universität freiburg

Programme guidebook M.Sc. Geology

(Examination Regulations 2019) Freiburg, Winter Semester 2024/2025

Field Trip to Gran Canaria SoSe 2023

Table of contents

List of abbreviations

Deutsch/English

Abkürzung/ Abbreviation	**Deutsch**	**Englisch**
M.Sc	Master of Science	*Master of Science*
M.A. / MA	Master of Arts	*Master of Arts*
BOK	Berufsorientierte Kompetenzen	*Career-orientated competences*
ECTS	ECTS-Leistungspunkte	*European Credit Transfer System*
EPICUR	*European Partnership for an Innovative Campus Unifying Regions*	
EUCOR	The European Campus (trinationaler Verbund zwischen 5 Universitäten)	*The European Campus (trinational alliance between 5 universities)*
Art	Art der Lehrveranstaltung	*Type of course*
Rec.. Sem.	empfohlenes Semester	*recommended semester*
FS	Fachsemester	*subject-specific semester*
HF	Hauptfach	*major subject*
NC	Numerus clausus / beschränktes Auswahlverfahren	*Numerus clausus / restricted admission*
P	Pflichtveranstaltung	*Required course*
WP	Wahlpflichtveranstaltung	*Required elective course*
PO	Prüfungsordnung	*Examination regulations*
PZ	Präsenzzeit	*Attendance time*
SZ	Selbststudienzeit	*Independent study*
V	Vorlesung	*Lecture*
SL	Studienleistung	*Coursework*
PL	Prüfungsleistung	*Graded assessment*
KL	Klausur	*Written examination*
Ü	Übung	*Exercise course*
S	Seminar	*Seminar*
SWS	Semesterwochenstunden	*Contact hours per week*

1. Description of the study programme

1.1 Brief description of the study programme

Study programme	M.Sc. Geology
Degree	Master of Science
Standard period of study (duration of study)	4 Semesters (2 years)
Type of study	Full-time study programme
Scope of study in ECTS credits	120 ECTS
Faculty	Faculty of Environment and Natural Resources
Institut	Institute of Earth and Environmental Sciences
Homepage	https://www.master-geo.uni-freiburg.de/
Language	English
Access requirements	A first degree with an average grade of at least 2.7 from a German university in a geoscientific or environmental a geosciences or environmental sciences bachelor's degree programme or an equivalent degree programme of at least an equivalent degree programme of at least three years' duration at a German or foreign university. Knowledge of the English language that is at least equivalent to level B2 of the Common European Framework of Reference. Within the framework of the university programme leading to the first degree in the subjects maths, physics, Chemistry and Geosciences courses with a total of 40 ECTS credits in total.
Possible Start of study	Winter semester only
Date/Version	PO 2019

1.2 General Information

This module guide provides information about the M.Sc. degree programme Geology. The programme offers an individual specialization to one of the four elective tracks, Mineralogy and Geochemistry, Geomechanics and Tectonics, Geohazards, and Applied Quaternary Geology, which reflect the main areas of geoscience research in Freiburg. The Master of Science (M.Sc.) is an internationally recognized degree, which can be completed within two years (four semesters) of study. English is the official language of instruction and communication. This guidebook aims at presenting the vision, structure, and content of the M.Sc. degree programme and provides necessary.

1.3 Overall Profile

Following the development of Geosciences over the last decades, the education in the M.Sc. degree programme Geology focuses first on contemporary methods more than on providing specific knowledge. It provides competences in the critical assessment of scientific literature, scientific writing, techniques of presentation and data handling. These rather general qualifications are not only essential for a scientific career but have also become increasingly important in many fields of professional activity.

Beyond these rather general aspects, the M.Sc. degree programme takes into account the ongoing specialization in all fields of science by offering four distinct elective tracks of topical specialization. These are Mineralogy and Geochemistry, Geomechanics and Tectonics, Geohazards, and Applied Quaternary Geology. Beyond focusing on a specific field of Geosciences, these elective tracks also extend the competences of the students in direction of either laboratory-oriented work, field work, theory or modeling and data analysis. The elective tracks reflect the research areas of the involved groups to some extent, so that components of research can be integrated into teaching, and a high quality can be achieved.

1.4 University of Freiburg Geosciences: Why to Complete M.Sc. Studies at Freiburg

The Institute of Earth and Environmental Sciences belongs to the Faculty of Environment and Natural Resources as part of one of Germany's leading universities. In recent years, the University of Freiburg has been ranked atop in research quality in Germany. The research and teaching interests of the groups contributing to the M.Sc. degree programme cover a wide range of exciting topics in geosciences. The following sections provide an overview of the areas of geoscience research at the University of Freiburg.

1.5 Sedimentary Geology and Quaternary Research

The youngest part of the geological history, the Quaternary period, i.e., the last 2.6 Ma, was characterized by rapid environmental developments caused by naturally occurring climate change. Furthermore, humans increasingly had an impact on processes on the Earth surface. In the terrestrial realm, these changes have been recorded in a variety of archives such as peat deposits and lakes as well as by sediments deposited by water, ice or wind. Investigating these archives helps to decipher natural climate variability and its impact on sedimentary systems. In collaboration with archaeological sciences, it also helps to understand how the human race developed and adopted to changing environments in the past.

1.6. Structural Geology and Tectonics

Structural Geology and Tectonics are core subjects in geology. Methodology used at Freiburg ranges from classical field mapping in the Alps to quantitative modeling and from remote sensing to nano-scale investigations. Our specific field of research is to compare standard brittle deformation with fast, rate-dependent dynamic deformation. For this, we are running a 3000 kN triaxial loading frame and a Split-Hopkinson-Pressure Bar to determine the mechanical properties under quasi-static and dynamic loading conditions.

1.7 Impact Crater Research and Planetary Geology

Impact crater research is a young discipline in geosciences. At Freiburg we explore terrestrial impact craters by means of field surveying, drilling campaigns, and microstructural analysis of shocked rocks. Our interdisciplinary research is devoted to understand the dynamics of impact cratering and also includes remote sensing of craters on Earth and other planetary bodies and the application of a variety of experimental techniques. In this respect a close collaboration exists to the Fraunhofer Ernst-Mach-Institute (EMI) Freiburg.

1.8 Data Analysis and Numerical Modeling

Modeling of geo-processes has become a major field in geosciences in the previous decades. Our research in this field focuses on long and short-term processes at the Earth's surface, mainly erosion in combination with tectonic processes and mass movements. Concepts of nonlinear dynamics in the context of geohazards also play a major part in our research. As a third subdomain, there has been active research in developing new methods of data analysis.

1.9 Near-Surface Geophysics

The exploration of the shallow subsurface with particular regard to sedimentary environments, mass movements and hydrogeology is actually built up at Freiburg. As seismic methods are a main subject of the Karlsruhe Institute of Technology (KIT) as a partner in the EUCOR network, our focus is on nonseismic methods (resistivity methods, ground-penetrating radar, and other electromagnetic methods).

1.10 Petrology and Evolution of the Lithosphere

Mineral assemblages and structures of rocks ultimately result from large-scale geological processes reflecting dynamics of the Earth. These processes include formation of ocean floor along mid-ocean spreading ridges, evolution of island arc systems and continental margins with their volcanic systems, or building of mountain ranges such as the Himalayas and the Alps. The wide range and continually changing pressure and temperature conditions cause chemical reactions in rocks that change their mineral associations, textures or produce partial melts. Our research includes a variety of subjects such as pressure-temperature conditions, magma production, differentiation and crystallization as principal tools to reconstruct the past and present processes occurring on Earth.

1.11 Mineral Resources

Enrichment and accumulation of metals in the Earth’s crust is a prerequisite for economically important mineral resources. These metal reserves are basis for the needs of our society and modern technologies. The mineral deposits occur in diverse geological settings, ranging from mid-ocean spreading ridges through magmatic arcs to stable cratons, and have been forming throughout the Earth’s geological history. Mineral exploration and geological interpretation employ a variety of micro analytical and imaging techniques that becomes increasingly essential tools in ore processing and metal extraction. Our research focuses on diverse magmatic and hydrothermal mineral deposit types, formation of their mineral associations and metal endowment including high-tech and critical metals.

1.12 Geochemistry of Water, Crustal Fluids and Water-Rock Interaction

The chemical interaction of water and rock is one of the most universal, yet complex processes in geology. The composition of surface and ground water is largely controlled by the reaction of water with rocks and minerals. At elevated temperatures, the intensity and rates of these interactions are even greater and they lead to diverse economically important systems – hydrothermal ore deposits, geothermal energy reservoirs or sites for sequestration and deposition of greenhouse gases. Understanding water-rock interaction is thus of great importance to applied geology and geochemistry, particularly in areas such as geothermal energy, applied hydrogeology, water chemistry or nuclear waste disposal.

1.13 Classical Growth of Semiconductor Crystals

Semiconductor materials like silicon, lead iodide, and cadmium telluride are of high importance in a number of industries like the computer industry. Relevant physical properties of such materials are often only achieved if the required semiconducting building blocks are cut from large single crystals of the corresponding chemical element or compound. We optimize conditions for the growth of such crystals, a growth which usually takes place at high temperatures in special furnaces. Close collaborations exist with the Fraunhofer Institute for Solar Energy Systems (ISE), the Fraunhofer Institutes for Applied Solid State Physics (IAF) and for Physical Measurement Techniques (IPM).

1.14 Crystal Growth in External Fields

To improve the quality of our application-relevant semiconductor crystals with respect to purity and position-independent structural uniformity, we investigate crystal growth also in external fields. These may be stationary or rotating magnetic fields or “Gravity fields” like under microgravity. In the latter case experiments are undertaken in space in special (manned) planes, (unmanned) rockets or (in the future) in the ISS (international space station).
Apart from working in close collaboration with the University of Freiburg Division of Chemistry, the department has close connections to the Freiburg Center for Materials Research (FMF), the Fraunhofer Institute for High-Speed Dynamics (Ernst-Mach-Institute EMI), the Fraunhofer Institute for Solar Energy Systems (ISE), the Fraunhofer Institute for Applied Solid State Physics (IAF), as well as the Fraunhofer Institute for Physical Measurement Techniques (IPM). All these institutions and facilities can be accessed within walking distance.

1.15 Analytical Facilities for Modern Quantitative Geosciences

The institute hosts advanced analytical facilities for research and teaching in the geosciences for both laboratory and field work. Besides a sample preparation laboratory for crushing and sieving as well as mineral separation and preparation of high-quality polished thin sections from geological or synthetic materials, the institute runs a 3000 kN triaxial loading frame for determination of static mechanical properties of solid rocks and a Split-Hopkinson bar for analyzing the behavior at rapid deformation. The kinematics of gravity-driven mass movements are studied in an analogue laboratory equipped with particle image velocimetry and stereo cameras.
The Quaternary research group operates a fully equipped laboratory for luminescence dating. Available geophysical devices include geoelectrics and ground-penetrating radar.
For the structural and chemical characterization of natural rocks and synthetic products two scanning electron microscopes equipped with EDX and an electron backscattered detector (EBSD), an electron microprobe, a WD-X-ray fluorescence spectrometer, and several optical microscopes are used. White-light interferometry is applied for the characterization of surface topographies. Atomic absorption spectroscopy, ion chromatography, and UV-VIS spectrometry are used for the analysis of fluids.
The structure of crystals – from the millimeter down to the picometer scale – can most effectively be investigated using X-ray methods. We use these methods to detect imperfections or in homogeneities in a

crystal (X-ray topography), to measure with highest precision the so-called lattice parameters (high-resolution X-ray diffractometry), to determine accurately the arrangement of the atoms in the crystal (X-ray single crystal diffractometry), or to identify the components of a crystal powder, e.g. a mineral powder (X-ray powder diffractometry). Trace element concentrations in natural waters, soils, and other materials can be analyzed with our atomic absorption spectrometry (Flame AAS and Graphite Furnace AAS) and other equipment (UV-VIS, IC, CSH2O-Determinators).
With our equipment for differential thermal analysis and differential scanning calorimetry we are able to study phase transitions, for instance melting or solidification, or the transition of a certain atomic arrangement in the crystals of a compound into a different arrangement (polymorphic transition) with respect to transition temperatures or transition enthalpies. Thermogravimetry is used to monitor quantitatively weight changes, which are, e.g., caused by thermal decomposition processes leading to new chemical compounds.

1.2 Application for the M.Sc. degree programme Geology

You can apply via the HIS platform during the application period for first-semester students (until 15 May). You need to register on the platform before you can apply.
Applications for the 1st semester were possible for the last time for the winter semester 2024/2025.
From the winter semester 2025/2026, the M.Sc. Earth Sciences programme will begin. Questions concerning the general application and admission procedure to the M.Sc. Geology degree programme should be addressed to the Application and Admission Coordinator, Ms. Alexandra Wicke and/or to the Academic Advisory Officer, Dr. Heike Ulmer. Ms. Alexandra Wicke is also the first contact for organizational enquires concerning the course of study.

Information for Prospective students:
Information about the application process (Admission Requirements/ Application procedure/ Dates and Deadlines / Costs: Tuition Fees) can be found on the homepage of the degree programme: MSc. Geology
Below you will find answers to the most frequently asked questions about applying and registering for university.
Have more questions? Feel free to call our hotline or visit the Student Service Center for quick information:
Tel: +49 (0)761 203-4246
Frequently Asked Questions

2.0 Advising and Contact Points

Service Center Studium

Central part of the tasks of the student services are: matriculation, re-registration and leave of absence to name just a few of the services provided by the Student Services Office.

If you have any questions regarding the content of your studies or application, the Academic Advisory Officer or the Head of the Geology degree programme will be happy to help you with advice and ideas. Consultation hours are arranged on a personal basis:

- **Student Advisory Support**

Dr. Heike Ulmer, Albertstr. 23-B, 2st floor, room 02 014
Tel. +49 (0)761/203-6480; ulmer(at)uni-freiburg.de

- **Head of the Geology Degree programme**

Prof. Dr. Stefan Hergarten, Albertstr. 23-B, 1st floor, room 01 011
Tel. +49 (0)761/203- 6471; stefan.hergarten(at)geologie.uni-freiburg.de

Questions concerning the general application and admission procedure should be addressed to the **Application and Admission Coordinator**.

If you have any questions about schedules of lectures, practical and exams, please contact the **Degree programme Coordinator** available during the opening hours and also by appointment.

The Programme Coordinator provides also information on field trip days achieved and the excursion modules posted on the transcript.

