LUDWIG-
MAXIMILIANS-
UNIVERSITÄT
MÜNCHEN

DRAFT

Module Handbook

Master's Programme: Geology (Master of Science, M.Sc.)

(120 ECTS credits)

Based on the *Prüfungs- und Studienordnung* of XX XXXX XXXX.

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Abbreviations and annotations

CP	Credit Points, ECTS credits
ECTS	European Credit Transfer and Accumulation System
h	hours
SoSe	summer semester
SWS	contact hours
WiSe	winter semester
WP	compulsory elective course
P	mandatory course

1. The ECTS credits assigned in the Module Handbook are designated as follows: Credit Points not listed in parentheses are awarded when the pertinent examination of the module or module parts have/has been completed successfully. Credit Points in parentheses are listed for calculatory purposes only.

2. The semester for taking a module can either be binding or may be considered as a recommendation, depending on the applicable data in Anlage 2 of the *Prüfungs- und Studienordnung* for your Programme. In this Module catalogue, the options are indicated as "scheduled semester" and "recommended semester".

3. Please note: The Module Handbook is merely intended to serve as an orientation whereas the provisions of the applicable version of the *Prüfungs- und Studienordnung* (in German only) of your Programme are legally binding. See: www.lmu.de/studienangebot and select your Programme, or consult the "Master's Degree Program in Geology" webpages (which also provide an unofficial English translation of the regulations).

4. The detailed contents of each module component and the suggested literature may change often, therefore these will be provided by each individual instructor at the beginning of the relevant semester in the form of a „course syllabus", either in print or online.

5. The Module Handbook lists all the allowed examination modalities for each module. If more than one type of examination is allowed, the specific type chosen each year for a module or module component will be provided at the beginning of the relevant semester by the instructors, as stated in the *Prüfungs- und Studienordnung*.

6. Unless otherwise indicated in writing by the instructor of the course or by the supervisor of the project, students are expected to pay for their own travel expenses and bring their own personal equipment, if the course / research project requires that field work be carried out.

Module: P 1 Geological Field Mapping and Exploration

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	P 1.1 Field Seminar	WiSe	30 h (2 SWS)	60 h	(3)
Field exercise	P 1.2 Field Mapping and Exploration	SoSe	-	90 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 2 contact hours per week for P1.1. Including time for self-study and field time, 180 hours have to be invested in total.

Module type	Mandatory module with mandatory courses.
Usability of the module in other Programmes	/
Elective guidelines	None
Entry requirements	There are no formal requirements, but this place-based core geological field course requires special preparation. This is a course requires students to pay for their own travel expenses and to bring their own equipment. See below and comments under "Additional Information". Bachelor-level courses in rock recognition, sedimentology, petrology, and structural geology are a recommended prerequisite. Extensive hiking and outdoor physical challenges require that students be physically fit. See additional comments below ("Additional Information"). Participants must have personal health insurance, travel insurance, personal medical precautions, and shots recommended or required (e.g. Tetanus). For updated information consult the official travel advisory pages. Students should be prepared for variable weather (heat, wind, rain, snow), rigorous days in the field and undeveloped camping and lodging conditions, pending the camp location. More detailed information will be distributed at the beginning of the course. Local cultural etiquette, responsible behavior, and obedience of the course rules are a basic prerequisite of the course. Inappropriate behavior may lead to exclusion from the course at the participants own costs and will result in failure of the course. Participation in the course is at the participant's own risk.
Semester	Module split over two semesters. P1.1: recommended semester 1.

	P1.2: scheduled semester 2.
Duration	The completion of the module takes 2 semesters.
Content	Geological field work is the traditional foundation of geology. This module combines traditional techniques in field geology and exploration with the modern digital and remote sensing mapping methods that allow better mapping of geologically interesting regions. The field seminar and the field course develop skills of observation and interpretation while teaching the technical aspects of advanced field mapping, synthesis, stratigraphic interpretation, structural analysis, geomorphological analysis, and resource-geology analysis. Preparation of maps, stratigraphic charts, geological cross-sections, and reports is an important part of the course. This place-based field camp exposes students to new natural, cultural, and social, and settings, which provides opportunity for personal and interpersonal growth. The module is based on the assumption that the expertise in rock recognition, sedimentology, petrology, and structural geology, and the basic skills in geological field methods have been already acquired in Bachelor-level courses. Further details will be given out at the beginning of the preparatory field seminar.
Learning outcomes	Students will acquire skills in advanced geological mapping, such as geological synthesis, geological data collection, construction of speciality maps and cross-sections, stratigraphic columns, analytical field mapping techniques, and the preparation of field reports with research-oriented background. Participants will also acquire expertise in regional reconnaissance mapping using remote sensing techniques and trip planning. Students will also improve their extracurricular qualifications such as personal and interpersonal skills.
Type of examination	Mapping report folder
Type of assessment	The successful completion of the module will be graded.
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Prof. Dr. Anke Friedrich
Language(s)	English
Additional information	Students who do not take P1.1 and P1.2 in consecutive semesters as recommended will most likely fail the module, as the contents of P1.1 are (1) tailored to a specific field location and (2) necessary for carrying out the tasks set in P1.2. Field locations may vary from year to year, and there is no textbook that students can "study" to get ready. Most of the preparation will be done in class discussions that are unique to any given year. Therefore students are strongly advised

against changing the order from the first and second semester sequence suggested. It is possible to move this sequence to third and fourth semester, especially for students with insufficient basic knowledge of rocks, minerals, and field methods (in such cases, it is up to the student to fill these gaps on his/her own before taking this course). For the same reasons, even though regular presence is not required in the seminar, it is strongly recommended.

Students who are unable to participate in the required field course must notify the Programme Coordinator no later than October 5th in their first semester of enrollment. Exemptions may be granted only on either medical or financial grounds. Notification must be made in writing, by submitting a formal request by letter accompanied by adequate documentation of medical or financial impediments, which will be then evaluated by the Examinations Board (*Prüfungsausschuss*).

Late notifications are possible only in exceptional cases (e.g. sudden injury/illness with permanent disability occurring after the October 5^{th} deadline). International students, who have already declared upon application to the Programme of having sufficient financial resources to support their studies, must document in detail their change in financial circumstances before being allowed an exemption on financial grounds.

Those students whose application for exemption is accepted, will be assigned a suitable alternative module with an equivalent number of ECTS by the Examinations Board (*Prüfungsaussschuss*). Due to the "mandatory" nature of the module being substituted, students do not have the possibility of taking a substitute module on their own. The "Geological Field Mapping and Exploration" module will not appear in the student's transcripts, and in its place the name of the module used for the substitution will appear instead. This substitute module cannot contain any components that the student has already used for credit elsewhere. Conversely, components used in the substitution cannot be used at a later date to claim credits in another module. Because of the interdependence between P1.1 and P1.2, a substitution will include the entire module; substitution of P1.2 alone is not permitted.

Module: P 2 Deformation and Transformation

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	P 2.0.1 Rheology	WiSe	60 h (4 SWS)	120 h	(6)
Integrated learning activity	P 2.0.2 Geochronology	WiSe	60 h (4 SWS)	120 h	(6)

For succesful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours per week. Including time for self-study, 180 hours have to be invested per semester.

Module type	Mandatory module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	One of the compulsory elective courses P 2.0.1 and P 2.0.2 must be taken. Students who take the compulsory elective course P 2.0.1 may not take the compulsory elective course WP 7.0.1. Students who take the compulsory elective course P 2.0.2 may not take the compulsory elective course 4.0.2.
Entry requirements	Previous successful participation in a Bachelor-level course in Polarization Microscopy (if taking P 2.0.1) or in Geochemistry (if taking P 2.0.2) is strongly recommended.
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	This module represents two core subdisciplines of geology that study deformation and transformation processes in rocks of the Earth's interior. In the module component *Rheology*, students are introduced into modern concepts that relate grain-scale deformation and transformation processes at depth to the large-scale rheological behavior of the lithosphere. The emphasis is on the microfabric development during deformation, recrystallization and dissolution-precipitation processes at metamorphic conditions. Flow laws and paleopiezometers derived from deformation experiments are discussed and used to obtain quantitative data on stress, strain and strain rate from specific microstructures. These topics will be addressed by a combination of lectures, reading seminars, exercises and polarized light microscopy.

