EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

Module Handbook

as at: 10.04.24

Geowissenschaften / Geosciences
Master of Science

Faculty of Science
Department of Geosciences

Contents

1. Admission Requirements

Prerequisites for the Master's program in Geowissenschaften / Geosciences are

- a Bachelor's degree in the subject of geosciences, or in a related program covering basically the same material, or an equivalent degree in which a grade of 3.0 or better was achieved
- a proof of knowledge of English at least at the level of B2 of the Common European Framework of Reference for Languages (CEFR)
- a minimum of six credit points in each of the following subjects/areas of knowledge must be completed in the prior Bachelor's or Master's degree studies:
  Mathematics
  Physics
  Chemistry
  Geology
  Mineralogy
  Earth Evolution and Palaeontology

If courses up to 30 CP are lacking, an admission is possible with the condition to catch up these courses within the framework of a learning agreement.

2. Qualification Goals

The research-oriented M.Sc. program "Geowissenschaften / Geosciences" is designed for students holding an undergraduate degree in Geosciences and related fields who are interested in an advanced process-oriented, quantitative, research-driven graduate education in the field of Geosciences.

The Geociences M.Sc. program conveys the necessary subject-specific and general skills of professional geoscientists in industry, administration, and research using a multidisciplinary teaching approach combining in-depth scientific knowledge with the acquisition of key generic competences, such as self-management, organization and problem-solving capabilities.

While detailed subject-specific competences acquired in the M.Sc. Geosciences depend on the individual focus of a student, the compulsory modules convey general geoscientific skills:

- Collecting and interpreting geoscientific data in the field, and putting them into their spatial, stratigraphic, genetic, and process-related contexts;
- Analyzing field samples with up-to date analytical tools, and designing, performing, and interpreting geoscientific experiments in the laboratory or in the field;
- Performing quantitative data analysis of collected geoscientific data and modeling geoscientific systems for process analysis and prediction.

In order to reach these qualification goals, all Geosciences students receive an extensive compulsory practical and methodological training in the field, complemented by advanced qualifications in analytical and experimental skills, subsequent data processing and interpretative methods applicable to all geoscientific aspects.

Independent of the individual student focus a common goal is that graduates acquire advanced competences for the comprehensive understanding of the underlying physical, chemical and biological mechanisms, processes and concepts relevant to their respective fields of specialization.

Geodynamics and Geophysics deal with measuring and modeling the physical processes forming the Earth's surface and interior. **Mineralogy** has a focus on rock-forming processes, the relevant geological conditions and settings and the chemical and physical characterization of geomaterials. **Paleontology** investigates and characterizes paleoecosystems and the evolution of life in Earth history.

Independent from their field of specialization, geoscience graduates will be able to:
- define and analyze geological problem sets
- plan and undertake appropriate field and laboratory investigations
- present and interpret data

and will therefore readily be able to find employment with respect to both practical and scientific applications in a wide range of fields including:
- Consulting and implementation of geo-engineering projects
- Mining and processing of geogenic raw materials
- Georesource management
- Risk assessment (geohazards)
- Exploration of oil, gas and ore deposits/subsurface investigations
- Research, education and administration
- Ceramic, cement and glass industries
- Materials sciences and analytics industries

Furthermore, the M.Sc. Geosciences programs lay an excellent foundation for pursuing **doctoral studies** in programs of Earth Sciences.

3. Module Overview

The Master's degree in Geosciences is designed for a standard study period of two years.

For a successful degree, students acquire 120 credit points from a program of compulsory modules (30 CP), elective modules (60 CP) and the Master's thesis. Students can focus on one of three sub-disciplines (**Geodynamics and Geophysics** or **Mineralogy** or **Paleontology**) or complete the course **without specialization**.

Compulsory Modules and Specializations

The compulsory program for all students of the M.Sc. Geosciences includes two method oriented "container" modules and a field course for advanced students.

The two method oriented modules: 1) *Experimental and Analytical Methods in Geo- and Environmental Sciences,* and 2) *Data Analysis and Modeling Methods in Geo- and Environmental Sciences* allow students to freely combine three methodological units from the respective modules on offer. This enables them to acquire methodological competence in experimental/analytical fields as well as in the field of data analysis and modeling, which are needed for their individual study focus, e.g. as part of their Master's thesis.

The advanced field course, *Advanced Field Methods in Geoscience*, ensures that practical field training, which represents a key, unique selling point for geoscience graduates on the job market, is anchored in the compulsory teaching.

Two modules, *Scientific Practice* and *Scientific Presentation* complete the compulsory courses.

The aim of the *Scientific Practice* module is to impart important practical and methodological skills in the conception, planning and implementation of research projects and to include these within a planned written project, usually representing the Master's thesis.

The *Scientific Presentation* module serves to acquire communication and presentation skills. Students learn to communicate and discuss their research using various forms of presentations. This module encompasses three parts: 1) a presentation in a Master's seminar, 2) a

prepared lecture within the working group, and 3) the completion of a poster with the results of the Master's thesis which will be presented to an expert audience.

The compulsory elective area offers students the opportunity to specialize in one of the three areas: 1) *Mineralogy,* 2) *Paleontology*, or 3) *Geodynamics and Geophysics* or to complete their studies without specialization. Depending on the personal study orientation, three modules each are stipulated within these specific specializations, which contain basic study contents necessary for the offered subjects.

Studying without a specialization requires, in addition to the compulsory modules, the successful participation in three of a list of ten specified modules in order to ensure a sufficiently broad geoscientific qualification.

The remaining modules can be chosen as desired and allow for considerable specialization as well as the opportunity to study the entire field of geoscientific research. If course capacities allow, available modules from the M.Sc. Applied and Environmental Geoscience can also be selected.

Upon request, additional modules related to the content and qualification objectives of the course can be admitted as elective modules by the chairperson of the examination board.

Module Overview and Areas of Specializations

In order to support students who wish to specialize in one of the subject areas on offer with the selection of an individual study plan, a number of modules have been compiled that represent a useful addition to the elective program beyond that of the required core module combinations of the respective subject areas.

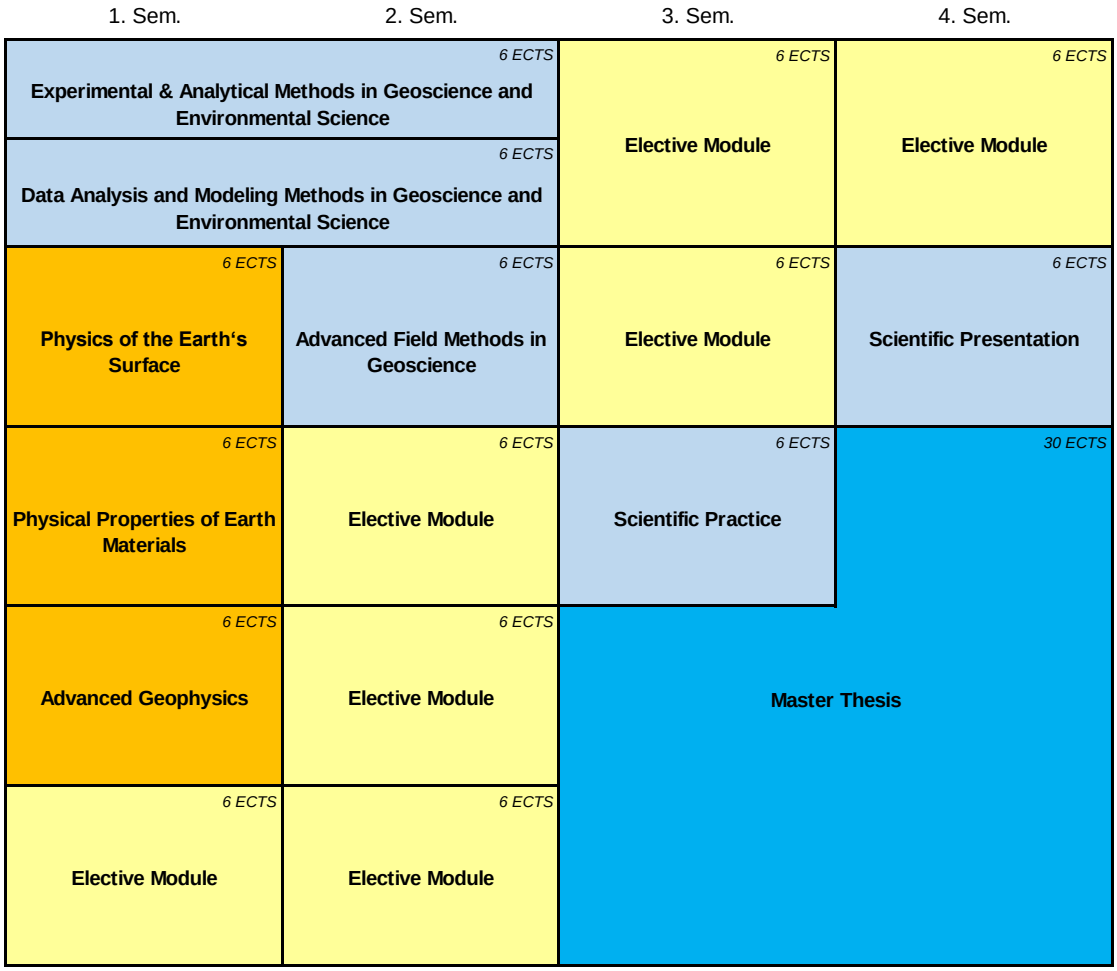
Medium of Instruction

The courses are offered in English. In the elective area, additional modules in German can also be chosen.

Specialization Geodynamics and Geophysics

MSc Geowissenschaften / Geosciences

Specialization: Geodynamics and Geophysics

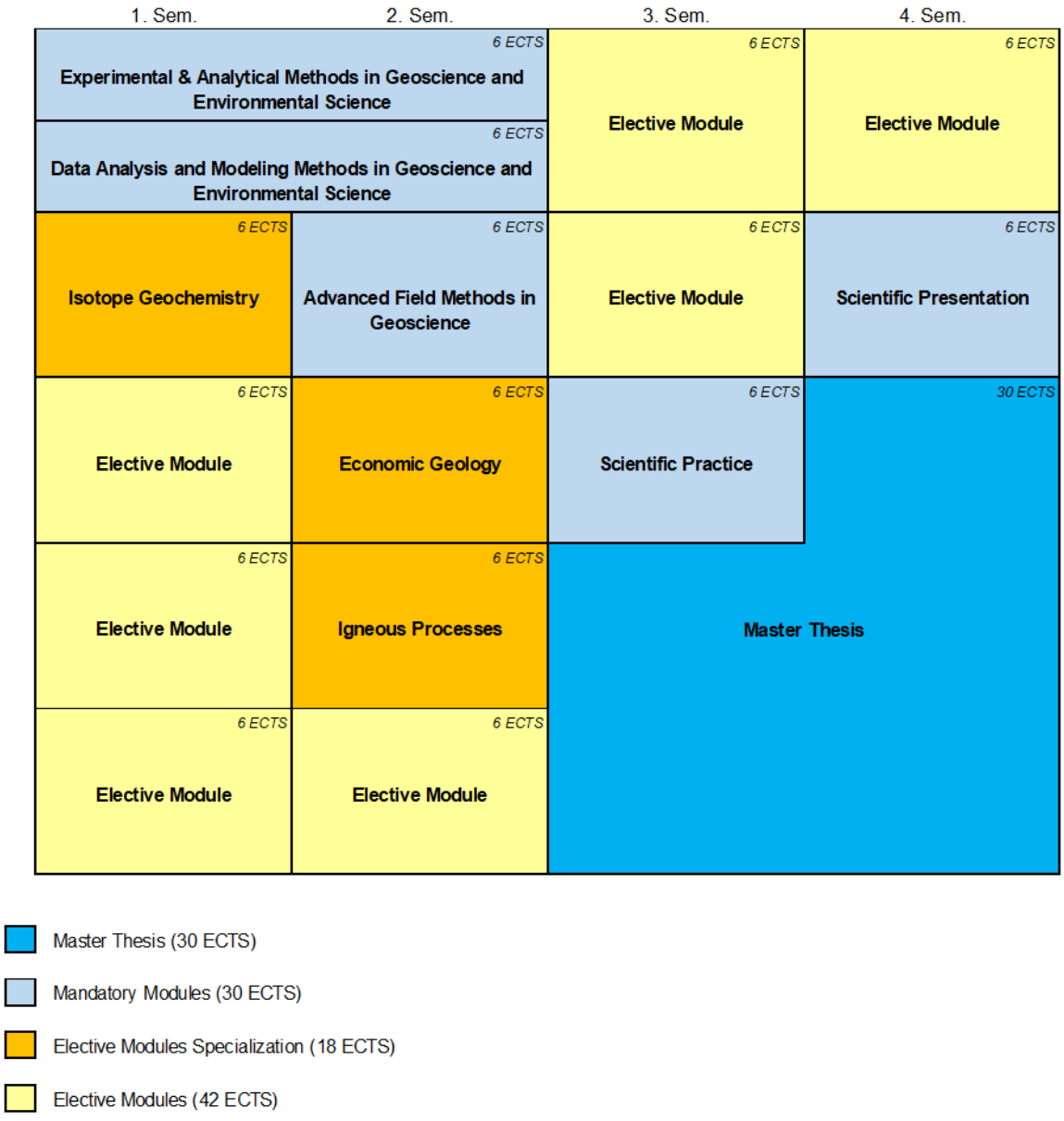


- Master Thesis (30 ECTS)
- Mandatory Modules (30 ECTS)
- Elective Modules Specialization (18 ECTS)
- Elective Modules (42 ECTS)