- **Degree programme Coordinator/ Application and Admission**

Ms. Alexandra Wicke, Albertstr. 23-B, 1st floor, room 01 020
Tel. +49 (0)761/203-6398; studienkoordination(at)geologie.uni-freiburg.de

Questions about registration for examinations and Transcripts of Records should be addressed to the Examination Office:

- **Examination Office**

http://www.unr.uni-freiburg.de/fakultaet/pruefungsamt
Albert-Ludwigs-Universität, Prüfungsamt der Fakultät für Umwelt und natürliche Ressourcen, Tennenbacherstr. 4, D-79085 Freiburg

The **Credit Recognition Officer** will answer questions regarding the recognition of achievements from abroad, other courses of study or other universities. Questions about the possibilities of a semester abroad are answered by the **Study Abroad Coordinator** of the geosciences:

- **Credit Recognition Officer Geosciences:**

Prof. Dr. Stefan Hergarten, Albertstr. 23-B, 1st floor, room 01 011
Tel. +49 (0)761/203- 6471; stefan.hergarten(at)geologie.uni-freiburg.de

- **Study Abroad Coordinator Geosciences:**

Prof. Dr. David Dolejš, Albertstr. 23-B, 1st floor, room 01 026
Tel. 0761/203-6395; david.dolejs(at)minpet.uni-freiburg.de

3.0 Structure of the M.Sc. degree programme Geology

The M.Sc. degree programme Geology (see Fig. 1) includes 120 ECTS points and is offered in English. To ensure high standards of teaching in an international academic setting, the degree programme has been certified by the Language Teaching Institution of the University of Freiburg (“Sprachlehrinstitut”) in 2016 with the EMI (English Medium Instruction) quality certificate.
The M.Sc. curriculum comprises six compulsory modules contributing 30 ECTS points compulsory for all elective tracks (blue in Fig. 1, for details see Sect. 2.1), while the remaining 90 ECTS points can be acquired according to the specific interests of the students to some degree. In order to achieve a specific, but balanced portfolio of qualifications, each student must select one out of the following four elective tracks:

- Mineralogy and Geochemistry
- Geomechanics and Tectonics
- Geohazards
- Applied Quaternary Geology

Each of these elective tracks comprises three compulsory modules (15 ECTS points, see Sect. 2.2). Beyond these compulsory modules, several specific electives are offered within each elective track (see. Sect. 2.3).
A total of 45 ECTS points is contributed by elective modules. In general, each module of this degree programme can be used as an elective, except for those modules that are compulsory either for the overall degree programme or for the selected elective track. The following further rules apply to the choice of electives:

- At least three modules must be taken from the catalog of modules explicitly assigned to the selected elective track (see Sect. 2.2, also marked with an E in the module description).
- Modules with a total amount of up to 15 ECTS points may be taken from other degree programmes of the Albert-Ludwigs-University and its partner universities in the EUCOR network. These modules must be graded and considered as appropriate in the context of the M.Sc. degree programme Geology, so that students must apply for such electives before starting the module. It is recommended to ask the Credit Recognition Officer/Head of Geology degree programme for assistance.
- Up to 5 out of the 15 ECTS points mentioned in the previous point can be covered by language courses offered by the Language Teaching Center of the University (SLI). In contrast to all other electives, these are unmarked.

The grade of a module is derived from the module examination. This module examination may be a single written or oral examination at a given time, but the majority of the modules uses more specific formats to test whether the required qualifications have been achieved. These examinations may consist of several components (e.g., regular homework and a seminar presentation) but are graded as a whole (by adding scores of the individual parts), so that the students are in principle free to choose how much effort they spend for each part. Details about the weighting are provided in the module descriptions (Sect. 3). Within some of the modules, ungraded academic achievements may also be required, which are the prerequisites for the successful completion of a module.
In analogy to cheating in written or oral exams, copying another student’s work, copying from literature or web sources without reference or using illicit materials is considered as academic misconduct in all components of exams (homework, reports, etc.). It leads to the loss of the entire score for the respective component of the module examination.
The modules use a combination of different forms of teaching and learning, such as small group work, scientific discussions, practical laboratory trails, theoretical exercises as homework, etc. The degree programme is characterized by a balanced combination of theoretical basics, laboratory courses, practical training and field work.
The Master's thesis covers the handling of a scientific topic, as well as the presentation of the results and interpretation within the scientific framework. The Master's thesis aims to show that the students are able

to familiarize themselves with a current geoscientific topic within the given period of six months, to use the methods and concepts learned and to present the results in an understandable form. It contributes 30 ECTS points.

3.1 Elective Track Mineralogy and Geochemistry

The elective track Mineralogy and Geochemistry offers education and research training in mineralogy, petrology, geochemistry, and mineral resources. The course curriculum is designed to extend foundations of petrology (metamorphic and magmatic processes, mineral transformations, properties of silicate magmas) and geochemistry (planetary differentiation, processes in the Earth's interior, oceans and surface). These foundations are followed by advanced courses leading to the formation of mineral resources, ore deposits as well as fluid-rock interaction in deep, geothermal and near-surface environments. The curriculum is complemented by practical modules that develop competence in laboratory analytical and experimental methods. Thesis projects are designed to acquire deeper understanding of geological processes through field observations, interpretation of mineral assemblages or experimental studies in laboratory. These approaches, together with phase equilibria and thermodynamic modeling, are used to interpret various metamorphic, magmatic or hydrothermal processes occurring on the Planet Earth as well as those leading to the formation of economic mineral resources. The compulsory specialization modules are highlighted in green in the following chart (Fig. 1). The elective track Mineralogy and Geochemistry offers a sound education in analyzing, modeling, and understanding of geologic materials and processes, bridging the gap towards material sciences, and opening a wide field of career options in research and applied industries.

3.2 Elective Track Geomechanics and Tectonics

The elective track Geomechanics and Tectonics provides the student with a sound theoretical as well as practical knowledge in the respective fields of rock mechanics, petrophysics, geophysics, tectonics and the gained qualifications offer a wide spectrum of career choices, e.g. in the mining industry, subsurface investigations, geological surveys. Practical expertise includes work in the rock mechanics laboratory that hosts a triaxial loading frame, Split-Hopkinson Pressure Bar, and Analogue Laboratory. Geophysical and petrophysical equipment comprise of a He-pycnometer, laser-sizer, white light-interferometer, optical and electron microscopy, and devices for seismic, ground-penetrating radar, and geoelectric analyses. Note that the modules Rock Mechanics and Petrophysics are offered biannually alternating in the winter term. The elective track also offers a planetary focus direction with the modules Planetary Dynamics and Impact Geology that are also offered biannually.

3.3 Elective Track Geohazards

Quantification and prediction of geohazards has become a major field of both research in geoscience as well as of professional activity of geoscientists. The elective track Geohazards provides a comprehensive coverage of the most relevant geohazards including the underlying physical processes, their relationship to geology, assessment of hazard and risk, as well of concepts of prediction. The specific geohazards considered in this track comprise those with a close relationship to geology (volcanism, earthquakes, tsunamis, landslides, meteorite impact) as well as hazards receiving an increasing interest due to their potential relationship to climate change (e.g., storms, floods and various types of mass movements). As modeling has become an essential part in hazard assessment, numerical modeling approaches are also an essential component of the degree programme. The elective track Geohazards consists of the compulsory and elective modules are marked by a light orange color in Fig. 1.

3.4 Elective Track Applied Quaternary Geology

Wide parts of the Earth surface are covered by Quaternary deposits, in particular the densely populated areas along rivers, coasts and on most plains. As a consequence, a large number of projects in applied geology are linked to Quaternary deposits. However, since most Quaternary deposits are unconsolidated, they differ significantly with regard to their properties and distribution compared to hard rock. The applied fields covered in the elective track Applied Quaternary Geology include hydrogeology, engineering geology, geotechnics, rock properties, environmental geosciences as well as the recognition of and the protection against natural hazards. To some extent, regulatory frameworks and economic aspects will be discussed during the courses. These topics are complemented by two modules focusing on how sediments are formed and on the environmental context during the Quaternary, a time that is characterized by massive and abrupt changes in climate. The elective track Applied Quaternary Geology consists of the compulsory and elective modules are marked by a dark orange color in Fig. 1.

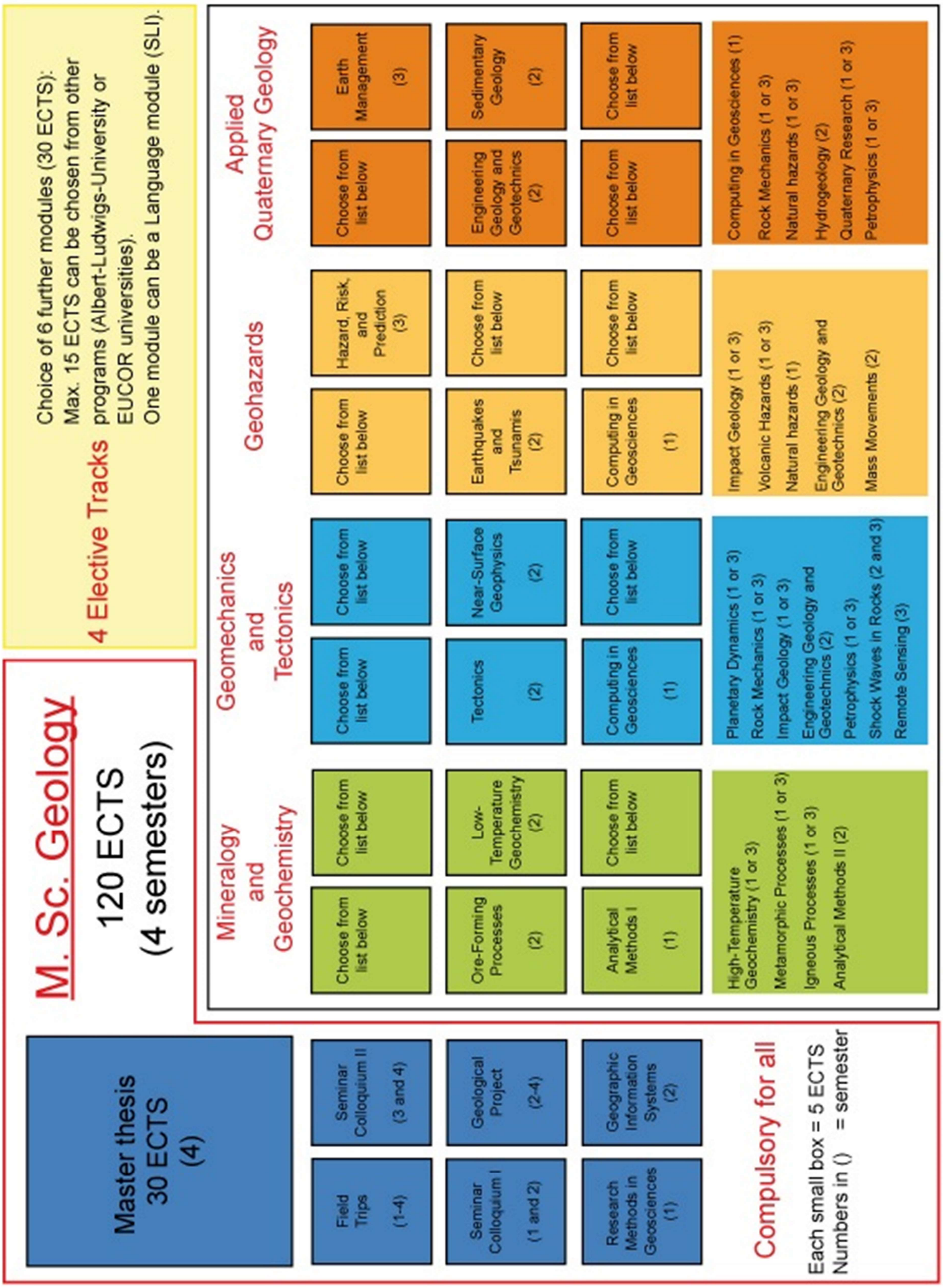

Fig. 1: Structure of the M.Sc. degree programme Geology

4. Module Overview -brief descriptions-

4.1 Required Modules *for all students*

Module	Responsible person	Course(s)	Type	ECTS points	recommended Semester
Research Methods in Geosciences	Preusser	Research Methods in Geosciences	L + P + S	5	1
Seminar and Colloquium I	Poelchau	Research Seminar	S	3	1 + 2
		Geoscience Colloquium I	C	2	
Field Trips	Ulmer	Field Trips and Visits to Industrial Facilities	F	5	1 to 4
Geographic Information Systems	Carboni	Geographic Information Systems	L + P	5	2
Geological Project	Preusser	Geological Project	P	5	2, 3 or 4
Seminar and Colloquium II	Poelchau	Research Seminar	S	3	3 + 4
		Geoscience Colloquium II	C	2	
Master Module	Hergarten		MT	30	4

4.2 Required Modules of the Elective Track´s -brief descriptions-

4.2.1 Required Modules Mineralogy and Geochemistry

Module	Coordinator	Courses	Type	ECTS points	recom-mended Semes-ter
Analytical Methods I	Wölki	Analytical Methods I	L + P	5	1
Low Temperature Geochemistry	Hockmann	Marine Geochemistry	L + P	2.5	2
		Isotope Geochemistry	L + P	2.5	2
Ore-Forming Processes	Dolejš	Ore-Forming Processes	L + P	5	2

4.2.2 Required Modules Geomechanics and Tectonics

Module	Coordina-tor	Courses	Type	ECTS points	recom-mended Semester
Computing in Geosciences	Hergarten	Computing in Geosciences	L + P	5	1
Tectonics	Kenkmann	Tectonics	L + P + S	5	2
Near-Surface Geophysics	Wilk	Near-Surface Geophysics	L + P	5	2

4.2.3 Required Modules Geohazards

Module	Coordinator	Courses	Type	ECTS points	recom-mended Semester
Computing in Geosciences	Hergarten	Computing in Geosciences	L + P	5	1
Earthquakes and Tsunamis	Hergarten	Earthquakes and Tsunamis	L + P	5	2
Hazard, Risk, and Prediction	Hergarten	Hazard, Risk, and Prediction	L + P	5	3

4.2.4 Required Modules Applied Quaternary Geology

Module	Coordinator	Courses	Type	ECTS points	recom-mende d Semester
Engineering Geology and Geotechnics	Preusser	Introduction to Engineering Geology	L	2.5	2
		Geotechnical Projects	S	2.5	
Sedimentary Geology	Preusser	Sedimentary Environments	L	3	2
		Logging Sediments	P	2	
Earth Management	Preusser	Earth Management	L + S	5	1 or 3

4.3 Required elective Modules Assigned to the Track -brief descriptions-

4.3.1 Required elective Modules Mineralogy and Geochemistry

Module	Coordinator	Courses	Type	ECTS points	recommended Semester
Igneous Processes	Dolejš	Igneous Processes	L + P	5	1 or 3
Metamorphic Processes	Dolejš	Metamorphic Processes	L + P	5	1 or 3
High Temperature Geochemistry	N.N.	Geochemical Evolution of the Mantle and the Crust	L + P	2.5	1 or 3
		High-Temperature Geochronology	L + P	2.5	
Analytical Methods II	Dolejš	Special Methods in Mineralogy	L + P	2	2
		High Resolution Spectroscopy	L + P	3	

4.3.2 Required elective Modules Geomechanics and Tectonics

Module	Coordinator	Courses	Type	ECTS points	recommended Semester
Petrophysics	Kenkmann	Petrophysics	L + P	2.5	1 or 3
		Rheology and Textures	L + P	2.5	
Rock Mechanics	Poelchau	Stress and Strain	L + P	2.5	1 or 3
		Brittle Rock Deformation	L + P	2.5	
Planetary Dynamics	Kenkmann	Planetary Dynamics	L + P	5	1 or 3
Impact Geology	Kenkmann	Impact Geology	L + P	5	1 or 3
Shock Waves in Rocks	Kenkmann	Shock Waves in Rocks I	L + P	3	1
		Shock Waves in Rocks II	L + P	2	2
Remote Sensing	Carboni	Remote Sensing	L + P	5	3
Engineering Geology and Geotechnics	Preusser	Introduction to Engineering Geology	L	2,5	2
		Geotechnical Projects	S	2,5	

4.3.3 Required elective Modules Geohazards

Module	Coordinator	Courses	Type	ECTS points	recom-mended Semester
Mass Movements	Hergarten	Mass Movements	L + P	5	2
Natural Hazards	Preusser, Stahl, Hanewinkel	Natural Hazards	L + F	5	1
Impact Geology	Kenkmann	Impact Geology	L + P	5	1 or 3
Engineering Geology and Geotechnics	Preusser	Introduction to Engineering Geology	L	2,5	2
		Geotechnical Projects	S	2,5	