	The primary goal is to enable students to use the microstructural record of metamorphic rocks to obtain information on the deformation and stress history as well as on the rheological behavior at depth. The module component *Geochronology* examines by physical methods when and for how long geological processes take place. Thus the formation and evolution of Earth and other planets can be tagged with 'absolute' ages. With geochronological methods we can date, for example, processes such as formation of continents, melting events in mantle and crust, metamorphism, erosion of the Earth's crust. The most accurate methods of age determination are based on the decay of radioactive atoms and the measurement of isotopic abundances with a mass spectrometer. In this module component, the geologically important dating methods (e.g. U-Pb, K-Ar, Rb-Sr, Sm-Nd, Lu-Hf, Re-Os, C-14, fission track dating, uranium series) will be presented and their capabilities and limitations demonstrated.
Learning outcomes	The goal of this module is for students to acquire advanced knowledge and to connect theory and practice in interpreting and/or dating geological events on the base of the microstructural, isotopic, and geochemical record of rocks. It is also to enable students to learn, understand and critically discuss specific features, limits and terminology that define the fields of rheology and geochronology, as well as to apply this knowledge in solving specific problems on the microstructural and geochronological record of rocks ("No Dates, No Rates").
Type of examination	Written or oral exam or written report or presentation. The definite exam modalities will be announced by the course instructor at the beginning of the semester.
Type of assessment	The successful completion of the module will be graded.
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Prof. Dr. Claudia Trepmann
Language(s)	English
Additional information	

Module: P 3 Surface Processes

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	P 3.0.1 Earth Surface Processes	WiSe	60 h (4 SWS)	120 h	(6)
Integrated learning activity	P 3.0.2 Sedimentary Basin Dynamics	WiSe	60 h (4 SWS)	120 h	(6)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours per week. Including time for self-study, 180 hours have to be invested per semester.

Module type	Mandatory module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	One of the compulsory elective courses P 3.0.1 and P 3.0.2 must be taken. Students who take the compulsory elective course P 3.0.1 may not take the compulsory elective course WP 7.0.2. Students who take the compulsory elective course P 3.0.2 may not take the compulsory elective courses P 5.0.2 and WP 7.0.7.
Entry requirements	Previous successful participation in a Bachelor-level course in Geomorphology and Calculus (if taking P 3.0.1) or in Tectonics and Sedimentology (if taking P 3.0.2) is strongly recommended.
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	This module represents two core subdisciplines of geology that study processes that affect and shape the Earth's surface on different scales in time and space. The course *Earth Surface Processes* introduces students to the physical concepts of geomorphology, which help to quantify the pace of landscape evolution over different timescales. These modern theories explain how landscape evolves through time under constant and/or variable boundary conditions. The presented concepts demonstrate basic flow laws for geomorphic agents such as for example water and ice, and emphasis will focus on the understanding of erosion and sediment transport processes in different landscapes. The topics will be addressed by a combination of lectures, reading seminars, and laboratory

	exercises, where the theoretical background will be applied by the students. The goal is to understand processes of landscape evolution and to enable students to identify, analyze, and interpret these processes quantitatively. In *Sedimentary Basin Dynamics* students are introduced to modern interdisciplinary concepts relating to the formation and evolution of lithospheric-scale sedimentary basins. Special emphasis will be given to theoretical concepts linking basins to orogenic systems, their plate tectonic context, and the key observations including sedimentary, stratigraphic, geological, geophysical, and geochronological data, which form the basis of basin analysis. The course may include a field trip to a sedimentary basin, case-studies, in-depth review of recent literature, and problem-sets to quantify basin evolution on a range of space and time scales.
Learning outcomes	The goal of this module is to acquire advanced interdisciplinary knowledge and to connect theory and practice in either Earth Surface Processes or Sedimentary Basin Dynamics. This module also enables students to learn, understand, and critically discuss specific features, limits and terminology that define each field, as well as to apply this knowledge in solving specific problems using modern analytical tools in context.
Type of examination	Written or oral exam or written report or presentation. The definite exam modalities will be announced by the course instructor at the beginning of the semester.
Type of assessment	The successful completion of the module will be graded.
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Prof. Dr. Miriam Dühnforth
Language(s)	English
Additional information	

Module: P 4 Active Tectonics

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	P 4.0.1 Modern Active Tectonics	WiSe	60 h (4 SWS)	120 h	(6)
Integrated learning activity	P 4.0.2 Geochronology	WiSe	60 h (4 SWS)	120 h	(6)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours per week. Including time for self-study, 180 hours have to be invested per semester.

Module type	Mandatory module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	One of the compulsory elective courses P 4.0.1 and P 4.0.2 must be taken. Students who take the compulsory elective course P 4.0.1 may not take the compulsory elective course WP 7.0.3. Students who take the compulsory elective course P 4.0.2 may not take the compulsory elective course P 2.0.2.
Entry requirements	Previous successful participation in a Bachelor-level course in Structural Geology, Tectonics, Seismology, or Geodynamics (if choosing P 4.0.1) or in Geochemistry (if choosing P 4.0.2) is strongly recommended.
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	This module represents two core subdisciplines of geology that study processes related to active deformation of the Earth's lithosphere. In *Modern Active Tectonics* students are introduced to the modern concepts from active tectonics that underlie our current understanding of the deformation the Earth. Special emphasis is placed on seismotectonics and on the tectonics and mechanics of accretionary wedges, orogenic wedges, and subduction zones. Specific topics treated in this module component change on a yearly basis.

	The module component *Geochronology* examines by physical methods when and for how long geological processes take place. Thus the formation and evolution of Earth and other planets can be tagged with 'absolute' ages. With geochronological methods we can date, for example, processes such as formation of continents, melting events in mantle and crust, metamorphism, erosion of the Earth's crust. The most accurate methods of age determination are based on the decay of radioactive atoms and the measurement of isotopic abundances with a mass spectrometer. In this module component, the geologically important dating methods (e.g. U-Pb, K-Ar, Rb-Sr, Sm-Nd, Lu-Hf, Re-Os, C-14, fission track dating, uranium series) will be presented and their capabilities and limitations demonstrated.
Learning outcomes	The goal of this module is for students to acquire advanced knowledge and to connect theory and practice in either Modern Active Tectonics or Geochronology. It is also to enable students to learn and understand the specific features, limits and terminology that define each field, and to apply this knowledge in solving specific problems.
Type of examination	Written or oral exam or written report or presentation. The definite exam modalities will be announced by the course instructor at the beginning of the semester.
Type of assessment	The successful completion of the module will be graded.
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Dr. habil. Sara Carena
Language(s)	English
Additional information	

Module: P 5 Geological Resources

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	P 5.0.1 Geology of Mineral Deposits	WiSe	60 h (4 SWS)	120 h	(6)
Integrated learning activity	P 5.0.2 Sedimentary Basin Dynamics	WiSe	60 h (4 SWS)	120 h	(6)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours per week. Including time for self-study, 180 hours have to be invested per semester.

Module type	Mandatory module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	One of the compulsory elective courses P 5.0.1 and P 5.0.2 must be taken. Students who take the compulsory elective course P 5.0.1 may not take the compulsory elective course WP 7.0.4. Students who take the compulsory elective course P 5.0.2 may not take the compulsory elective courses P 3.0.2 and WP 7.0.7.
Entry requirements	If taking P 5.0.2, previous successful participation in a Bachelor-level course in Tectonics and Sedimentology is strongly recommended.
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	This module represents two core subdisciplines of geology that are relevant to exploration for geological resources. The module component *Geology of Mineral Deposits* gives an overview over the economically significant types of mineral deposits. Their global distribution, economic relevance, geological environment (from the regional scale to the scale of the ore-body) as well as models for their genesis are discussed. Manifestations of ore-forming processes and relevant characteristic for their exploration are presented. In exercises the gained knowledge will be applied and deepened. For these exercises several hand specimens of different mineral deposits are available. The primary goal is for the students to acquire a

	comprehensive knowledge on the different types of mineral deposits, their specific characteristics as well as key-factors for their genesis. In *Sedimentary Basin Dynamics* students are introduced to modern interdisciplinary concepts relating to the formation and evolution of lithospheric-scale sedimentary basins. Special emphasis will be given to theoretical concepts linking basins to orogenic systems, their plate tectonic context, and the key observations including sedimentary, stratigraphic, geological, geophysical, and geochronological data, which form the basis of basin analysis. The course may include a field trip to a sedimentary basin, case-studies, in-depth review of recent literature, and problem-sets to quantify basin evolution on a range of space and time scales.
Learning outcomes	The goal of this module is for students to acquire advanced knowledge and to connect theory and practice in either Geology of Mineral Deposits or Sedimentary Basin Dynamics. This module also enables students to learn, understand, and critically discuss specific features, limits and terminology that define each field, as well as to apply this knowledge in solving specific problems using modern analytical tools in context.
Type of examination	Written or oral exam or written report or presentation. The definite exam modalities will be announced by the course instructor at the beginning of the semester.
Type of assessment	The successful completion of the module will be graded.
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Prof. Dr. Robert Marschik
Language(s)	English
Additional information	

Module: P 6 Modern Geology I

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Seminar	P 6.0.1 Advanced Deformation and Transformation 1	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 6.0.2 Advanced Surface Processes 1	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 6.0.3 Advanced Active Tectonics 1	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 6.0.4 Advanced Earth Magnetism 1	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 6.0.5 Advanced Isotope Geochemistry and Geochronology 1	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Mandatory module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	One of the compulsory elective courses P 6.0.1 - P 6.0.5 must be taken.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	The seminars in this module deal with the latest research in the major areas of geology. It consists of reading, presenting and discussing current research papers. This module is part of a series of four modules, one in each semester (P 6, P 7, P 12, P 13), that address the need for students to familiarize themselves with reading scientific literature by reading and discussing it on a regular basis.
Learning outcomes	The goal of this module is for students to learn to critically analyze and synthesize scholarly literature in the relevant field.
Type of examination	Presentation
Type of assessment	The successful completion of the module will not be graded (pass/fail).

Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Dr. habil Sara Carena
Language(s)	English
Additional information	/

Module: P 7 Modern Geology II

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Seminar	P 7.0.1 Advanced Deformation and Transformation 2	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 7.0.2 Advanced Surface Processes 2	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 7.0.3 Advanced Active Tectonics 2	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 7.0.4 Advanced Earth Magnetism 2	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 7.0.5 Advanced Isotope Geochemistry and Geochronology 2	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Mandatory module with compulsory elective courses..
Usability of the module in other Programmes	/
Eelective guidelines	One of the compulsory elective courses P 7.0.1 – P 7.0.5 must be taken.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The seminars in this module deal with the latest research in the major areas of geology. It consists of reading, presenting and discussing current papers. This module is part of a series of four modules, one in each semester (P 6, P 7, P 12, P 13), that address the need for students to familiarize themselves with reading scientific literature by reading and discussing it on a regular basis.
Learning outcomes	The goal of this module is for students to critically analyze and synthesize scholarly literature in the relevant field.
Type of examination	Presentation

Type of assessment	The successful completion of the module will not be graded (pass/fail).
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Dr. habil. Sara Carena
Language(s)	English
Additional information	/

Module: P 8 Guided Scientific Research

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Personal consultation	P 8.1 Project Supervision	SoSe	8 h (0,5 SWS)	7 h	(0,5)
Project	P 8.2 Research laboratory	SoSe	8 h (0,5 SWS)	157 h	(5,5)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 1 contact hour. Including time for self-study, 180 hours have to be invested per semester.

Module type	Mandatory module with mandatory courses.
Usability of the module in other Programmes	/
Elective guidelines	None
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	This module consists of a short research project, which should be on a topic outside the student's main topic of interest in order to broaden the student's knowledge and research-oriented experience. The project will be carried out either in the field or in one of the laboratories in the Department of Earth and Environmental Sciences.
Learning outcomes	Students will learn to (1) formulate research questions and hypotheses, (2) understand approaches and methods, and (3) analyze and evaluate data and results.
Type of examination	Written report and presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Prof. Dr. Anke Friedrich
Language(s)	English

Additional information	Selection of the project supervisor should be made by the end of the lecture period of the preceeding (first) semester. Ideally, the supervisor of the guided research project is not the same as for the main research project (Master‘s thesis). The student is expected to meet with the project supervisor for about one hour each week, and spend the remaining hours working independently on the project. The hours of presence and individual study indicated above are a required accounting formality. The total workload is 180 hours, one hour per week of which is spent in meetings with the project supervisor (16 hours total of actual "presence"), and the rest in individual work on the project itself. Individual study in this context does not mean that the student works at home. If work needs to be carried out in a laboratory or specific field location, the student needs to be physically present in the laboratory or field, but these hours are not classroom "presence" hours. Also, the meetings with the supervisor are obviously not part of any evaluation, even if formally they have been assigned 0.5 ECTS. The evaluation is on the final report and presentation only.

Module: P 9 Geological Methods I

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	P 9.0.1 Quantitative Geological Mapping 1	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	P 9.0.2 Quaternary Dating Methods	SoSe	30 h (2 SWS)	60 h	(3)
Fiel exercise	P 9.0.3 Quantitative Geological Mapping 2	SoSe	-	90 h	(3)
Integrated learning activity	P 9.0.4 Methods of Mineral Resources	SoSe	30 h (2 SWS)	60 h	(3)
Workshop	P 9.0.5 Geological Computer Modeling	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	P 9.0.6 Scientific Programming	SoSe	60 h (4 SWS)	120 h	(6)
Lecture	P 9.0.7 Analytical Methods in Geochemistry	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	P 9.0.8 High-resolution Microscopic Methods	SoSe	45 h (3 SWS)	135 h	(6)
Workshop	P 9.0.9 Neotectonics	SoSe	60 h (4 SWS)	120 h	(6)
Lecture	P 9.0.10 Mathematical Geology 1	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	P 9.0.11 Quantitative Microfabric Analysis	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	P 9.0.12 Geological Sample Preparation 1	SoSe	30 h (2 SWS)	60 h	(3)
Fiedl exercise	P 9.0.13 Lidar and GPS mapping	SoSe	-	90 h	(3)
Integrated learning activity	P 9.0.14 Geothermobarometry	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 0-4 contact hours. Including time for self-study, 180 hours have to be invested per semester.

Module type	Mandatory module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	With regard to the compulsory elective courses P 9.0.1 – P 9.0.14, courses must be taken with a total value of 6 ECTS credits. Students who take the compulsory elective course P 9.0.1 may not take the compulsory elective course WP 4.0.13. Students who take the compulsory elective course P 9.0.3 may not take the compulsory elective course WP 4.0.14. Students who take the compulsory elective course P 9.0.5 may not take the compulsory elective course WP 4.0.4. Students who take the compulsory elective course P 9.0.8 may not take the compulsory elective

	course WP 5.0.4. Students who take the compulsory elective course P 9.0.9 may not take the compulsory elective course WP 4.0.9. Students who take the compulsory elective course P 9.0.14 may not take the compulsory elective course WP 5.0.3.
Entry requirements	Previous successful participation in P 5.0.1 (if taking P 9.0.4), or in P 4.0.1 (if taking P 9.0.5), or in P 2.0.1 (if taking P 9.0.11), is strongly recommended. Previous successful participation in a Bachelor-level course in Basic Calculus and Linear Algebra, and in Data Analysis, is strongly recommended if taking P 9.0.6. If taking P 9.0.13, it is strongly recommended to simultaneously attend P 9.0.1.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	This module deals with several key methods in geology, both field-oriented or laboratory-oriented. Student can choose either one or two methods to focus on. The fields covered serve as a supplement to the student's own research area, or as an extension to the existing knowledge in related fields of geosciences. *Quantitative Geological Mapping 1*. In this course, students will be given the opportunity to improve their theoretical background in remote-sensing and geodetic field mapping skills. Students learn coordinate systems, reference frames, their transformation, absolute and relative positioning techniques. Students enrolled in this course may also want to enroll in LiDAR and GPS mapping. *Quaternary Dating Methods*. This course provides students with an overview of modern geochronological techniques used to date young geological surfaces, deposits, structures, and other features. Examples of the dating methods include various cosmogenic radionuclide dating techniques, (U-Th)/He thermochronology, radiocarbon dating, and new developments in Quaternary geochronology. *Quantitative Geological Mapping 2*. This field course focuses on specific advanced geological mapping techniques, such as those needed in resource geology, structural geology, glaciological geomorphology, or geophysics. Location of place-based mapping course may vary from year to year. In some years, students may choose from several options, in other years no course might be offered. The module component *Methods of Mineral Resources* introduces the students into the basics of reflected and polarized light microscopy. The physical background as well as methods of sample preparation, qualitative and quantitative techniques will be discussed. Optical characterization of opaque, ore-forming minerals as well as techniques for the systematic identification will be presented and practiced. Among others the following characteristics will be determined: color recognition, relative reflectance, anisotropy, relative hardness, ore-fabric. Ore-deposit specific properties as well as paragenetic and metallogenetic

aspects will be discussed. The primary goal is to enable students to identify opaque minerals under the microscope and to recognize and interpret specific ore-fabrics.

Geological Computer Modeling covers the basic introduction to software used to solve geological problems, for example GoCAD and Coulomb. Participants will learn to which problems the programs can be applied, and how to use the software at the basic level.

Scientific Programming familiarises students with the basic tools and concepts they need as scientists in order to efficiently design, implement and test computer programs. The topics of the course include fundamentals of procedural and object-oriented programming with languages such as Fortran, C and C++, basic parallelization with MPI and OpenMP, as well as tools for debugging and performance analysis. Besides this the course deals with tools for modern software development like automatic builds, debuggers, version control and integrated development environments.

In *Analytical Methods in Geochemistry* students may choose from a variety of modern geochemical analysis methods. The practical aspects of the analyses will be carried out in the laboratory facilities of the Department of Earth and Environmental Sciences. Offerings vary on a yearly basis.

In *High-resolution Microscopic Methods* a comprehensive overview on various microscopic techniques for the characterization of solid materials will be given. Advanced theoretical background and practical knowledge on polarized light microscopy, X-ray and atomic force microscopy as well as electron microscopy with specific emphasis on transmission electron microscopy are presented. Students gain hands-on experience on the respective microscopes.

Neotectonics offers in-depth insights into modern concepts and basic tools to study young horizontal and vertical deformation of the earth’s surface at scales ranging from decades to millions of years. Methods covered in the course include structural, thermochronological, geological remote sensing, tectono-geomorphic, paleoseismological, seismological, and space-geodetic analysis. The goal of the course is to assimilate these different data to construct deformation or strain paths for regional deforming surfaces, active plate boundaries, and actively deforming intraplate regions.