Specialization Mineralogy

MSc Geowissenschaften / Geosciences

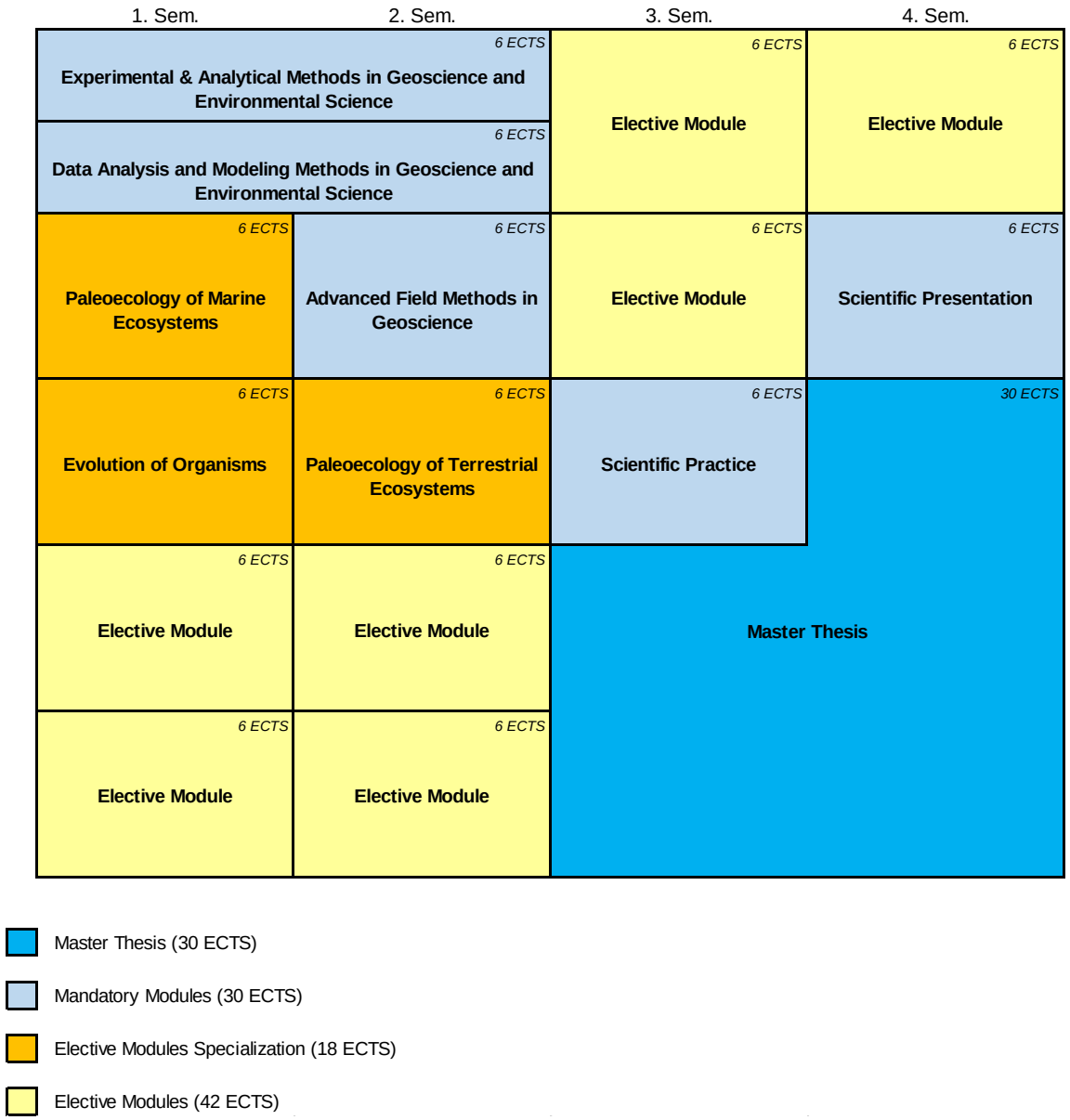
Specialization: Mineralogy



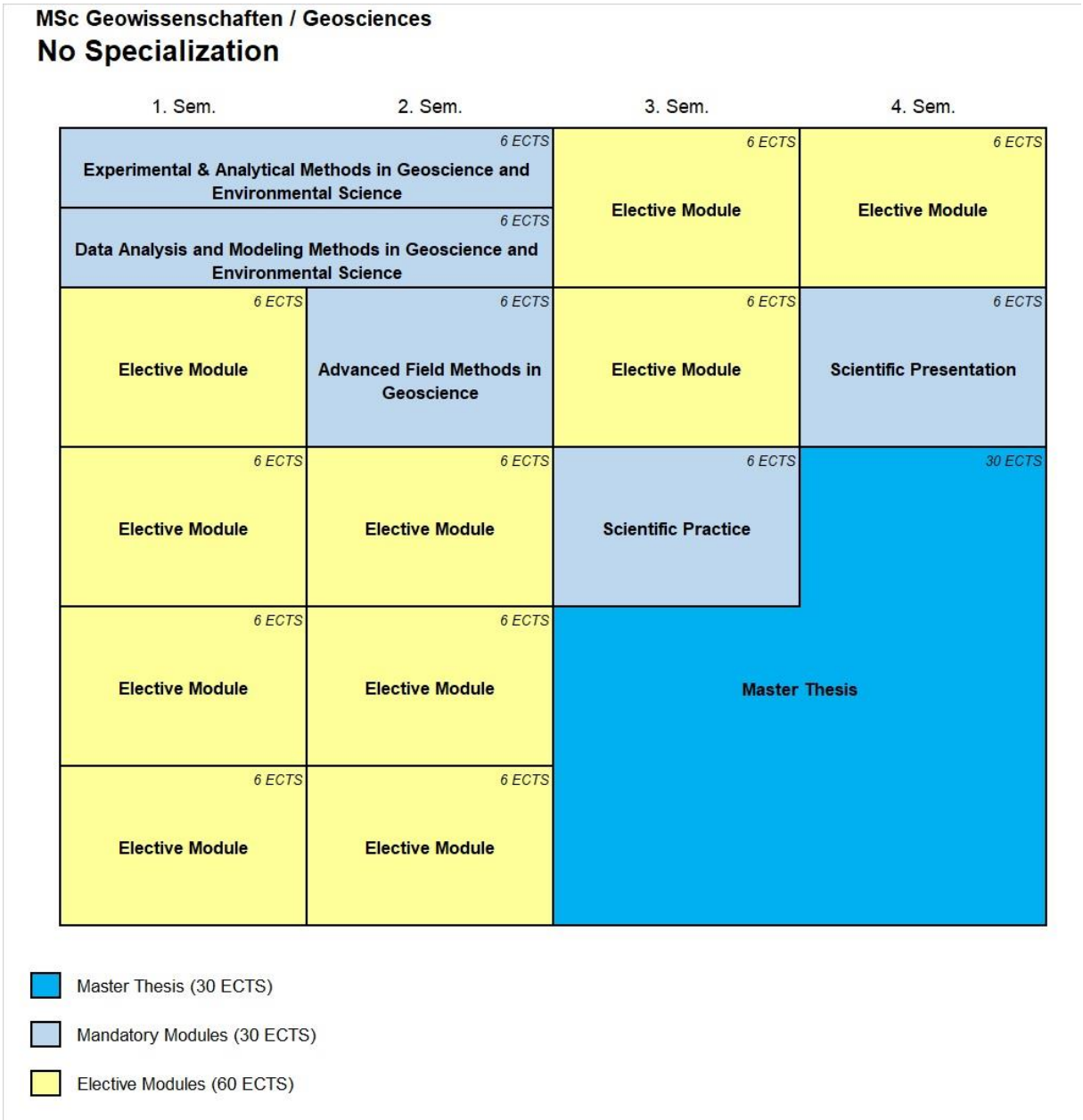
Specialization Paleontology

MSc Geowissenschaften / Geosciences

Specialization: Paleontology



Study without Specialization



In addition to the compulsory modules three modules of the following list need to be successfully completed:

- Advanced Geophysics
- Advanced Sedimentology
- Economic Geology
- Evolution of Organisms
- Igneous Processes
- Isotope Geochemistry
- Paleoecology of Marine Ecosystems
- Paleoecology of Terrestrial Ecosystems
- Physics of the Earth‘s Surface
- Physical Properties of Earth Materials

4. Module Handbook M.Sc. Geowissenschaften / Geosciences

This module handbook serves as a comprehensive overview for the Master's Degree in Geosciences at the University of Tübingen.

The content of the modules and the lecturers can be subject to change. The respective module coordinator is responsible for further information and questions concerning the individual modules.

Legende		**Legend**	
Benotungssystem:	b = benotet ub = unbenotet (bestanden/nicht bestanden) kP = keine Prüfung	**Grading System:**	g = graded ng = not graded (pass/fail) nE = no exam
Prüfungsform / Studienleistung:	K = Klausur MP = Mündliche Prüfung HA =Hausarbeit/Hausaufgaben, Bericht R = Referat/Präsentation LP =Laborprotokoll ET = erfolgreiche Teilnahme	**Assessment / Study Requirement:**	WE = written assessment OE = oral assessment A = assignment / term paper, written report R = report, presentation LP = lab protocol / journal SP = successful participation
Prüfungsdauer:	Dauer der Prüfung in *min*	**Duration of Assessment:**	Duration of the assessment in *min*
Gewichtung:	Gewichtung der Prüfungsnote für die Modulnote	**Weighting:**	Weighting of grade for the module
SWS:	Semesterwochenstunden	**CH:**	Credit Hours
Status:	o = obligatorisch f = fakultativ	**Status:**	c = compulsory op = optional
Art der Lehrform:	V = Vorlesung S = Seminar Ü = Übung/Tutorium GÜ = Geländeübung LP = Laborpraktikum PR = Projekt	**Type of Lecture:**	L = lecture S = seminar E = exercise/tutorial FC = field course LC = laboratory course PR = project
CP:	Leistungspunkte (ECTS-Punkte)	**CP:**	Credit Points (ECTS)

Compulsory Modules

Module Number	*Module Title*	*Module Coordinator*	*CP*	*Semes-ter*
M 101	Scientific Practice	Merkel	6	W / S
M 103	Scientific Presentation	Bocherens	6	W / S
M 104	Master Thesis (Abschlussmodul)	-	30	W / S
M 305	Advanced Field Methods in Geoscience	Bons	6	W / S
M 317	Data Analysis and Modeling Methods in Geoscience and Environmental Science	Drews	6	W / S
M 321	Experimental and Analytical Methods in Geoscience and Environmental Science	Schulz, Berthold	6	W

Elective Modules

Module Number	*Module Title*	*Module Coordinator*	*CP*	*Semes-ter*
Modules Applied Geosciences (participation in some modules only if capacity allows)				
M 201	Groundwater Modeling 1	Cirpka	6	W
M 202	Hydrogeological Field Investigation Techniques	Leven	6	S
M 203	Groundwater Modeling 2	Yuan	6	W
M 205	Remediation of Contaminated Sites	Finkel	6	S
M 206	Case Studies in Environmental Geosciences	Cirpka	6	W
M 207	Environmental Chemistry	Zarfl	6	W
M 208	Environmental Isotope Chemistry	Taubald	6	S
M 209	Environmental Chemistry Lab	Haderlein	6	W
M 210	Environmental Microbiology and Geomicrobiology	Kappler	6	S
M 211	Geomicrobiology Lab	Kappler	6	S
M 212	Advanced Geophysics	Drews	6	W
M 213	GIS and Remote Sensing	Schäuble, Lörcher	6	W
M 214	Geotechnical Engineering	Leven	6	W
M 216	Atmospheric Physics	Platis	6	S
M 218	Environmental Analytical Chemistry	Zwiener	6	W
M 221	Environmental and Human Health Risk Assessment of Chemicals	Escher	6	W
~~M 222~~	~~Hydrogeochemical Modeling~~ ➔ substituted by module M 242		~~6~~	~~S~~

M 227	Sustainable Environmental Biotechnology Systems 1	Angenent	6	S
M 228	Sustainable Environmental Biotechnology Systems 2	Angenent	6	W
M 232	Internship	Glotzbach	6	W / S
M 239	Geo-Bio-Interactions in Tropical Landscapes of Kenya	Otieno, Dippold	6	W
M 241	Climate Modeling	Rehfeld	6	S
M 242	Modeling of Reactions, Microbial Dynamics and Bioreactive Transport	Cirpka	6	S
M 243	Tropical Ecology of South America	Ebner	6	W, every other year
M 244	Geothermal Reservoirs	Süß	6	S
Modules Mineralogy und Geology				
M 301	Physics of the Earth's Surface	Glotzbach	6	W
M 302	Metamorphic Processes	Markl	6	W
M 303	Physical Properties of Earth Materials	Bons	6	W
M 304	M.Sc. Field Practicals	Bons	6	W /S
M 306	Experiment Earth	Nowak	6	S
M 308	Isotope Geochemistry	Schönberg	6	W
M 311	Carbonate Facies Analysis	Nebelsick	6	W
M 312	Advanced Sedimentology	Fitzsimmons	6	W
M 314	Igneous Processes	Marks	6	S
M 315	Glaciology	Weikusat	6	W
M 316	Geochemistry of the Mantle and Crust	Siebel	6	W / S
M 320	Advanced Field Methods in Geoscience 2	Bons	6	W / S
M 322	Climate Dynamics	Rehfeld	6	S
M 324	Economic Geology	Staude	6	S
M 325	Data Analysis and Modeling Methods in Geoscience and Environmental Science 2	Drews	6	W / S
M 326	Experimental and Analytical Methods in Geoscience and Environmental Science 2	Schulz, Berthold	6	S
M 327	Advanced Magmatic Petrology	Markl	6	W
Modules Paleontology				
M 401	Terrestrial Ecosystems – excavation and laboratory internship	Böhme	6	S
M 402	Evolution of Organisms	Werneburg	6	W
M 403	Palaeoecology of Terrestrial Ecosystems	Bocherens	6	S

M 404	Micropaleontology	Junginger	6	W, every other year
M 405	Palaeoecology of Marine Ecosystems	Nebelsick	6	W
M 407	Conservation Palaeoecology	Bocherens	6	W
M 408	Vertebrates and Plants of the Cenozoic	Böhme	6	W
M 409	Marine Geology und Geochemistry	Schulz	6	W
M 503	Paleobotany/Palynology	Böhme	6	W
Additional Elective Modules				
ASHE 6b	Material Science and Archaeological Ceramics: Manufacturing and Material Properties of Ancient and Modern Ceramics	Amicone	6	S
ASHE 6b	Material Science and Archaeological Ceramics: Ancient Pottery and its Pigments	Amicone	6	S
ASHE 9b	Material Science and Archaeological Ceramics: Ceramic Petrography and Geochemistry	Amicone	6	W
T@T WiSe 23/24_SoSe 24	Biogeochemistry of Soil Contamination	Mehrnoosh Gol-Soltani	6	W 23/24 / S 24
Single Events / Teach@Tübingen Lectures / M.Sc. Modules from other Departments on demand after approval of the examination board				

Upon request, additional course-relevant modules can be admitted as elective modules by the chairperson of the examination board.

Module Number: **M 101**	Module Title: **Scientific Practice**					Type of Module: M.Sc. Compulsory			
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h	Contact Time: Approx. 20 h				Private Study: 160 h			
Duration Module Coordinator	1 semester	Merkel							
Regular Cycle	every semester (recommended in the 3rd semester)								
Language	English								
Learning- / Teaching Forms	Individual guidance by supervisor, scientific papers								
Module Content	• Compilation of an example research proposal of an individually selected topic in agreement and under supervision of a responsible supervisor • Independent studies in the selected topic including literature research • Formulation of an appropriate problem set, analysis of relevant processes, presentation of the research outline, the required methodologies and the research goals • Set-up of a research schedule including the individual milestones • Writing of the research proposal								
Qualification Goals	• In addition to well-founded professional competence, successful scientific work also requires conceptual and planning competences before and during a research project. In setting up an exemplary research proposal, students will collect experiences in all important steps of planning a research project. • Preparing a research proposal in a written report helps students to acquire important methodological expertise to become acquainted with new fields of research, to identify and discuss relevant problem scenarios, to develop feasible methodological approaches and to present them in an appropriate written form.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Scientific Practice	*PR*	*c*	*1*	*6*	*A*	*-*	*ng*	*-*
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience								
Prerequisites	-								

Module Number: **M 103**	Module Title: **Scientific Presentation**								Type of Module: M.Sc. Compulsory
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 60 h / 4 SWS						Private Study: 120 h
Duration Module Coordinator	1 semester				Bocherens				
Regular Cycle	every semester								
Language	English								
Learning- / Teaching Forms	Oral seminar presentations and poster								
Module Content	• Four participations at the Master's Day event, including one attendance with a poster presentation of the results of the Master's Thesis project • A presentation of the results of the Master Thesis in the respective research group • Attendance at 8 institute seminars								
Qualification Goals	A professional presentation of scientific research projects and their results is a fundamental prerequisite of a successful career both in scientific as well as in the economic world. Students are able to present their research projects in various forms (oral presentation and poster) and acquire in communication skills and presentation competence through oral presentation and discussion with a competent audience.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Attendance of 8 Institute Seminars and 4 participations on the Master Day	*S*	*c*	*2*	*6*	*R*	*-*	*-*	*-*
	Poster Project	*PR*	*c*	*1*		*A*	*-*	*-*	*-*
	Presentation of the M.Sc. thesis in the Research Group	*PR*	*c*	*-*		*R*	*-*	*-*	*-*
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience								
Prerequisites	Scientific Practice								

<table>
<tr><td>Module Number:
M 104</td><td colspan="3">Module Title:
Master Thesis (Abschlussmodul)</td><td colspan="4">Type of Module:
M.Sc. Compulsory</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="7">30</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
900 h</td><td colspan="2">Contact Time:
variable depending on the activity</td><td colspan="3">Private Study:
variable depending on the activity</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="4">Respective supervisors</td></tr>
<tr><td>Regular Cycle</td><td colspan="7">every semester</td></tr>
<tr><td>Language</td><td colspan="7">German or English (for AEG only in English)</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="7">Independent research project under supervision (100%)</td></tr>
<tr><td>Module Content</td><td colspan="7">Literature research, field and/or laboratory tasks preparation of a scientific essay</td></tr>
<tr><td>Qualification Goals</td><td colspan="7">• Students independently prepare a research outline and perform a scientific study
• Preparation of a scientific essay</td></tr>
<tr><td rowspan="2">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Master Thesis</td><td>PR</td><td>c</td><td>-</td><td>30</td><td>A</td><td>6 months</td><td>g</td><td>1</td></tr>
<tr><td>Applicability</td><td colspan="7">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="7">Completion of all required courses</td></tr>
</table>