4.3.4 Required elective Modules Applied Quaternary Geology

Module	Coordinator	Courses	Type	ECTS points	recom-mended Semester
Quaternary Research	Preusser	Quaternary Research	L + S + P	5	1 or 3
Hydrogeology	**N.N.**	Advanced Hydrogeology	L + P	2.5	2
		Aqueous Geochemistry	L + P	2.5	2
Computing in Geosciences	Hergarten	Computing in Geosciences	L + P	5	1
Petrophysics	Kenkmann	Petrophysics	L +P	2.5	1 or 3
		Rheology and Textures	L +P	2.5	
Rock Mechanics	Poelchau	Stress and Strain	L + P	2.5	1 or 3
		Brittle Rock Deformation	L + P	2.5	
Natural Hazards	Preusser, Stahl, Hanewinkel	Natural Hazards	L + F	5	1 or 3

4.3.5 Further required elective Modules regardless of which Track

Module	Coordinator	Courses	Type	ECTS points	recom-mended Semes-ter
Chemical Thermodynamics of Geomaterials	Dolejš	Chemical Thermodynamics Of Geomaterials	L + P	5	2
Mineral Physics	Prescher	Mineral Physics	**L + P**	**5**	**2**
Geothermics and Geothermal Energy	Dolejš	Geothermics and Geothermal Energy		5	3

5.0 Required subject Modules - full description –

5.1 Research Methods in Geosciences (ECTS-Points)

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Research Methods in Geosciences	V	2,5	2	P	SL	1
Endogene Geologie	Ü	2,5	2	P	SL, PL	1

Workload of the module	150 h in total	60 h classroom-based course of study	90 h Independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. F. Preusser		
Lecturer	Prof. Dr. F. Preusser, JProf. Dr. C. Prescher		
Participation requirements according to the examination regulations	• None		
Expected prior knowledge and notes on preparation	• Registration by e-mail, addressed to the responsible person is required.		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Winter Semester only		
Teaching/learning forms	• Lecture • Seminar • Practical sessions		
Modul Content	Students will learn how scientific research and applied studies are initiated, funded and carried out. They will be trained in the usage of general scientific databases as well as specific geological databases, and how different publications can be accessed. Students will be instructed in the three essentials of scientific knowledge sharing: scientific papers, scientific posters and scientific presentations. Moreover, the critical analysis and review of papers and presentations is a key learning outcome. Additionally, students will become familiar with how scientific data should be processed and statistically analyzed and how the results of such analyses are presented in the form of scientific graphs. Finally, students are instructed on how to write a thesis.		
Learning and qualification goals	Students can/are capable of: • The foundation of scientific work are skills and methods such as the correct way to work with scientific resources and databases, the analysis and critical review of the work of others, the analysis and interpretation of data, and the presentation of data and scientific results. • In this module advanced scientific working skills and methods are introduced. By this, it forms the basis of the entire curriculum. • After this module, the students will understand how scientific articles and reports are structured. • They will know about different publication platforms. Approaches how to organise and perform own communications will be trained.		
Coursework	• Regular attendance in the seminar and in the practical part.		
Graded assessment	• Written exam (30 Min.) • Oral presentation		

	• Project reports
Grading	• Written exam20 % • Oral presentation 10% • Project reports 70 %
Applicability of the Module	--
Modul Number	10LE09MO-2019-120
Course Nummer	V: 10LE09MO-2019-120 / Ü: 10LE09Ü-ID121115
SL/PL Nummer	SL: 10LE09SL-2019-120-SL / PL: 10LE09PL-2019-120-P1

5.1.2 Seminar and Colloquium I (5 ECTS -Points)

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Research Seminar (a)	V	2,5	2	P	SL	1
Geoscience Colloquium (b)	Ü	2,5	2	P	SL, PL	1

Arbeitsaufwand des Moduls	150 h in total	60 h classroom-based course of study	90 h Independent study
Semesterwochenstunden	4		
Responsible person	Dr. M. Poelchau		
Lecturers	Prof. Dr. F. Preusser, JProf. Dr. C. Prescher		
Participation requirements according to the examination regulations	• None		
Expected prior knowledge and notes on preparation	• None		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Every Semester		
Teaching/learning forms	• (a) Seminar with discussion • (b) Seminar with discussion		
Modul Content	(a) The research seminar is a platform for presenting current in-house research topics. It is expected that students present results of their B.Sc. thesis. On a regular basis doctorate students report on their current state of their Ph.D projects. Members of the academic staff also contribute to the research seminar by presenting conference talks, etc. The research seminar is aimed at inspiring scientific debates between students and staff scientists. A further objective is to inform students about the research topics that are addressed in the institute. (b) Presentations on up-to-date research topics, presented by invited and often internationally renowned speakers. The scientific spectrum comprises research topics of the institute (e.g. impact, planetology, structural geology, earth history, mineral, ore and oil deposits, geohazards, geothermal energy, environmental mineralogy, hydrology, geochemistry, crystal growth) and other branches of geosciences. To enhance the practical aspect of the curriculum speakers from companies and industries are specifically welcome.		
Learning and qualification goals	Students can/are capable of: The students improve their presentation skills by giving an own presentation and by discussing the presented topic with the audience. Moreover, they are trained in discussing topics at different scientific levels from presentations by their classmates, by the scientific staff, and by invited external speakers. • In addition, the students get the chance to establish contacts to external researchers.		
Ungraded academic achievement	• (a) Regular attendance, own presentations; • (b) Regular attendance Regular attendance in the seminar and in the practical part.		
Graded assessment	---		
Grading			
Applicability of the Module	--		

Modul Number	10LE09MO-2019-130
Course Nummer	
SL/PL Nummer	SL: 10LE09SL-2019-130-SL

5.1.3 Field Trips (5 ECTS -Points)

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Field Corurse	required subject	5	2	P	SL	1

Workload oft the module	150 h in total	60 h classroom-based course of study	90 h Independent study
Weekly contact hours	4		
Responsible person	Dr. H. Ulmer		
Lecturer	All Lecture Geo-Sciences		
Participation requirements according to the examination regulations	• None		
Expected prior knowledge and notes on preparation	• None		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Every Semester		
Teaching/learning forms	• Field trip/visit at industrial facility, practical training in the field including data acquisition: (GPS, fabric, sampling strategies, drilling, etc.)		
Modul Content	Field trips to rock outcrops play a fundamental role in understanding geological concepts. They are an essential part of the geological learning process in complementing classroom and lab teaching of science concepts. They also provide visual images that are needed to work with more abstract contents of modeling, remote sensing etc. Field trips involve elements of both instructor-led explanation and student centered exploration / discovery. Reviewing the trip afterwards is an important activity for cementing observations and interpretations into a comprehensive sense of conceptual understanding. Field trips range from day trips to field campaigns or residential courses of up to 2 weeks. Thematically they cover a wide variety of topics from understanding the regional geology of an area to studying specific geological phenomena like sedimentation, volcanism, metamorphism or environmental aspects. “Classical” geological areas are visited like the Alps, Iceland, Aeolian Islands, Eifel, Bohemian Massif, to name a few. Visits at industrial facilities play an important role linking scientific research and application centered industrial development in geosciences and material sciences. A wide variety of companies and research institutes is visited, ranging from energy generation to waste handling and from raw material production to high-tech material design.		
Learning and qualification goals	In this module the core expertise of geoscientists – field work – is trained more extensively than it was possible in the B.Sc. programm. Excursions are aimed at testing, applying and accompanying the theoretical knowledge acquired in the lectures and are ideal opportunities for exchange between students and lecturer. Upon participation at field trips the students refine their power of observation. Students learn to write concise reports. They enhance higher-order cognitive skills and inquiry skills, and understand geological processes in time and space. Students		

	improve in geo-literacy and in knowledge of the regional geology. Visiting at industrial facilities students gain hands-on experience in manufacturing processes, application of geosciences in energy and materials' development and production, working life, and career prospects.
Ungraded academic achievement	Report
Graded assessment	None
Grading	
Applicability of the Module	--
Modul Number	10LE09MO-2019-140
SL/PL Nummer	

5.1.4 Geographic Information Systems

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Research Seminar (a)	V	2,5	2	P	SL	1
Geoscience Colloquium (b)	Ü	2,5	2	P	SL, PL	1
Arbeitsaufwand des Moduls	150 h in total		60 h classroom-based course of study		90 h Independent study	
Semesterwochenstunden	4					
Responsible person	Dr. M. Poelchau					
Lecturers	Prof. Dr. F. Preusser, JProf. Dr. C. Prescher					
Participation requirements according to the examination regulations	• None					
Expected prior knowledge and notes on preparation	• None					
Language/s	English					
Module duration	1 Semester					
Frequency of offer	Every Semester					
Teaching/learning forms	• Field trip/visit at industrial facility, practical training in the field including data acquisition: (GPS, fabric, sampling strategies, drilling, etc.)					
Modul Content	(Field trips to rock outcrops play a fundamental role in understanding geological concepts. They are an essential part of the geological learning process in complementing classroom and lab teaching of science concepts. They also provide visual images that are needed to work with more abstract contents of modeling, remote sensing etc. Field trips involve elements of both instructor-led explanation and student centered exploration / discovery. Reviewing the trip afterwards is an important activity for cementing observations and interpretations into a comprehensive sense of conceptual understanding. Field trips range from day trips to field campaigns or residential courses of up to 2 weeks. Thematically they cover a wide variety of topics from understanding the regional geology of an area to studying specific geological phenomena like sedimentation, volcanism, metamorphism or environmental aspects. "Classical" geological areas are visited like the Alps, Iceland, Aeolian Islands, Eifel, Bohemian Massif, to name a few. Visits at industrial facilities play an important role linking scientific research and application centered industrial development in geosciences and material sciences. A wide variety of companies and research institutes is visited, ranging from energy generation to waste handling and from raw material production to high-tech material design.					
Learning and qualification goals	In this module the core expertise of geoscientists – field work – is trained more extensively than it was possible in the B.Sc. programm. Excursions are aimed at testing, applying and accompanying the theoretical knowledge acquired in the lectures and are ideal opportunities for exchange between students and lecturer. Upon participation at field trips the students refine their power of observation. Students learn to write concise reports. They enhance higher-order cognitive skills and inquiry skills, and understand geological processes in time and space. Students					

	improve in geo-literacy and in knowledge of the regional geology. Visiting at industrial facilities students gain hands-on experience in manufacturing processes, application of geosciences in energy and materials' development and production, working life, and career prospects.
Ungraded academic achievement	
Graded assessment	Report
Grading	
Applicability of the Module	--
Modul Number	10LE09MO-2019-140
SL/PL Nummer	

5.1.5 Geological Projekt (5 ECTS -Points)

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Research Seminar (a)	V	2,5	2	P	SL	1
Geoscience Colloquium (b)	Ü	2,5	2	P	SL, PL	1
Arbeitsaufwand des Moduls	150 h in total		60 h classroom-based course of study		90 h Independent study	
Semesterwochenstunden	4					
Responsible person	Dr. M. Poelchau					
Lecturers	Prof. Dr. F. Preusser, JProf. Dr. C. Prescher					
Participation requirements according to the examination regulations	• None					
Expected prior knowledge and notes on preparation	• None					
Language/s	English					
Module duration	1 Semester					
Frequency of offer	Every Semester					
Teaching/learning forms	• (a) Seminar with discussion • (b) Seminar with discussion					
Modul Content	(a) The research seminar is a platform for presenting current in-house research topics. It is expected that students present results of their B.Sc. thesis. On a regular basis doctorate students report on their current state of their Ph.D projects. Members of the academic staff also contribute to the research seminar by presenting conference talks, etc. The research seminar is aimed at inspiring scientific debates between students and staff scientists. A further objective is to inform students about the research topics that are addressed in the institute. (b) Presentations on up-to-date research topics, presented by invited and often internationally renowned speakers. The scientific spectrum comprises research topics of the institute (e.g. impact, planetology, structural geology, earth history, mineral, ore and oil deposits, geohazards, geothermal energy, environmental mineralogy, hydrology, geochemistry, crystal growth) and other branches of geosciences. To enhance the practical aspect of the curriculum speakers from companies and industries are specifically welcome.					
Learning and qualification goals	Students can/are capable of: The students improve their presentation skills by giving an own presentation and by discussing the presented topic with the audience. Moreover, they are trained in discussing topics at different scientific levels from presentations by their classmates, by the scientific staff, and by invited external speakers. • In addition, the students get the chance to establish contacts to external researchers.					
Ungraded academic achievement	• (a) Regular attendance, own presentations; • (b) Regular attendance Regular attendance in the seminar and in the practical part.					
Graded assessment	---					
Grading						
Applicability of the Module	--					
Modul Number	10LE09MO-2019-130					

Course Nummer	
SL/PL Nummer	SL: 10LE09SL-2019-130-SL

5.1.6 Seminar and Colloquium II (5 ECTS -Points)

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Research Seminar (a)	V	2,5	2	P	SL	1
Geoscience Colloquium (b)	Ü	2,5	2	P	SL, PL	1

Arbeitsaufwand des Moduls	150 h in total	60 h classroom-based course of study	90 h Independent study
Semesterwochenstunden	4		
Responsible person	Dr. M. Poelchau		
Lecturers	Prof. Dr. F. Preusser, JProf. Dr. C. Prescher		
Participation requirements according to the examination regulations	• None		
Expected prior knowledge and notes on preparation	• None		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Every Semester		
Teaching/learning forms	• (a) Seminar with discussion • (b) Seminar with discussion		
Modul Content	(a) The research seminar is a platform for presenting current in-house research topics. It is expected that students present results of their B.Sc. thesis. On a regular basis doctorate students report on their current state of their Ph.D projects. Members of the academic staff also contribute to the research seminar by presenting conference talks, etc. The research seminar is aimed at inspiring scientific debates between students and staff scientists. A further objective is to inform students about the research topics that are addressed in the institute. (b) Presentations on up-to-date research topics, presented by invited and often internationally renowned speakers. The scientific spectrum comprises research topics of the institute (e.g. impact, planetology, structural geology, earth history, mineral, ore and oil deposits, geohazards, geothermal energy, environmental mineralogy, hydrology, geochemistry, crystal growth) and other branches of geosciences. To enhance the practical aspect of the curriculum speakers from companies and industries are specifically welcome.		
Learning and qualification goals	Students can/are capable of: The students improve their presentation skills by giving an own presentation and by discussing the presented topic with the audience. Moreover, they are trained in discussing topics at different scientific levels from presentations by their classmates, by the scientific staff, and by invited external speakers. • In addition, the students get the chance to establish contacts to external researchers.		
Ungraded academic achievement	• (a) Regular attendance, own presentations; • (b) Regular attendance Regular attendance in the seminar and in the practical part.		
Graded assessment	---		
Grading			
Applicability of the Module	--		
Modul Number	10LE09MO-2019-130		

Course Nummer	
SL/PL Nummer	SL: 10LE09SL-2019-130-SL

5.1.7 Master Module (30 ECTS -Points)

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Research Seminar (a)						
Geoscience Colloquium (b)						
Arbeitsaufwand des Moduls						
Semesterwochenstunden						
Responsible person						
Lecturer						
Participation requirements according to the examination regulations						
Expected prior knowledge and notes on preparation						
Language/s						
Module duration						
Frequency of offer						
Teaching/learning forms						
Modul Content						
Learning and qualification goals						
Ungraded academic achievement						
Graded assessment						
Grading						
Applicability of the Module						
Modul Number						
Course Nummer						
SL/PL Nummer						

5.2 Required Modules of the Elective Track´s –full discription-

5.2.1 Required Modules Mineralogy and Geochemistry

5.2.1.1 Analytical Methods I

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Research Methods in Geosciences	V	2,5	2	P	SL	1

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. David Dolejš		
Lecturer	Dr. Dominic Wölki		
Participation require-ments according to the examination regulations	• None		
Expected prior knowledge and notes on preparation	• None		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Winter Semester only		
Teaching/learning forms	• Lecture • Practical course		
Modul Content	Students are introduced into the theoretical background of major analytical methods and machinery in modern mineralogy, geochemistry, and crystal-lography. They learn to decide upon the appropriate method and analytical settings for a given analytical problem. They perform all steps from sample preparation to analysis at the machine, evaluate result quality and are able to plot and interpret these results in their relevant context. Students are thus introduced to a spectrum of standard instrumental techniques, which are widespread in research as well as in industry.		
Learning and qualification goals	• Students can/are capable of: • Students are introduced into the theoretical background of major analyt-ical methods and machinery in modern mineralogy, geochemistry, and crystallography. • They learn to decide upon the appropriate method and analytical settings for a given analytical problem. They perform all steps from sample prep-aration to analysis at the machine, evaluate result quality and are able to plot and interpret these results in their relevant context. • Students are thus introduced to a spectrum of standard instrumental techniques, which are widespread in research as well as in industry.		
Coursework	• Regular attendance in the seminar and in the practical part.		
• Graded assessment	• Written reports • Short written test (30 min.)		