In *Mathematical Geology I*, students will learn numerical methods or other advanced mathematical concepts in geology. Students may choose from a number of courses offered in the Munich Geocenter.

In *Quantitative Microfabric Analysis* different electron-microscopic and polarized light microscopic techniques are discussed via specific case studies relevant for modern microfabric analytics. Students will work on electron backs

	scatter diffraction (EBSD) data sets. They gain hands-on experience on scanning electron microscopy (SEM) and sample preparation for transmission electron microscopy (ion thinning). The course is a combination of discussing case studies, microscopic exercises as well as EBSD data processing and interpretation. *Geological Sample Preparation 1*. In this practical course, students will learn the most common techniques used to process geological rock samples collected in the field for geochronological or geochemical analysis. Students will learn to crush rocks and separate minerals by physical, chemical, and hand-picking methods. The course takes place in the rock separation facilities of the Department of Earth and Environmental Sciences. *LiDAR and GPS mapping*. In this course students will learn the practical aspects to modern high-precision space- and ground-based geodetic techniques, such as LiDAR and GPS technology. They learn how to operate the 3-D Light-Detection-and-Ranging scanner (LiDAR) and the high-precision space-geodetic mapping devices (e.g., GPS) in the field, including real-time kinematic observations and post-processing techniques. The theoretical portion of this course is offered as Quantitative Geological Mapping I. Students are strongly encouraged to enroll in this course concurrently. In *Geothermobarometry* students are introduced into thermodynamic principles of metamorphic petrology and their application to the determination of metamorphic conditions (geothermobarometry). Calculations of univariant equilibria based on coexisting mineral solid solutions with petrogenetic significance are applied.
Learning outcomes	Students strengthen and widen their knowledge of fundamental methods and their analytical skills.
Type of examination	Written or oral exam or written report or presentation or Mapping Report Folder or case study. The definite exam modalities will be announced by the course instructor at the beginning of the semester.
Type of assessment	The successful completion of the module will be graded.
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Prof. Dr. Anke Friedrich
Language(s)	English
Additional information	

Module: WP 1 Geophysics

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 1.0.1 Geodynamics	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 1.0.2 Paleomagnetism	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 1.0.3 Crystal Physics	SoSe	45 h (3 SWS)	135 h	(6)
Integrated learning activity	WP 1.0.4 Petrophysics	SoSe	45 h (3 SWS)	45 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 3-5 contact hours per week. Including time for self-study, 180 hours have to be invested per semester.

Module type	Compulsory elective module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	Two of the compulsory elective modules WP 1 – WP 5 must be taken. With regard to the module's compulsory elective courses WP 1.0.1 – WP 1.0.4, courses must be taken with a total value of 6 ECTS credits. Students who take the compulsory elective course WP 1.0.1 may not take the compulsory elective course WP 2.0.3. Students who take the compulsory elective course WP 1.0.2 may not take the compulsory elective course WP 4.0.6. Students who take the compulsory elective course WP 1.0.3 may not take the compulsory elective course WP 4.0.11. Students who take the compulsory elective course WP 1.0.4 may not take the compulsory elective courses WP 4.0.7 and WP 5.0.1.
Entry requirements	If taking WP 1.0.4, previous participation in a Bachelor-level (or higher) course in Polarization Microscopy is strongly recommended.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	This module covers the geophysical bases necessary for a modern understanding of Earth Sciences. The module addresses both geophysical methods and material properties relevant to geology, and current global perspectives at the interface between geophysics and geology. In *Geodynamics* students are introduced to the modern dynamic

	concepts of fluid dynamics that underlie our current understanding of the internal structure and dynamics of the Earth. Special emphasis is placed on the integration of a wide range of geological and geodetic constraints on inferences of structure and evolution of the deep Earth. In *Paleomagnetism* students will learn about the origins of magnetic remanence, and about what the magnetic signatures in rocks tell us about geomagnetic field behavior (reversal frequency, secular variation, etc.), continental drift, true polar wander, and other geological phenomena. Observatory and satellite observations of the historic Earth's field will also be discussed. The practical part of the course will include excursions and accompanying laboratory work in which students will learn to drill and orient cores, measure their magnetic remanence in the lab and interpret the data. In *Crystal Physics* the primary thematic focus is the linear anisotropic crystal properties. Specifically, topics are discussed such as: symmetric and antisymmetric tensors, tensor surfaces and their properties, Mohr circle construction, crystal symmetry and tensors, principal axis transformations, coordinates product method, properties (paramagnetic and diamagnetic susceptibility, electrical polarization, pyroelectricity, ferroelectricity, stress tensor, deformation tensor, stress deformation relations, compressibility, thermal expansion, direct and inverse piezoelectric effect, effect of the crystal symmetry on the elasticity and thermal and electrical conductivity). In *Petrophysics* students are introduced into advanced concepts of rock physics and fluid-rock interactions that control lithospheric deformation processes. Emphasis is on the interplay between petrological, geological and geophysical processes.
Learning outcomes	The students will acquire knowledge of geophysical processes and methods and learn to apply mathematical and physical principles to connect geological and geophysical perspectives.
Type of examination	Written or oral exam or written report or presentation or case study. The definite exam modalities will be announced by the course instructor at the beginning of the semester.
Type of assessment	The successful completion of the module will be graded.
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Dr. habil. Sara Carena
Language(s)	English
Additional information	

Module: WP 2 Global Aspects

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 2.0.1 Global Tectonics	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 2.0.2 Global Geochemical Cycles	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 2.0.3 Geodynamics	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 2.0.4 Global Soils	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 2.0.5 Soil Science	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours per week. Including time for self-study, 180 hours have to be invested per semester.

Module type	Compulsory elective module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	Two of the compulsory elective modules WP 1 – WP 5 must be taken. With regard to the module's compulsory elective courses WP 2.0.1 – WP 2.0.5, two compulsory elective courses must be taken. Students who take the compulsory elective course WP 2.0.1 may not take the compulsory elective course WP 4.0.1. Students who take the compulsory elective course WP 2.0.2 may not take the compulsory elective course WP 4.0.2. Students who take the compulsory elective course WP 2.0.3 may not take the compulsory elective course WP 1.0.1. Students who take the compulsory elective course WP 2.0.5 may not take the compulsory elective course WP 4.0.10.
Entry requirements	If taking WP 2.0.1, previous successful participation in either P 4.0.1 or P 3.0.2/5.0.2 is strongly recommended. If taking WP 2.0.2, previous successful participation in a Bachelor-level (or higher) course in Geochemistry is strongly recommended.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The components of this module are based on the analysis of global data sets, such as the regional geological structure and age oft he rocks on all continents and oceans, the geochemical and isotopic distribution patterns, the geophysical mapping of the Earth, or other data derived

	from them. The current state of research will be presented, which provides the theoretical framework fort he interpretation and explanation oft he records. In *Global Tectonics* students are introduced to the modern geological concepts that form our current understanding of the formation, architecture and evolution of the Earth's crust and upper mantle through time. Special emphasis is placed on the integration of a wide range of geological, geochemical, geophysical, and geodetic constraints on inferences of structure and evolution of the shallow Earth. *Global Geochemical Cycles* covers of chemical differentiation and evolution of the Earth using trace elements and isotope data. Using geochemical data from ocean ridges and ocean island basalts the modern knowledge of the upper and lower Earth mantle will be presented as well as the geochemical processes that produce such data. In addition, evidence for the recycling oceanic crust and continental detritus will be shown and models for the development of geochemical reservoirs will be discussed. In *Geodynamics* students are introduced to the modern dynamic concepts of fluid dynamics that underlie our current understanding of the internal structure and dynamics of the Earth. Special emphasis is placed on the integration of a wide range of geological and geodetic constraints on inferences of structure and evolution of the deep Earth. *Global Soils* introduces students to the general classification of soils in different climatic regions of the Earth. The overview will cover soils from arid to humid regions as well as tropical to polar regions. For each location, specific soil characteristics such as stage of soil development, clay content, hydrological state, and physical properties will be presented. *Soil Science* introduces students to the basic terminology and modern concepts in soil sciences. The principles of soil transformation and processes of soil pedogenesis will be presented as well as the dependence of soil types on the source material. In addition, a specific emphasis will be placed on soil types in central Europe.
Learning outcomes	The students will learn to understand complex data in the context of modern, process-oriented research, and to analyze its theoretical framework.
Type of examination	Written or oral exam or written report or presentation or case study. The definite exam modalities will be announced by the course instructor at the beginning of the semester.
Type of assessment	The successful completion of the module will be graded.
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Prof. Dr. Anke Friedrich

Language(s)	English

Additional information

Module: WP 3 Geoindustry

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 3.0.1 Industrial Minerals	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 3.0.2 Environmental Geology	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 3.0.3 Mineral Economics	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 3.0.4 Risk Analysis	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 3.0.5 Exploration	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours per week. Including time for self-study, 180 hours have to be invested per semester.

