling programme on a specific issue related to planetary interiors.
Contents	*Structure of Earth and Planetary interiors : Thermodynamic potentials* Maxwell's relations Mineralogical transformations Equations of state PREM Current 3D models and principles of seismic tomography *Dynamics of Earth and Planetary interiors* : Thermal budget of the Earth Conservation of energy and momentum equations, dimentionalization of equations Notions of thermal boundary layer, dimensionless numbers Viscous rheology and thermal convection in the mantle Inertial terms in a rotating system: geostrophic equilibrium, ocean (including icy satellite oceans) / outer core applications → illustration with the ASPECT project: Nu/Ra laws, description of dynamics
Teaching and assessment methods	Teaching consists of both magistral lectures and practicals Assessment: written exams and practical reports
Bibliography	References are given during the lectures
Prerequisites	Undergraduate level courses on basic geophysics and on mathematics (especially vector calculus and linear algebra)

Aqueous alteration through the solar system

<table>
<tr><td colspan="3">Affiliated TU: M1 EPS-S1</td></tr>
<tr><td colspan="2">Duration: 24h</td><td>Number of ECTS: 3</td></tr>
<tr><td colspan="2">Year/semester: M1/S1</td><td>Language: English</td></tr>
<tr><td>Coordinator</td><td colspan="2">Anne GAUDIN – Benjamin RONDEAU</td></tr>
<tr><td>Learning objectives</td><td colspan="2">• Understand the geological and fluid-rock interaction processes responsible for the development of alteration minerals, mostly weathering and hydrothermalism.
• Observe and describe at macroscopic scale and under optical microscope the petrological modifications of rocks related to the increase of their alteration degree.
• Characterize the mineralogy of altered rocks by X-Ray Diffration (XRD) analyses using the EVA software including ICDD powder diffraction databases for phase identification.
• Identify clay minerals from XRD patterns obtained from oriented clay fractions with treatments testing their swelling capacity and their behaviour under heating.
• Perform Scanning Electron Micrsocope (SEM) examination of micro-phases morphology and chemical composition by Energy Dispersive Spectroscopy (EDS) measurements.
• Process SEM-EDS chemical data: calculation of structural chemical formulae, reporting in ternary diagrams.
• Write a synthetic report of observations, laboratory analyses and interpretations issues from a case study.</td></tr>
<tr><td>Contents</td><td colspan="2">- Geological and fluid-rock interaction processes of weathering and hydrothermalism.
- Petrological and mineralogical features resulting of these processes.
- Significance of these processes through time and space: implications for paleoenvironmental reconstitutions (climate, pH/redox conditions, composition of the atmosphere …), and sub-surface igneous processes.
- Investigation of examples on Earth, Mars, Enceladus.
- Examination and analyses of several petrological examples by optical microscopy, X-ray diffraction and Scanning Electron Microscopy with EDS equipment: weathering profiles developed from an ultrabasic rock (amphibolite) and from an acidic rock (micaschist), and hydrothermalism examples (deep-sea black smockers, continental hot springs silica sinters).
- Principles of Scanning Electron Microscopy and of X-Ray Diffraction.</td></tr>
<tr><td>Teaching and assessment methods</td><td colspan="2">Teaching consists of both magistral lectures and practicals
Assessment: Practical reports</td></tr>
<tr><td>Bibliography</td><td colspan="2">Bibliography is given in the dedicated online Madoc pedagogic space</td></tr>
<tr><td>Prerequisites</td><td colspan="2">Minerals identification and rocks characterization skills acquired during Bachelor’s Degree.</td></tr>
</table>

Introduction to scientific research and professional integration

Affiliated TU: M1 EPS-S1			
Duration: 16h		Number of ECTS: 2	
Year/semester: M1/S1			Language: English
Coordinator	Gabriel TOBIE		
Learning objectives	• Being able to situate oneself in the professional environment of scientific professions linked to the research field.		
Contents	Learning how to do resumes, how to find internship, scholarship for PhD, how to get through professional interviews in the research field. Learning the necessary steps to write a scientifical report, including bibliographical work and LaTeX redaction.		
Teaching and assessment methods	Teaching consists of both tutorials and practicals Assessment: bibliography report		
Bibliography	References given during the tutorials		