Module Number: **M 305**	Module Title: **Advanced Field Methods in Geoscience**								Type of Module: M.Sc. Compuslory / Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: circa 14 field days			Private Studies: 0-40 h			
Duration Module Coordinator	Block course, circa 14 days			Bons					
Regular Cycle	annual								
Language	English								
Learning- /Teaching Forms	Supervised field exercise in small groups. Mapping and analysis of geological data, in conjuction with report writing and graphical data presentation (geological maps, stratigraphic columns, cross sections, etc.)								
Module Content	One mapping course entails: • Geological mapping of an area, individually or in small groups • Drawing of a geological map, as well a graphical representation of the stratigraphy and/or lithological relationships in the form of stratigraphical columns, cross sections, etc. • Writing of a report that summarizes the observations and interpretation of the geology and geological history of the mapping area • Depending on the duration of the course, credits may need to be gained with additional assignments. This must be defined and announced by the course leader before the mapping course itself. These can be, for example, additional field days, participation in preparation seminars, home work, etc.								
Qualification Goals	Students learn to independently apply geological field methods and techniques and gain practical experience in the geological analysis of a new area. They will undertake measurements, determine lithologies and stratigraphic sequences and will put these in their spatial context. The ability to make geological maps, cross sections and stratigraphical columns is among the core competencies of a geoscientist.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	Advanced Field Methods in Geoscience	*FC*	*c*	*6*	*6*	*A*	*-*	*g*	*1*
Applicability	Compulsory: M.Sc. Geowissenschaften/Geosciences, Elective: M.Sc. Applied & Environmental Geoscience								
Prerequisites	Successfully completed B.Sc. degree in geosciences								

<table>
<tr><td>Module Number:
M 317</td><td colspan="3">Module Title:
Data Analysis and Modeling Methods in Geo-science and Environmental Science</td><td>Type of Module:
M.Sc. Compulsory / Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="4">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td>Workload:
180 h</td><td colspan="2">Contact Time:
3 x 20 h / 4 SWS</td><td>Private Study:
3 x 40 = 120 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="2">1-2 semester</td><td colspan="2">Drews</td></tr>
<tr><td>Regular Cycle</td><td colspan="4">every semester</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="4">Lectures and Computer Exercises for Data Analysis and Modeling</td></tr>
<tr><td>Module Content</td><td colspan="4">World-wide technical advances in monitoring the surface and sub-surface result in a new data environment for modern Geo- and Environmental sciences. Problem solving increasingly requires rigorous models and also integration of observations varying in space and time. Extracting the relevant information is achieved with computational methods that also require an understanding of the underlying mathematical principles.
It is subdivided into units, which include:
Finite Element Method
Fourier- and Laplace-Transform Techniques
Geographical Information Systems
Introduction Scientific Programming (Matlab)
Introduction Scientific Programming (Python)
Introduction to R
Introduction to Time Series Analysis
Machine Learning 1
Machine Learning 2
Principles of Model Calibration
Remote Sensing of River Systems
Each unit counts for two credits. Students are free to select 3 units out of the units offered. Another 3 units can be used to fill a second container module M325 (Data-Analysis and Modeling Methods in Geo- and Environmental Sciences 2).
The individual units are offered either over four weeks within the lecturing period of the semester, or as one-week block course.
The selection of units may vary with the instructors from year to year. Some units require prior participation in other units of this module (check with instructors beforehand).</td></tr>
<tr><td>Qualification Goals</td><td colspan="4">The goals of this module are
that students are able to understand selected mathematical concepts
that they can implement them computationally, that they can apply them to geo- and environmental related problems
develop relevant technical skills for data analysis and modelling
applied problem solving skills using Matlab / Python / R</td></tr>
<tr><td>Requirements for Obtaining Credit, Grading, Weight if appl.</td><td colspan="4"><table>
<tr><th>Courses</th><th>Type of Lecture</th><th>Status</th><th>CH</th><th>CP</th><th>Type of Exam / Study Require-</th><th>Duration of Exam</th><th>Grading System</th><th>Weighting</th></tr>
<tr><td>Variable Topics</td><td>L,E</td><td>c</td><td>2</td><td>2</td><td>R,A</td><td>-</td><td>g</td><td>1/3</td></tr>
<tr><td>Variable Topics</td><td>L,E</td><td>c</td><td>2</td><td>2</td><td>R,A</td><td>-</td><td>g</td><td>1/3</td></tr>
</table></td></tr>
</table>

	Variable Topics	*L,E*	*c*	*2*	*2*	*R,A*	*-*	*g*	*1/3*
Applicability	Compulsory: M.Sc. Geowissenschaften/Geosciences, Elective: M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geosciences This module compliments other geology, geoecology, and environmental sciences courses (e.g. Advanced Geophysics, Climate Dynamics, Physics of the Earth's Surface) by providing a background for quantitative data analysis and modelling.								
Prerequisites	(TBD w.r.t. Python, Matlab, R)								

Module Number: **M 321**	Module Title: **Experimental and Analytical Methods in Geoscience and Environmental Science**								Type of Module: M.Sc. Compulsory / Elective
Credits (ECTS)	6 (3x2)								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h						Private Study: 90 h
Duration Module Coordinator	1 semester			Schulz, Berthold					
Regular Cycle	every winter semester								
Language	English								
Learning- / Teaching Forms	Laboratory exercises and lectures								
Module Content	The module is designed to advanced students to gain access to and knowledge of selected and frequently used analytical methods in geosciences, lectured by analytical experts/groups of the institute in theory and "hands on the machines". Units are: • Environmental Nanoscience • Instrumental Chemical Analysis Methods • Introduction to Dating Rocks and Sediments • Introduction to Electron Microscopy • Material Characterization Methods • Methods of Structural Analysis: X-ray Diffraction and Infrared/Raman Spectroscopy • Wet Chemical Analysis of Major and Trace Elements Each unit counts for 2 credits. Students are free to select 3 units out of the units offered. More advanced techniques are offered in module M326 (Experimental and Analytical Methods in Geoscience and Environmental Science 2). The individual units are offered either over 4 weeks within the lecturing period of the semester, or as one-week block course. In small groups, the units allow direct contact to staff scientists, advanced laboratories and institute infrastructure. Group sizes are limited, based on the maximum available staff and laboratory capacities.								
Qualification Goals	The courses are designed to learn and test a variety of instrumental methods and to get familiar with the laboratory work flows and routines.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Variable Topics	*L,E*	*c*	*2*	*2*	*R,A,OE*	*-*	*g*	*1/3*
	Variable Topics	*L,E*	*c*	*2*	*2*	*R,A,OE*	*-*	*g*	*1/3*
	Variable Topics	*L,E*	*c*	*2*	*2*	*R,A,OE*	*-*	*g*	*1/3*
Applicability	Compulsory: M.Sc. Geowissenschaften/Geosciences, Elective: M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geosciences								
Prerequisites	-								

<table>
<tr><td>Module Number:
M 201</td><td colspan="4">Module Title:
Groundwater Modeling 1</td><td>Type of Module:
M.Sc. Compulsory / Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="5">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="2">Contact Time:
90 h / 6 SWS</td><td>Private Study:
90 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Cirpka</td></tr>
<tr><td>Regular Cycle</td><td colspan="5">every winter semester (1st semester)</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="5">Ex-cathedra lecture sessions and computer exercises</td></tr>
<tr><td>Module Content</td><td colspan="5">The module gives an introduction into the processes and mathematical description of flow and transport and aquifers and soils (physical hydrogeology and groundwater hydraulics). The emphasis is on closed-form solutions of the groundwater-flow and transport equations. Topics include:
Characterization of aquifers
Concept of the porous medium
Derivation of the groundwater-flow and Richards equation
Analytical solutions (steady-state and transient 1-D solutions, well hydraulics)
Regional groundwater flow
Multi-phase partitioning of solutes
Derivation of the advection-dispersion equation
Analytical solutions for solute transport</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">Students know the basic concepts of quantitative subsurface hydrology in different geological environments and acquire general competences in the basic physical principles of groundwater flow and transport. They can calculate groundwater flow and solute transport for simple geometries and are aware of the underlying assumptions. They acquire the key competences needed to tackle standard hydrogeological problems by analytical solutions.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Groundwater Modeling 1</td><td>L</td><td>c</td><td>4</td><td>3</td><td rowspan="2">WE</td><td rowspan="2">90</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>E</td><td>c</td><td>2</td><td>3</td></tr>
<tr><td>Applicability</td><td colspan="5">Compulsory: M.Sc. Applied & Environmental Geoscience; Elective: M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology</td></tr>
<tr><td>Prerequisites</td><td colspan="5">Students have a firm background in mathematics and physics corresponding to the competences acquired in the BSc modules Mathematik für Naturwissenschaftler and Physik. They have basic programing skills in Matlab.</td></tr>
</table>

Module Number: **M 202**	Module Title: **Hydrogeological Field Investigation Techniques**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Study: 90 h
Duration Module Coordinator	1 semester			Leven					
Regular Cycle	every summer semester (subsequent to the module Groundwater Modeling 1)								
Language	English								
Learning- / Teaching Forms	Lecture with exercises (during semester) and field course (1 week block course)								
Module Content	The module deals with methods of applied hydrogeology, and focuses in particular on techniques for hydrogeologic site investigation for which the theoretical basis of hydrogeological investigation techniques is taught and consolidated in exercises. As part of a field course, the hydrogeological site investigation techniques are is transferred into practice. Methods, which are discussed in the module include among others: drilling methods, well construction, groundwater sampling, pumping tests under various boundary conditions, single well methods, and tracer testing.								
Qualification Goals	Students are able to independently plan, carry out, and evaluate hydrogeological field tests. They develop investigation strategies for a hydrogeological exploration of a site, guide and carry out site investigations and collect and analyze data. They generate a local hydrogeological site characterization of the aquifer resp. the subsurface and provide hydrogeological parameters of the subsurface. They are able to apply their knowledge and understanding as well as their problem solving skills in new and unfamiliar situations.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Hydrogeological Investigation Techniques	*L/E*	*c*	*3*	*3*	*WE*	*180*	*g*	*0.5*
	Hydrogeological Field Course	*FC*	*c*	*3*	*3*	*A*	*-*	*g*	*0.5*
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience It is related to other method-oriented modules of applied geosciences (e.g. Geotechnical Engineering, Praktische Hydrogeologie, Hydrogeologie und Wasserchemie, Geophysics).								
Prerequisites	The module requires the competences of the M.Sc. module "Groundwater Modeling 1".								

<table>
<tr><td>Module Number:
M 203</td><td colspan="4">Module Title:
Groundwater Modeling 2</td><td>Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="5">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="2">Contact Time:
90 h / 6 SWS</td><td>Private Study:
90 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Yuan</td></tr>
<tr><td>Regular Cycle</td><td colspan="5">every summer semester (recommended 2nd semester)</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="5">Theoretical aspects of numerical flow-and-transport modeling are taught in ex-cathedra lecture sessions. Extensive computer exercise tutorials provide students with ‘hands on’ experiences in modeling groundwater-flow and transport problems.</td></tr>
<tr><td>Module Content</td><td colspan="5">The module gives an introduction into the numerical modeling of groundwater flow and conservative transport. Topics include:
Discretization methods for groundwater flow (Finite Volume Method) and solute transport (particle tracking, Finite Volume Method)
Finite Volumes “by hand”
Modeling of steady-state and transient groundwater flow with MODFLOW
Calibration of numerical groundwater-flow models
Modeling of solute transport with MT3DMS</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">Students understand the principles of computer models for groundwater flow and solute transport. They can set up simple numerical models themselves. They can use standard computer codes for groundwater flow-and-transport problems. They are proficient in the workflow of practical groundwater-flow modeling studies (design of a site-specific conceptual model, discretization of the problem, use of professional simulation software, calibration of the model to data, reporting).</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Groundwater Modeling 2</td><td>L</td><td>c</td><td>4</td><td>4</td><td rowspan="2">WE</td><td rowspan="2">180</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>E</td><td>c</td><td>2</td><td>2</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="5">Students have competences corresponding to those of the MSc Module Groundwater Modeling 1. They have basic programing skills in Matlab.</td></tr>
</table>

Module Number: **M 205**	Module Title: **Remediation of Contaminated Sites**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 60 h / 4 SWS						Private Study: 120 h
Duration Module Coordinator	1 semester				Finkel				
Regular Cycle	every summer semester (recommended in the 3rd semester)								
Language	English								
Learning- / Teaching Forms	Flipped classroom: Students work individually on lectures, which are followed by discussion sessions including tutorials; additionally. students work on case study projects to address practical problems quantitatively.								
Module Content	• Subsurface contaminant distribution • Non aqueous phase liquids in porous media (NAPLs): Behavior and dissolution kinetics • Dissolved compounds: Transport in groundwater • Site investigation and sampling strategies • Integral pumping tests • In situ and ex situ source zone remediation technologies • Plume remediation: Natural attenuation, permeable reactive barriers, pump-and-treat • Remediation technology selection: Technical, economical and environmental aspects • Integrated contaminated land management								
Qualification Goals	Students learn to address real case scenarios of contaminated sites and to interpret the inherent contamination characteristics due to subsurface conditions and the compounds under consideration. The comprehensive overview on practical aspects of contaminant hydrogeology involves building of conceptual models of a contaminated site, assessing potential risks and developing solution strategies for subsurface contaminations, a key competence of environmental geoscientists.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Remediation of Contaminated Sites	*L,E*	*c*	*2*	*3*	*A*	*2h*	*g*	*0,5*
		PR	*c*	*2*	*3*	*R*	*-*	*g*	*0,5*
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience								
Prerequisites	M.Sc. modules "Groundwater Modeling 1", "Environmental Chemistry" or equivalent competences								

Module Number: **M 206**	Module Title: **Case Studies in Environmental Geosciences**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 30 h / 2 SWS						Private Study: 150 h
Duration Module coordinator	1 semester				Cirpka				
Regular Cycle	every winter semester (recommended 3rd semester)								
Language	English								
Learning- / Teaching Forms	The module uses several seminar sessions at the beginning of the semester to introduce problems sets which are to be solved in teams. Several project meetings with the lecturer give the individual groups feedback on their work on a regular basis. Project presentations and discussion complete the module.								
Module Content	This course is aimed to apply methods and techniques acquired in previous modules on typical environmental problems. • Several case studies will be presented along with all relevant data • Students will work in small groups addressing specific problem scenarios • Starting from initial data sets students will analyze the problem, develop solution strategies and present their solution								
Qualification Goals	Highly specific subject oriented projects enable students to analyze a problem, set up fundamental assumptions, collect and evaluate available data. Solving complex problems in environmental geosciences generally includes multidisciplinary approaches from various fields of expertise such as hydrogeology and hydrogeochemistry. Dealing with such scenarios students gain experience in designing conceptual site models, define the relevant physical and chemical processes involved and develop a solution strategy. The integrative module fosters a variety of competences including the capacity for analysis and teamwork, quantitative problem solving skills and presentation and reporting skills.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Case Studies in Environmental Geosciences	*PR*	*c*	*2*	*6*	*R*	*30*	*g*	*1*
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience								
Prerequisites	Competences corresponding to the M.Sc. modules "Grondwater Modeling 1" and "Groundwater Modeling 2"								

Module Number: **M 207**	Module Title: **Environmental Chemistry**								Type of Module: M.Sc. Compulsory / Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Study: 90 h
Duration Module coordinator	1 semester			Zarfl					
Regular Cycle	every winter semester (recommended for 1st semester)								
Language	English								
Learning- / Teaching Forms	Lectures, Exercises, Tutorial, Team work								
Module Content	• Chemical thermodynamics in aqueous systems • Sorption and partitioning processes of organic and inorganic compounds • Sorption kinetics • Practical applications and case studies								
Qualification Goals	• Role of particles as sorbents, vectors and reactants for contaminants • Quantitative understanding of partitioning and sorption mechanisms of organic and inorganic compounds in the hydrosphere • Knowledge of sorption QSARs for various classes of contaminants • Sorption kinetics and retarded diffusion in porous media • Assessment of contaminant release and cleanup strategies at contaminated sites								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Environmental Chemistry Lecture	*L*	*c*	*2*	*6*	*WE*	*120*	*g*	*1*
	Environmental Chemistry Exercises	*E*	*c*	*2*					
	Environmental Chemistry Tutorials	*E*	*op*	*2*					
Applicability	Compulsory: M.Sc. Applied & Environmental Geoscience, Elective: M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology								
Prerequisites	Basic knowledge in chemistry, physics, hydrogeology								