Module type	Compulsory elective module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	Two of the compulsory elective modules WP 1 – WP 5 must be taken. With regard to the module's compulsory elective courses WP 3.0.1 – WP 3.0.5, two compulsory elective courses must be taken. Students who take the compulsory elective course WP 3.0.1 may not take the compulsory elective course WP 4.0.3. Students who take the compulsory elective course WP 3.0.3 may not take the compulsory elective course WP 4.0.5.
Entry requirements	If taking WP 3.0.3, previous successful participation in P 5.0.1 is strongly recommended.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The module addresses a number of important, industry-related fields of geosciences. These are general natural-materials extraction industry as well as natural risk and environmental protection issues. To base the topics on current developments and issues, a significant portion of

	these components may be taught by invited representatives from relevant industry and insurance companies. In *Industrial Minerals* students will learn about industrial minerals and common resources. Terminology, importance, development, exploration and processing of resources will be presented. Specific focus will be placed on deposits in central Europe, for example on gypsum, anhydrite, phosphates, and special clays. The practical part of this course includes field trips and analyses at exploration sites in central Europe. In *Environmental Geology* students are introduced to practical aspects of modern environmental problems including waste repositories, water pollution, groundwater issues, and atmospheric pollution. Course content varies annually to capture special opportunities in the field of environmental geology. *Mineral Economics* covers the principles of economic geology. Students will learn about exploration and the evaluation of reservoirs as well as the marketing of resources. Other topics include prospect exploration, reservoir estimation, exploration and prospecting methods, smelting, resource trade and stock market. In *Risk Analysis* students are introduced to practical aspects of analysis of natural hazards and risks. Course content varies annually to capture special opportunities in the field of risk analysis. Examples include, but are not limited to earthquakes, landslides, flooding, meteorite impacts, and volcanic eruptions. This course is particularly suited as an interdisciplinary course for students in geosciences, environmental studies, history, sociology. The course is also offered for certificate participants of the Rachel Carson Center. In *Exploration* students are introduced to practical aspects of modern geological exploration. Course content varies annually to capture special opportunities in the field of exploration geology, such as geothermal energy prospecting, gold, rare earths, oil shale exploration, etc.
Learning outcomes	Students will get an overview of the application of geoscientific knowledge and methods in various fields of industry. They will acquire insights into their future profession and learn to properly organize their future portfolio.
Type of examination	Written or oral exam or written report or presentation or case study. The definite exam modalities will be announced by the course instructor at the beginning of the semester.
Type of assessment	The successful completion of the module will be graded.
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Prof. Dr. Anke Friedrich

Language(s)	English

Additional information

Module: WP 4 Complementary Fields I

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 4.0.1 Global Tectonics	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.0.2 Global Geochemical Cycles	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 4.0.3 Industrial Minerals	SoSe	30 h (2 SWS)	60 h	(3)
Workshop	WP 4.0.4 Geological Computer Modeling	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 4.0.5 Mineral Economics	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 4.0.6 Paleomagnetism	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 4.0.7 Petrophysics	SoSe	45 h (3 SWS)	45 h	(3)
Lecture	WP 4.0.8 Landslides	SoSe	60 h (4 SWS)	120 h	(6)
Workshop	WP 4.0.9 Neotectonics	SoSe	60 h (4 SWS)	120 h	(6)
Integrated learning activity	WP 4.0.10 Soil Science	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 4.0.11 Crystal Physics	SoSe	45 h (3 SWS)	135 h	(6)
Exercise course	WP 4.0.12 Geomicrobiology	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 4.0.13 Quantitative Geological Mapping 1	SoSe	30 h (2 SWS)	60 h	(3)
Field exercise	WP 4.0.14 Quantitative Geological Mapping 2	SoSe	-	90 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 2-5 contact hours. Including time for self-study, 180 hours have to be invested per semester.

Module type	Compulsory elective module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	Two of the compulsory elective modules WP 1 – WP 5 must be taken. With regard to the module's compulsory elective courses WP 4.0.1 –

	WP 4.0.14, courses must be taken with a total value of 6 ECTS credits. Students who take the compulsory elective course WP 4.0.1 may not take the compulsory elective course WP 2.0.1. Students who take the compulsory elective course WP 4.0.2 may not take the compulsory elective course WP 2.0.2. Students who take the compulsory elective course WP 4.0.3 may not take the compulsory elective course WP 3.0.1. Students who take the compulsory elective course WP 4.0.4 may not take the compulsory elective course P 9.0.5. Students who take the compulsory elective course WP 4.0.5 may not take the compulsory elective course WP 3.0.3. Students who take the compulsory elective course WP 4.0.6 may not take the compulsory elective course WP 1.0.2. Students who take the compulsory elective course WP 4.0.7 may not take the compulsory elective courses WP 1.0.4 and WP 5.0.1. Students who take the compulsory elective course WP 4.0.9 may not take the compulsory elective course P 9.0.9. Students who take the compulsory elective course WP 4.0.10 may not take the compulsory elective course WP 2.0.5. Students who take the compulsory elective course WP 4.0.11 may not take the compulsory elective course WP 1.0.3. Students who take the compulsory elective course WP 4.0.13 may not take the compulsory elective course P 9.0.1. Students who take the compulsory elective course WP 4.0.14 may not take the compulsory elective course P 9.0.3.
Entry requirements	If taking WP 4.0.5, previous successful participation in P 5.0.1 is strongly recommended. If taking WP 4.0.1, previous successful participation in P 4.0.1 or P 3.0.2/P 5.0.2 is strongly recommended. Previous successful participation in a Bachelor-level (o higher) course in Geochemistry is strongly recommended if taking WP 4.0.2. If taking WP 4.0.4 previous successful participation in P 4.0.1 is strongly recommended. Previous successful participation in a Bachelor-level (or higher) course in Polarization Microscopy is highly recommended if taking WP 4.0.7).
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	This module includes different areas of focus in geology. Students have the opportunity to supplement their own research area or to extend their knowledge in neighboring areas of geosciences. In *Global Tectonics* students are introduced to the modern geological concepts that form our current understanding of the formation, architecture and evolution of the Earth's crust and upper mantle through time. Special emphasis is placed on the integration of a wide range of geological, geochemical, geophysical, and geodetic constraints on inferences of structure and evolution of the shallow Earth. *Global Geochemical Cycles* covers of chemical differentiation and evolution of the Earth using trace elements and isotope data. Using

geochemical data from ocean ridges and ocean island basalts the modern knowledge of the upper and lower Earth mantle will be presented as well as the geochemical processes that produce such data. In addition, evidence for the recycling oceanic crust and continental detritus will be shown and models for the development of geochemical reservoirs will be discussed.

In *Industrial Minerals* students will learn about industrial minerals and common resources. Terminology, importance, development, exploration and processing of resources will be presented. Specific focus will be placed on deposits in central Europe, for example on gypsum, anhydrite, phosphates, and special clays. The practical part of this course includes field trips and analyses at exploration sites in central Europe.

Geological Computer Modeling covers the basic introduction to software used to solve geological problems, for example GoCAD and Coulomb. Participants will learn to which problems the programs can be applied, and how to use the software at the basic level.

Mineral Economics covers the principles of economic geology. Students will learn about exploration and the evaluation of reservoirs as well as the marketing of resources. Other topics include prospect exploration, reservoir estimation, exploration and prospecting methods, smelting, resource trade and stock market.

In *Paleomagnetism* students will learn about the origins of magnetic remanence, and about what the magnetic signatures in rocks tell us about geomagnetic field behavior (reversal frequency, secular variation, etc.), continental drift, true polar wander, and other geological phenomena. Observatory and satellite observations of the historic Earth's field will also be discussed. The practical part of the course will include excursions and accompanying laboratory work in which students will learn to drill and orient cores, measure their magnetic remanence in the lab and interpret the data.

In *Petrophysics* students are introduced into advanced concepts of rock physics and fluid-rock interactions that control lithospheric deformation processes. Emphasis is on the interplay between petrological, geological and geophysical processes.

The course *Landslides* introduces students to the basic principals of landslides types and processes as well as causes and triggers. In addition, the analysis of different motion and transportation types is one additional important aspect along with appropriate investigation techniques for monitoring, hazard mapping, and the application of zoning techniques. Students will also learn about the principles of risk assessment and management for landslides and other gravitational hazards, which enables them to conduct and interpret basic risk analyses and cost-benefit optimization of landslide mitigation measures. This course is designed as lectures, exercises, and optional field days.