• Grading	• Written reports 80 % • Short written test 20 %
Applicability of the Module	--
Modul Number	10LE09MO-2019-310
Course Nummer	10LE09MO-2019-310
SL/PL Nummer	SL: 10LE09SL-2019-310-SL / PL: 10LE09PL-2019-310-P1

5.2.1.2 Low Temperature Geochemistry

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Marine Geochemistry	V	2,5	2	P	SL	2
Isotope Geochemistry						

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. Kerstin Hockmann		
Lecturer	Prof. Dr. Kerstin Hockmann		
• Participation requirements according to the examination regulations	• None		
Expected prior knowledge and notes on preparation	• Basic knowledge in Geochemistry at the level of B.Sc. course "Geochemistry".		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Summer Semester only		
Teaching/learning forms	• Lecture • Practical course		
Modul Content	Course a) introduces the concepts, the methods and the applications of marine geochemistry. Teaching topics include basic oceanographic principles operating in the marine realm, ocean basin bathymetry, the chemical properties of seawater, trace elements and isotopes and their distribution in the water column, the marine carbon cycle, ocean water circulation, hydrothermal processes and life on the sea floor, as well as formation and distribution of marine sediments. Marine mineral resources and environmental issues will also be covered. The focus of course b) is on radiogenic and stable isotope systems and their principles and applications in low-temperature environments. Topics and systems include: • K-Ar and Ar-Ar methods and the meaning of cooling ages • Fundamentals of stable isotope geochemistry, including definitions, terminology, basic • principles and standards • U-series disequilibrium dating • Sr and Nd isotopic variations of sea water • Principles of fission-track-dating • Cosmogenic isotope analysis and geomorphology.		
Learning and qualification goals	Students can/are capable of: The module covers the key aspects of marine geochemistry and methods in environmental and low-temperature isotope geochemistry and provides the student with an introduction to fundamental concepts of oceanography and isotope geology. The individual qualifications and skills of the module are specified below: a) In the course "Marine Geochemistry", students will develop skills for understanding the		

	• basic principles and theories associated with the geochemical processes occurring in the oceans. • The student will be familiar with sources and sinks of chemical elements or compounds, • their distributions and their variability in the oceanic system and gather an understanding of how marine and coastal environments are impacted by natural climate variability or human activities. In the course “Isotope Geochemistry”, students learn about • the principles of low-temperature radiogenic and stable isotope methods. • They examine a variety of isotope systems and dating techniques, and become familiar with possible sources of error. • Several lectures include classroom exercises on the same topic. • At the end of the course the students will be familiar with • the fundamentals of isotope geochemistry and know which isotopic system is suitable to solve a certain geological problem. • She/he will also be able to interpret isotope data and understand Earth processes through isotope geochemistry.
• Coursework	• None
Graded assessment	• Written Examination
Grading	• Written examination 100 %
Applicability of the Module	--
Modul Number	10LE09MO-2019-310
Course Nummer	10LE09V-2019-320-1 10LE09V-2019-320-2
SL/PL Nummer	SL: 10LE09SL-2019-310-SL / PL: 10LE09PL-2019-310-P1

5.2.1.3 Ore-Forming Processes

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Ore-Forming Processes	L + E	5	4	P	SL	2

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study

Weekly contact hours	4
Responsible person	Prof. Dr. Kerstin Hockmann
Lecturer	Prof. Dr. Kerstin Hockmann
Participation requirements according to the examination regulations	• None
Expected prior knowledge and notes on preparation	• Basic knowledge in geochemistry at the level of B.Sc. course "Geochemistry".
Language/s	English
Module duration	1 Semester
Frequency of offer	Summer Semester only
Teaching/learning forms	• Lecture • Practical course
Modul Content	• Introduction to ore systems and deposits • Metals and sulfur in ultramafic and mafic systems • Sulfide and oxide ore assemblages • Magmatic fluid phase • Mineral equilibria in hydrothermal fluids • Hydrothermal transport of metals • Computational models of reactive fluid flow • Alteration geochemistry • Fluid flow in the Earth's crust • Metamorphic and sedimentary ore-forming fluids • Supergene and surface processes • Metamorphism of ore deposits.
Learning and qualification goals	This course is devoted to processes of metal distribution, transport and enrichment in Earth's lithosphere. We use process-oriented approach from mantle-derived mafic magmas and their metal budget through silicic magmas, their volatiles, exsolution and fractionation of metals towards a large group of hydrothermal and fluid-rock interaction processes. The course concludes with near-surface processes such as and fluid flow in sedimentary basins and ore-forming processes near Earth's surface (weathering and supergene mobilization).
Coursework	• None
Graded assessment	• Project report
Grading	• Project report 100 %
Applicability of the Module	--

Modul Number	10LE09MO-2019-330
Course Nummer	10LE09V-2019-330
PL Nummer	10LE09PL-2019-330-P1

5.2.2 Required Modules Geomechanics and Tectonics

5.2.2.1 Computing in Geosciences

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Computing in Geosciences	L + E	5	4	P	SL	2

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study

Weekly contact hours	4
Responsible person	Prof. Dr. Stefan Hergarten
Lecturer	Prof. Dr. Stefan Hergarten
Participation require-ments according to the examination regulations	• None
Expected prior knowledge and notes on preparation	• Basic knowledge in mathematics and computing, e.g., on the level of “Modellierung and “Datenanalyse” from the B.Sc. Geowissenschaften
Language/s	English
Module duration	1 Semester
Frequency of offer	Winter Semester only
Teaching/learning forms	• Lecture • Practical exercises • Homework
Modul Content	Numerical data analysis, visualization, and process modeling have become essential parts of quantitative geosciences. The successful students are able to describe simple processes in terms of differential equations and are able to implement fundamental schemes (finite difference methods) for the nu-merical solution in a high-level programming language (MATLAB). Beyond this, the students shall be able to assess which method is suitable for a given problem and be aware of potential pitfalls.
Learning and qualification goals	The class starts with an introduction to process modeling using simple pop-ulation models based on ordinary differential equations und their implemen-tation using explicit and implicit Euler schemes. The following main part of the module comprises the basic equations behind the models widely used for modeling mass and heat transport processes, solid mechanics, ground-water flow, and landform evolution based on partial differential equations. After discussing the respective equations, the underlying principles, and their mathematical properties, the simplest numerical techniques in the field of partial differential equations (finite differences, upstream schemes) are discussed. Theory is accompanied by a step-by-step introduction to the MATLAB programming environment and exercises focusing on implement-ing the models in MATLAB and analysing the results.
Coursework	• None
Graded assessment	• marked homework to be solved during the semester (software develop-ment and mathematical considerations) and • online exercises to be solved in the class

Grading	• Homework 85 % • online exercises 15 %
Applicability of the Module	--
Modul Number	10LE09MO-2019-410/510/670
Course Nummer	10LE09V-2019-410/510/670
PL Nummer	10LE09PL-2019-410/510/670-P1

5.2.2.2 Tectonics

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Tectonics	L + E	5	4	P	SL	2

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. Thomas Kenkmann		
Lecturer	Prof. Dr. Thomas Kenkmann, Dr. Michael Poelchau		
Participation require-ments according to the examination regulations	• None		
Expected prior knowledge and notes on preparation	• Basic knowledge in mathematics and computing, e.g., on the level of “Modellierung and “Datenanalyse” from the B.Sc. Geowissenschaften		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Winter Semester only		
Teaching/learning forms	• Lecture • Practical exercises		
Modul Content	A variety of plate tectonic scenarios is reviewed and their physical boundary conditions and associated geological phenomena are addressed. Case studies for each of the chapters are presented by the participants. The course also considers tectonic structures on other planets and satellites. The agenda of the module is: Divergent motion: • Continental graben tectonics • Passive continental margins and basin formation • Basin & Range tectonics Transcurrent motion: Continental transform faults Inversion tectonics Convergent motion: • Accretionary wedges • Andean style orogeny • Cordillera style orogeny • Alpine style orogeny • Wrinkle ridges and lobate scarps Radial Motion: • Volcano and plume tectonics • Salt diapirism		
Learning and qualification goals	This module deals with various plate tectonic scenarios. The students allocate structural characteristics and physical boundary conditions to these plate tectonic settings. The module provides a basic understanding of the geodynamics of the tectonic environments, e.g. the state of stress in the lithosphere. The presentation of case studies by the students familiarize them with various tectonic and geophysical techniques of crust-scale analyses.		
Coursework	• Homework (data interpretation and calculations)		
Graded assessment	• Written examination (90 minutes) • and oral presentation		

Grading	• Written examination 60 % • Oral presentation 40 %
Applicability of the Module	--
Modul Number	10LE09MO-2019-410/510/670
Course Nummer	10LE09V-2019-410/510/670
PL Nummer	10LE09PL-2019-410/510/670-P1

5.2.2.2 Near-Surface Geophysics

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Near-Surface Geophysics	L	5	4	P	SL	2

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study
Weekly contact hours	4		
Responsible person	Dr. Jakob Wilk		
Lecturer	Dr. Jakob Wilk		
Participation requirements according to the examination regulations	• Successful completion of the module **Computing in Geosciences** is a prerequisite for taking the module Near-Surface Geophysics		
Expected prior knowledge and notes on preparation			
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Summer Semester only		
Teaching/learning forms	• Lecture accompanied by homework and field experiments. • Practical exercises		
Modul Content	The module focuses on the methods most relevant for the exploration of the shallow subsurface: • seismics • resistivity methods • ground-penetrating radar • geomagnetics Both the theory behind the methods and the respective techniques of data analysis are considered. Understanding is deepened by exercises in the class, homework, and experiments in field.		
Learning and qualification goals	Geophysical methods of subsurface exploration have received a growing interest in many fields of geosciences during the previous decades. The module focuses on the most important geophysical methods used in hydrogeology, environmental geology and engineering geology suitable for the exploration of the shallow subsurface. The module provides a basic understanding of these methods and expands on their application. The students learn which of the techniques is most appropriate under given conditions, to analyze the respective field data, and how to use the available instruments for the investigation of shallow geological structures.		
Coursework	• Regular attendance in the field measurements		
Graded assessment	• Homework (calculations and computer-based data analysis) to be solved during the semester • including reports of the field work		
Grading	• Homework ----- % • Reports ----- %		
Applicability of the Module	--		

Modul Number	10LE09MO-2019-430
Course Number	10LE09V-2019-430
CW/GA Nummber	CW: 10LE09SL-2019-430-SL / GA: 10LE09PL-2019-430-P1

5.2.3. Required Modules Geohazards

5.2.3.2 Computing in Geosciences

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Computing in Geosciences	L + E	5	4	P	SL	2
Workload of the module	150 h total	60 h classroom-based course of study		90 h independent study		
Weekly contact hours	4					
Responsible person	Prof. Dr. Stefan Hergarten					
Lecturer	Prof. Dr. Stefan Hergarten					
Participation require-ments according to the examination regulations	• None					
Expected prior knowledge and notes on preparation	• Basic knowledge in mathematics and computing, e.g., on the level of “Modellierung and “Datenanalyse” from the B.Sc. Geowissenschaften					
Language/s	English					
Module duration	1 Semester					
Frequency of offer	Winter Semester only					
Teaching/learning forms	• Lecture • Practical exercises • Homework					
Modul Content	Numerical data analysis, visualization, and process modeling have become essential parts of quantitative geosciences. The successful students are able to describe simple processes in terms of differential equations and are able to implement fundamental schemes (finite difference methods) for the numerical solution in a high-level programming language (MATLAB). Beyond this, the students shall be able to assess which method is suitable for a given problem and be aware of potential pitfalls.					
Learning and qualification goals	The class starts with an introduction to process modeling using simple population models based on ordinary differential equations und their implementation using explicit and implicit Euler schemes. The following main part of the module comprises the basic equations behind the models widely used for modeling mass and heat transport processes, solid mechanics, groundwater flow, and landform evolution based on partial differential equations. After discussing the respective equations, the underlying principles, and their mathematical properties, the simplest numerical techniques in the field of partial differential equations (finite differences, upstream schemes) are discussed. Theory is accompanied by a step-by-step introduction to the MATLAB programming environment and exercises focusing on implementing the models in MATLAB and analysing the results.					
Coursework	• None					
Graded assessment	• marked homework to be solved during the semester (software development and mathematical considerations) and • online exercises to be solved in the class					

Grading	• Homework 85 % • online exercises 15 %
Applicability of the Module	--
Modul Number	10LE09MO-2019-410/510/670
Course Nummer	10LE09V-2019-410/510/670
PL Nummer	10LE09PL-2019-410/510/670-P1

5.2.3.1 Earthquakes and Tsunamis

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Earthquakes and Tsunamis	V +Ü	5	4	P	SL	2

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study

Weekly contact hours	4
Responsible person	Prof. Dr. S. Hergarten
Lecturer	Prof. Dr. S. Hergarten
Participation requirements according to the examination regulations	• Successful completion of the module Computing in Geosciences is a prerequisite for taking the module Earthquakes and Tsunamis.
Expected prior knowledge and notes on preparation	
Language/s	English
Module duration	1 Semester
Frequency of offer	Summer Semester only
Teaching/learning forms	• Lecture accompanied by homework and field experiments. • Practical exercises
Modul Content	The first part of the module focusing on seismology and seismic hazard combines the classical theory of wave propagation with geological and statistical aspects comprising the following topics: • Types of elastic waves and theory of wave propagation • Focal mechanisms; seismic moment tensor • Localization of earthquakes • Earthquake intensity and magnitude; different definitions of magnitude and their relevance In the second part, the theoretical concepts of wave propagation and the concepts of intensity and magnitude are transferred to the propagation of tsunami waves.
Learning and qualification goals	Earthquakes and tsunamis are among the most important natural hazards on Earth and thus a major fields of professional activity in the context of geohazards. As a main qualification, the successful students are able bring the rather extensive and complicated theory of seismology and tsunami propagation into the context of geohazards and include their theoretical knowledge

	in hazard assessment. Beyond this, they are able to understand und interpret scientific results on historical and recent events as well as hazard assessment provided in the literature in a realistic way.
Coursework	• None
Graded assessment	• Homework (analytical and computer-based calculations) to be solved during the semester.
Grading	• Homework 100 %
Applicability of the Module	--
Modul Number	10LE09MO-2019-520
Course Number	10LE09S-2019-520
CW/GA Nummber	GA: 10LE09PL-2019-520-P1

5.2.3.3 Hazard, Risk, and Prediction

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Hazard, Risk, and Prediction	V +Ü	5	4	P	SL	2
Workload of the module	150 h total		60 h classroom-based course of study		90 h independent study	