Module Number: **M 208**	Module Title: **Environmental Isotope Chemistry (Environmental Chemistry 2)**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Study: 90 h
Duration Module coordinator	1 semester			Taubald					
Regular Cycle	every summer semester								
Language	English								
Learning- / Teaching Forms	Lectures, exercises, team work, presentations								
Module Content	• Basic principles of isotope geochemistry (definitions, fractionation mechanisms, etc.) • Relevant isotope systems for the hydrosphere (esp. C, H, O, N, S) • Organic and Compound-specific organic isotope chemistry • Application of isotope systems for forensic and process identification purposes • Principles of isotope analysis • Applications and case studies								
Qualification Goals	• Knowledge of prospects, limitations and applications of isotope methods in environmental chemistry • Knowledge of theory and interpretation of isotope fractionation processes • Knowledge of basic principles and applications of core methods for isotope analysis • Application of isotope methods in the context of contaminant hydrology (natural attenuation and tracer studies)								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Inorganic Environmental Isotope Chemistry	*L*	*c*	*2*	*3*	*WE*	*120*	*g*	*0,5*
	Inorganic Environmental Isotope Chemistry Exercises	*E*	*c*	*1*					
	Organic Environmental Isotope Chemistry	*L*	*c*	*2*	*3*	*A*	*120*	*g*	*0,5*
	Organic Environmental Isotope Chemistry Exercises	*E*	*c*	*1*					
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience								
Prerequisites	Basic knowledge in chemistry and physics for geoscientists								

<table>
<tr><td>Module Number:
M 209</td><td colspan="4">Module Title:
Environmental Chemistry Lab
(Environmental Chemistry 3)</td><td>Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="5">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="2">Contact Time:
90 h / 6 SWS</td><td>Private Study:
90 h</td></tr>
<tr><td>Duration
Module coordinator</td><td colspan="3">1 semester</td><td colspan="2">Haderlein</td></tr>
<tr><td>Regular Cycle</td><td colspan="5">every winter semester</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="5">Lab experiments in small teams; project, seminar</td></tr>
<tr><td>Module Content</td><td colspan="5">• Analytical methods for organic & inorganic contaminants in environmental samples
• Concepts and methods for the quantification of contaminants and degradation processes
• Insights in current research projects in the fields of environmental chemistry & environmental microbiology</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">• Knowledge and application of key lab techniques in environmental chemistry (Sampling, extraction- & enrichment techniques, chromatography (IC, GC, HPLC); mass spectrometry; stable isotope analyses)
• Experimental design; practical laboratory skills; evaluation and interpretation of experimental data and their uncertainty.
• Knowledge of current research topics in environmental chemistry & microbiology.</td></tr>
<tr><td rowspan="4">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="3">Environmental Chemistry Lab</td><td>LC</td><td>c</td><td>5</td><td rowspan="2">6</td><td>SP</td><td>-</td><td>g</td><td>0,4</td></tr>
<tr><td>PR</td><td>c</td><td>1</td><td>LP</td><td>-</td><td>g</td><td>0,6</td></tr>
<tr><td colspan="8">Grading is based on the lab performance, lab protocols and final report; no final exam.</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology,
M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="5">General chemistry; aquatic chemistry; micobiology on B.Sc. level
M.Sc. module "Environmental Chemistry 1"</td></tr>
</table>

<table>
<tr><td>Module Number:
M 210</td><td colspan="4">Module Title:
Environmental Microbiology and Geomicro-biology</td><td>Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="5">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="2">Contact Time:
60 h / 4 SWS</td><td>Private Study:
120 h</td></tr>
<tr><td>Duration
Module coordinator</td><td colspan="3">1 semester</td><td colspan="2">Kappler</td></tr>
<tr><td>Regular Cycle</td><td colspan="5">every summer semester</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="5">Lecture and seminar (student presentations)</td></tr>
<tr><td>Module Content</td><td colspan="5">• General environmental microbiology and geomicrobiology
• Microbial degradation of pollutants
• Redox zonation, thermodynamics
• Microbe-mineral interactions
• Bioremediation
• Biogeochemical cycles</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">The students
• can read and evaluate current literature about various topics in Environmental Microbiology and Geomicrobiology and can present these topics to an inter-disciplinary audience of students
• obtain an advanced and detailed understanding of current topics Geomicrobi-ology and Environmental Microbiology
• understand the kinetics and energetics of microbially catalyzed processes and the consequences of these processes for the environment
• know about the contribution role of microbial processes for biogeochemical cycling (C, N, S, Fe, Si, P)
• know about environmental behavior and microbial transformation of selected organic and inorganic pollutants
• understand the interactions of microorganisms with solid substrates (minerals and surfaces)</td></tr>
<tr><td rowspan="2">Requirements for Obtain-ing Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Environmental Micro-biology and Geo-microbiology</td><td>L,S</td><td>c</td><td>4</td><td>6</td><td>R</td><td>45</td><td>g</td><td>1</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="5">Geomicrobiology; basic knowledge in microbial physiology and in microbial ecology</td></tr>
</table>

Module Number: **M 211**	Module Title: **Geomicrobiology Lab Course**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h						Private Study: 90 h
Duration Module coordinator	2 weeks lab course; report writing afterwards			Kappler					
Regular Cycle	every summer semester								
Language	English								
Learning- / Teaching Forms	Lab exercises								
Module Content	• Cultivation and microscopic characterization of microorganisms • Quantification of microbial activities • Analysis of nucleic acids (DNA, qPCR) • Active participation in a current research project of the Geomicrobiology research group								
Qualification Goals	The students • can apply various microbial lab techniques (sterile working techniques) • are able to follow and interpret microbial activities quantitatively • know about different microbial metabolic pathways, in particular microbial formation and transformation of minerals • know about current topics in geomicrobiology • understand and are able to present research questions, hypotheses, experimental approaches and methods, results from their experiments and the data evaluation and interpretation								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Geomicrobiology Lab	*LC*	*c*	*6*	*6*	*SP*	*-*	*-*	*-*
						R	*-*	*g*	*1*
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience								
Prerequisites	Geomicrobiology; basic knowledge in microbial physiology and in microbial ecology								

Module Number: **M 212**	Module Title: **Advanced Geophysics**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 75 h / 6 SWS						Private Study: 105 h
Duration Module coordinator	1 semester				Drews				
Regular Cycle	Every winter semester								
Language	English								
Learning- / Teaching Forms	The module uses a combination of in-class lectures, in-class & applied exercises, and online videos.								
Module Content	This module teaches advanced methods in geophysics including data acquisition, processing and modelling. In each semester we will typically explore one or two methods in-depth (e.g., refraction seismics, electrical resistivity tomography, ground-penetrating radar, magnetics) and develop a full processing chain from first principals, e.g., including survey planning, data acquisition, forward modeling and data integration using computational inverse techniques.								
Qualification Goals	(1) Gain an advanced understanding for specific geophysical methods. (2) Understand the principals of forward and inverse modelling and apply it with computational methods. (3) Build-up transferable skills (e.g., signal analysis and numerical modeling) also applicable in many other geo- and environmental disciplines.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Advanced Geophysics	*L*	*o*	*4*	*4*	*WE/ OE*	*90*	*g*	*1*
		FC	*o*	*1*	*2*				
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Applied & Environmental Geoscience								
Prerequisites	Solid understanding of basic geophysical sub-surface imaging taught at the BSc levels. Programming skills are helpful but not strictly essential and can also be acquired in class.								

<table>
<tr><td>Module Number:
M 213</td><td colspan="4">Module Title:
GIS and Remote Sensing</td><td>Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="5">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="2">Contact Time:
75 h / 5 SWS</td><td>Private Study:
105 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Schäuble, Lörcher</td></tr>
<tr><td>Regular Cycle</td><td colspan="5">every winter semester</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="5">Lectures and accompanying guided computer exercises, project assignment.</td></tr>
<tr><td>Module Content</td><td colspan="5">• General introduction to GIS (definition, components, applications and samples)
• Acquisition of geo-datasets: getting field data with personal GPS-smartphones (Android, iOS) and public datasets using web sources
• Application of GIS by considering the most important aspects in practice, e.g. map projections, georeferencing of scanned images, GPS-data, digitizing of maps, analysis of vector and raster datasets, presentation and visualization of spatial datasets.
• Usage of free software: QGIS (with plugins) for scientific analysis and Google Earth Pro for data preparation and distribution to the public
• Introduction to remote sensing and advanced raster analysis, e.g. surface analysis and hydrological simulations.
• Students have to complete a small GIS project at the end of the course</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">Students will get the knowledge to use Geographical Information Systems (GIS) in general and for their own scientific projects. They will learn how get the geodata to do that as well. This course combines lectures, computer exercises and GPS field work. Special emphasis is set on practical applications, usability and simplicity. Only GIS software will be used that is freely available (QGIS). Thus, knowledge and workflows can be applied at any time with private notebooks, tablets and smartphones.
After completion, the students will have a basic but complete understanding of all relevant aspects of GIS from A-Z. They can start with their own projects from the scratch. QGIS has implemented additional and high-rated GIS software as well (GRASS, SAGA), so every scientific examination can be done.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Geographical information systems and Remote Sensing</td><td>L</td><td>c</td><td>2</td><td rowspan="2">6</td><td rowspan="2">A</td><td rowspan="2">-</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>E</td><td>c</td><td>2</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Applied & Environmental Geoscience, (M.Sc. Geowissenschaften/Geosciences and M.Sc. Geoökologie/Geoecology if capacity allows)</td></tr>
<tr><td>Prerequisites</td><td colspan="5">Smartphone (Android, iOS or other brand)</td></tr>
</table>

Module Number: **M 214**	Module Title **Geotechnical Engineering**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Study: 90 h
Duration Module Coordinator	1 semester				Leven				
Regular Cycle	every winter semester								
Language	English								
Learning- / Teaching Forms	Lecture with exercises (during semester) and lab course (1 week block course)								
Module Content	The module deals with methods of soil mechanics and geotechnical engineering. In a lecture the basic principles of geotechnical classification of soils and rocks, geotechnical investigation methods, and procedures for determining mediated soil and geomechanical parameters are taught and will be consolidated in exercises. During the soil mechanics laboratory course, various geotechnical laboratory methods for determining basic geotechnical soil and rock parameters are practically applied, analyzed, and evaluated.								
Qualification Goals	Students are able to independently develop an investigation plan for a geotechnical and soil mechanical investigation at a site, to carry out and guide a sampling campaign. Evaluating the soil mechanical data, they determine relevant geotechnical parameters, analyze them and present them in a report The students are able to apply their knowledge and understanding as well as their problem solving skills in new and unfamiliar situations.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Course*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Geotechnical Engineering	*L*	*c*	*2*	*3*	*WE*	*120*	*g*	*0.5*
	Soil Mechanics Lab	*LC*	*c*	*3*	*3*	*A*	*-*	*g*	*0.5*
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Applied & Environmental Geosciences, (M.Sc. Geoecology if capacity allows) It is related to other method-oriented modules of applied geosciences (e.g. Hydrogeological Field Investigations Techniques, Haydrogeologie and Water Chemistry, Geophysics).								
Prerequisites	Basic physical, mathematical, and geological knowledge								

Module Number: **M 216**	Module Title: **Atmospheric Physics**		Type of Module: M.Sc. Elective
Credits (ECTS)	6		
Workload - Contact Time - Private Study	Workload: 180 h	Contact Time: 60 h / 4 SWS	Private Study: 120 h
Duration Module Coordinator	1 semester	Platis	
Regular Cycle	every summer semester		
Language	English		
Learning- / Teaching Forms	Theoretical aspects of atmospheric physics that are taught in lectures are accompanied by exercises and tutorials in small groups. Field exercises provide 'hands-on' experience and insights in handling atmospheric research.		
Module Content	This course presents the main features of atmospheric physics with a focus on the boundary layer and airborne research. Aircraft have been applied very effectively in many aspects of environmental research and are a powerful instrument for studying the Earth's surface and atmosphere. Instrumented aircraft in situ measurements with minimum disturbances to the atmosphere between sensor and object. Since the recent development of small unmanned aerial vehicles (UAV) research aircraft have opened new possibilities in boundary layer research. This module gives an introduction to these exciting research topics and covers the following topics in lecture, tutorials and hands-on practice: • Introduction to atmospheric physics and the boundary layer • history of research flight • the physics of flight: aerodynamics, avionics and inertial navigation systems, coordinate systems, aircraft icing • measurement and calibration of basic thermodynamic quantities: temperature, pressure, altitude, water vapour, wind vector • turbulent fluxes and small-scale turbulence • flight strategies and field exercise (with UAV) • software strategies for atmospheric data analysis (using RAMA)		
Qualification Goals	Students are familiar with the potential and limits of research aircraft in general, especially regarding UAV, airborne measurement instruments and flight strategies. They will be able to decide what instruments (in terms of suitable aircraft and sensors) are suited for certain environmental studies, particularly regarding costs and experimental effort. They plan, carry out and analyze flight experiments for environmental studies in the lower troposphere.		

Requirements for Obtaining Credit, Grading, Weight if appl.

Courses	*Type ofLecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
Atmospheric Physics	*L*	*c*	*2*	*3*	*WE*	*120*	*g*	*0,66*
	E	*c*	*1*	*2*	-	-	-	-
	S	*c*	*1*	*1*	*R*	-	-	*0,33*

Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Applied & Environmental Geosciences
Prerequisites	Lectures on mathematics and physics of a B.Sc. study, completed by lectures on thermodynamics, atmospheric physics and basics in flow mechanics (UWP1 and UWP2 of the B.Sc. Umweltnaturwissenschaften)

Module Number: **M 218**	Module Title: **Environmental Analytical Chemistry**		Type of Module: M.Sc. Elective
Credits (ECTS)	6		
Workload - Contact Time - Private Study	Workload: 180 h	Contact Time: 90 h / 6 SWS	Private Study: 90 h
Duration Module Coordinator	1 semester	Zwiener	
Regular Cycle	every winter semester (recommended for the 1st semester)		
Language	English		
Learning- / Teaching Forms	The module combines classroom lectures and exercises with a one-week laboratory practical course, which allows students to apply their theoretical classroom knowledge and gain practical laboratory skills. Regular homework and lab presentations give feedback on individual study progress.		
Module Content	The module focuses on: • Analysis of new emerging and polar compounds in environmental media • Basic principles of atmospheric pressure ionization techniques and mass spectrometry • Advanced applications of instrumental analytical techniques with liquid chromatography-mass spectrometry • Special approaches for ultratrace analysis		
Qualification Goals	Students understand the properties of polar compounds. They acquire the theoretical competence to select appropriate problem-oriented analytical methods for environmental pollutants. At the same time the acquired practical skills allow them to handle sophisticated analytical instruments and to develop suitable analytical methods for variable contamination scenarios on demand. Both, the theoretical knowledge and the practical laboratory skills are key competences for environmental scientists.		

Requirements for Obtaining Credit, Grading, Weight if appl.