Introduction to Earth and Planetary Processes – Field Trip

Affiliated TU: M1 EPS-S1	
Duration: 54h	Number of ECTS: 5
Year/semester: M1/S1	Teaching language: English
Coordinator	Stéphane POCHAT
Learning objectives	• Develop skills in observation, description and data collection of natural examples of different geological processes and geological objects • Develop skills in the use of various instruments and techniques to measure and monitor geological processes (ex: electrical survey). • Enhance critical thinking and problem-solving skills: Students will have the opportunity to apply their knowledge of geological concepts and theories to real-world situations. • Develop teamwork and communication skills: Field trips often involve working in groups, which can help students develop their communication and collaboration skills as they work together to collect and analyze data. • Develop skills in scientific writing and communication, including the preparation of research papers and poster creation and presentation.
Contents	This course aims to give an overview of several disciplines which will be addressed during the master, and this through 8 days of field trips. The guideline of the field trips is to conducted multidisciplinary approach on each studded geological object – from description/analysis of the object to its interpretation in term of geological processes and history. The aim of the course is to give uniform scientific methods for students in order to analyze geological objects and processes and will be completed by bibliographic work and poster creation about the topic addressed during the fieldtrip. The list of the studied sites may vary from year to year but will always illustrate both inner and outer processes in "Earth and Planetary Sciences": example of possible fieldtrip places - impact cratering processes (ex: Rochechouart analog) - magmatic processes (present-day or former example of magmatic processes in France) - alteration processes (ex: Penestin weathering profile analysis) - surface processes (ex: French Alps glaciers and landscape) - subsurface geophysical methods (ex: electric survey) etc....
Teaching and assessment methods	Teaching consists mainly of practical fieldwork. Assessment: oral presentation and fieldwork reports
Bibliography	References will be provided during the courses.
Prerequisites	Fieldwork in geology at the undergraduate level

Geographic Information Systems 1

Affiliated TU: M1 EPS-S1	
Duration: 24h	Number of ECTS: 3
Year / Semester: M1/S1	Language: English
Coordinator	Bruno FREIRE BOA DE JESUS – Laetitia LE DEIT
Learning objectives	• Theorical knowledge about GIS and its different uses. • Main applications of GIS through environmental sciences. • Differences between the main variables of GIS (vectors and rasters). • Basic knowledge on the different maps existing, cartographic projections, main kinds of vectorial operations and rasters, main databases.
Contents	- Navigate through the QGIS interface - Realization of operations with information layers - Examine the layers proprieties - Look for a spatial object from attribute tables - Introduce data into a GIS - Digitize line or polygon vector data - Control topological errors - Realize basic and statistical operations with vector data - Georeference a picture - Make calculation with raster data - Produce basic maps
Teaching and assessment methods	Teaching consists mainly of practicals, complemented by a few introduction lectures. Assessment: written exam and project report

Data Analysis and numerical modeling

Affiliated TU: M1 EPS-S1	
Duration: 48h	Number of ECTS: 6
Year/semester: M1/S1	Language: English
Coordinator	Éric BEUCLER
Learning objectives	• Discovering/improving the Python language and how to use it in the context of data analysis (time series and statistical analyses), inverse problem solving and finite difference numerical modeling. • Solving a geophysical problem like the temperature diffusion and implement its numerical solution in some application cases. • Formulating and implement inverse problem solving methods in geophysics
Contents	Discovering Python language and existing libraries for data analysis and graph production. - Introduction to statistical dispersion indicators (moments) and multivariate statistics (PCA). - Time-frequency analysis of geophysical data sets. - Numerical methodes: root finding, linear regression, least squares problems and Bayesian explorations. - Numerical modelling of heat diffusion using finite difference schemes and applications in some geological cases
Teaching and assessment methods	Teaching consists of lectures and practicals Assessment: written exam

Bibliography	
Prerequisites	Basic knowledge in Python

Surface processes : Exploring different regimes of erosion, landform development, and sediment deposition