Weekly contact hours	4
Responsible person	Prof. Dr. S. Hergarten
Lecturer	Prof. Dr. S. Hergarten
Participation requirements according to the examination regulations	• Successful completion of the module Computing in Geosciences is a prerequisite for taking the module Earthquakes and Tsunamis.
Expected prior knowledge and notes on preparation	
Language/s	English
Module duration	1 Semester
Frequency of offer	Winter Semester only
Teaching/learning forms	• Lecture combined with • discussion, • practical exercises and • homework.
Modul Content	The main topics of the module are: • Hazard and risk • Event-size distributions and frequency-magnitude relations; general concepts and distributions for different geohazards • Recurrence times • Temporal correlations • Assessment of predictions • Self-organized criticality.
Learning and qualification goals	Assessing hazard and risk is one of the major fields of professional work in the context of geohazards. This module provides a synthesis of the specific modules of the Elective Track Geohazards. The successful students are able to apply theoretical concepts from statistics to hazard assessment, to derive hazard maps and can distinguish between the terms hazard and risk. Beyond this, the students achieve basic knowledge about concepts of prediction and about contemporary theoretical concepts unifying different types of geohazards and improve their abilities in analysing data quantitatively.
Coursework	• None
Graded assessment	• Homework (analytical and computer-based calculations) to be solved during the semester.
Grading	• Homework 100 %
Applicability of the Module	--
Modul Number	10LE09MO-2019-530

Course Number	10LE09V-2019-530
GA Nummber	10LE09PL-2019-530-P1

5.2.4 Required Modules Applied Quaternary Geology

5.2.4.1 Engineering Geology and Geotechnics

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Introduction to Engineering Geology (a)	L	2,5	2	P	SL+PL	2
Geotechnical Projects (b)	S	2,5	2	P		

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study

Weekly contact hours	4
Responsible person	Prof. Dr. Frank Preusser
Lecturer	Prof. Dr. Frank Preusser
Participation requirements according to the examination regulations	• None
Expected prior knowledge and notes on preparation	• None
Language/s	English
Module duration	1 Semester
Frequency of offer	Winter Semester only
Teaching/learning forms	(a) Lecture mixed with practical exercises (b) Seminar
Modul Content	(a) The course will introduce basic concepts, nomenclature and problems of applied geology with a focus on physical properties of unconsolidated sediments (soils). This will be combined with some practical work on basic methods and approaches. (b) Students will put together an oral presentation on a selected geotechnical project and will present and discus this in class.
Learning and qualification goals	Many students will find work in the field of engineering and environmental geology. This course aims at providing the necessary basic background in this field. Attendees will be familiar with the basic concepts, nomenclature and problems of applied geology and hence should be able to communicate about and approach applied aspects in geosciences.
Coursework	• (a) Active participation in the exercises; • (b) Attendance of the seminar
Graded assessment	• (a) Written examination about (90 minutes) • (b) Lab report about • (b) oral presentation
Grading	• (a) Written examination 60 % • (a) Lab report about 10 % • (b) oral presentation 30 %
Applicability of the Module	--
Modul Number	10LE09MO-2019-610/495/595

Course Number	(a) 10LE09V-2019-610/495/595-1 (b) 10LE09V-2019-610/495/595-2
GA Nummber	CW: 10LE09S L-2019-610/495/595-SL GA: 10LE09PL-2019-610/495/595-P1

5.2.4.2 Sedimentary Geology

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Sedimentary environments (a)	L	2,5	2	P	SL+PL	2
Logging sediments (b)	S	2,5	5 days	P		

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. Frank Preusser		
Lecturer	Prof. Dr. Frank Preusser		
Participation requirements according to the examination regulations	• None		
Expected prior knowledge and notes on preparation	• None		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Summer Semester only		
Teaching/learning forms	(a) Lecture (b) Practical Course		
Modul Content	(a) This course concentrates on the sedimentary dynamics and archives found such as in glacial, fluvial, aeolian, and coastal settings. After this course students will understand these sedimentary systems in detail, will be able to describe and interpret sedimentary sequences, and put these observations into a local, regional and global context. (b) Students will learn how to describe (log) sediments in outcrops and cores.		
Learning and qualification goals	Students who successfully complete this module will have developed an understanding of modern sedimentology. The module is subdivided into two courses, one focusing on the theoretical background and the other on practical issues of describing sediments.		
Coursework	• (b) Attendance of the practical part		
Graded assessment	• (a) Written tests during the term (60 %) • (b) project report (40 %)		
Grading	• (a) Written tests 60 % • (a) project report 40 %		
Applicability of the Module	--		
Modul Number	10LE09MO-2019-620		
Course Number	(a) 10LE09V-2019-620-1 (b) 10LE09V-2019-620-2		
CW/GA Nummber	CW: 10LE09SL-2019-620-SL GA: 10LE09PL-2019-620-P1		

5.2.4.3 Earth Management

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Earth Management	L	5	4	P	SL+PL	1

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. Frank Preusser		
Lecturer	Prof. Dr. Frank Preusser		
Participation requirements according to the examination regulations	• None		
Expected prior knowledge and notes on preparation	• None		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Winter Semester only		
Teaching/learning forms	(a) Lecture (b) Practical Course		
Modul Content	This course introduces the following topical fields: • Methods of protection against geohazards (floods, mass movements) • Soil erosion, causes and countermeasures • Concepts of landscape sculpturing such river regulation • Hazardous substances (natural and artificial chemicals, dust, hydrate) • Geo-engineering		
Learning and qualification goals	Students who successfully complete this module will have developed an understanding of how the Earth surface is modified and what kind of hazards are introduced by humans. This will include the presentation of the legal framework, regulations, procedures as well as economic aspects related to the wider field of geosciences.		
Coursework	• Regular attendance in the seminar and submission of the project report.		
Graded assessment	• Two written tests (20%) • oral presentation (40%) during term • plus project report until the end of semester (40 %)		
Grading	• Written tests 20 % • Oral Presentation 40% • Project report 40 %		
Applicability of the Module	--		
Modul Number	10LE09MO-2019-630		
Course Number	(a) 10LE09V-2019-620-1 (b) 10LE09V-2019-620-2		
CW/GA Nummber	CW: 10LE09SL-2019-630-SL GA: 10LE09PL-2019-630-P1		

5.3 Required elective Modules Assigned to the Track -full descriptions-

5.3.1 Required elective Modules Mineralogy and Geochemistry

5.3.1.1 Igneous Processes

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Igneous Processes	L +Ü	5	4	P	SL+PL	1
Workload of the module	150 h total	60 h classroom-based course of study		90 h independent study		
Weekly contact hours	4					
Responsible person	Prof. Dr. David Dolejš					
Lecturer	Prof. Dr. David Dolejš					
Participation requirements according to the examination regulations	• None					
Expected prior knowledge and notes on preparation	• Knowledge of petrology at the Bachelor level					
Language/s	English					
Module duration	1 Semester					
Frequency of offer	Winter Semester only – biannually 2025/2026 next					
Teaching/learning forms	Lecture and Practical Course					
Modul Content	The principal objectives of this course are understanding of atomistic structure of silicate melts, physical properties of silicate magmas, use of phase diagrams, crystallization kinetics (nucleation, growth, crystal size distribution), magma rheology, internal dynamics of magma chambers, formation of crystal fabric, volatiles in silicate magmas, eruptive styles and pyroclastic deposits. The students obtain versatile knowledge of formation, evolution and behavior of magmas in the Earth's crust and mantle.					
Learning and qualification goals	Structure of silicate melts • Physical properties of melts and magmas • Melt generation in the Earth • Magma differentiation: crystal-melt equilibria • Phase equilibrium modeling of magmatic systems: MELTS software • Geothermobarometry of igneous rocks • Crystal nucleation and growth • Crystallization, crystal size distribution and rheological thresholds • Magma differentiation: mechanical dynamics • Volatiles in silicate magmas, fluid exsolution and degassing • Dynamics of volcanic eruptions					
Coursework	• None					
Graded assessment	• Project report (sample analysis, data interpretation)					
Grading	• Project report 100 %					

Applicability of the Module	--
Modul Number	10LE09MO-2019-630
Course Number	(a) 10LE09V-2019-620-1 (b) 10LE09V-2019-620-2
CW/GA Nummber	CW: 10LE09SL-2019-630-SL GA: 10LE09PL-2019-630-P1

5.3.1.2 Metamorphic Processes

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Metamorphic Processes	L + Ü	5	4	P	SL+PL	1

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. David Dolejš		
Lecturer	Prof. Dr. David Dolejš		
Participation requirements according to the examination regulations	• None		
Expected prior knowledge and notes on preparation	• Knowledge of petrology at the Bachelor level		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Winter Semester only – biannually 2024/2025 next		
Teaching/learning forms	Lecture and Practical Course		
Modul Content	• Metamorphism: equilibrium and kinetic concepts • Crystal chemistry of rock-forming minerals • Composition space and thermodynamics of minerals • Construction of metamorphic phase diagrams: Theriak software • Local and partial equilibria • Inverse equilibrium models: Thermocalc software • Metamorphic crystallization and local mass transport • Chemical potentials and reaction affinity as driving forces for phase transformations • Deformation laws and paleopiezometry • Rheology of polymineralic and partially molten rocks • Metamorphic fluids, internal and external buffering		
Learning and qualification goals	The students acquire ability to interpret metamorphic processes and conditions using mineral-fluid equilibria and kinetics. The learning goals include temperature ranges of regional and contact metamorphic conditions, and perform chemographic analysis of mineral assemblages. They learn principles of mineral thermodynamics, inverse modeling and geothermobarometry including working knowledge of software packages Thermocalc, Theriak and Perplex. Attention will be paid to deformation mechanisms in natural rocks and interpretation of deformation and recrystallization textures in the polarization microscope. Students will be able to interpret metamorphic conditions associated with diverse tectonic settings in the lithosphere.		
Coursework	• None		
Graded assessment	• Project report (sample description, analysis and interpretation)		
Grading	• Project report 100 %		
Applicability of the Module	--		

Modul Number	10LE09MO-2019-360
Course Number	10LE09MO-2019-360
CW/GA Nummber	GA: 10LE09MO-2019-360-P1

5.3.1.3 High Temperature Geochemistry

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Geochemical evolution of the Earth's mantle and crust	L +Ü	2,5	2	WP	PL	1
High-Temperature Geo-chronology		2,5	2			
Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study			
Weekly contact hours	4					
Responsible person	Prof. Dr. Kerstin Hockmann					
Lecturer	• Prof. Dr. Kerstin Hockmann					
Participation requirements according to the examination regulations	• None					
Expected prior knowledge and notes on preparation	Basic knowledge in geochemistry at the level to B.Sc. course "Geochemistry"					
Language/s	English					
Module duration	1 Semester					
Frequency of offer	Winter Semester only					
Teaching/learning forms	Lecture and Practical Course					
Modul Content	Course (a) provides essential insight into magmatic processes associated with plate boundary environments (mid-ocean ridges and subduction zones) and within plate regions (ocean islands and volcanic plateaus). The geochemical and isotopic composition of the different mantle reservoirs will be discussed and magmatic and tectonic processes along subduction zones will be explored. The lecture also focusses on fundamental processes that gave rise to the characteristic geochemical features of the continental crust and the different mantle reservoirs. These topics provide the basis for homework questions and student reports. The focus of courses (b) is on radiogenic isotope systems and their principles and applications in high-temperature geology. Topics and systems include: • • Principles of the Rb-Sr, U-Th-Pb, Sm-Nd and Lu-Hf dating and tracing methods • • Isotopes as tracers of sources and processes; presentation of case studies • • Radionuclides and their measurement techniques.					
Learning and qualification goals	The module contains two courses. Course (a) gives insight into the composition and evolution of the Earth's mantle and crust. Course (b) covers the key aspects of high-temperature radiometric dating and tracing methods. The individual qualifications and skills of the module are specified as follows: (a) The silicate Earth encompasses the crust and mantle. On successful completion of course (a), students should be able to know how these two major reservoirs were created and modified over geological time and about the magmatic processes that lead to their present composition. Basaltic					

	rocks from mid-ocean ridges and intraplate volcanoes place constraints on the composition of the underlying mantle the presence of small- or large-scale heterogeneities. Subduction zone volcanism causes the large earth-quakes and volcanic hazard but it also helps to understand the processes, which lead to the formation and composition of the continental crust. (b) In this course, students learn about the principles of high-temperature radiogenic isotope methods. They realize that isotopes are indispensable tools for reconstructing various Earth processes, palaeo-environmental conditions and for radiometric dating. Several lectures include classroom exercises on the same topic. At the end of the course the students will be familiar with the fundamentals of isotope geochemistry and know which isotopic system is suitable to solve a certain geological problem. She/he will also be able to interpret isotope data and understand Earth processes through isotope geochemistry.
Coursework	• None
Graded assessment	• Written examination (120 minutes)
Grading	• Written examination 100 %
Applicability of the Module	--
Modul Number	10LE09MO-2019-370
Course Number	------------
GA Nummber	GA: 10LE09MO-2019-370-P1

5.3.1.4 Analytical Methods II

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Advanced Analytical Methods (a)	L +Ü	2,5	3	WP	PL	2
High-Resolution Spectroscopy (b)		2,5	2			

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. Michael Fiederle		
Lecturer	Prof. Dr. Michael Fiederle		
Participation requirements according to the examination regulations	• None		
Expected prior knowledge and notes on preparation	• The module Analytical Methods I must have been completed.		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Summer Semester only		
Teaching/learning forms	(a) Lecture + laboratory practical sessions (small groups of 2-3 students) (b) 3D multimedia introduction into the various methods, supported by solving problems and discussion of results in practical sessions.		
Modul Content	(a) The emphasis of this course is on important mineralogical techniques used in ore geology, petrology, geomaterials, soil science, and environmental science. Students explore various methods, e.g. cathodoluminescence, fluid inclusions on heating-freezing stage, reflected light microscopy, clay mineral preparation techniques etc. both in theory and in the laboratory, where hands-on experience is an essential part of the course. (b) The course provides tools for the characterization of solid state materials: UV-VIS and IR spectroscopy, surface analysis methods using X-ray photon spectroscopy (XPS), secondary ion mass spectroscopy (SIMS), laser-induced breakdown spectroscopy (LIBS), and Auger spectroscopy (AGS). To analyze the local geometry, the chemical state and coordination spheres of atoms X-ray absorption spectroscopy (XAS), extended absorption fine structure (EXAFS), and X-ray absorption near-edge Structure (XANES) will be presented. To find the oxidation state of atoms (e.g., $Fe2+$, $Fe3+$), Mössbauer spectroscopy will be explained. Other high-resolution methods discussed are: Raman spectroscopy, STM and AFM microscopy, and TEM microscopy.		
Learning and qualification goals	Advanced analytical methods are essential for the investigation of solid state materials and the understanding of the correlation between material properties and technology. The analytical methods are an important part of this curriculum. The students will be competent in choosing analytical techniques for the characterization of solid state materials. The students will be able to analyse and evaluate experimental data and identify different classes of solid state materials. (a) Students learn to prepare rocks and minerals for specific analytical applications and apply these methods. They amplify their knowledge in several		

	techniques and are able to deduce on the composition and formation conditions of these samples. (b) This course covers spectroscopic and diffraction methods and the students will be able to differentiate the interaction between crystalline material with probe beams like X-rays, ionized particles, electrons and photons. They interpret the outcome of these interactions for mass spectroscopy, surface analysis, diffraction and tomography.
Coursework	(a) presence in the practical part; (b) analysis of experimental data and solution of exercise problems
Graded assessment	• Written reports on (a) • Written test on (b)
Grading	• Report 40 % • Test 60 %
Applicability of the Module	--
Modul Number	10LE09MO-2019-340
Course Number	(a) 10LE09V-2019-340-1 (b) 10LE09V-2019-340-2
GA Nummber	GA: 10LE09MO-2019-340-P1

5.3.2 Required elective Modules Geomechanics and Tectonics

5.3.2.1 Petrophysics

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Petrophysics (a)	L +Ü	2,5	2	WP	PL	2
Rheology and Textures (b)		2,5	2			

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. T. Kenkmann		
Lecturer	(a) Prof. Dr. T. Kenkmann; Dr. M. Poelchau (b) Dr. M. Poelchau		
Participation requirements according to the examination regulations			
Expected prior knowledge and notes on preparation	Experience in polarized light microscopy is beneficial.		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Winter Semester only – biannual next: WiSe 2025/26		
Teaching/learning forms	(a) Lecture + Exercises/Homework (b) Lecture and practical work at the polarizing microscope.		
Modul Content	a) Petrophysics is the study of the physical properties of rocks. Its objective is to explain why rocks have the properties they do. In particular, how the relative amounts and arrangements of the minerals that comprise them determine their physical properties. Petrophysics is key in numerous applications of geosciences and various fields of rock engineering and well logging. The course program comprises the following sections: (i)Rock classifications, (ii) Density, (iii) Porosity & Permeability, (iv) Radioactive Properties, (v) Geomechanical Properties (vi) Electrical properties, (vii) Magnetic properties, (viii) Well-logging. (b) Rheology is the study of the flow of matter. In Earth Sciences the focus of rheology is on the ductile flow of mid- and lower crustal rocks in response to applied forces at elevated temperatures. This course is designed to introduce the theory of plasticity and presents various flow laws (Newtonian, power law, etc.) of rocks and how these were determined. The flow behavior is compared with deformation mechanisms operating in the ductile field (diffusion creep, dislocation creep, dislocation glide, etc.). A major goal of the course is to gain practice in interpreting deformation features observed in rock thin sections under the polarizing microscope. A crucial role in deciphering deformation mechanisms is the analysis of shape- and crystallographic preferred orientations of deformed polycrystalline aggregates. Techniques are presented how rock textures can be measured and interpreted.		