Neotectonics offers in-depth insights into modern concepts and basic tools to study young horizontal and vertical deformation of the earth's surface at scales ranging from decades to millions of years. Methods

	covered in the course include structural, thermochronological, geological remote sensing, tectono-geomorphic, paleoseismological, seismological, and space-geodetic analysis. The goal of the course is to assimilate these different data to construct deformation or strain paths for regional deforming surfaces, active plate boundaries, and actively deforming intraplate regions. *Soil Science* introduces students to the basic terminology and modern concepts in soil sciences. The principles of soil transformation and processes of soil pedogenesis will be presented as well as the dependence of soil types on the source material. In addition, a specific emphasis will be placed on soil types in central Europe. In *Crystal Physics* the primary thematic focus is the linear anisotropic crystal properties. Specifically, topics are discussed such as: symmetric and antisymmetric tensors, tensor surfaces and their properties, Mohr circle construction, crystal symmetry and tensors, principal axis transformations, coordinates product method, properties (paramagnetic and diamagnetic susceptibility, electrical polarization, pyroelectricity, ferroelectricity, stress tensor, deformation tensor, stress deformation relations, compressibility, thermal expansion, direct and inverse piezoelectric effect, effect of the crystal symmetry on the elasticity and thermal and electrical conductivity). *Geomicrobiology* introduces students to laboratory methods for the analysis of geobiologically relevant communities of microorganisms. The focus will be on important molecular biology methods commonly used for the study of microbial communities, which should enable students to analyze experimental data from microbial communities of geobiological importance. *Quantitative Geological Mapping 1*. In this course, students will be given the opportunity to improve their theoretical background in remote-sensing and geodetic field mapping skills. Students learn coordinate systems, reference frames, their transformation, absolute and relative positioning techniques. Students enrolled in this course may also want to enroll in LiDAR and GPS mapping. *Quantitative Geological Mapping 2*. This field course focuses on specific advanced geological mapping techniques, such as those needed in resource geology, structural geology, glaciological geomorphology, or geophysics. Location of place-based mapping course may vary from year to year. In some years, students may choose from several options, in other years no course might be offered.
Learning outcomes	This module offers further opportunities for students to broaden their knowledge of geology early on and avoid narrow specialization too soon in the Programme.
Type of examination	Written or oral exam or written report or presentation or Mapping Report Folder or case study. The definite exam modalities will be announced by the course instructor at the beginning of the semester.
Type of assessment	The successful completion of the module will be graded.

Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Prof. Dr. Miriam Dühnforth
Language(s)	English
Additional information	

Module: WP 5 Petrology I

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 5.0.1 Petrophysics	SoSe	45 h (3 SWS)	45 h	(3)
Integrated learning activity	WP 5.0.2 Polarization Microscopy	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 5.0.3 Geothermobarometry	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 5.0.4 High-resolution Microscopic Methods	SoSe	45 h (3 SWS)	135 h	(6)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 3-5 contact hours per week. Including time for self-study, 180 hours have to be invested per semester.

Module type	Compulsory elective module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	Two of the compulsory elective modules WP 1 – WP 5 must be taken. With regard to the module's compulsory elective courses WP 4.0.1 – WP 4.0.14, courses must be taken with a total value of 6 ECTS credits. Students who take the compulsory elective course WP 5.0.1 may not take the compulsory elective courses WP 1.0.4 and WP 4.0.7. Students who take the compulsory elective course WP 5.0.3 may not take the compulsory elective course P 9.0.14. Students who take the compulsory elective course WP 5.0.4 may not take the compulsory elective course P 9.0.8.
Entry requirements	Previous successful participation in a Bachelor-level (or higher) course in Polarization Microscopy is strongly recommended, if taking WP 5.0.1. Simultaneous participation in WP 5.0.1 is recommended, if taking WP 5.0.2.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	This module addresses the petrological processes as well as techniques to obtain information on these processes from material

	characterization of igneous, sedimentary and metamorphic rocks. In *Petrophysics* students are introduced into advanced concepts of rock physics and fluid-rock interactions that control lithospheric deformation processes. Emphasis is on the interplay between petrological, geological and geophysical processes. In *Polarization Microscopy* advanced skills on the application of polarized light microscopic techniques to characterize metamorphic, sedimentary and igneous rocks will be trained. The aim is to use the gained data to interpret the dynamic processes within petrological systems. In *Geothermobarometry* students are introduced into thermodynamic principles of metamorphic petrology and their application to the determination of metamorphic conditions (geothermobarometry). Calculations of univariant equilibria based on coexisting mineral solid solutions with petrogenetic significance are applied. In *High-resolution Microscopic Methods* a comprehensive overview on various microscopic techniques for the characterization of solid materials are given. Advanced theoretical background and practical knowledge on polarized light microscopy, X-ray and atomic force microscopy as well as electron microscopy with specific emphasis on transmission electron microscopy are presented. Students gain hands-on experience on the respective microscopes.
Learning outcomes	The goal is for students to understand deformation and transformation processes in igneous and metamorphic rocks. They will acquire the ability to analyze and interpret relevant data with respect to petrological, geophysical and geological processes.
Type of examination	Written or oral exam or written report. The definite exam modalities will be announced by the course instructor at the beginning of the semester.
Type of assessment	The successful completion of the module will be graded.
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Prof. Dr. Claudia Trepmann
Language(s)	English
Additional information	

Module: P 10 Independent Scientific Research

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Master`s thesis	P 10.1 / I Master thesis	WiSe	-	270 h	(9)
Master`s thesis	P 10.1 / II Master thesis	SoSe	-	540 h	(18)
Thesis defense	P 10.2 Thesis defense	SoSe	-	90 h	(3)

For successful completion of the module, 30 ECTS credits have to be acquired. Class attendance averages about 0 contact hours. Including time for self-study, 900 hours have to be invested.

Module type	Mandatory module with mandatory courses.
Usability of the module in other Programmes	/
Elective guidelines	None
Entry requirements	Successful completion of the modules P 1 – P 9 and of one of the modules WP 1 - WP 5
Semester	Recommended semester: 3 and 4
Duration	The completion of the module takes 2 semesters.
Content	This module consists of the independent production of a scientific paper, which addresses a complex scientific problem and produces a novel solution, with final discussion of the outcome of the work in front of a panel of geoscientists.
Learning outcomes	Students learn to transfer acquired technical and methodological knowledge and their unique interpretation of the data they collected. They learn also to solve scientific problems independently.
Type of examination	Master's thesis and thesis defense
Type of assessment	The successful completion of the module will be graded.
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Prof. Dr. Anke Friedrich

Language(s)	English
Additional information	/

Module: P 11 Geological Methods II

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Lecture	P 11.0.1 Photogrammetry and Remote Sensing	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	P 11.0.2 Experimental Geochemistry	WiSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	P 11.0.3 Precise GNSS	WiSe	60 h (4 SWS)	120 h	(6)
Integrated learning activity	P 11.0.4 Microthermometry	WiSe	30 h (2 SWS)	60 h	(3)
Exercise course	P 11.0.5 Electron Microprobe	WiSe	30 h (2 SWS)	60 h	(3)
Exercise course	P 11.0.6 Mathematical Geology 2	WiSe	45 h (3 SWS)	45 h	(3)
Exercise course	P 11.0.7 Mathematical Geology 3	WiSe	45 h (3 SWS)	45 h	(3)
Integrated learning activity	P 11.0.8 Geological Sample Preparation 2	WiSe	30 h (2 SWS)	60 h	(3)
Exercise course	P 11.0.9 Soil Science Methods	WiSe	60 h (4 SWS)	120 h	(6)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4-6 contact hours per week. Including time for self-study, 180 hours have to be invested per semester.

Module type	Mandatory module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	With regard to the module's compulsory elective courses P 11.0.1 – P 11.0.09, courses must be taken with a total value of 6 ECTS credits. Students who take the compulsory elective course P 11.0.1 may not take the compulsory elective course WP 6.0.3. Students who take the compulsory elective course P 11.0.2 may not take the compulsory elective course P 8.0.2. Students who take the compulsory elective course P 11.0.9 may not take the compulsory elective course WP 9.0.5.
Entry requirements	Previous successful participation in a Bachelor-level (or higher) course in Geochemistry is strongly recommended, if taking P 10.0.2. If taking P 10.0.7, simultaneous participation in P 10.0.6 is strongly recommended. If taking P 11.0.8, previous successful

	participation in P 9.0.12 is strongly recommended.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This module presents several important methods that pertain to key areas in geology, ranging from analytical techniques to applied mathematics. In *Photogrammetry and Remote Sensing* definitions of photogrammetry and remote sensing, their characterization, applications and development are presented. The students are introduced into stereoscopic observations and measurements, photogrammetric image analysis and digitial stereoanalysis. The students are further introduced into radiometric basics and multispectral classifications. *Experimental Geochemistry* introduces the students into relevant experimental techniques in petrologie and geochemistry (high-temperature furnaces, pressure vessels, piston cylinder, multianvil and diamond cell apparatusses). Specific petrological problems will be discussed that can be addresed by these experimental techniques, considering capabilites and limits. *Precise GNSS* deals with the Global Navigation Satellite Systems (GNSS) such as the GPS, the Russian GLONASS, or the upcoming European Galileo system that are used today in a large variety of fields, ranging from car navigation to high precision positioning applications for geodetic and geodynamic studies. GNSS measurements are well suited to monitor local and regional deformations as well as site displacements on continental scales caused by tectonic motions. The course is focusing on these precise geodetic applications. After a short introduction into the working principles of GNSS, modeling approaches for propagation corrections and site displacements as well as analysis strategies such as ambiguity resolution and datum definition procedures are discussed. The first main goal of this course is to make students familiar with GNSS, with the models employed and with processing strategies used for precise GNSS positioning applications. The second goal is bringing students into direct contact with GNSS tracking data in practical lab experiments. In this part of the course students are brought into contact with GNSS raw tracking data. In lab experiments they will gain hands-on experience with tracking data through simple experiments using Matlab. More involved experiments are performed using scientific analysis software to investigate the impact of different effects and analysis strategies on positioning results. *Microthermometry* introduces students into the petrographic and thermodynamic basics of microthermometry, i.e. the characterization of fluid inclusions in minerals with the aim to reconstruct the coditions during their formation. Microscopic characterisation of fluid inclusions as well as the phase transitions during heating and cooling, the deduction of isochors and isopleths will be discussed. Geologically relevant phase systems