Affiliated TU: M1 EPS-S1	
Duration: 36h	Number of ECTS: 5
Year/semester: M1/S1	Language: English
Coordinator	Stéphane POCHAT
Learning objectives	• Understanding the fundamental concepts and principles of the processes and agents that shape the Mars and Earth's surfaces. • Developing skills in interpreting and analyzing landforms, topographic maps, and other geospatial data. • Gaining knowledge of the major geomorphic systems, such as rivers, hillslopes, glaciers and wind. • Familiarity with numerical methods and tools used in numerical geomorphology, including GIS, remote sensing, and mathematical models. • Ability to apply numerical methods to solve practical problems in geomorphology, such as assessing the impact of land use change on erosion rates or predicting the evolution of river channels over time. • Developing skills in scientific writing and communication, including the preparation of research papers and presentations on geomorphic topics.
Contents	Earth surface processes is the study of erosion, transport, and deposition of unconsolidated sediment under the influence of gravity, flowing water, air, and ice, processes which sculpt the landforms and will produce deposition of consolidated sedimentary rocks (sedimentary strata). The nature of sedimentary deposits is related to the processes of sediment production and erosion in the source area. Therefore, sedimentology and earth surfaces processes are intimately related. The way of interpreting the origin of ancient sedimentary deposits is to compare them with modern sedimentary deposits, or with theoretical models based on knowledge of modern sedimentary processes. Then, the sedimentary record can be interpreted in terms of past surface processes and landforms, leading to reconstruction of the geography, tectonics, and climate of the past (i.e., Planet history). Knowledge of Earth surface processes, landforms, and sedimentary deposits is also being used increasingly to interpret the present and past surface environments on other planets (e.g., Mars), and such interpretation requires particular care in view of the different physical, chemical conditions on other planets. - interactions between tectonic and surface processes - hillslope processes and evolution, mass movements; - fluvial and lake processes and landforms; - glacial, paraglacial and periglacial processes and landforms - aeolian processes and landforms; - theoretical (physics and mathematics), experimental and quantitative geomorphology and dating (cosmonucleids on Earth)
Teaching and assessment methods	Teaching consists of lectures and practicals Assessment: written exams and practical reports

Anglais preparation TOEIC – UEL – Optionnal – Distance learning

Affiliated TU: Energy systems		
Duration:	Number of ECTS:	
Year/semester: M1		Language: English
Coordinator	Sylvie KERVISION – Laurie LABARBE	
Learning objectives	• Recognize and anticipate the formats of English language certifications. • Answer questions posed during certification tests. • Optimize their certification results through a study methodology applied during practice sessions.	
Contents	Preparation for an English certification (level B2 and above) - Overview of exam formats - Practice exercises - Tips for maximizing your score	
Teaching and assessment methods	E- learning	

Teaching Unit (TU) : M1 EPS-S2

Field remote-sensing and mapping – Lectures and lab

Affiliated TU: M1 EPS-S2		
Duration: 24h	Number of ECTS: 2.5	
Year/semester: M1/S2		Language: English
Coordinator	Patrick LAUNEAU – Benjamin RONDEAU	
Learning objectives	• Investigate a complex geological object: contrasted units imbricated in the collapse of a subduction zone. • Integrate mineralogical-petrological and spectroscopic information, combined with microstructure observations. • Establishing maps of these complementary information. • Confronting airborne remote sensing with field spectrometry, laboratory hyperspectral imagery and field structural observation with thin section analysis. • Understanding the link between structure and gradient of rock weathering	
Contents	Preparatory part to the field: - Reminder of tectonics and metamorphic petrology courses - Image analysis - Practical work on thin sections and field photography - Hand specimens and optical microscope investigation of thin sections (mineralogy, metamorphic and structural petrology) - Spectroscopic characterization of hand-specimens in reflectance (visible-NIR-SWIR range). Definition of spectral criteria for each mineral phases and assemblages	
Teaching and assessment methods	Teaching consists of both lectures and practicals	

Bibliography	Bibliography is given in the dedicated online Madoc pedagogic space
Prerequisites	Minerals identification and rocks characterization skills acquired during Bachelor's Degree. Spectroscopic skills developed in the "Principles of Remote Sensing" teaching unit (M1)