Learning and qualification goals	(a) The successful student is getting acquainted with the petrophysical properties of the most important rock types. They quantitatively determine and measure porosities, mineral constituents, fabric of rocks etc. and correlate them with petrophysical data. Students are enabled to interpret petrophysical borehole data with respect to lithology, porosity, structure, and economic potential. (b) Students will describe rock fabrics and mineral constituents of metamorphic and igneous rocks making use of polarizing microscopes. They will identify and describe shape-preferred orientations as well as crystallographic preferred orientations. They will recall and apply techniques to measure rock textures and interpret pole figures and orientation distribution functions. Based on rock textures and fabric analysis the successful students are able to decipher deformation mechanisms and associated flow laws of natural rocks and estimate the conditions during deformation (pressure, temperature, strain, strain rate).
Coursework	Regular attendance in the practical parts of (a) and (b) completion of exercises (a)
Graded assessment	• Written examination (90 minutes), • Presentation the project work in oral and written form (b)
Grading	• Written examination 60 % • Project work 40 %
Applicability of the Module	--
Modul Number	10LE09MO-2019-340
Course Number	(a) 10LE09V-2019-340-1 (b) 10LE09V-2019-340-2
GA Nummber	GA: 10LE09MO-2019-340-P1

5.3.2.2 Rock Mechanics

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Stress and Strain (a)	L +Ü	2,5	2	WP	PL	2
Brittle Rock Deformation (b)		2,5	2			

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. T. Kenkmann		
Lecturer	(a) Prof. Dr. T. Kenkmann; Dr. M. Poelchau (b) Dr. M. Poelchau		
Participation requirements according to the examination regulations	• The module Computing in Geosciences should be either completed or attended in the same semester.		
Expected prior knowledge and notes on preparation	-------------		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Winter Semester only – biannual next: WiSe 2024/25		
Teaching/learning forms	(a) Lecture + exercises (b) Lecture, exercises and laboratory work		
Modul Content	(a) Forces which are responsible for the deformations of the earth's crust act instantaneously and cannot be stored in rocks through time. Deformations of rocks are persistant and all the studied deformations are old, but the related stresses are not visible any more. Furthermore, it is impossible to measure stress directly and only very special fabrics allow to describe state and direction of stresses. Nevertheless, one of the major goals of the lecture is to understand the distribution of forces in the earth and how those forces act to produce the different structures. There are lots of practical reasons to do this: earthquakes, oil well blowouts, motor of plate tectonics, landslides etc. The deals with stress acting on a plane and stress at a point leading to the concept of principle and deviatory stresses, which mathematically are described by stress tensor and 3x3 stress matrix. Different states of stresses and stress fields are introduced and presented methods of measurements include fault-slip analysis, stylolites, wellbore break-out, etc. The strain concept is mathematically based on continuous deformation thus strain is a branch continuum mechanics. In nature deformation is much more complex and far beyond being continuous. In this lecture all different aspects of a deforming rock system are introduced i.e. homogeneous vs. heterogeneous strain, progressive strain, infinitesimal vs. finite strain. We introduce to various quantitative strain measurement techniques including Fry and Rf-phi. (b) Brittle rock deformation is concerned with evaluating, through controlled laboratory experiments, the effects of environmental and material factors on the deformational behavior of rocks. The course deals with rock elasticity,		

	friction, various modes of brittle failure, brittle-toductile transition, plastic deformation, and dynamic deformation. The course consists of a theoretical part and a practical part.
Learning and qualification goals	(a) The successful student is getting acquainted with matrix calculations to calculate principal stress and strain states in rocks and to determine orientation of the principal axis of stress and strain. Students use graphical techniques to determine normal and shear stresses. Students become familiar with various methods of paleo-stress measurement and the measurement of recent stress fields in the crust. The quantification of strain accumulated in rocks is trained as well. Students get familiar with connecting stress and strain in linear isotropic elastic materials. (b) Students become familiar with the concepts of rock deformation and know how to derive rock mechanical characteristics such as the tensile strength, uniaxial compressive strength, Mohr-Coulomb strength, dynamic and static friction, Poisson ratio, Young Modulus, Tangent Modulus, and the dynamic increase factor.
Coursework	(a) Homework (b) Report of the experimental analyses
Graded assessment	• Written examination (a + b) • lab report about (b) (10 %)
Grading	• Written examination 90 % • Lab report 10 %
Applicability of the Module	--
Modul Number	10LE09MO-2019-450/690
Course Number	(a) 10LE09MO-2019-450/690-1 (b) 10LE09MO-2019-450/690-2
GA Nummber	GA: 10LE09MO-2019-450/690-P1

5.3.2.3 Planetary Dynamics

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Planetary Dynamics	L + Ü	5	3	WP	PL	1 or 3

Workload of the module	150 h total	45 h classroom-based course of study	105 h independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. T. Kenkmann		
Lecturer	Prof. Dr. T. Kenkmann		
Participation requirements according to the examination regulations			
Expected prior knowledge and notes on preparation	The module Computing in Geosciences should be either completed or attended in the same semester.		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Winter Semester only – biannual next: WiSe 2024/25		
Teaching/learning forms	Lecture with audio-visual demonstrations, numerical simulations and high speed videos of experiments. Practical part partly at the polarizing microscope. Investigation of impactite rocks and meteorites. Exercises. Each participant presents a space mission in an oral and written contribution.		
Modul Content	Understanding Earth requires a planetological perspective. The course starts with a grand tour through our solar system. The formation (accretion, differentiation) of the solar system and the planetological boundary conditions and physical properties of planetary bodies are given. Our knowledge on the solar system is closely linked with the technological development of space craft and exploration techniques. The practical course deals with remote sensing methods and imagery. Students shall interpret planetary surfaces by means of active geological processes. Volcanic eruptions and tectonic activities of terrestrial planets are linked with the interior structure of these bodies. Planetary surface processes (fluvial, aeolian, impact) and atmospheres are further topics that are compared between different planetary bodies. Minor bodies in the Solar system of the asteroid belt, the Kuiper belt and the Oort cloud are investigated as well. The giant planets of the outer solar system and their satellites complete the introduction to the solar system.		
Learning and qualification goals	Why is the Solar System the way it is? Students attending the course successfully know why. The students describe the planetary bodies by means of their physical, chemical, and astronomical boundary conditions. They can interpret surface features and conclude on dynamic interior and exterior geological processes that are dominant on and within these bodies. The students apply remote sensing techniques in combination with geo-information systems (GIS) to unravel the history of planets. Students understand that the evolution of the Earth and life to its present state is a consequence of a specific set of planetary boundary conditions. Students recapitulate the strategies, boundary conditions, requirements and major findings of various space missions.		

Coursework	(a) Homework (b) Report of the experimental analyses
Graded assessment	• Written examination • Exercises
Grading	• Written examination 70% • Exercises 30%
Applicability of the Module	--
Modul Number	10LE09MO-2019-440
Course Number	10LE09V-2019-440
GA Number	10LE09MO-2019-440-P1

5.3.2.4 Impact Geology

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Impact Geology	L + Ü	5	4	WP	PL	1 or 3

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study

Weekly contact hours	4
Responsible person	Prof. Dr. T. Kenkmann
Lecturer	Prof. Dr. T. Kenkmann
Participation requirements according to the examination regulations	
Expected prior knowledge and notes on preparation	
Language/s	English
Module duration	1 Semester
Frequency of offer	Winter Semester only – biannual next: WiSe 2025/26
Teaching/ learning forms	Lecture, exercises, project Screening Earth with presentation
Modul Content	The collision of solid bodies is one of the most fundamental geological processes in our solar system forming and reshaping planetary surfaces. The size-frequency distribution of impact craters on planetary surfaces and the current cratering rate and impact probability are presented including mitigation strategies. Composition and provenance of asteroids, comets and meteorites and their importance as possible impacting projectiles are highlighted. Special emphasis is drawn on Near Earth Asteroids and NEO monitoring. The physics of impact crater formation including contact- and compression, excavation, and modification provide the base for understanding geological phenomena in terrestrial and planetary craters. The principles of the progressive shock metamorphism as well as impact petrography are taught in practical exercises. The course gives introductions to the morphology, structural geology, geophysical characteristics of impact craters, and their environmental effects on the hydrosphere and atmosphere. Modern techniques to investigate impact structures including remote sensing, computational simulation, and experimental methods are shown. Within the “Screening Earth” project, the participants undertake a crater search survey on earth utilizing Google Earth© imagery. Promising structures will be investigated in greater detail using geological maps, geophysical data, and further remote sensing resources. In an oral presentation the students introduce to their projects and assess the likelihood of the discovered structures being impact craters. Students will plan a scientific expedition to their discovered structures.
Learning and qualification goals	Students will be able to estimate the statistical risk and threat of impact events and know the basics of Near Earth Asteroids and NEO-monitoring. The successful student can recapitulate the short-term geological and physical processes that occur during an impact. Students will deduce impact en-

	ergies from crater morphologies and are able to determine the age of a planetary surface by measuring the size-frequency distribution of impact craters on it. They will be able to correctly describe impact lithologies, impact-induced microstructures, and impact structures. These skills will enable them to become competent in discovering new impact structures on Earth using remote sensing techniques, where they will be responsible for planning and conducting their own project (project “Screening Earth”). Here, they will improve their skills in scientific presentations and defend their ideas in scientific debates. They will learn to prepare the logistics for a scientific expedition.
Coursework	
Graded assessment	• Written examination (90 min.) • Homework (calculations) • Oral presentation
Grading	• Written examination 70& • Homework 15% • Oral presentation 15%
Applicability of the Module	--
Modul Number	10LE09MO-2019-470/570
Course Number	10LE09V-2019-470/570
GA Nummber	10LE09MO-2019-470/570-P1

5.3.2.5 Shock Waves in Rocks

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Shock Waves in Rocks I (a)	L + Ü	3	2	WP	PL	1
Shock Waves in Rocks II (b)	L + Ü	2	2	WP	PL	2

Workload of the module	150 h total	(a) 30 h; (b) 30 h classroom-based course of study	(a) 60 h; (b) 30 h independent study
Weekly contact hours	2		
Responsible person	Prof. Dr. Thomas Kenkmann		
Lecturer	Prof. Dr. Frank Schäfer		
Participation requirements according to the examination regulations			
Expected prior knowledge and notes on preparation			
Language/s	English		
Module duration	1 Semester		
Frequency of offer	(a) Winter Semester (b) Summer Semster		
Teaching/ learning forms	(a) Alternating lectures and exercises (b) Workshop: alternating lectures and exercises		
Modul Content	a) The lecture starts with an introduction into shock waves, where they occur, and what they are applied for. A mathematical description of shock waves in one dimension is then given, starting from first principles. Also, the concept of equation of state for solids is introduced, and how to use them for shock wave computations. The lecture includes a number of exercises, also including computations with spreadsheets. b) The lecture starts with an introduction in to thermodynamic theory. Then, the principles of the shock- and release processes are taught, followed by computations of the thermodynamic heating of materials following a shockwave passage. The lecture includes a number of exercises, using spreadsheets.		
Learning and qualification goals	Collisions of planetary bodies are among the most fundamental processes in solar system. During such impact processes, the materials of the involved bodies are subject to extreme dynamical loads that are always associated with the generation and propagation of shock waves. The students achieve a basic understanding of the fundamentals of shock wave physics, applications of shock waves, the mathematical description of shock waves in one dimension, and the thermodynamic processes relevant for meteorite impact. They are able to draw conclusions from the respective mathematical equations and develop simple implementation in computer codes.		
Coursework			
Graded assessment	• Written examination (90 min.) • Homework (analytical and computer-based calculations)		

Grading	• Written examination 50% • Homework 50%
Applicability of the Module	--
Modul Number	10LE09MO-2019-480
Course Number	(a) 10LE09V-2019-480-1 (b) 10LE09V-2019-480-2
GA Nummber	10LE09MO-2019-480-P1

5.3.2.6 Remote Sensing

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Remote Sensing	L + Ü	5	4	WP	PL	1

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. Thomas Kenkmann		
Lecturer	Dr. Filippo Carboni		
Participation requirements according to the examination regulations			
Expected prior knowledge and notes on preparation	The module Geographic Information Systems must have been completed.		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Winter Semester only – biannual next: WiSe 2025/26		
Teaching/ learning forms	Lecture and practical work		
Modul Content	The course gives students a thorough understanding of digital remote sensing and analysis techniques and applications. The module explores basic principles of remote sensing and the use of suitable software packages for quantitative analysis, e.g. GIS. In addition, the students will be trained to perform qualitative analyses with special focus on visual image interpretation. The course combines lecture-based teaching with linked practical exercises and includes case studies from the focus areas of the M.Sc. Geology program.		
Learning and qualification goals	The increasing quality, resolution and availability of remote sensing data, especially over the last years, permit unprecedented opportunities for geological and geomorphological analyses with a high measure of precision. The applications of remote sensing analyses show a strong multidisciplinary character and consequently, the use, handling and analysis of such data has become indispensable in modern geosciences. The students should gain both a theoretical and practical understanding of remote sensing data and the ability to work independently using appropriate software applications for geoscientific issues.		
Coursework			
Graded assessment	• Homework (computer-based data analysis) • Written project report		
Grading	• Homework 60% • Written project report 40%		
Applicability of the Module	--		
Modul Number	10LE09MO-2019-490		
Course Number	10LE09MO-2019-490		
GA Nummber	10LE09PL-2019-490-P1		

5.3.2.7 Engineering Geology and Geotechnics

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Introduction to Engineering Geology (a)	L	2,5	2	WP	SL+PL	2
Geotechnical Projects (b)	S	2,5	2	P		