	e.g., H_2O, CO_2, CO_2-CH_4, H_2O-NaCl, H_2O-CO_2, H_2O-NaCl-$CaCl_2$, H_2O-NaCl-KCl, H_2O-CO_2-NaCl will be considered. The module component *Electron Microprobe* introduces students to the technique of insitu-determination of chemical composition of Geomaterials using the electron microprobe. This technique is essential for many further petrological and geothermobarmetric investigations. Topics are electron diffraction, as well as wavelength and energy disperisive systems. The students gain hands-on experience using the electron microprobe. *Mathematical Geology 2* introduces students to the application of numerical models to analyze the properties of soils, rocks and mountains. The theoretical background will be presented and practical exercises will deepen the gained knowledge. *Mathematical Geology 3* will introduce students to the application of numerical models to solve problems on engineering-technical properties of soils, rocks and mountains. In *Geological Sample Preparation 2* students will be introduced into advanced geological sample preparation techniques. Geological sample preparation is a vital base for any further analytical study. The module component *Soil Science Methods* addresses the chemical, physical, mineralogical and microbiological characterization of soil in the laboratory. Students will discuss the results in view of soil genesis as well as living space, buffer and storage functions of soils.
Learning outcomes	The students will be able to either deepen their knowledge within their own field of specialization, or broaden it to neighboring fields. They will acquire advanced knowledge of both theoretical and applied aspects of different methods that can be applied in geology.
Type of examination	Written or oral exam or written report or presentation or case study. The definite exam modalities will be announced by the course instructor at the beginning of the semester.
Type of assessment	The successful completion of the module will be graded.
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Prof. Dr. Claudia Trepmann
Language(s)	English
Additional information	

Module: P 12 Modern Geology III

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Seminar	P 12.0.1 Advanced Deformation and Transformation of Rocks 3	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 12.0.2 Advanced Surface Processes 3	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 12.0.3 Advanced Active Tectonics 3	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 12.0.4 Advanced Earth Magnetism 3	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 12.0.5 Advanced Isotope Geochemistry and Geochronology 3	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Mandatory module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	One of the module's compulsory elective courses P 12.0.1 – P 12.0.5 must be taken.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The seminars in this module deal with the latest research in the major areas of geology, and consists in reading, presenting and discussing current papers. This module is part of a series of four modules, one in each semester (P 6, P 7, P 12, P 13), that address the need for students to familiarize themselves with reading scientific literature by reading and discussing it on a regular basis.
Learning outcomes	The goal of this module is for students to critically analyze and synthesize scholarly literature in the relevant field.
Type of examination	Presentation

Type of assessment	The successful completion of the module will not be graded (pass/fail).
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Dr. habil. Sara Carena
Language(s)	English
Additional information	/

Module: WP 6 Geodesy and Remote Sensing

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 6.0.1 Tectonic Geodesy	WiSe	60 h (4 SWS)	120 h	(6)
Integrated learning activity	WP 6.0.2 Earth Rotation and Solid Earth Physics	WiSe	75 h (5 SWS)	105 h	(6)
Lecture	WP 6.0.3 Photogrammetry and Remote Sensing	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 6.0.4 Earth Gravity Field	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4-5 contact hours. Including time for self-study, 180 hours have to be invested per semester.

Module type	Compulsory elective module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	Two of the compulsory elective modules must be taken. With regard to the module's compulsory elective courses WP 6.0.1 – WP 6.0.4, courses must be taken with a total value of 6 ECTS credits. Students who take the compulsory elective course WP 6.0.3 may not take the compulsory elective course P 11.0.1.
Entry requirements	Previous successful participation in a Bachelor-level course in Basic Calculus and Linear Algebra is strongly recommended, if taking WP 6.0.1 or WP 6.0.2.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	Remote sensing and satellite-based methods, which form the basis of this module, are becoming increasingly important in the natural sciences and engineering. This applies to geology in particular, considering the importance of accurate and large scale measurements of the Earth surface and the improvements in mapping obtained by applying photogrammetric methods. This module offers a solid introduction into these methods with particular emphasis on their application to research in geology. *Tectonic Geodesy* addresses geodetic techniques (e.g. GPS/GNSS, InSAR) to determine tectonic and seismic displacement fields in view of deformation models. Freely available data sets will be presented.

	Students work on GPS/GNSS-data in statistical and kinematic applications. They model co- and postseismic surface motion and compare the results with geodetic data. In *Photogrammetry and Remote Sensing* definitions of photogrammetry and remote sensing, their characterization, applications and development are presented. The students are introduced into stereoscopic observations and measurements, photogrammetric image analysis and digitial stereoanalysis. The students are further introduced into radiometric basics and multispectral classifications. In *Earth Rotation and Solid Earth Physics* the students will learn advanced concepts of the internal structure of the Earth. Special emphasis is placed on the three-dimensional gross Earth structure, its influence on mass and heat transport, the constituent elastic materials and their high-pressure and high-temperature properties and the expression of large scale planetary dynamics on geodetic observables including gravity and rotation. *Earth Gravity Field* gives an introduction into the theory of the Earth's gravity field and its mathematical representation. Topics treated are on the one side observables and parameterisation of the gravity field, as well as principles of terrestrial and satellite gravimetry. Additionally we discuss theories of mass compensation, the geoid, solid Earth tides, heights and the various types of gravity anomalies and spatial and temporal variations. Further topics include spectral analysis on the globe and techniques of inverse modeling. In the course students are made familiar with the role of the Earth's gravity field as part of earth sciences, its theory, measurement and interpretation.
Learning outcomes	Upon successfully completing the module the students will have acquired knowledge of techniques and models of gravity field modeling, GNSS analysis, or remote sensing. They will be able to independently analyze data and evaluate existing analyses.
Type of examination	Written or oral exam or written report. The definite exam modalities will be announced by the course instructor at the beginning of the semester.
Type of assessment	The successful completion of the module will be graded.
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Dr. Amir Abolghasem
Language(s)	English
Additional information	

Module: WP 7 Complementary Fields II

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 7.0.1 Rheology	WiSe	60 h (4 SWS)	120 h	(6)
Integrated learning activity	WP 7.0.2 Earth Surface Processes	WiSe	60 h (4 SWS)	120 h	(6)
Integrated learning activity	WP 7.0.3 Modern Active Tectonics	WiSe	60 h (4 SWS)	120 h	(6)
Integrated learning activity	WP 7.0.4 Geology of Mineral Deposits	WiSe	60 h (4 SWS)	120 h	(6)
Integrated learning activity	WP 7.0.5 Geochronology	WiSe	60 h (4 SWS)	120 h	(6)
Integrated learning activity	WP 7.0.6 Crust and Mantle Petrology	WiSe	60 h (4 SWS)	120 h	(6)
Integrated learning activity	WP 7.0.7 Sedimentary Basin Dynamics	WiSe	60 h (4 SWS)	120 h	(6)
Integrated learning activity	WP 7.0.8 Physics and Chemistry of Melts	WiSe	45 h (3 SWS)	135 h	(6)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours per week. Including time for self-study, 180 hours have to be invested per semester.