Field Remote-sensing and mapping – Field work Groix

Affiliated TU: M1 EPS-S2		
Duration: 24h	Number of ECTS: 2.5	
Year/semester: M1/S2		Language: English
Coordinator	Patrick LAUNEAU – Benjamin RONDEAU	
Learning objectives	• Investigate a complex geological object: contrasted units imbricated in the collapse of a subduction zone. • Integrate mineralogical-petrological and spectroscopic information, combined with microstructure observations. • Establishing maps of these complementary information. • Confronting airborne remote sensing with field spectrometry, laboratory hyperspectral imagery and field structural observation with thin section analysis. • Understanding the link between structure and gradient of rock weathering	
Contents	Field part: - Investigation of an area with contrasted rocks from ultrabasic to acidic and from fresh to strongly weathered. Characterization of their structural imbrication. - Hand specimens and optical microscope investigation of thin sections (mineralogy, metamorphic and structural petrology) - Spectroscopic characterization of hand-specimens in reflectance (visible-NIR-SWIR range). Definition of spectral criteria for each mineral phases and assemblages - Hyperspectral Airborne remote sensing of the outcropping area and mapping of the spectroscopic criteria identified in the field and on sample in the laboratory - Confrontation of the spectroscopic criteria maps with the lithological maps drawn in the field.	
Teaching and assessment methods	Field landscape reading, data acquisition; Assessment: oral presentation of the field notebook; writing of a synthesis report of the observations and petrological and structural interpretation	
Bibliography	Bibliography is given in the dedicated online Madoc pedagogic space	
Prerequisites	Technical skills for the use of geological field tools	

Experimental petrology

Affiliated TU: M1 EPS-S2		
Duration: 24h	Number of ECTS: 3	
Year/semester: M1/S2		Language: English
Coordinator	Yann MORIZET – Olivier BOLLENGIER	
Learning objectives	• Understanding the physical and chemical properties of rocks and minerals: Through experimental petrology, students can gain a deep understanding of the physical and chemical properties of rocks and minerals, including how they form, how they interact with different environments, and how they behave under different conditions. • Familiarity with laboratory techniques: Students will learn how to use various laboratory techniques and equipment used in experimental petrology, including furnaces, pressure vessels, and analytical instruments.	

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	• Conducting experiments: Students will learn how to design and conduct experiments to investigate geological processes, including high-pressure or low-temperature experiments. • Analyzing data: Students will learn how to analyze and interpret the results of their experiments using statistical and other data analysis techniques
Contents	In this teaching unit, the students will follow courses and practicals on different methods from which: - Syntheses techniques: either low temperature with cryostatic device (i.e. ices) and high temperature with controlled atmosphere furnaces (i.e. silicates minerals and glasses) ; high pressure using diamond anvil cell, piston-cylinder and autoclave. - Raman and FTIR spectroscopy: characterization of different synthesised materials (i.e. minerals, ices, amorphous) at molecular scale. - Mass Spectrometry: investigating the isotopic fractionation of elements within a solid material. - Synchrotron facility: The benefits of using Large Research instruments for studying Earth-related materials. - The students will apprehend how it is possible to relate macroscopic properties of materials to microscopic observation using state-of-the-art analytical techniques.
Teaching and assessment methods	Theoretical lectures on the different analytical and experimental methods. Practicals in group. Visit to synchrotron facility. Assessment: written and oral exams.
Prerequisites	Basic chemistry and physics.

Deformation of Planetary Lithospheres

Affiliated TU: M1 EPS-S2	
Duration: 32h	Number of ECTS: 4
Year/semester: M1/S2	Language: English
Coordinator	Olivier BOURGEOIS
Learning objectives	• Define the lithosphere and its rheological structure on different planetary bodies • Observe and quantify deformation of planetary lithospheres • Model deformation of planetary lithospheres • Interpret deformation of different planetary lithospheres in relation to their rheology
Contents	- Overview of deformation in planetary lithospheres - Rheology of planetary lithospheres - Observation of lithosphere deformation - Long-wavelength lithosphere deformation - Short-wavelength lithosphere deformation - Practical work: Experimental, analytical, and numerical modeling of lithosphere deformation
Teaching and assessment methods	Teaching consisting of both lectures and practicals Assessment: written exam and practical report