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study

Weekly contact hours	4
Responsible person	Prof. Dr. Frank Preusser
Lecturer	Prof. Dr. Frank Preusser
Participation requirements according to the examination regulations	• None
Expected prior knowledge and notes on preparation	• None
Language/s	English
Module duration	1 Semester
Frequency of offer	Winter Semester only
Teaching/learning forms	(a) Lecture mixed with practical exercises (b) Seminar
Modul Content	(a) The course will introduce basic concepts, nomenclature and problems of applied geology with a focus on physical properties of unconsolidated sediments (soils). This will be combined with some practical work on basic methods and approaches. (b) Students will put together an oral presentation on a selected geotechnical project and will present and discus this in class.
Learning and qualification goals	Many students will find work in the field of engineering and environmental geology. This course aims at providing the necessary basic background in this field. Attendees will be familiar with the basic concepts, nomenclature and problems of applied geology and hence should be able to communicate about and approach applied aspects in geosciences.
Coursework	• (a) Active participation in the exercises; • (b) Attendance of the seminar
Graded assessment	• (a) Written examination about (90 minutes) • (b) Lab report about • (b) oral presentation
Grading	• (a) Written examination 60 % • (a) Lab report about 10 % • (b) oral presentation 30 %
Applicability of the Module	--
Modul Number	10LE09MO-2019-610/495/595
Course Number	(a) 10LE09V-2019-610/495/595-1 (b) 10LE09V-2019-610/495/595-2
GA Nummber	CW: 10LE09S L-2019-610/495/595-SL GA: 10LE09PL-2019-610/495/595-P1

5.3.3 Required elective Modules Geohazards

5.3.3.1 Mass Movements

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Mass Movements	L	5	3	WP	SL+PL	2

Workload of the module	150 h total	45 h classroom-based course of study	105 h independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. Stefan Hergarten		
Lecturer	Prof. Dr. Stefan Hergarten		
Participation requirements according to the examination regulations			
Expected prior knowledge and notes on preparation	• The module Computing in Geosciences must have been completed.		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Summer Semester only		
Teaching/learning forms	Lecture mixed with practical exercises and homework.		
Modul Content	The class starts with an overview over the various processes of mass movements and their characteristic properties. Afterwards the basic models of slope stability are discussed (method of slices, Bishop's method). The main part of the module concerns the different types of rapid mass movements (sliding, falling, avalanching) and their quantitative description. Understanding is deepened by exercises covering the range from implementation of simple models to hazard assessment.		
Learning and qualification goals	Mass movements are the most important type of geohazards in mountainous regions. Assessing hazard and risk related to the various types of mass movements (shallow and deep-seated landslides, rockslides, rockfalls, rock avalanches, debris flows, and snow avalanches) is one of the biggest fields of professional activity in the context of geohazards. The module provides a basic understanding of the respective processes, their representation by differential equations and their implementation in numerical models. The students learn how to implement the simplest versions of the models in own computer codes (MATLAB), to assess which type of model is suitable for a given situation, and where the limitations in application to real-world scenarios are.		
Coursework			
Graded assessment	• Homework (computer-based calculations) to be solved during the semester.		
Grading	• Homework 100%		
Applicability of the Module	--		
Modul Number	10LE09MO-2019-120		
Course Number	10LE09V-2019-540		
GA Nummber	10LE09MO-2019-540-P1		

5.3.3.3 Natural Hazards

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Natural Hazards	L	5	4	WP	SL+PL	2

Workload of the module	150 h total	45 h classroom-based course of study	105 h independent study

Weekly contact hours	4
Responsible person	Prof. Dr. M. Hanewinkel; Prof. Dr. K. Stahl; Prof. Dr. F. Preusser
Lecturer	Prof. Dr. M. Hanewinkel; Prof. Dr. K. Stahl; Prof. Dr. F. Preusser
Participation requirements according to the examination regulations	
Expected prior knowledge and notes on preparation	The module Computing in Geosciences must have been completed.
Language/s	English
Module duration	1 Semester
Frequency of offer	Summer Semester only
Teaching/learning forms	Lecture mixed with practical exercises and homework.
Modul Content	The course deals with the major natural hazards that globally affect ecosystems and human societies such as geological, hydrological, meteorological and climatological hazards. Based on the general framework of the risk management process it defines hazard types, definitions and concepts (incl. vulnerability) and introduces into the major steps of the process including risk identification, risk evaluation (assessment), risk handling and differentiates between risk and crisis management. The module then gives more in-depth introductions into hydroclimatic hazards such as heavy floods as well as drought and low floods including processes and characteristics as well as indices and impact based forecasting. It deals as well includes mass movements such as slumps, debris flows and rockfalls as well as sea level rise, coastal erosion, deposition and flooding. Basics regarding earthquakes and tsunamis will be introduced. Climate extremes such as heatwaves, wildfires and strong winds will be dealt with. Abiotic and biotic disturbances to forests such as storm, snow and pest and diseases will be introduced together with management strategies to minimize the impact of these disturbances like integrated pest management. Socio-economic aspects like attitude towards risk and different types of cause- and effect-oriented risk handling strategies will be taught. Methodological topics such as modelling and more detailed management approaches will be developed separately in different topical groups (hydro- geo -and forestry related topics) together with the supervisors. Based on annotated bibliographies that are discussed with supervisors the students prepare individual presentations in small groups that can deal with either case studies or more complex research topics e.g. on compound hazards events that are then presented and discussed in several sessions with whole group of the course.
Learning and qualification goals	• Students can/are capable of/have to knowledge of: • To apply a generalized framework for the identification, evaluation and handling of risks to the different hazards that are presented in the module

	• To assess and evaluate the most important facts and handling tools (such as maps, indices, monitoring systems…) related to the discussed hazard • To select relevant information (scientific articles, web-based information…) related to the chosen topical hazards and produce an annotated bibliography for the chosen hazard • To present a relevant case study or more complex research topic (e.g. compound hazards) to the group and discuss the topic
Coursework	
Graded assessment	• Presentation of 20 minutes of a specific topic of the course + 10 minutes' discussion – by two students jointly (10 minutes each) - 80% of the mark for the presentation (40% for correctness of the content and 40% for quality of the oral presentation) – 20% for an annotated bibliography and topic proposal).
Grading	• Presentation of 20 minutes of a specific topic of the course + 10 minutes' discussion – by two students jointly (10 minutes each) - 80% of the mark for the presentation (40% for correctness of the content and 40% for quality of the oral presentation) – 20% for an annotated bibliography and topic proposal).
Applicability of the Module	--
Modul Number	10LE07MO-M.13006
Course Number	10LE07V-M.13006
GA Nummber	10LE07PL-M.13006

5.3.3.4 Impact Geology

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Impact Geology	L + Ü	5	4	WP	PL	1 or 3

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. T. Kenkmann		
Lecturer	Prof. Dr. T. Kenkmann		
Participation requirements according to the examination regulations			
Expected prior knowledge and notes on preparation			
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Winter Semester only – biannual next: WiSe 2025/26		
Teaching/ learning forms	Lecture, exercises, project Screening Earth with presentation		
Modul Content	The collision of solid bodies is one of the most fundamental geological processes in our solar system forming and reshaping planetary surfaces. The size-frequency distribution of impact craters on planetary surfaces and the current cratering rate and impact probability are presented including mitigation strategies. Composition and provenance of asteroids, comets and meteorites and their importance as possible impacting projectiles are highlighted. Special emphasis is drawn on Near Earth Asteroids and NEO monitoring. The physics of impact crater formation including contact- and compression, excavation, and modification provide the base for understanding geological phenomena in terrestrial and planetary craters. The principles of the progressive shock metamorphism as well as impact petrography are taught in practical exercises. The course gives introductions to the morphology, structural geology, geophysical characteristics of impact craters, and their environmental effects on the hydrosphere and atmosphere. Modern techniques to investigate impact structures including remote sensing, computational simulation, and experimental methods are shown. Within the "Screening Earth" project, the participants undertake a crater search survey on earth utilizing Google Earth© imagery. Promising structures will be investigated in greater detail using geological maps, geophysical data, and further remote sensing resources. In an oral presentation the students introduce to their projects and assess the likelihood of the discovered structures being impact craters. Students will plan a scientific expedition to their discovered structures.		
Learning and qualification goals	Students will be able to estimate the statistical risk and threat of impact events and know the basics of Near Earth Asteroids and NEO-monitoring. The successful student can recapitulate the short-term geological and phys-		

	ical processes that occur during an impact. Students will deduce impact energies from crater morphologies and are able to determine the age of a planetary surface by measuring the size-frequency distribution of impact craters on it. They will be able to correctly describe impact lithologies, impact-induced microstructures, and impact structures. These skills will enable them to become competent in discovering new impact structures on Earth using remote sensing techniques, where they will be responsible for planning and conducting their own project (project "Screening Earth"). Here, they will improve their skills in scientific presentations and defend their ideas in scientific debates. They will learn to prepare the logistics for a scientific expedition.
Coursework	
Graded assessment	• Written examination (90 min.) • Homework (calculations) • Oral presentation
Grading	• Written examination 70& • Homework 15% • Oral presentation 15%
Applicability of the Module	--
Modul Number	10LE09MO-2019-470/570
Course Number	10LE09V-2019-470/570
GA Nummber	10LE09MO-2019-470/570-P1

5.3.3.5 Engineering Geology and Geotechnics

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Introduction to Engineering Geology (a)	L	2,5	2	P	SL+PL	2
Geotechnical Projects (b)	S	2,5	2	P		

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. Frank Preusser		
Lecturer	Prof. Dr. Frank Preusser		
Participation requirements according to the examination regulations	• None		
Expected prior knowledge and notes on preparation	• None		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Winter Semester only		
Teaching/learning forms	(a) Lecture mixed with practical exercises (b) Seminar		
Modul Content	(a) The course will introduce basic concepts, nomenclature and problems of applied geology with a focus on physical properties of unconsolidated sediments (soils). This will be combined with some practical work on basic methods and approaches. (b) Students will put together an oral presentation on a selected geotechnical project and will present and discus this in class.		
Learning and qualification goals	Many students will find work in the field of engineering and environmental geology. This course aims at providing the necessary basic background in this field. Attendees will be familiar with the basic concepts, nomenclature and problems of applied geology and hence should be able to communicate about and approach applied aspects in geosciences.		
Coursework	• (a) Active participation in the exercises; • (b) Attendance of the seminar		
Graded assessment	• (a) Written examination about (90 minutes) • (b) Lab report about • (b) oral presentation		
Grading	• (a) Written examination 60 % • (a) Lab report about 10 % • (b) oral presentation 30 %		
Applicability of the Module	--		
Modul Number	10LE09MO-2019-610/495/595		
Course Number	(a) 10LE09V-2019-610/495/595-1 (b) 10LE09V-2019-610/495/595-2		
GA Nummber	CW: 10LE09S L-2019-610/495/595-SL GA: 10LE09PL-2019-610/495/595-P1		

5.3.4 Required elective Modules Applied Quaternary Geology

5.3.4.1 Quaternary Research

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Quaternary Geology	L	5	4	WP	PL	1 or 3

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. Frank Preusser		
Lecturer	Prof. Dr. Frank Preusser		
Participation requirements according to the examination regulations	• None		
Expected prior knowledge and notes on preparation	• Basic understanding of geology and sedimentology.		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Winter Semester only- biannual next: WiSe 2025/26		
Teaching/learning forms	Lecture, seminar and practical work.		
Modul Content	This course concentrates on 1) an introduction to the main proxies used for environmental/climatic reconstruction, 2) an introduction to the dating methods most commonly used in Quaternary research, and 3) an overview of the history of main environmental and climatic changes that occurred during the Quaternary. After this course students will gain a comprehensive picture of Quaternary research and will be able to design projects related to the multi-proxy analysis of climate/environmental change in various contexts. They will themselves present the regional Quaternary geology of selected regions such as the Upper Rhine Graben, the northern Alpine Foreland or Northern Germany.		
Learning and qualification goals	Students who successfully complete this module will have developed an understanding of how environmental conditions in the recent past are reconstructed and on how the Earth changed during the Quaternary. They will also know about the structure of Quaternary deposits in key regions of our planet.		
ursework			
Graded assessment	• Written exam (50 %, 75 minutes), oral presentation (30%) and project report (20 %)		
Grading	• Written examination 50% • Oral presentation 30 % • Project report about 20 %		
Applicability of the Module	--		
Modul Number	10LE09MO-2019-640		
Course Number	10LE09V-2019-640		
GA Nummber	10LE09MO-2019-640-P1		

5.3.4.3 Computing in Geosciences

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Computing in Geosciences	L + E	5	4	P	SL	2

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. Stefan Hergarten		
Lecturer	Prof. Dr. Stefan Hergarten		
Participation require-ments according to the examination regulations	• None		
Expected prior knowledge and notes on preparation	• Basic knowledge in mathematics and computing, e.g., on the level of “Modellierung and “Datenanalyse” from the B.Sc. Geowissenschaften		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Winter Semester only		
Teaching/learning forms	• Lecture • Practical exercises • Homework		
Modul Content	Numerical data analysis, visualization, and process modeling have become essential parts of quantitative geosciences. The successful students are able to describe simple processes in terms of differential equations and are able to implement fundamental schemes (finite difference methods) for the numerical solution in a high-level programming language (MATLAB). Beyond this, the students shall be able to assess which method is suitable for a given problem and be aware of potential pitfalls.		
Learning and qualification goals	The class starts with an introduction to process modeling using simple population models based on ordinary differential equations und their implementation using explicit and implicit Euler schemes. The following main part of the module comprises the basic equations behind the models widely used for modeling mass and heat transport processes, solid mechanics, groundwater flow, and landform evolution based on partial differential equations. After discussing the respective equations, the underlying principles, and their mathematical properties, the simplest numerical techniques in the field of partial differential equations (finite differences, upstream schemes) are discussed. Theory is accompanied by a step-by-step introduction to the MATLAB programming environment and exercises focusing on implementing the models in MATLAB and analysing the results.		
Coursework	• None		
Graded assessment	• marked homework to be solved during the semester (software development and mathematical considerations) and • online exercises to be solved in the class		
Grading	• Homework 85 % • online exercises 15 %		

Applicability of the Module	--
Modul Number	10LE09MO-2019-410/510/670
Course Nummer	10LE09V-2019-410/510/670
PL Nummer	10LE09PL-2019-410/510/670-P1