Courses	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
Environmental Analytical Chemistry	*L*	*c*	*3*	*3*	*WE*	*120*	*g*	*0,5*
	LC	*c*	*3*	*3*	*LP*	*-*	*g*	*0,5*

Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience
Prerequisites	Basic knowledge in chemistry, environmental analytics and statistics

<table>
<tr><td>Module Number:
M 221</td><td colspan="4">Module Title:
Environmental and Human Health Risk Assessment of Chemicals</td><td>Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="6">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="2">Contact Time:
60 h / 2 SWS + 1 week block course</td><td colspan="2">Private Study:
120 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester + 1st week of March (block course)</td><td colspan="3">Escher</td></tr>
<tr><td>Regular Cycle</td><td colspan="6">every winter semester</td></tr>
<tr><td>Language</td><td colspan="6">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="6">Lecture and exercises
Groups of three students conduct a comprehensive environmental and human health risk assessment for one selected chemical each according to the European regulation for industrial chemicals. The risk assessment is performed stepwise in the exercises in groups and then compiled by each student into a written technical report (chemical risk assessment dossiers)
Seminar
In the first week of March, there is a 5-day block with seminar-style applications and special topics and presentations of the chemical risk assessment dossiers. At the end of the week the chemical risk assessment dossiers are completed and will be graded.</td></tr>
<tr><td>Module Content</td><td colspan="6">• Regulatory methods for environmental risk assessment of chemicals (industrial chemicals, pesticides, pharmaceuticals), European regulation REACH, human vs. ecological risk assessment
• PBT assessment (persistence, bioaccumulation, toxicity), classification and labelling of chemicals
• Environmental exposure analysis: emission patterns, multimedia fate and transport models for quantifying environmental exposure, predicted and measured exposure concentration
• Environmental effect analysis: estimation of hazard potential, tests for ecotoxicity, dose-effect relationships, extrapolation methods, classification of chemicals according to modes of toxic action
• Human health risk assessment of chemicals. Exposure estimations and human health effects, cancer risk, risk quotient
• Integrated testing strategy for toxicity and ecotoxicity including prediction methods
• Risk assessment methods (deterministic vs. probabilistic), risk assessment vs. hazard assessment, uncertainty and sensitivity analyses, precautionary principle
• Specific topics: risk assessment of mixtures, risk assessment of transformation products, dynamic risk assessment, water quality assessment</td></tr>
<tr><td>Qualification Goals</td><td colspan="6">The students are familiar with regulatory approaches to environmental risk assessment of chemicals and can perform a regulatory risk assessment for an industrial chemical. They are aware of pitfalls and challenges and know about new approaches to risk assessment that are still in the research stage.</td></tr>
<tr><td rowspan="4">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="3">Environmental Risk Assessment</td><td>L</td><td>c</td><td>2</td><td rowspan="3">6</td><td>A</td><td>-</td><td>g</td><td>1</td></tr>
<tr><td>S</td><td>c</td><td>2</td><td>R</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td></td><td></td><td></td><td></td><td>-</td><td>-</td><td>-</td></tr>
</table>

Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience
Prerequisites	

Module M 222 "Hydrogeochemical Modeling" is substituted by module M 242 "Modeling of Reactions, Microbial Dynamics and Bioreactive Transport".

Module Number: **M 227**	Module Title: **Sustainable Environmental Biotechnology Systems 1**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h (6 SWS)						Private Studies: 90 h
Duration Module Coordinator	1 semester				Angenent				
Regular Cycle	every summer semester								
Language	English								
Learning- / Teaching Forms	The module combines class room lectures and field trips.								
Module Content	This course will offer a systems approach to understand energy systems that include a bioprocessing step, such as anaerobic digestion, anaerobic fermentation, microbial fuel cells, and photobioreactors with algae. In general, this course focuses on biomass-to-bioenergy conversion, including introduction to major treatment steps, such as pretreatment steps, fermentation steps, and product separation steps. The course integrates physics, engineering, environmental impacts, economics, and sustainable development. Different energy generation technologies will be compared to gain an understanding of the advantages and limitations of these technologies. Students are expected to be interested in and appreciate the need for quantitative aspects of energy systems. An emphasis of this course is technical and economic analysis of large-scale energy systems and their conceptual design.								
Qualification Goals	This course is intended to students to gain the capabilities to: 1. Use a systems approach to design renewable bioenergy systems. 2. Explain the energy conversion processes for biomass systems. 3. Evaluate the advantages and limitations of renewable bioenergy systems. 4. Assess a system by using nontechnical factors (environmental impacts, economics, and sustainable development) during the design phase. 5. Identify which information is missing during the design phase.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	Sustainable Environmental Biotechnology Systems 1	*L*	*c*	*3*	*6*	*A*	*-*	*g*	*0,5*
		E	*c*	*3*		*A*	*-*	*g*	*0,5*
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience, M.Sc. Biologie								
Prerequisites	Basic knowledge in microbiology or chemistry or physics or geosciences or engineering								

<table>
<tr><td>Module Number:
M 228</td><td colspan="4">Module Title:
Sustainable Environmental Biotechnology Systems 2</td><td>Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="5">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="2">Contact Time:
90 h (6 SWS)</td><td>Private Studies:
90 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Angenent</td></tr>
<tr><td>Regular Cycle</td><td colspan="5">every winter semester</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="5">The module combines class room lectures and a group design project.</td></tr>
<tr><td>Module Content</td><td colspan="5">This course will offer a systems approach to understand energy systems that include a bioprocessing step, such as anaerobic digestion, anaerobic fermentation, microbial fuel cells, and photobioreactors with algae. In general, this course focuses on biomass-to-bioenergy conversion, including introduction to major treatment steps, such as pretreatment steps, fermentation steps, and product separation steps. The course integrates physics, engineering, environmental impacts, economics, and sustainable development. Different energy generation technologies will be compared to gain an understanding of the advantages and limitations of these technologies. Students are expected to be interested in and appreciate the need for quantitative aspects of energy systems. An emphasis of this course is technical and economic analysis of large-scale energy systems and their conceptual design.</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">This course is intended to students to use the capabilities from Sustainable Environmental Biotechnology Systems 1 to:
1. Excel in a team-oriented design experience, focused on the application of renewable bioenergy technologies.
2. Design a "real life" renewable bioenergy system.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirements</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Sustainable Environmental Biotechnology Systems 2</td><td>L</td><td>c</td><td>2</td><td rowspan="2">6</td><td rowspan="2">A</td><td rowspan="2">-</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>E</td><td>c</td><td>4</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience, M.Sc. Biologie</td></tr>
<tr><td>Prerequisites</td><td colspan="5">Basic knowledge in microbiology or chemistry or physics or geosciences or engineering
"Sustainable Environmental Biotechnology Systems 1"</td></tr>
</table>

Module Number: **M 232**	Module Title: **Internship**					Type of Module: M.Sc. Elective			
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: -			Private Study: 180 h			
Duration Module coordinator	4 weeks			Glotzbach					
Regular Cycle	every semester								
Language	English								
Learning- / Teaching Forms	Work experience								
Module Content	The module consists of a 4-week internship in a company or consultancy active in the field of geoscience, geoecology and /or environmental consulting.								
Qualification Goals	Students get practical training and contact potential employers. They aquire work experience in the occupational fields dealing with geoscientific and environmental topics. They bring their theoretical knowledge into practice and improve presentation and discussion skills.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Internship	*PR*	*c*	*-*	*-*	*R*	*-*	*ng*	
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience								
Prerequisites	-								

<table>
<tr><td>Module Number:
M 239</td><td colspan="3">Module Title:
Geo-Bio-Interactions in Tropical Landscapes of Kenya</td><td>Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="4">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td>Workload:
180 h</td><td>Contact Time:
120 h / 8 SWS</td><td>Private Study:
60 h</td><td></td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="2">1 Semester</td><td colspan="2">Otieno, Dippold</td></tr>
<tr><td>Regular Cycle</td><td colspan="4">Wintersemester/Summersemester (March/April)</td></tr>
<tr><td>Language</td><td colspan="4">English</td></tr>
<tr><td>Learning-/Teaching Forms</td><td colspan="4">Besides transfering basic knowledge via lectures, the field course will include practical excercises in various landscape and ecological zones of Kenya (monitoring data will be collected, evaluated and scientifically discussed). Pre- and post-field trip presentations will deepen the understanding of relevant processes in the respective landscapes and ecosystems.</td></tr>
<tr><td>Module Content</td><td colspan="4">The module contains basic lectures on geology, geomorphology, hydrology, pedology and ecology of the visited landscapes with specific focus on Biosphere-Geosphere Interactions. The following landscapes and ecosystems will be covered:
• Marine and costal ecosystems
• Dry and humid savannah (several national parks and mzima springs)
• Highland landscapes (rift valley formation, volcanism (Mt. Elgon) and inland lakes systems)
• Tropical rainforests (national park)
• Lake Victoria basin landscapes
Anthropogenically affected areas will be characterized in parallel to their natural systems (mostly national parks) to understand human impact on African ecosystems. Collected knowledge and data will be summarized in scientific presentations at the end of the course.</td></tr>
<tr><td>Qualification Goals</td><td colspan="4">Students will gain a fundamental understanding of the processes shaping Geo- and Biosphere in tropical landscapes and be able to describe the ecosystems in detail. They will be able to characterize interactions between parent material, geomorphology, water availability and movement, soil development (WRB classification) and the living organisms and their ecological interactions of a broad set of tropical ecosystems and landscape units. Students will be able to describe and quantify human impact on tropical ecosystems.</td></tr>
<tr><td>Requirements for obtaining Credit, Grading, Weight, etc.)</td><td colspan="4"><table>
<tr><th>Courses</th><th>Type of Lecture</th><th>Status</th><th>CH</th><th>CP</th><th>Type of Exam / Study Requirement</th><th>Duration of Exam</th><th>Grading System</th><th>Weighting</th></tr>
<tr><td rowspan="2">Field Course on Geo-Bio-Interactions in tropical landscapes of Kenya</td><td>L,S</td><td>c</td><td>2</td><td rowspan="2">6</td><td rowspan="2">R</td><td rowspan="2">2 x 15 min</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>FC</td><td>c</td><td>6</td></tr>
</table></td></tr>
<tr><td>Applicability</td><td colspan="4">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology (can be used for Field Ecology 2), M.Sc. Applied and Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="4">It is recommended but not obligatory to have participated in the module Geosphere-Biosphere Interactions (M 230).</td></tr>
</table>

<table>
<tr><td>Module Number:
M 241</td><td colspan="4">Module Title:
Climate Modelling</td><td colspan="4">Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="8">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="3">Contact Time:
60 h / 4 SWS</td><td colspan="3">Private Study:
120 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="4">1 semester</td><td colspan="4">Rehfeld</td></tr>
<tr><td>Regular Cycle</td><td colspan="8">every summer semester</td></tr>
<tr><td>Language</td><td colspan="8">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="8">Climate models are a powerful tool for understanding climate change, and are continuously growing more detailed and accurate. Models help us to work through complicated problems and understand complex systems.
Lectures introduce how the climate system is represented in models. In the *exercises*, students experiment with models, and learn the practical programming required for climate data analysis and scientific understanding of global warming. The exercise includes *tutorials* that enable students to run simulations with an Earth System Model of Intermediate Complexity. Students document and present their results at the end of the course in a *term paper*.</td></tr>
<tr><td>Module Content</td><td colspan="8">The module will cover fundamentals of climate systems, climate components, energy balance, key climate drivers and the hierarchy of climate models. This will include box models, models of intermediate complexity and fully coupled models. It will explain the underlying basics and the numerical formulation of the fundamental equations in climate models, including parameterisation of processes not directly resolved by the climate model. This module will further emphasize on radiation and convection schemes in model and the aspects determining climate sensitivity to greenhouse gas increase.
Specifically, this module will address the following questions:
• What equations do climate models solve?
• How do climate models solve these equations?
• What components of the climate system are represented in climate models?
• What are the capabilities and limitations of these models?
• How do we evaluate the performance of climate models?</td></tr>
<tr><td>Qualification Goals</td><td colspan="8">At the end of this course students will be able to:
• Understand the fundamental physics in climate models.
• Assess the quality of model results.
• Analyze the output and document their findings.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Climate Modelling</td><td>L</td><td>c</td><td>2</td><td>2</td><td rowspan="2">A/R</td><td rowspan="2">25</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>E</td><td>c</td><td>2</td><td>2</td></tr>
<tr><td>Applicability</td><td colspan="8">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="8">Advanced knowledge on the climate system *or* advanced programming experience is required.</td></tr>
</table>

<table>
<tr><td>Module Number:
M 242</td><td colspan="4">Module Title:
Modeling of Reactions, Microbial Dynamics and Bioreactive Transport</td><td>Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="5">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="2">Contact Time:
60 h / 4 SWS</td><td>Private Study:
120 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Cirpka</td></tr>
<tr><td>Regular Cycle</td><td colspan="5">every summer semester</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="5">Theoretical aspects of reaction and microbial dynamics and bioreactive transport are taught in ex-cathedra lecture sessions. Extensive computer exercise provide students with ‘hands on’ experiences in modeling (bio)reactive systems in mixed reactors and coupled to solute transport.</td></tr>
<tr><td>Module Content</td><td colspan="5">The module gives an introduction into mathematical and numerical modeling of reactions, inter-phase mass transfer, microbial dynamics, and reactive transport relevant for the fate of compounds and microorganisms in porous media. Topics include:
• Modeling of mixed systems:
o Mass balance considerations in mixed systems
o Speciation calculation
o Competitive sorption in equilibrium
o Mass-transfer kinetics
o Stoichiometry of bioreactions
o Rate laws of microbial dynamics
o Numerical simulation of isotope fractionation
• Modeling of bioreactive transport
o Coupled simulation of 1-D transport, microbial dynamics and turnover of reactants
o Multi-dimensional, mixing-controlled bioreactive transport
o Analysis of controlling factors</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">Students can formulate mathematical models of reactive systems (with and without transport) and solve them numerically. They can critically assess which processes dominate under which conditions. They acquire key competences in the quantitative, process-based analysis of reactive systems influenced by microbial processes.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Modeling of Reactions, Microbial Dynamics and Bioreactive Transport</td><td>L</td><td>c</td><td>2</td><td>3</td><td>WE</td><td rowspan="2">120</td><td rowspan="2">g</td><td>0.5</td></tr>
<tr><td>E</td><td>c</td><td>2</td><td>3</td><td>A</td><td>0.5</td></tr>
<tr><td>Applicability</td><td colspan="8">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="8">Students have competences corresponding to those of the M.Sc. Modules "Groundwater Modeling 1" and "Environmental Chemistry". They have basic programing skills in Matlab.</td></tr>
</table>

Module Number: **M 243**	Module Title: **Tropical Ecology of South America**		Type of Module: M.Sc. Elective
Credits (ECTS)	6		
Workload - Contact Time - Private Study	Workload: 180 h	Contact Time: 10 SWS	Private Studies: 30 h
Duration Module Coordinator	1 Semester	Ebner	
Regular Cycle	winter semester (every other year)		
Language	English		
Learning- / Teaching Forms	Field camp, excursions, seminar		
Module Content	This interdisciplinary course deals with the structure, function and dynamics of neotropical ecosystems under different geological, climatic and land-use-related conditions. To record bio-geo-interactions in South American habitats, methods used in botany, zoology, ecophysiology, paleontology, and anthropogeography as well as from earth and environmental sciences are applied. The following topics will be addressed: geology and geological history of South America, water and carbon balance of tropical forests, flora and fauna of different biomes, food relationships, bionics, bioindicators, characterization of river basins, shallow water ecosystems, water relationships between plants, soils and atmosphere, climate change today and in the past, land and forest management systems. Particular attention is paid to the importance of biological diversity for the stability and functionality of tropical ecosystems. Possibilities of sustainable land use while maintaining important ecosystem functions (such as recycling of water, sequestration of carbon, etc.), e.g. through agroforestry systems, are highlighted. The course is conducted in cooperation with various partner universities. The field trip is accompanied by a seminar on n Neotropical ecosystems, focusing on the Atlantic rainforest of Brazil, with its, botanical, zoological, geological and climatic characteristics. Topics are: vegetation and soils of selected regions as a reflection of the climatic and geological boundary conditions, geology and earth history, nutrient and water relationships in tropical rainforests, biodiversity patterns, bioindicators, treetops as a pool of ideas for bionics, ecophysiology of epiphytes, climate change effects and adaptations, soils and agriculture, principles and methods of near-natural reforestation, agroforestry systems. The course ends with a summary of the results and a final exam.		
Qualification Goals	During the field camp, students learn to apply field methods for recording the natural conditions (e.g. vegetation recordings, describing soil profiles, creating geological maps, sediment analyses, measuring the microclimate and soil water balance, recording the animal population, bio-indicators), as well as measuring environmental processes (e.g. runoff quantities and particle load in streams, atmospheric deposition, plant-driven water and carbon fluxes), nutrient relationships (e.g. analysis of stomach contents of frogs) and reconstruction of ecosystem history (e.g. through pollen analysis. It provides a platform to expand species knowledge related to Neotropical fauna and flora. The data collected will be analyzed and discussed in terms of biodiversity patterns, ecosystem functions, response of neotropical ecosystems to climate change and anthropogenic influences. Various forms of land use (in particular agroforestry systems, cacao rubber, yerba mate, araucaria) are examined and evaluated with regard to their impact on biodiversity and ecosystem functions. A comparison of different forms of land use takes place in the context of global requirements and socio-economic conditions of the Global South.		

Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	Preparatory seminar	*L*	*c*	*2*	*6*	*WE*	*120*	*g*	*1*
	Geoecological field internship Brazil (3 weeks)	*S*	*c*	*10*					
Applicability	M.Sc. Geoökologie/Geoecology, MSc Geowissenschaften, MSc Applied Environmental Geoscience, applicable in M.Sc. Evolution und Ökologie								
Prerequisites	Language course Portuguese is recommended								

Module Number: **M 244**	Module Title: **Geothermal Reservoirs**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 70 h / 5 SWS						Private Studies: 110 h
Duration Module Coordinator	1 semester				Süß				
Regular Cycle	every summer semester								
Language	English								
Learning- / Teaching Forms	Lectures accompanied by exercises and computer tutorials & block course								
Module Content	• General introduction to principles of deep geothermal energy extraction • Understanding geothermal reservoir geology and reservoir dynamics • Exploration methods for geothermal reservoirs • Reservoir characterization techniques for geothermal reservoirs • Field development and economics of deep geothermal energy production								
Qualification Goals	The students with little or no background in deep subsurface exploration will learn about the key technologies needed to characterize the underground. This will include the mapping of reservoir rocks using seismic method and the quantification of reservoir volumes using well information. The students will learn the integration of the data into static and dynamic models for geothermal energy production, including the analysis of key uncertainties and their impact on the economic viability of a geothermal energy production project.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	Exploration of deep geothermal reservoirs	*L, E*	*c*	*3*	*3*	*WE*	*45*	*g*	*50%*
	Modelling of deep geothermal reservoirs	*L, E*	*c*	*2*	*3*	*WE*	*45*	*g*	*50%*
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Applied & Environmental Geoscience								
Prerequisites	Introduction to Geosciences or equivalent								

<table>
<tr><td>Module Number:
M 301</td><td colspan="4">Module Title:
Physics of the Earth’s Surface</td><td>Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="5">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="2">Contact Time:
90 h / 6 SWS</td><td>Private Study:
90 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Glotzbach</td></tr>
<tr><td>Regular Cycle</td><td colspan="5">every winter semester</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="5">This module includes a combination of lectures and exercises where the exercises include either computer exercises or scientific paper discussions related to the lecture topics.</td></tr>
<tr><td>Module Content</td><td colspan="5">This module gives an introduction into the physics of Earth’s surface, with emphasis on processes shaping the Earth’s surface on human and geological timescales. Most importantly an overview of the relevant cycles (energy, water, relevant elements/gases) acting on Earth’s surface will be given.
Specific topics addressed in the lecture include:
• Earth’s surface energy balance
• Carbon and hydrological cycle and mass balance
• How and why tectonics, topography, and climate interact over short and long (million year) timescales.
• Physical and mathematical approaches for understanding erosion and sedimentation by rivers, hillslopes, glacial, and biotic processes.
• Topics addressed in the exercises and discussion include:
• Computer exercises using Arc or Q-GS to visualize and analyze Earth’s surface
• Computer exercises using Matlab and other software to investigate physical and geochemical processes discussed in lectures.</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">Goals of this class center around enabling students to:
• Understand the physics and relations between Earth’s shaping processes on different temporal and spatial scales
• Visualize, quantify and model Earth’s surface processes using computer software tools.
• Develop skills in critically reading scientific literature.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Require-</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Physics of the Earth’s Surface</td><td>L</td><td>c</td><td>4</td><td>4</td><td>WE</td><td>90</td><td>g</td><td>0,7</td></tr>
<tr><td>E</td><td>c</td><td>2</td><td>2</td><td>R</td><td></td><td>g</td><td>0,3</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience
This module compliments other geoscience, applied environmental geoscience and geoecology modules. Students are provided with the context for how the atmosphere (climate), hydrosphere, biosphere, and tectonic processes interact to produce the Earth’s surface. It also complements modules in physical geography by providing a physics and math based understanding of surface processes active both human relevant, and geologic (million year) timescales.</td></tr>
<tr><td>Prerequisites</td><td colspan="5">Introductory geology</td></tr>
</table>

Module Number: **M 302**	Module Title: **Metamorphic Processes**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 60 h / 4 SWS						Private Study: 120 h
Duration Module Coordinator	1 semester			Markl					
Regular Cycle	Every Summer semester								
Language	English								
Learning- / Teaching Forms	The module is offered as a compact course and combines lectures, practices in thin-section microscopy (in the presence of the lecturer, 7 days) and self-studies on thin-section microscopy (3 days) of selected samples with the interpretations based on these practical exercises.								
Module Content	Taught are aspects of the metamorphic changes in various lithologies depending on p, T and plate tectonic regime. Special care is taken to teach the identification of metamorphic assemblages and textures by polarization microscopy and their interpretation using petrological phase diagrams.								
Qualification Goals	The main goal of this module is a basic understanding of ramifications for the formation of metamorphic rocks. Students should after completing the module be able to analyse and interpret unknown metamorphic rocks genetically to understand the paleotectonic regime in which they formed. The extensive practical exercises using the polarization microscope allow them to acquire advanced knowledge of working with rocks in general and with metamorphic rocks in specifics.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Metamorphic processes	*L*	*c*	*2*	*4*	*E*	*90*	*g*	*1*
		E	*c*	*2*	*2*	*SP, R*	*-*		
Applicability	M.Sc. Geowissenschaften/Geosciences This module is tightly connected to the M.Sc. modules "Igneous Processes" and "Advanced Structural Geology". All three modules use polarization microscopy to understand mineral textures in rocks to deduce interpretations of their geological context of formation.								
Prerequisites	Basic knowledge in mineralogy, of using a polarization microscope and of the application of phase diagrams to the interpretation of geological processes								

Module Number: **M 303**	Module Title: **Physical Properties of Earth Materials**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Study: 90 h
Duration Module Coordinator	1 semester			Bons					
Regular Cycle	every winter semester								
Language	English								
Learning- / Teaching Forms	Lectures and practicals (microscopy, computer exercises)								
Module Content	The course focuses on the mechanical properties of rocks and ice under natural conditions. It covers • An overview of the most important deformation mechanism and processes. • A derivation of the governing equations (flow laws) that describe the rheology of rocks and ice. • Description and interpretation of deformation (micro-) structures, with particular attention to recognising expressions of deformation processes and establishing the resulting mechanical properties. • Application of rock deformation theory for geological and glaciological problems. The course consists of lectures and practical exercises, including microscopy.								
Qualification Goals	Main aim of the module is to make students acquainted with the deformation processes that occur in rocks and ice. This includes being able to: • recognize deformation structures; • interpret the processes that produced these structures; • infer conditions of deformation from these structures; • as well as the rheological properties of the materials at the time of deformation • apply the insights to better understand the evolution of glaciological and geological problems, such as the flow of ice sheets and glaciers, subduction systems, etc. In the end, the students will have gained the necessary skills to work in academic research, as well as applied research, where the mechanical behaviour of rocks and ice plays a role.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Physical properties of Earth materials	*L*	*c*	*4*	*4*	*WE*	*120*	*g*	*0,7*
		LC	*c*	*2*	*2*	*A*	*-*	*g*	*0,3*
Applicability	M.Sc. Geowissenschaften/Geosciences The module provides advanced knowledge and skills in the fields of rock mechanics, rheology and of structural analysis and interpretation the recognition and interpretation of deformation structures. These are a necessary prerequisite of any field based-study, from basin analysis to the study of high-grade metamorphic or igneous marklcomplexes, as well as for the understanding of the behaviour of glaciers and polar ice sheets. The module is thus of direct practical relevance to all geoscience students, no matter whether they intend to pursue and academic or industrial career.								
Prerequisites	B.Sc. module "Strukturgeoplogie und Tektonik" or equivalent Optical mineralogy/microscopy English (read & write)								

Module Number: **M 304**	Module Title: **M.Sc. Field Practicals**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 18 field days						Private Studies: 36 h
Duration Module Coordinator	18 days over 4 semester				Bons				
Regular Cycle	mostly in summer semester, but field days may also be offered in winter semester								
Language	English								
Learning- /Teaching Forms	Excursions and field exercises								
Module Content	A total of 18 field days must be accrued. Field days include • Visits to outcrops in the field, quarries, digs, and museums, exhibitions, research institutions and companies relevant to geosciences • Advanced geoscientific field exercises A maximum of 7 field days from mapping courses can count as field days for this module, but only in exceptional cases and only if agreed upon with the mapping course leader in advance								
Qualification Goals	Building on the experience acquired during BSc studies in the field-oriented description and analysis of geological, pedological, engineering geology and other geoscientific field data, students will expand and advance their practical, methodological and theoretical insight and knowledge. By exposure to a variety of areas and topics, students will expand their knowledge of geoscience in a regional context.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	18 field days offered by the department	*FE*	*c*	*10*	*6*	*A*	*-*	*ng*	*-*
	Lecturers and excursion leaders may require additional assignments, such as reports, for the field days to be credited to the module.								
Applicability	M.Sc. Geowissenschaften/Geosciences (other students from the Department of Geosciences if capacity allows)								
Prerequisites	Normally no prerequisites, but lecturers may, at their discretion and depending on the topic, set certain prerequisites. Some special excursions and field exercises (for example in mountainous terrain) may require a certain level of fitness.								

Module Number: **M 306**	Module Title: **Experiment Earth**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Study: 90 h
Duration Module Coordinator	1 Semester			Nowak					
Regular Cycle	every summer semester								
Language	English								
Learning- / Teaching Forms	The module consists of lectures, seminars and exercises								
Module Content	• Instruction of theoretical and practical fundamentals of experimental approaches in mineralogy and petrology (e.g. magmatic differentiation processes, phase relationships in siliceous melts). • Mineral phases and volatile compounds, Fluid-rock interactions and space-resolved analytics.								
Qualification Goals	Experimental methods and their application in simulation of magmatic and metamorphic processes in the lab are a key competence in mineralogy. Safe working procedures in space-resolved quantitative analytics, in combination with data analysis and interpretation give students good prerequisites for independent research-oriented activities in the field of petrology and mineralogy.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Experiment Earth	*L,S*	*c*	*3*	*3*	*R*	*-*	*g*	*1*
		E	*c*	*3*	*3*	*H*	*-*	*-*	*-*
Applicability	M.Sc. Geowissenschaften/Geosciences The module is closely related to the M.Sc. modules "Igneous Processes" and "Isotope Geochemistry" and a key to understanding physico-chemical models to quantify magmatic and metamorphic processes.								
Prerequisites	B.Sc. elective module "Mineralogische Analysemethoden" or equivalent								

<table>
<tr><td>Module Number:
M 308</td><td colspan="4">Module Title:
Isotope Geochemistry</td><td colspan="4">Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="8">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="3">Contact Time:
90 h / 6 SWS</td><td colspan="3">Private Study:
90 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="5">Schönberg</td></tr>
<tr><td>Regular Cycle</td><td colspan="8">every winter semester</td></tr>
<tr><td>Language</td><td colspan="8">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="8">Lectures, exercises, oral and written presentations</td></tr>
<tr><td>Module Content</td><td colspan="8">The module consists of 3 main parts:
1. Theory of isotope geochemistry: Detailed view on applications of radiogenic isotope systems as geochemical indicators for assimilation and fractionated crystallization (AFC). U-Th disequilibrium dating and its applications. Heavy ‘non-traditional’ stable isotope systems (e.g. Cr, Fe, Mo) and their applications.
2. Theory of Mass spectrometry: Basic instrumental set-up of various mass spectrometers, focusing on systems used to determine isotope ratios. Isotope dilution for exact quantitative element concentration analysis.
3. Literature study: The experience gained during parts 1&2 of this module are applied to isotope geochemical literature. Papers published in international journals will be summarized in oral and written presentations.</td></tr>
<tr><td>Qualification Goals</td><td colspan="8">Upon completion of the module students:
• have detailed knowledge how radiogenic isotope ratios can be used for the identification and quantification of magmatic processes
• understand how the U-Th disequilibrium can be used in dating young rocks/minerals and those in turn allow statement about changes in climate and bioproductivity understand how stable isotope variations of heavy elements (transition metals) allow statements on the formation mineral deposits as well as in the field of environmental geochemistry can be used to identify sources of contamination
• know the basic set-up of a mass spectrometer, the methodological differences with respect to other analytical techniques
• will be able to assess the quality of published isotope data and the interpretations drawn from those</td></tr>
<tr><td rowspan="4">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Isotope Geochemistry</td><td>L, E</td><td>c</td><td>3</td><td>3</td><td rowspan="2">WE</td><td rowspan="2">120</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>Mass Spectrometry</td><td>L,E</td><td>c</td><td>2</td><td>2</td></tr>
<tr><td>Literature Study</td><td>E</td><td>c</td><td>1</td><td>1</td><td>R</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Applicability</td><td colspan="8">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="8">Basic knowledge from the B.Sc. Geowissenschaften or from a comparable B.Sc. degree</td></tr>
</table>

Module Number: **M 311**	Module Title: **Carbonate Facies Analysis**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 60 h / 4 SWS						Private Studies: 120 h
Duration Module Coordinator	1 semester				Nebelsick				
Regular Cycle	last time winter semester 2025/26								
Language	English								
Learning- / Teaching Forms	The necessary basic and advanced knowledge will be mediated during lectures. In the practical part of the course, the students will learn to analyze thin sections and use other methods to identify components, reconstruct ecological parameters and interpret the importance carbonates in the rock record. Data and methodologies recovered from the literature as well as from project work based on specific case studies will be presented.								
Module Content	The identification of the most important abiotic and biotic components and resulting facies types as found in carbonates. The reconstruction of depositional environments in both recent and fossil carbonate systems including both non-marine and marine facies ranging from shelf deposits including reefs to deep water. Application of relevant methodologies applied to carbonate facies analysis including thin section analysis and other techniques.								
Qualification Goals	The students will obtain the basic knowledge needed to identify, analyze and interpret the constituent components and diagenetic processes of carbonate facies. They will learn the composition and distribution of both recent and fossil carbonate facies of both marine and non-marine sedimentary environments. They will learn to use the relevant methodologies to study carbonates including high resolution microscopy, quantification methodologies and statistical analysis of component distributions. The students will be able to interpret depositional environments with respect to both abiotic and biotic parameters. The participants will analyze carbonates with respect to the evolution of organisms as well as their contribution to depositional environments and thus to the rock record through time.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Carbonate Facies Analysis	*L*	*c*	*2*	*2*	*A, R, LP, SP*	*-*	*f*	*1*
		E	*c*	*2*	*2*				
		P R	*c*	*2*	*2*				
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Applied & Environmental Geoscience								
Prerequisites	Basics in earth history and paleontology								

<table>
<tr><td>Module Number:
M 312</td><td colspan="4">Module Title:
Advanced Sedimentology</td><td colspan="4">Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="8">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="3">Contact Time:
90 h / 6 SWS</td><td colspan="3">Private Study:
90 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="5">Fitzsimmons</td></tr>
<tr><td>Regular Cycle</td><td colspan="8">Every winter semester</td></tr>
<tr><td>Language</td><td colspan="8">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="8">The range of sedimentary environments will be introduced in the seminars (4 ECTS). Homework exercises will include preparation for the exercises and will assist students to learn the lecture material. Accompanying exercises (2 ECTS) will involve the active discussion of case studies and exploration of methods for investigating sediments and sedimentary rocks.</td></tr>
<tr><td>Module Content</td><td colspan="8">This course will focus on modern (and Quaternary) sediments, by:
• Reviewing the various environmental and climatic settings for the production, transport and deposition of different sediment types
• Gaining familiarity with the range of analytical techniques used to characterise and quantify modern sedimentary environments
• Placing sedimentary environments in the context of land-water-atmosphere interactions
• Investigating changes in sedimentary environments through time, including Anthropocene and potential future changes
Exercises will include the identification of different sediment types, exposure to a range of analytical techniques, and journal club discussions relating to the above.</td></tr>
<tr><td>Qualification Goals</td><td colspan="8">Students will gain familiarity with the different types of modern (and Quaternary) sedimentary environments as analogues for the sedimentary rocks covered in the Bachelor degree. They will be exposed to the various analytical techniques used for investigating and quantifying modern and Quaternary sedimentary processes. The skills learnt in this course will prepare students for dealing with a range of geological problems in active sedimentary environments, including addressing Anthropocene and future change.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Advanced sedimentology</td><td>S</td><td>c</td><td>4</td><td>4</td><td rowspan="2">A</td><td rowspan="2">-</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>E</td><td>c</td><td>2</td><td>2</td></tr>
<tr><td>Applicability</td><td colspan="8">M.Sc. Geowissenschaften/Geosciences, M.Sc. Applied & Environmental Geoscience</td></tr>
<tr><td>Prerequisites</td><td colspan="8">Successfully completed B.Sc. degree in Geosciences or Advanced Environmental Geosciences</td></tr>
</table>