Magmatic processes through the solar system

Affiliated TU: M1 EPS-S2	
Duration: 24h	Number of ECTS: 3
Year/semester: M1/S2	Language: English
Coordinator	Antoine BEZOS – Gaël CHOBLET
Learning objectives	• Use your knowledge in geophysics, geodynamics, petrology and geochemistry to transpose the same scientific question from one planetary body to another. • Use the petrological tool to determine the conditions of P,T and fO2 during magma genesis • Examine how simple physical laws can apply to volcanism and magmatism • Envision the history of planets through the role of one ubiquitous phenomenon, magmatism.
Contents	Magmatism is the process that dominates the differentiation of the rocky bodies of the solar system. It is the vector of the history of planetary interiors, the source of primitive atmospheres and it shapes the planetary surfaces. The four scientific axes described below will be addressed through the prisms of petrology-geochemistry and internal geodynamics (numerical modelling, geophysical observables): - Formations and crystallization of magmatic oceans: their role in the evolutionary path of planetary bodies, their relation with planetary atmosphere - Magmatism and heat transfer: the source of magmatism , thermal evolution of magmatic planetary bodies - Two phase flow and physical/chemical aspects: some physical aspects of volcanism, two phase equation phenomenology, the role of reactive transport - The continental crust recipe: portrait of the continental crust, the role of volatiles
Teaching and assessment methods	Teaching consisting of both lectures and tutorials Assessment: written exams

Subsurface Geophysical Exploration

Affiliated TU: M1 EPS-S2	
Duration: 24h	Number of ECTS: 3
Year/semester: M1/S2	Language: English
Coordinator	Mickaël BONNIN
Learning objectives	The module aims to illustrate in a practical way (practical work and TD) different methods of subsurface geophysical prospection. The module will emphasize a multi-method approach (same object observed with several methods). The main objective of the module is to understand the strengths/weaknesses of each method for a proper interpretation of the results and to know how to implement the different devices to answer a given question.
Contents	General introduction to subsurface geophysics with a multi-method approach (complementarity of methods) : - Electrical methods: presentation and practice of the main devices, namely trailed, probing and multi-electrode. Analysis of data acquired during a field camp in the 1st semester.

	- Geological radar: field measurements and studies of the performance and limitations of geological radar based on the interpretation of the sections acquired during the module. - LF electromagnetism (VLF, RMT): field illustration of different approaches (VLF and RMT) and interpretation of the sections. - Seismic methods: study of seismic refraction with acquisition and interpretation of seismic lines. Introduction to the H/V method for the study of site effects with analysis of data acquired during a field camp in 1st semester.
Teaching and assessment methods	Teaching consists of both tutorials and practicals (fieldworks) Assessment: practical reports

Principles of Remote Sensing

Affiliated TU: M1 EPS-S2	
Duration: 48h	Number of ECTS: 3
Year/semester: M1/S2	Language: English
Coordinator	Patrick LAUNEAU – Pierre GERNEZ
Learning objectives	Master remote sensing software for mapping: • rock mineralogy and petrology, soil composition and structural features of planetary surfaces • artificialized land in urban area and mining monitoring • vegetation cover, species association and relative biomass estimation • turbidity and blooms in ocean or rivers • relief change with photogrammetry and LiDAR Students will also be able to evaluate the best potential platforms in archive or scheduled for launch for their thematic studies
Contents	- Basic electromagnetism, color definition and human vision - Light matter interactions - Balance of incident versus reflection + transmission + absorption - Light detection: photon count, calibration in radiance and irradiance, r reflectance % in land and Rrs reflectance per steradian in ocean - Multispectral Ocean color remote sensing of turbidity - Multispectral image analysis: histogram, indices, PCA, classifications - Image processing: smoothing, gradient, Laplacian, edge detection - Relief analysis by photogrammetry and LiDAR - Optical model in laboratory, simple versus intimate mixture and MGM - Atmospheric correction for all outdoor planetary studies - Hyperspectral analysis: MNF, PPI, SAM, unmixing, spectral feature - Hyperspectral Ocean color remote sensing of bloom - Instrument overview - Overview of radar interferometry for topographic change monitoring
Teaching and assessment methods	Teaching consisting of both lectures and tutorials Assessment: written exams and practical report
Prerequisites	Basic knowledge in remote sensing, spectroscopic techniques