5.3.4.4 Petrophysics

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Petrophysics (a)	L +Ü	2,5	2	WP	PL	2
Rheology and Textures (b)		2,5	2			
Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study			
Weekly contact hours	4					
Responsible person	Prof. Dr. T. Kenkmann					
Lecturer	(a) Prof. Dr. T. Kenkmann; Dr. M. Poelchau (b) Dr. M. Poelchau					
Participation requirements according to the examination regulations	• Experience in polarized light microscopy is beneficial.					
Expected prior knowledge and notes on preparation	-------------					
Language/s	English					
Module duration	1 Semester					
Frequency of offer	Winter Semester only – biannual next: WiSe 2025/26					
Teaching/learning forms	(a) Lecture + Exercises/Homework (b) Lecture and practical work at the polarizing microscope.					
Modul Content	a) Petrophysics is the study of the physical properties of rocks. Its objective is to explain why rocks have the properties they do. In particular, how the relative amounts and arrangements of the minerals that comprise them determine their physical properties. Petrophysics is key in numerous applications of geosciences and various fields of rock engineering and well logging. The course program comprises the following sections: (i)Rock classifications, (ii) Density, (iii) Porosity & Permeability, (iv) Radioactive Properties, (v) Geomechanical Properties (vi) Electrical properties, (vii) Magnetic properties, (viii) Well-logging. (b) Rheology is the study of the flow of matter. In Earth Sciences the focus of rheology is on the ductile flow of mid- and lower crustal rocks in response to applied forces at elevated temperatures. This course is designed to introduce the theory of plasticity and presents various flow laws (Newtonian, power law, etc.) of rocks and how these were determined. The flow behavior is compared with deformation mechanisms operating in the ductile field (diffusion creep, dislocation creep, dislocation glide, etc.). A major goal of the course is to gain practice in interpreting deformation features observed in rock thin sections under the polarizing microscope. A crucial role in deciphering deformation mechanisms is the analysis of shape- and crystallographic preferred orientations of deformed polycrystalline aggregates. Techniques are presented how rock textures can be measured and interpreted.					
Learning and qualification goals	(a) The successful student is getting acquainted with the petrophysical properties of the most important rock types. They quantitatively determine and measure porosities, mineral constituents, fabric of rocks etc. and correlate					

	them with petrophysical data. Students are enabled to interpret petrophysical borehole data with respect to lithology, porosity, structure, and economic potential. (b) Students will describe rock fabrics and mineral constituents of metamorphic and igneous rocks making use of polarizing microscopes. They will identify and describe shape-preferred orientations as well as crystallographic preferred orientations. They will recall and apply techniques to measure rock textures and interpret pole figures and orientation distribution functions. Based on rock textures and fabric analysis the successful students are able to decipher deformation mechanisms and associated flow laws of natural rocks and estimate the conditions during deformation (pressure, temperature, strain, strain rate).
Coursework	Regular attendance in the practical parts of (a) and (b) completion of exercises (a)
Graded assessment	• Written examination (90 minutes), • Presentation the project work in oral and written form (b)
Grading	• Written examination 60 % • Project work 40 %
Applicability of the Module	--
Modul Number	10LE09MO-2019-340
Course Number	(a) 10LE09V-2019-340-1 (b) 10LE09V-2019-340-2
GA Nummber	GA: 10LE09MO-2019-340-P1

5.3.4.5 Rock Mechanics

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Stress and Strain (a)	L +Ü	2,5	2	WP	PL	2
Brittle Rock Deformation (b)		2,5	2			

Workload of the module	150 h total	60 h classroom-based course of study	90 h independent study
Weekly contact hours	4		
Responsible person	Prof. Dr. T. Kenkmann		
Lecturer	(a) Prof. Dr. T. Kenkmann; Dr. M. Poelchau (b) Dr. M. Poelchau		
Participation requirements according to the examination regulations	• The module Computing in Geosciences should be either completed or attended in the same semester.		
Expected prior knowledge and notes on preparation	-------------		
Language/s	English		
Module duration	1 Semester		
Frequency of offer	Winter Semester only – biannual next: WiSe 2024/25		
Teaching/learning forms	(a) Lecture + exercises (b) Lecture, exercises and laboratory work		
Modul Content	(a) Forces which are responsible for the deformations of the earth's crust act instantaneously and cannot be stored in rocks through time. Deformations of rocks are persistant and all the studied deformations are old, but the related stresses are not visible any more. Furthermore, it is impossible to measure stress directly and only very special fabrics allow to describe state and direction of stresses. Nevertheless, one of the major goals of the lecture is to understand the distribution of forces in the earth and how those forces act to produce the different structures. There are lots of practical reasons to do this: earthquakes, oil well blowouts, motor of plate tectonics, landslides etc. The deals with stress acting on a plane and stress at a point leading to the concept of principle and deviatory stresses, which mathematically are described by stress tensor and 3x3 stress matrix. Different states of stresses and stress fields are introduced and presented methods of measurements include fault-slip analysis, stylolites, wellbore break-out, etc. The strain concept is mathematically based on continuous deformation thus strain is a branch continuum mechanics. In nature deformation is much more complex and far beyond being continuous. In this lecture all different aspects of a deforming rock system are introduced i.e. homogeneous vs. heterogeneous strain, progressive strain, infinitesimal vs. finite strain. We introduce to various quantitative strain measurement techniques including Fry and Rf-phi. (b) Brittle rock deformation is concerned with evaluating, through controlled laboratory experiments, the effects of environmental and material factors on the deformational behavior of rocks. The course deals with rock elasticity,		

	friction, various modes of brittle failure, brittle-toductile transition, plastic deformation, and dynamic deformation. The course consists of a theoretical part and a practical part.
Learning and qualification goals	(a) The successful student is getting acquainted with matrix calculations to calculate principal stress and strain states in rocks and to determine orientation of the principal axis of stress and strain. Students use graphical techniques to determine normal and shear stresses. Students become familiar with various methods of paleo-stress measurement and the measurement of recent stress fields in the crust. The quantification of strain accumulated in rocks is trained as well. Students get familiar with connecting stress and strain in linear isotropic elastic materials. (b) Students become familiar with the concepts of rock deformation and know how to derive rock mechanical characteristics such as the tensile strength, uniaxial compressive strength, Mohr-Coulomb strength, dynamic and static friction, Poisson ratio, Young Modulus, Tangent Modulus, and the dynamic increase factor.
Coursework	(a) Homework (b) Report of the experimental analyses
Graded assessment	• Written examination (a + b) • lab report about (b) (10 %)
Grading	• Written examination 90 % • Lab report 10 %
Applicability of the Module	--
Modul Number	10LE09MO-2019-450/690
Course Number	(a) 10LE09MO-2019-450/690-1 (b) 10LE09MO-2019-450/690-2
GA Nummber	GA: 10LE09MO-2019-450/690-P1

5.3.4.6 Natural Hazards

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Natural Hazards	L	5	4	WP	SL+PL	2
Workload of the module	150 h total		45 h classroom-based course of study		105 h independent study	
Weekly contact hours	4					
Responsible person	Prof. Dr. M. Hanewinkel; Prof. Dr. K. Stahl; Prof. Dr. F. Preusser					
Lecturer	Prof. Dr. M. Hanewinkel; Prof. Dr. K. Stahl; Prof. Dr. F. Preusser					
Participation require-ments according to the examination regulations						
Expected prior knowledge and notes on preparation	The module Computing in Geosciences must have been completed.					
Language/s	English					
Module duration	1 Semester					
Frequency of offer	Summer Semester only					
Teaching/learning forms	Lecture mixed with practical exercises and homework.					
Modul Content	The course deals with the major natural hazards that globally affect ecosystems and human societies such as geological, hydrological, meteorological and climatological hazards. Based on the general framework of the risk management process it defines hazard types, definitions and concepts (incl. vulnerability) and introduces into the major steps of the process including risk identification, risk evaluation (assessment), risk handling and differentiates between risk and crisis management. The module then gives more in-depth introductions into hydro climatic hazards such as heavy floods as well as drought and low floods including processes and characteristics as well as indices and impact based forecasting. It deals as well includes mass movements such as slumps, debris flows and rock falls as well as sea level rise, coastal erosion, deposition and flooding. Basics regarding earthquakes and tsunamis will be introduced. Climate extremes such as heatwaves, wildfires and strong winds will be dealt with. Abiotic and biotic disturbances to forests such as storm, snow and pest and diseases will be introduced together with management strategies to minimize the impact of these disturbances like integrated pest management. Socio-economic aspects like attitude towards risk and different types of cause- and effect-oriented risk handling strategies will be taught. Methodological topics such as modelling and more detailed management approaches will be developed separately in different topical groups (hydro- geo -and forestry related topics) together with the supervisors. Based on annotated bibliographies that are discussed with supervisors the students prepare individual presentations in small groups that can deal with either case studies or more complex research topics e.g. on compound hazards events that are then presented and discussed in several sessions with whole group of the course.					
Learning and qualification goals	• Students can/are capable of/have to knowledge of: • To apply a generalized framework for the identification, evaluation and handling of risks to the different hazards that are presented in the module					

	• To assess and evaluate the most important facts and handling tools (such as maps, indices, monitoring systems…) related to the discussed hazard • To select relevant information (scientific articles, web-based information…) related to the chosen topical hazards and produce an annotated bibliography for the chosen hazard • To present a relevant case study or more complex research topic (e.g. compound hazards) to the group and discuss the topic
Coursework	
Graded assessment	• Presentation of 20 minutes of a specific topic of the course + 10 minutes' discussion – by two students jointly (10 minutes each) - 80% of the mark for the presentation (40% for correctness of the content and 40% for quality of the oral presentation) – 20% for an annotated bibliography and topic proposal).
Grading	• Presentation of 20 minutes of a specific topic of the course + 10 minutes' discussion – by two students jointly (10 minutes each) - 80% of the mark for the presentation (40% for correctness of the content and 40% for quality of the oral presentation) – 20% for an annotated bibliography and topic proposal).
Applicability of the Module	--
Modul Number	10LE07MO-M.13006
Course Number	10LE07V-M.13006
GA Nummber	10LE07PL-M.13006

5.3.5 Further required elective Modules regardless of which Track

5.3.5.1 Chemical Thermodynamics of Geomaterials

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Chemical Thermodynamics of Geomaterials	L	5	3	WP	SL+PL	2
Workload of the module	150 h total	45 h classroom-based course of study		105 h independent study		
Weekly contact hours	4					
Responsible person						
Lecturer						
Participation requirements according to the examination regulations						
Expected prior knowledge and notes on preparation	• The module Computing in Geosciences must have been completed.					
Language/s	English					
Module duration	1 Semester					
Frequency of offer	Summer Semester only					
Teaching/learning forms	Combination of lectures and practical sessions.					
Modul Content	• Review of thermodynamic laws and functions • Thermodynamic processes and phase transformations • Thermal properties of substances • Pressure-temperature-volume equations of state • Partial properties and mixing • Thermodynamic models for mixtures (solid solutions, melts) • Pressure-temperature-volume models for fluids and gases • Thermodynamic origin of phase stability and phase diagrams • Mathematical methods for calculation of phase diagrams					
Learning and qualification goals	Thermodynamics provides universal basis for understanding stability, equilibria, transformations and reactions of materials. Thermodynamic modelling of phase equilibria, construction of phase diagrams and prediction of element partitioning between phases form basis for interpretation of pressure-temperature paths of metamorphic rocks, for modelling differentiation mechanisms of magmas as well as to design and optimize numerous technological processes such as material syntheses, crystallization, smelting, combustion, fluid extraction etc. This module focuses on thermodynamic properties of solid, liquid and gaseous phases that govern their stability and phase equilibria. We will discuss behaviour of solids, melts and fluids at high temperature and pressure, equations of state, thermodynamic datasets for diverse applications and methods for prediction of phase equilibria and phase diagrams.					
Coursework						
Graded assessment	• Written report					
Grading	• Written report 100%					

Applicability of the Module	--
Modul Number	10LE09MO-2019-380
Course Number	10LE09MO-2019-380
GA Nummber	10LE09MO-2019-380-P1

5.3.5.2 Mineral Physics

<table>
<tr><th>Course(s)/ Modulparts</th><th>Type of course</th><th>ECTS</th><th colspan="2">SWS</th><th>P/WP</th><th>PL/SL</th><th>Rec.. Sem.</th></tr>
<tr><td>Mineral Physics</td><td>L</td><td>5</td><td colspan="2">4</td><td>WP</td><td>SL+PL</td><td>2</td></tr>
<tr><td>Workload of the module</td><td colspan="2">150 h total</td><td colspan="2">60 h classroom-based course of study</td><td colspan="3">90 h independent study</td></tr>
<tr><td>Weekly contact hours</td><td colspan="7">4</td></tr>
<tr><td>Responsible person</td><td colspan="7">JProf. Dr. Clemens Prescher</td></tr>
<tr><td>Lecturer</td><td colspan="7">JProf. Dr. Clemens Prescher</td></tr>
<tr><td>Participation requirements according to the examination regulations</td><td colspan="7"></td></tr>
<tr><td>Expected prior knowledge and notes on preparation</td><td colspan="7"></td></tr>
<tr><td>Language/s</td><td colspan="7">English</td></tr>
<tr><td>Module duration</td><td colspan="7">1 Semester</td></tr>
<tr><td>Frequency of offer</td><td colspan="7">Summer Semester only</td></tr>
<tr><td>Teaching/learning forms</td><td colspan="7">Lecture and exercises.</td></tr>
<tr><td>Modul Content</td><td colspan="7">• High pressure mineralogy (major stable phases in Earth and other planetary bodies)
• Thermodynamics (brief reminder)
• Experimental methods for performing high pressure and high temperature experiments
• Computational methods to study materials under extreme conditions
• Equations of state (static and shock)
• Pressure scales
• Elasticity
• Lattice dynamics
• Defects and their impact on physical properties
• Rheology
• Exercises
• Visualize and understand atomic structure of materials
• Focus on data analysis (e.g. matlab or python) of experimental methods
• Writing simple scripts for processing and visualization of data
• Processing high-pressure x-ray diffraction data (e.g. LeBail fit and equations of state fits)
• Performing simple ab-initio and molecular dynamic simulations (abinit).</td></tr>
<tr><td>Learning and qualification goals</td><td colspan="7">Mineral Physics is the study of mineralogical questions though the application of crystallography, condensed matter physics and solid-state chemistry. The goal of this course is understanding how the structure of materials and their physical and chemical properties have a strong connection to large-scale planetary processes. Investigation of thermodynamic and properties of minerals at the atomic scale are crucial to interpret and understand observational data from seismology, geodynamics geochemistry and planetary science. Students in this course will be introduced to different experimental and computational methods to study the structure, phase stability and properties of materials at extreme conditions prevalent in planetary interiors.</td></tr>
</table>

Coursework	
Graded assessment	• Oral presentation (on one recent paper) and exercise report/homework report (analysis of data with explanation and own scripts written)
Grading	• Oral presentation ----% • Written report ----%
Applicability of the Module	--
Modul Number	10LE09MO-2019-730
Course Number	10LE09MO-2019-730
GA Nummber	10LE09PL-2019-730-P1

5.3.5.3 Geothermics and Geothermal Energy

Course(s)/ Modulparts	Type of course	ECTS	SWS	P/WP	PL/SL	Rec.. Sem.
Geothermics and Geo-thermal Energy	L	5	4	WP	SL+PL	2

Workload of the module	150 h total	9 days (75 h) Will be scheduled before the regular start of lectures	75 h independent study

Weekly contact hours	4
Responsible person	Prof. Dr. David Dolejš
Lecturer	Prof. Dr. D. Dolejš and EUCOR instructors
Participation requirements according to the examination regulations	
Expected prior knowledge and notes on preparation	
Language/s	English
Module duration	1 Semester
Frequency of offer	Summer Semester only
Teaching/ learning forms	9-day short course at the geothermal site in Soultz-sous-Forêts (France) consisting of lectures, practical sessions, software exercises and field visits. The short course is offered at the beginning of the winter semester term, before the regular start of the lectures.
Modul Content	
Learning and qualification goals	• Despite its great potential the utilization of geothermal energy is still slowly emerging compared to other sources of renewable energy and continues to pose challenges concerning geology and engineering. This module is designed as practically oriented short course at a geothermal site and will cover the following topics: • local geological setting • visit to geothermal facility • evaluation of drill holes and site visit • geophysical monitoring of geothermal fields • fluid-rock interaction and modelling • numerical reservoir modelling • The students will acquire theoretical understanding and practical experience with design and exploitation of geothermal energy using specific geological, geophysical and geochemical methods and models.
Coursework	
Graded assessment	• Short quizzes during the course and final seminar presentation
Grading	• Short quizzes during the course and final seminar presentation 100%
Applicability of the Module	--
Modul Number	10LE09MO-2019-710
Course Number	10LE09V-2019-710
GA Nummber	10LE09V-2019-710-P1