<table>
<tr><td>Module Number:
M 314</td><td colspan="4">Module Title:
Igneous Processes</td><td colspan="4">Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="8">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="3">Contact Time:
90 h / 6 SWS</td><td colspan="3">Private Study:
90 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="4">1 semester</td><td colspan="4">Marks</td></tr>
<tr><td>Regular Cycle</td><td colspan="8">every summer semester</td></tr>
<tr><td>Language</td><td colspan="8">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="8">Lecture, Exercise, Practical</td></tr>
<tr><td>Module Content</td><td colspan="8">Major aspects of the formation, evolution and modification of melts are regarded in the context of plate tectonics. For this purpose, microscopic investigations of magmatic rock sections, the interpretation of phase diagrams and computer-aided modeling of magmatic processes based on geochemical data are used. Additionally, the module deals with details of volcanic processes.</td></tr>
<tr><td>Qualification Goals</td><td colspan="8">The major qualification goal of the module is the principal understanding of the formation and differentiation of melts. Based on this knowledge, the Master students are enabled to analyze unknown occurrences of magmatic rocks and to interpret them with regard to petrogenesis and the paleotectonic setting of formation.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Igneous Processes</td><td>L</td><td>c</td><td>4</td><td>4</td><td>WE</td><td>90</td><td>g</td><td>0,8</td></tr>
<tr><td>E</td><td>c</td><td>2</td><td>2</td><td>R</td><td>-</td><td>g</td><td>0,2</td></tr>
<tr><td>Applicability</td><td colspan="8">M.Sc. Geowissenschaften/Geosciences
There are close relationships to the M.Sc. modules „Metamorphic Processes" and „Experiment Earth"</td></tr>
<tr><td>Prerequisites</td><td colspan="8">Firm background in basic mineralogy and petrology equivalent to contents taught in the BSc modules "Mineralogie und Petrologie" and "Geochemie"</td></tr>
</table>

<table>
<tr><td>Module Number:
M 315</td><td colspan="4">Module Title:
Glaciology</td><td colspan="4">Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="8">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="3">Contact Time:
90 h / 6 SWS</td><td colspan="3">Private Studies:
90 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="4">1 semester</td><td colspan="4">Weikusat</td></tr>
<tr><td>Regular Cycle</td><td colspan="8">every winter semester</td></tr>
<tr><td>Language</td><td colspan="8">English/German (can be held in German depending on students)</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="8">Two weeks block course including lectures, tutorials and exercises. Poster presentations</td></tr>
<tr><td>Module Content</td><td colspan="8">Topics covered in lectures and exercises:
• Components of the earth’s cryosphere in recent and palaeo-time scales
• Cryosphere and climate (sea level)
• Ice cores (palaeo-climate records)
• Material ice (modifications, crystal structure, defects, physical properties)
• Micro-dynamics of ice (deformation and recrystallization mechanisms)
• Formation processes of natural ice (e.g. meteoric glacial ice, sea ice, ice shelf ice, marine ice)
• Mass balance of glaciers and ice sheets (ablation and accumulation measurements and processes, e.g. melting, calving)
• Ice dynamics (stress and strain, deformation modes, flow features, flow law)
• Poster session on hot topics in glaciological research (exam):
• basics poster preparation and presentation techniques
• present a topic / recent research paper on a poster and a 5 min. oral presentation and 5 min questions / discussion</td></tr>
<tr><td>Qualification Goals</td><td colspan="8">During the course the students will:
• Gather general knowledge of the field about the cryosphere and the related glaciological subtopics
• Develop an understanding of the physical processes relevant for the cryosphere
• Acquire an up to date overview of current glaciological research topics and being able to evaluate conclusions in a critical way
• Acquire expertise in assessing cryosphere related information with respect to modern climate change discussions
• Gather practical experience in simple ice core data processing and ice dynamic modelling (exercises and tutorials).</td></tr>
<tr><td rowspan="4">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="3">Glaciology</td><td>L</td><td>c</td><td>4</td><td>4</td><td rowspan="3">R</td><td rowspan="3">-</td><td rowspan="3">g</td><td rowspan="3">1</td></tr>
<tr><td>E</td><td>c</td><td>1</td><td>1</td></tr>
<tr><td>S</td><td>c</td><td>1</td><td>1</td></tr>
<tr><td>Applicability</td><td colspan="8">M.Sc. Geowissenschaften/Geosciences, M.Sc. Applied & Environmental Geoscience
The module covers topics related to the material of the core modules mineralogy, geodynamics and applied geosciences.</td></tr>
<tr><td>Prerequisites</td><td colspan="8">Fundamentals in geology/mineralogy and physics</td></tr>
</table>

Module Number: **M 316**	Module Title: **Geochemistry of the Mantle and Crust**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Studies: 90 h
Duration Module Coordinator	2 semesters				Siebel				
Regular Cycle	every second winter (lecture) and summer semester (field trip)								
Language	English								
Learning- / Teaching Forms	• Lecture (short course) on the basics of the evolution of the Earth crust and mantle • Field trip (usually 5 days) to present an overview of crustal and mantle rocks and magma formation processes								
Module Content	This module is comprised of a lecture session (short course at the end of the winter semester) and a field trip (during the summer) related to the lecture topics The lecture gives insight into the composition and evolution of the Earth's mantle and crust. During the field trip a variety of rock types (magmatic and volcanic) from these two major reservoirs will be explored.								
Qualification Goals	On successful completion of the course students should be able to know how crust and mantle were created and modified over geological time and about the magmatic processes which lead to their present-day composition.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Geochemistry of the mantle and crust	*L*	*c*	*2*	*6*	*A*	*-*	*g*	*1*
		FC	*c*	*4*		*SP*	*-*	*-*	*-*
Applicability	M.Sc. Geowissenschaften/Geosciences The module covers topics related to the major geological systems such as the Earth's crust mantle and the understanding of their internal structure and composition. The field trip illustrates basic and specific phenomena of igneous rocks originating from these two major Earth reservoirs.								
Prerequisites	Apart from geological and geochemical fundamentals there are no other essential requirements.								

Module Number: **M 320**	Module Title: **Advanced Field Methods in Geoscience 2**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: circa 14 field days						Private Studies: 0-40 h
Duration Module Coordinator	block course, circa 14 days			Bons					
Regular Cycle	annual								
Language	English								
Learning- /Teaching Forms	Supervised field exercise in small groups. Mapping and analysis of geological data, in conjuction with report writing and graphical data presentation (geological maps, stratigraphic columns, cross sections, etc.)								
Module Content	One mapping course entails: • Geological mapping of an area, individually or in small groups • Drawing of a geological map, as well a graphical representation of the stratigraphy and/or lithological relationships in the form of stratigraphical columns, cross sections, etc. • Writing of a report that summarizes the observations and interpretation of the geology and geological history of the mapping area • Depending on the duration of the course, credits may need to be gained with additional assignments. This must be defined and announced by the course leader before the mapping course itself. These can be, for example, additional field days, participation in preparation seminars, home work, etc..								
Qualification Goals	Students learn to independently apply geological field methods and techniques and gain practical experience in the geological analysis of a new area. They will undertake measurements, determine lithologies and stratigraphic sequences and will put these in their spatial context. The ability to make geological maps, cross sections and stratigraphical columns is among the core competencies of a geoscientist.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	Advanced Field Methods in Geoscience 2	*FC*	*c*	*6*	*6*	*A*	*-*	*g*	*1*
Applicability	M.Sc. Geowissenschaften/Geosciences								
Prerequisites	B.Sc. degree in geosciences and successful participation in the M.Sc. module "Advanced Field Methods in Geoscience" Participation only in case of sufficient capacity and approval of the instructor.								

<table>
<tr><td>Module Number:
M 322</td><td colspan="4">Module Title:
Climate Dynamics</td><td colspan="4">Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="8">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="3">Contact Time:
60 h / 4 SWS</td><td colspan="3">Private Study:
120 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="5">Rehfeld</td></tr>
<tr><td>Regular Cycle</td><td colspan="8">every summer semester</td></tr>
<tr><td>Language</td><td colspan="8">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="8">Lectures introduce fundamental concepts of climatology, the physical processes governing the climate system on different space and time scales, and empirical ways to describe and detect climate change.
In computer exercises, students learn to model basic physical processes in the atmosphere and apply classic and modern mathematical-statistical methods to describe, explain and predict different elements of the climate system.</td></tr>
<tr><td>Module Content</td><td colspan="8">This module offers an introduction to atmospheric processes, factors governing climate and climate change, links between climate and other Earth systems, and climate change of the past, present and future. Furthermore, it teaches the theoretical and practical knowledge of numerical models and mathematical-statistical techniques required for the description, explanation and prediction of climate. Module core content includes:
• processes governing the climate system on different scales: from orbital and tectonic controls to fast local feedbacks
• interactions between climate and other Earth systems (e.g. oceans and biosphere)
• climate change and its causes in the past, present and future
• physics-based numerical modelling of the atmosphere
• common empirical tools for climatology</td></tr>
<tr><td>Qualification Goals</td><td colspan="8">Students have a basic understanding of the physical processes governing climate and climate change and are able to understand and apply basic numerical models and common empirical techniques to typical problems in climatology. The students will be able to apply these models and implement these tools as self-developed programming code.</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Climate Dynamics</td><td>L</td><td>c</td><td>2</td><td>2</td><td rowspan="2">R</td><td rowspan="2">25</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>E</td><td>c</td><td>2</td><td>2</td></tr>
<tr><td>Applicability</td><td colspan="8">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience, M.Sc. Geographie</td></tr>
<tr><td>Prerequisites</td><td colspan="8">Knowledge of statistics and programming is useful, but not strictly required. No prior knowledge of climatology or meteorology is required.</td></tr>
</table>

Module Number: **M 324**	Module Title: **Economic Geology**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Time	Workload: 180 h		Contact times: 90 h / 6 SWS						Private Studies: 90 h
Duration Module Coordinator	1 semester			Staude					
Regular Cycle	every summer semester								
Language	English / German (can be held in German depending on students)								
Learning- /Teaching Forms	The module consists of lectures, complemented by exercises and compulsory 6-day field trip								
Module Content	This module gives insights into the exploration and mining practices used by geologists in the mineral and metal mining sector. The lecture will cover initial theoretical exploration praxis to practical greenfield and brownfield exploration, mining development stages, and mining geology. The focus is set on drilling (methods, planning, supervising, logging), data handling (databases, QAQC – Quality Assurance Quality Control, modelling) and data reporting (JORC code). The practical part focusses on drill core logging and 3-dimensional mapping in an underground mine including the exercise of appropriate report writing skills.								
Qualification Goals	In this module the students learn the methods and procedures of the international exploration and mining industry, independently of the commodity. A main aim is to learn the importance of data quality and data management throughout the exploration and mining stages.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Applied Economic Geology	*L*	*c*	*2*	*2*	*R& WE*	*60*	*g*	*1/3*
	Logging and Mapping Practical	*FC*	*c*	*4*	*4*				*2/3*
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Applied & Environmental Geoscience								
Prerequisites	The completion of the B.Sc. module "Georessourcen" (or similar lecture) is required.								

Module Number: **M 325**	Module Title: **Data Analysis and Modeling Methods in Geo-science and Environmental Science 2**	Type of Module: M.Sc. Elective
Credits (ECTS)	6	
Workload - Contact Time - Private Study	Workload: 180 h	Contact Time: 3 x 20 h / 4 SWS Private Study: 3 x 40 = 120 h
Duration Module Coordinator	1 semester	Drews
Regular Cycle	every semester	
Language	English	
Learning- / Teaching Forms	Lectures and Computer Exercises for Data Analysis and Modeling	
Module Content	This module is for students who want to increase their knowledge about data analysis and modeling methods acquired in module M317 (Data Analysis and Modeling Methods in Geoscience and Environmental Science 1). The content of the module is described in module M317. The individual units are offered either over four weeks within the lecturing period of the semester, or as one-week block course. The selection of additional 3 units out of the units offered in M317 can be used to fill module M325 (each unit counts for two credits). Some units require prior participation in other units of this module (check with instructors beforehand).	
Qualification Goals	The goals of this module are • that students are able to understand selected mathematical concepts • that they can implement them computationally, that they can apply them to geo- and environmental related problems • develop relevant technical skills for data analysis and modelling • applied problem solving skills using Matlab / Python / R	

Requirements for Obtaining Credit, Grading, Weight if appl.

Courses	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Require-*	*Duration of Exam*	*Grading System*	*Weighting*
Variable Topics	*L,E*	*c*	*2*	*2*	*R,A*	*-*	*g*	*1/3*
Variable Topics	*L,E*	*c*	*2*	*2*	*R,A*	*-*	*g*	*1/3*
Variable Topics	*L,E*	*c*	*2*	*2*	*R,A*	*-*	*g*	*1/3*

Applicability	Compulsory: M.Sc. Geowissenschaften/Geosciences, Elective: M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geosciences This module compliments other geology, geoecology, and environmental sciences courses (e.g. Advanced Geophysics, Climate Dynamics, Physics of the Earth's Surface) by providing a background for quantitative data analysis and modelling.
Prerequisites	(TBD w.r.t. Python, Matlab, R)

Module Number: **M 326**	Module Title: **Experimental and Analytical Methods in Geoscience and Environmental Science 2**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h						Private Study: 90 h
Duration Module Coordinator	1 semester			Schulz, Berthold					
Regular Cycle	every summer semester								
Language	English								
Learning- / Teaching Forms	Lectures and laboratory exercises								
Module Content	The module is for students deeply interested in analytical methods. It offers access to more "advanced" techniques. Units are: • Advanced Electron Microscopy • Advanced Methods for Dating Rocks and Sediments • Quaternary Case Studies: Putting together the Story of Lake Filling and Drying in the Australian Desert • Dating Quaternary Sediments • Introduction to Mössbauer Spectroscopy • Material Orientated Computer Tomography • The Geology of Building Stones (starting summer semester 2024) Each unit counts for 2 credits. Students are free to select 3 units out of the units offered, including the units offered in module M321 (Experimental and Analytical Methods in Geoscience and Environmental Science 1). In small groups, the units allow direct contact to staff scientists, advanced laboratories and institute infrastructure. Group sizes are limited, based on the maximum available staff and laboratory capacities. The individual units are offered either over 4 weeks within the lecturing period of the semester, or as one-week block course.								
Qualification Goals	The courses are designed to learn and to test a variety of specific instrumental methods and to get familiar with the laboratory work flows and routines.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Variable Topics	*L,E*	*c*	*2*	*2*	*R,A,OE*	*-*	*g*	*1/3*
	Variable Topics	*L,E*	*c*	*2*	*2*	*R,A,OE*	*-*	*g*	*1/3*
	Variable Topics	*L,E*	*c*	*2*	*2*	*R,A,OE*	*-*	*g*	*1/3*
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geosciences								
Prerequisites	-								

Module Number: **M 327**	Module Title: **Advanced Magmatic Petrology**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h	Contact Time: 75 h / 5 SWS							Private Study: 105 h
Duration Module Coordinator	1 semester				Markl				
Regular Cycle	every summer semester								
Language	English								
Learning- / Teaching Forms	The module is offered as a compact course and combines lectures, practices in thin-section microscopy (in the presence of the lecturer, 7 days) and self-studies on thin-section microscopy (3 days) of selected samples with the interpretations based on these practical exercises.								
Module Content	Taught are aspects of magmatic rocks in various tectonic setting and of various chemical families (granites, basalts, carbonatites, alkali rocks ...). Special care is taken to teach the identification of magmatic assemblages and textures by polarization microscopy and their interpretation (equilibrium/non-equilibrium, zoning, magma processes, degassing ...).								
Qualification Goals	The main goal of this module is a basic understanding of ramifications for the formation of magmatic rock suites. Students should after completing the module be able to analyse and interpret unknown magmatic rocks with regards to their formation, evolution and crystallization processes. The extensive practical exercises using the polarization microscope allow them to acquire advanced knowledge of working with rocks in general and with magmatic rocks in specifics.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Magmatic processes	*V*	*o*	*3*	*4*	*K*	*90*	*b*	*1*
		Ü	*o*	*2*	*2*	*ET/R*	*-*	*ub*	*-*
Applicability	This module is tightly connected to the modules on "Igneous Processes" and „Metamorphic Processes". All three modules use polarization microscopy to understand mineral textures in rocks to deduce interpretations of their geological context of formation.								
Prerequisites	Basic knowledge in mineralogy, petrology, of using a polarization microscope and of the application of phase diagrams to the interpretation of geological processes Completion of the Igneous Processes module								