Anglais preparation TOEIC – UEL – Optionnal – Distance learning

Affiliated TU: M1 EPS-S2			
Duration:		Number of ECTS:	
Year/semester: M1			Language: English
Coordinator	Sylvie KERVISION – Laurie LABARBE		
Learning objectives	Upon completion of this course, students will be able to: • Recognize and anticipate the formats of English language certifications. • Complete the answers required by certification tests. • Optimize their certification results through a study methodology applied during practice sessions.		
Content	Preparing for an English certification (B2 level and above) - Overview of exam formats - Practice exercises - Tips for maximizing your score		
Teaching and assessment methods	E-learning		

History and philosophy of Sciences of the Universe (free teaching unit)

Affiliated TU: M1 EPS-S2			
Duration: 24h		Number of ECTS: Not applicable	
Year/semester: M1/S2			Language: French
Coordinator	Walter SCOTT		
Learning objectives	We trace the history of astronomy from Copernicus to the present day, highlighting conceptual and technical innovations (celestial mechanics, general relativity, spectroscopy) on the one hand, and discoveries of celestial objects (double or variable stars, nebulae, black holes, pulsars) on the other. To learn more about the history of the sciences of the universe		
Contents	- Presentation of the course. The Copernican Revolution. - The Universe, from Kepler to Bradley. - Comsology and celestial mecanics, from Newton to Herschel. - Birth of astrophysics. - The correlations era, the emergence of statistical astronomy. - Comsogonic theories et spiral nebulae. - General relativity and relativistic cosmology. - Expansion of the Universe, stellar evolution and gavitational waves.		
Teaching and assessment methods	Magistral classes, reading.		
Bibliography	R. Taton and C. Wilson, eds, Planetary Astronomy from the Renaissance to the Rise of Astrophysics, Part A (1989), Part B (1995). Cambridge University Press.		

Internship

Affiliated TU: M1 EPS-S2		
Duration: 2 month	Number of ECTS: 6	
Year/semester: M1/S2		
Coordinator	Olivier BOURGEOIS	
Learning objectives	The specific learning outcomes of a Planetology and Geosciences Internship can vary depending on the goals and objectives of the internship program and the individual interests and background of the intern. • Gaining practical experience in collecting and analyzing data related to planetary and geosciences research, such as geological fieldwork, satellite image analysis, or laboratory experiments. • Applying scientific theories and principles to real-world research questions and problems. • Deepening understanding of topics in planetary and geosciences, such as the formation and evolution of planets (Earth, Mars, Venus...), satellites (Titan, Europa), the behavior of natural systems over time from deep inside to surface processes. • Gaining exposure to the methods and practices of scientific research, such as experimental design, data analysis etc.... and ethical considerations. • Developing skills in scientific communication, including writing reports, giving presentations, and collaborating with colleagues.	
Content	The purpose of the internship is to introduce the student to professional life in the field of fundamental research in Planetology and Geosciences. This internship is intended to be carried out in a research laboratory in Nantes (e.g. LPG-UMR 6112), in other universities or other research organizations (e.g. Université G. Eiffel). The internship can take place in France or abroad. The internship is the subject of an agreement between Nantes University, the intern and the host organization, in which the followings are indicated in particular: the subject of the internship, the name of the supervisor and the name of the referent teacher. The supervisor guides the work of the trainee. The teacher-referent ensures that the internship runs smoothly by guiding the student through the various steps, from the drafting of the internship agreement to the defense – the teacher-referents are responsible for the module.	
Teaching and assessment methods	The work done during the internship will be evaluated with a written report (in english), a private defense (jury members) and finally a public defense in front of all the members of the LPG.	
Bibliography	Provided by the supervisor before the start of the internship	
Prerequisites	Depending on the chosen research topic	

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