Module Number: **M 401**	Module Title: **Terrestrial Ecosystems – Excavation and Laboratory Internship**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Studies: 90 h
Duration Module Coordinator	1 semester				Böhme				
Regular Cycle	every summer semester								
Language	English								
Learning- /Teaching Forms	During the excavation and laboratory internship students learn in the field basic techniques of excavating and recovering fossils. It includes common techniques of sediment treatment and subsequent analytical procedures in the laboratory. The results have to be documented in excavation- and lab reports.								
Module Content	• Fundamentals of paleontological excavation methods • Types of continental sediments and their description • Analytical field methods • Fossil recovery, documentation, sampling • Treatment of continental sediments (wet sieving) • Preparation of fossil vertebrates • Isotope laboratory, preparation of fossil material for geochemical isotope analyses								
Qualification Goals	The methodical search for fossils in a systematic paleontological excavation requires basic competences in methodology and practical experience. The students know the practical and methodical procedure of prospecting continental fossil assemblages. They have practical experience in paleontological excavation methods, treatments and analyses including the isotope geochemistry. This comprehensive knowledge enable them to participate on future excavation campaigns and are a fundamental requirement for their own advanced research activities.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of lecture*	*Status*	*CH*	*CP*	*Assessment / Study requirement*	*Duration of assessment*	*Grading system*	*weighting*
	Field course (7 field days)	*FC*	*c*	*5*	*3*	*A*	*-*	*ng*	*0,5*
	Laboratory internship (5 days)	*LC*	*c*	*3*	*3*	*LP*	*-*	*g*	*0,5*
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology								
Prerequisites	Basics in palaeontology and sedimentary geology								

Module Number: **M 402**	Module Title: **Evolution of Organisms**								Type of Module: Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90 h						Private Studies: 90 h
Duration Module Coordinator	1 semester			Werneburg					
Regular Cycle	every winter semester								
Language	English								
Learning- /Teaching Forms	Lecture and practical								
Module Content	The lecture provides an overview about the comparative anatomy of all major vertebrate groups (fishes, amphibians, reptiles, and mammals). We focus on 10 prominent features of vertebrate anatomy (skeleton, eyes, skin, etc.), discuss major transitions in evolution, and study variation in form and function. Aspects of embryology, zoology, and paleontology are always considered. The practical contains the observation of a variety of animal organ preparations and microscopy to learn about fundamental aspects of vertebrate morphology. An excursion and/or the dissection of a vertebrate will be offered. The zoological, paleontological, and embryonic collections of Tübingen University will be consulted to gain first-hand observations.								
Qualification Goals	Explaining and evaluating the composition of the vertebrate body; being able to trace variation in form and function through evolution and embryology and to derive paleoecological conclusions based on anatomical features.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	Evolutionary Vertebrate Morphology	*L*	*c*	*4*	*4*	*WE/ OE*	*45*	*g*	*2/3*
	Evolutionary Vertebrate Morphology	*E*	*c*	*2*	*2*	*SP/L P/R*	*30*	*g*	*1/3*
Applicability	M.Sc. Geowissenschaften/Geosciences (obligatory for the specialization in paleontology), M.Sc. Geoökologie/Geoecology Student of other disciplines (Biologie, Ökogeologie, Archäologie, etc.) are most welcome to join.								
Prerequisites	Basic knowledge on animal evolution and anatomy.								

Module Number: **M 403**	Module Title **Palaeoecology of Terrestrial Ecosystems**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 90h / 6 SWS						Private Study: 90 h
Duration Module Coordinator	1 semester			Bocherens					
Regular Cycle	every summer semester								
Language	English								
Learning- / Teaching Forms	A wide range of teaching methods are used. Subject specific theoretical and practical skills are presented during lectures and in exercise sessions. Seminar sessions introduce presentation and reporting elements which address generic communication and presentation skills.								
Module Content	• Important characteristics of terrestrial ecosystems nowadays and in the past • Description of the main approaches (autoecology, synecology, geochemical tracers) • Taphonomy, diagenesis and palaeoecology of terrestrial ecosystems • Initial adaptations and the early terrestrial record • Terrestrial ecosystems through time • The role of biotic and abiotic factors in the evolution of terrestrial ecosystems • The impact of mass extinctions on terrestrial ecosystems • Changes in terrestrial ecosystems and human evolution								
Qualification Goals	• Students are familiar with the history of life on land and can apply the methods used to reconstruct this history. • They have the ability to critically assess specialized literature related to this field and to appropriately present research topics in written and oral form.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Paleoecology of Terrestrial Ecosystems	*L*	*o*	*3*	*3*	*WE*	*120*	*g*	*1*
		S	*o*	*2*	*2*	*R*	-	-	-
		E	*o*	*1*	*1*	*A*	-	-	-
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology								
Prerequisites	B.Sc. courses "History of the Earth", "Palaeontology", "Palaeobiology" or equivalent								

Module Number: **M 404**	Module Title: **Micropaleontology**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 60 h / 4 SWS						Private Studies: 120 h
Duration Module Coordinator	1 semester				Junginger				
Regular Cycle	winter semester (every other year)								
Language	English								
Learning- / Teaching Forms	Lectures are accompanied by practical laboratory and microscopy exercises.								
Module Content	The module introduces the biology, ecology, morphology and geological significance and evolution of important microfossil groups. The role of microfossils as paleoenvironmental indicators and in industrial micropalaeontology and biostratigraphy is discussed. Students learn the practical skills of processing and analyzing micropaleontological samples.								
Qualification Goals	Students are familiar with the process of identification and classification of microfossils and understand the evolutionary history and geological significance of microfossil-producing organisms. They are able to independently carry out paleoenvironmental analyses and age determinations with microfossils and are able to critically evaluate micropaleontological data. Practical skills in processing of micropaleontological material from sampling to interpretation and the understanding of the potential industrial applications of micropalaeontology are a key competence needed exploration of oil and gas reservoirs.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Micropaleontology	*L*	*c*	*2*	*3*	*WE*	*90*	*g*	*1*
		E	*c*	*2*	*3*				
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology The module covers topics related the fields of sedimentology and stratigraphy.								
Prerequisites	B.Sc. modules "Erdgeschichte", "Sedimente & Stratigraphie", "Paläontologie" or equivalent								

Module Number: **M 405**	Module Title: **Palaeoecology of Marine Ecosystems**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 60 h / 4 SWS						Private Studies: 120 h
Duration Module Coordinator	1 semester				Nebelsick				
Regular Cycle	every winter semester								
Language	English								
Learning- / Teaching Forms	The necessary knowledge basis will be mediated during lectures. In the practical part of the course, the students will learn to analyze relevant ecological parameters using information contained in fossil material. Ancient marine environments will be reconstructed using fossils, depositional fabrics and associated sediments.								
Module Content	Relationships between organisms and their environment Analysis of organism relationships between taxa Ecosystem analysis of marine depositional systems								
Qualification Goals	The students will obtain the following qualifications: Basic knowledge will be attained with respect to functional morphology, organism-relationships and ecosystems in fossil depositional systems. After attending the module, the participants will be able to make ecological interpretations of individual marine fossils, to analyze the species interactions as well as reconstruct ancient ecosystems. They will be able to apply their knowledge to recognize the reciprocal interaction of biological and physical parameters in marine ecosystems using relevant data from the geological record. The participants will be able to apply different methods for paleontological interpretations. They will be able to solve complex problems with respect to functional morphology, actualistic paleontology, animal relationships such as predation and encrustations as well as the paleoecology of marine ecosystems.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Palaeoecology of Marine Ecosystems	*L*	*c*	*4*	*3*	*A*	*-*	*g*	*1*
		E	*c*	*2*	*3*				
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Biologie								
Prerequisites	Basics in palaeontology and biology								

<table>
<tr><td>Module Number:
M 407</td><td colspan="4">Module Title
Conservation Palaeoecology</td><td colspan="4">Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="8">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="3">Contact Time:
90 h / 6 SWS</td><td colspan="3">Private Study:
90 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="4">1 semester</td><td colspan="4">Bocherens</td></tr>
<tr><td>Regular Cycle</td><td colspan="8">every winter semester</td></tr>
<tr><td>Language</td><td colspan="8">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="8">A wide range of teaching methods are used. Subject specific theoretical and practical skills are presented during lectures and in exercise sessions. Seminar sessions introduce presentation and reporting elements which address generic communication and presentation skills.</td></tr>
<tr><td>Module Content</td><td colspan="8">• Conservation of species and ecosystems needs to consider knowledge from their past, since most ecosystems today are strongly impacted by current and past human impact and most endangered species are relicts or refugee species.
• Description of the main approaches (palaeobiogeography, palaeogenetics, geochemical tracers, niche reconstruction)
• Reconstruction of fundamental niche of endangered species
• Holocene and Pleistocene rewilding for sustainable future ecosystems
• Evolution of human impact in the Pleistocene and Holocene
• Lessons from deep time ecosystems (greenhouse Earth, mass extinction recovery)</td></tr>
<tr><td>Qualification Goals</td><td colspan="8">• Students are familiar with the importance of taking information from paleobiology to help in conservation decision making.
• They have the ability to critically assess specialized literature related to this field and to appropriately present research topics in written and oral form.</td></tr>
<tr><td rowspan="4">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="3">Conservation Palaeoecology</td><td>L</td><td>o</td><td>3</td><td>3</td><td>WE</td><td>120</td><td>g</td><td>1</td></tr>
<tr><td>S</td><td>o</td><td>2</td><td>2</td><td>R</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>E</td><td>o</td><td>1</td><td>1</td><td>A</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Applicability</td><td colspan="8">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology</td></tr>
<tr><td>Prerequisites</td><td colspan="8">B.Sc. module "Climatology and Ecosystems of the Earth" or equivalent</td></tr>
</table>

<table>
<tr><td>Module Number:
M 408</td><td colspan="5">Module Title:
Vertebrates and Plants of the Cenozoic</td><td colspan="4">Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="9">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="3">Workload:
180 h</td><td colspan="3">Contact Time:
90 h / 6 SWS</td><td colspan="3">Private Study:
90 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="4">1 semester</td><td colspan="5">Böhme</td></tr>
<tr><td>Regular Cycle</td><td colspan="9">every winter semester</td></tr>
<tr><td>Language</td><td colspan="9">English</td></tr>
<tr><td>Learning- / Teaching Forms</td><td colspan="9">Lectures are combined with exercises using the extensive palaeontological teaching and exercise collection.</td></tr>
<tr><td>Module Content</td><td colspan="9">• Principles of terrestrial stratigraphy (biostratigraphy) and taphonomy
• Plants as proxy for vegetation, climate and environments
• Vertebrates as climate and environmental proxies
• Plant morphology and botanical taxonomy
• Fundamentals of osteology and evolution of continental vertebrates of the Cenozoic
• Exercises for the determination of Cenozoic vertebrates and macroflora</td></tr>
<tr><td>Qualification Goals</td><td colspan="9">• Understanding biological interactions of continental processes
• Fundamentals of morphology and evolution of Cenozoic vertebrates and plants
• Insight into the variety of reconstruction methods (climate, environment, vegetation)
• Experience in the determination of continental fossils (vertebrates, plants)</td></tr>
<tr><td rowspan="3">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Vertebrates and Plants of the Cenozoic</td><td>L</td><td>c</td><td>3</td><td>3</td><td rowspan="2">OE</td><td rowspan="2">30</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>E</td><td>c</td><td>3</td><td>3</td></tr>
<tr><td>Applicability</td><td colspan="9">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology</td></tr>
<tr><td>Prerequisites</td><td colspan="9">Basics in paleontology</td></tr>
</table>

<table>
<tr><td>Module Number:
M 409</td><td colspan="4">Module Title:
Marine Geology and Geochemistry</td><td>Type of Module:
M.Sc. Elective</td></tr>
<tr><td>Credits (ECTS)</td><td colspan="5">6</td></tr>
<tr><td>Workload
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="2">Contact Time:
90 h / 6 SWS</td><td>Private Studies:
90 h</td></tr>
<tr><td>Duration
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="2">Schulz</td></tr>
<tr><td>Regular Cycle</td><td colspan="5">every winter semester</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning- /Teaching Forms</td><td colspan="5">Teacher-centered teaching; studying literature on the subject, talk/exposé, handouts, laboratory practice.</td></tr>
<tr><td>Module Content</td><td colspan="5">• Evolution and structure of ocean basins and –margins
• Marine sedimentation and –accumulation
• Marine natural resources
• Ocean circulation/effects of currents and waves
• Chemical evolution of the ocean system
• Natural and anthropogenic tracers
• Methods of survey and sampling</td></tr>
<tr><td>Qualification Goals</td><td colspan="5">Students will understand the marine-geological processes between the ocean floor, sedimentation, ocean circulation and the biogeochemical cycles. Candidates learn to analyse and interpret the modern depositional facies, and how to describe elemental fluxes and –fractionations of the oceans. Laboratory and methodological practice on sediment processing and -characterization will provide skills and competence using the large variety of sediment core profiles from the Tübingen repository.</td></tr>
<tr><td rowspan="4">Requirements for Obtaining Credit, Grading, Weight if appl.</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CP</td><td>Type of Exam / Study Requirements</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Marine Geochemistry</td><td>L,S</td><td>c</td><td></td><td>2</td><td rowspan="3">R</td><td rowspan="3">-</td><td rowspan="3">g</td><td rowspan="3">1</td></tr>
<tr><td>Marine Geology</td><td>L,S</td><td>c</td><td></td><td>2</td></tr>
<tr><td>Marine Geology</td><td>E</td><td>c</td><td></td><td>2</td></tr>
<tr><td>Applicability</td><td colspan="5">M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Applied & Environmental Geoscience
Related M.Sc. modules are "Paleoecology of Marine Systems", "Isotope Geochemistry" and "Carbonate Facies Analysis"</td></tr>
<tr><td>Prerequisites</td><td colspan="5">B.Sc. modules "Einführung in die Geowissenschaften", "Erdgeschichte", "Sedimente und Stratigraphie", "Paläontologie"
Course limited to 14 students.</td></tr>
</table>

Module Number: **M 503**	Module Title: **Paleobotany/Palynology**								Type of Module: M.Sc. Elective
Credits (ECTS)	6								
Workload - Contact Time - Private Study	Workload: 180 h		Contact Time: 75 h / 5 SWS						Private Study: 105 h
Duration Module Coordinator	1 semester				Böhme				
Regular Cycle	every winter semester								
Language	English								
Learning- / Teaching Forms	The course is being held as a block module, which flexibly combines lectures with practical training units in the laboratory, at the microscope and on the computer.								
Module Content	• Plant fossils as a basis for paleoecological reconstructions • Fundamentals in terrestrial palynology: preparation, microscopy, determination of extant and fossil pollen • Quantitative methods to reconstruct climate and vegetation • Discussion of current research topics in paleobotany.								
Qualification Goals	After completing the module, the participants have the knowledge to use plant fossils for environmental reconstructions. With the ability to evaluate the potential of plant fossils as environmental indicators in different contexts, as well as the practical experience in palynological methods of treatments and analyses, the students acquire important basic skills in the field of palynology. Practical exercises of quantitative methods for climate and vegetation analyses will be a fundamental part of the course as well as their application on an individual topic elaborated on in a written module thesis. Together, this will enable the participants to better understand, analyse, and handle scientific research questions in the field of paleobotany and palynology.								
Requirements for Obtaining Credit, Grading, Weight if appl.	*Courses*	*Type of Lecture*	*Status*	*CH*	*CP*	*Type of Exam / Study Require-*	*Duration of Exam*	*Grading System*	*Weighting*
	Paleobotany/Palynology	*L*	*o*	*3*	*3*	*A*	*-*	*g*	*1*
		E	*o*	*2*	*3*				
Applicability	M.Sc. Geowissenschaften/Geosciences, M.Sc. Geoökologie/Geoecology, M.Sc. Naturwissenschaftliche Archäologie								
Prerequisites	Basics in palaeontology, archaeology, biology								