Module type	Compulsory elective module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	Two of the compulsory elective modules WP 6 – WP 9 must be taken. With regard to the compulsory elective courses WP 7.0.1 – WP 7.0.8, one compulsory elective course must be taken. Students who take the compulsory elective course WP 7.0.1 may not take the compulsory elective course P 2.0.1. Students who take the compulsory elective course WP 7.0.2 may not take the compulsory elective course P 3.0.1. Students who take the compulsory elective course WP 7.0.3 may not take the compulsory elective course P 4.0.1. Students who take the compulsory elective course WP 7.0.4 may not

	take the compulsory elective course P 5.0.1. Students who take the compulsory elective course WP 7.0.6 may not take the compulsory elective course WP 8.0.4. Students who take the compulsory elective course WP 7.0.7 may not take the compulsory elective courses P 3.0.2 and P 5.0.2. Students who take the compulsory elective course WP 7.0.8 may not take the compulsory elective course WP 8.0.3.
Entry requirements	Previous successful participation in a Bachelor-level course in Polarization Microscopy (if taking WP 7.0.1) or in Basic Calculus and Geomorphology (if taking WP 7.0.2) or in Structural Geology/Tectonics/Geodynamics (if taking WP 7.0.3) or in Geochemistry (if taking WP 7.0.5) or in Basic Petrology (if taking WP 7.0.6 or WP 7.0.8) or Tectonics/Sedimentology (if taking WP 7.0.7) is strongly recommended.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This module covers several key areas of interest in the broader field of geology, from processes at the Earth's surface (e.g. WP7.0.2) to endogenic processes, including magmatism (e.g. WP7.0.8). In the module component *Rheology*, the students are introduced into modern concepts that relate grain-scale deformation and transformation processes at depth to the large-scale rheological behavior of the lithosphere. The emphasis is on the microfabric development during deformation, recrystallization and dissolution-precipitation processes at metamorphic conditions. Flow laws and paleopiezometers derived from deformation experiments will be discussed and used to obtain quantitative data on stress, strain and strain rate from specific microstructures. These topics will be addressed by a combination of lectures, reading seminars, exercises and polarized light microscopy. The primary goal is to enable students to use the microstructural record of metamorphic rocks to *obtain information on the deformation and stress history as well as on the rheological behavior at depth.* The course *Earth Surface Processes* introduces students to the physical concepts of geomorphology, which help to quantify the pace of landscape evolution over different timescales. These modern theories explain how landscape evolves through time under constant and/or variable boundary conditions. The presented concepts demonstrate basic flow laws for geomorphic agents such as for example water and ice, and emphasis will focus on the understanding of erosion and sediment transport processes in different landscapes. The topics will be addressed by a combination of lectures, reading seminars, and laboratory exercises, where the theoretical background will be applied by the students. The goal is to understand processes of landscape evolution and to enable students to identify, analyze, and interpret these processes quantitatively. In *Modern Active Tectonics* students are introduced to the modern concepts from active tectonics that underlie our current understanding

of the deformation the Earth. Special emphasis is placed on seismotectonics and on the tectonics and mechanics of accretionary wedges, orogenic wedges, and subduction zones. Specific topics treated in this module component change on a yearly basis.

The module component *Geology of Mineral Deposits* gives an overview over the economically significant types of mineral deposit. Their global distribution, economic relevance, geological environment (from the regional to the scale of the ore-body) as well as the models for their genesis will be discussed. Manifestations of ore-forming processes as well as relevant characteristic for their exploration will be presented. In exercises the gained knowledge will be applied and deepened. For these exercises several hand specimens of the different mineral deposits are available. The primary goal is for the students to acquire a comprehensive knowledge on the different types of mineral deposit, their specific characteristics as well as the key-factors for their genesis.

Geochronology examines by physical methods when and for how long geological processes take place. Thus the formation and evolution of Earth and other planets can be tagged with 'absolute' ages. With geochronological methods we can date, for example, processes such as formation of continents, melting events in mantle and crust, metamorphism, erosion of the Earth's crust. The most accurate methods of age determination are based on the decay of radioactive atoms and the measurement of isotopic abundances with a mass spectrometer. In this module component, the geologically important dating methods (e.g. U-Pb, K-Ar, Rb-Sr, Sm-Nd, Lu-Hf, Re-Os, C-14, fission track dating, uranium series) will be presented and their capabilities and limitations demonstrated.

Crust and Mantle Petrology deals with the petrologic evolution of planet Earth and leads students towards an understanding of the origin and evolution of igneous and metamorphic rocks through space and time. Main topics include, among others, protoplanets and chondrites, Earth differentiation, pressure and temperature gradients in the Earth's crust and interior, magma generation (Tholeiitic, Alkalic and Calc-alkalic series), igneous processes in different tectonic environments, partial melting in the mantle (from different reservoirs) and in the crust (under different P-T and H2O conditions), processes modifying the initial composition of magmas, ascent and intrusion of magmas and changes of melting and metamorphic conditions with space and time.

In *Sedimentary Basin Dynamics* students are introduced to modern interdisciplinary concepts relating to the formation and evolution of lithospheric-scale sedimentary basins. Special emphasis will be given to theoretical concepts linking basins to orogenic systems, their plate tectonic context, and the key observations including sedimentary, stratigraphic, geological, geophysical, and geochronological data, which form the basis of basin analysis. The course may include a field trip to a sedimentary basin, case-studies, in-depth review of recent literature, and problem-sets to quantify basin evolution on a range of space and time scales.

Physics and Chemistry of Melts is an introduction to rheology and

	thermodynamics of glasses, liquids and magmas (the glass transition), and geologically important physical properties (density, viscosity, heat capacity, etc.). It covers techniques for their measurement, the effects of pressure, temperature and composition on these properties (especially volatile content), and the theoretical (thermodynamic) basis for current models of physical properties.
Learning outcomes	Students will either deepen their knowledge in a specific field, or broaden it to another field outside the field chosen for their Master's thesis research.
Type of examination	Written or oral exam or written report or presentation. The definite exam modalities will be announced by the course instructor at the beginning of the semester.
Type of assessment	The successful completion of the module will be graded.
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Prof. Dr. Miriam Dühnforth
Language(s)	English
Additional information	

Module: WP 8 Petrology II

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 8.0.1 Magma Dynamics and Physical Volcanology	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 8.0.2 Experimental Geochemistry	WiSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 8.0.3 Physics and Chemistry of Melts	WiSe	45 h (3 SWS)	135 h	(6)
Integrated learning activity	WP 8.0.4 Crust and Mantle Petrology	WiSe	60 h (4 SWS)	120 h	(6)
Integrated learning activity	WP 8.0.5 Advanced Mineral Deposit Geology	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 3-4 contact hours per week. Including time for self-study, 180 hours have to be invested per semester.

Module type	Compulsory elective module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	Two of the compulsory elective modules WP 6 – WP 9 must be taken. With regard to the compulsory elective courses WP 8.0.1 – WP 8.0.5, must be taken with a total value of 6 ECTS credits. Students who take the compulsory elective course WP 8.0.2 may not take the compulsory elective course P 11.0.2. Students who take the compulsory elective course WP 8.0.3 may not take the compulsory elective course WP 7.0.8. Students who take the compulsory elective course WP 8.0.4 may not take the compulsory elective course WP 7.0.6.
Entry requirements	Previous successful participation in a Bachelor-level course in Basic Petrology (if taking WP 8.0.1 or WP 8.0.3 or WP 8.0.4) is strongly recommended. If taking WP 8.0.5, previous successful participation in P 5.0.1 is strongly recommended.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This module gives and advanced view into the fundamentals of the processes of formation and evolution of igneous and metamorphic

	rocks, as well as ore mineralizations, in space and time, and gives an introduction to the relevant experimental techniques. *Magma Dynamics and Physical Volcanology* addresses physical and chemical processes in view of magmatic activity. Reasons and efficiency of the generation of melt are discussed in relation to the geotectonic environment. Emphasis is on near-surface modifications (decrease of pressure and temperature) that occur during magma rise through the upper crust (< 2km). The influence of melt composition on the eruption behaviour of volcanoes, as well as the characteristic magmatic deposits and techniques on the recognition of volcanic hazards are discussed. *Experimental Geochemistry* introduces students into relevant experimental techniques in petrology and geochemistry (high-temperature furnaces, pressure vessels, piston cylinder, multianvil and diamond cell apparatusses). Specific petrological problems will be discussed that can be addressed by these experimental techniques, considering capabilites and limits. *Physics and Chemistry of Melts* is an introduction to rheology and thermodynamics of glasses, liquids and magmas (the glass transition), and geologically important physical properties (density, viscosity, heat capacity, etc.). It covers techniques for their measurement, the effects of pressure, temperature and composition on these properties (especially volatile content), and the theoretical (thermodynamic) basis for current models of physical properties. *Crust and Mantle Petrology* deals with the petrologic evolution of planet Earth and leads students towards an understanding of the origin and evolution of igneous and metamorphic rocks through space and time. Main topics include, among others, protoplanets and chondrites, Earth differentiation, pressure and temperature gradients in the Earth's crust and interior, magma generation (Tholeiitic, Alkalic and Calc-alkalic series), igneous processes in different tectonic environments, partial melting in the mantle (from different reservoirs) and in the crust (under different P-T and H2O conditions), processes modifying the initial composition of magmas, ascent and intrusion of magmas and changes of melting and metamorphic conditions with space and time. In *Advanced Mineral Deposits*, specific economically significant mineral deposits are presented. Geological and genetic models are critically discussed on the base of specific case studies. Techniques in mineral deposit research and their implication for exploration will be addressed. Typical country rock modifications and paragenetic characteristics will be investigated on hand specimens and microscopic sections to explain their relevance.
Learning outcomes	Students will develop an understanding of the processes at the core of various petrological problems, and they will learn to analyze and interpret data relevant to these processes.
Type of examination	Written or oral exam or written report or presentation. The definite exam modalities will be announced by the course instructor at the

	beginning of the semester.
Type of assessment	The successful completion of the module will be graded.
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Prof. Dr. Claudia Trepmann
Language(s)	English
Additional information	

Module: WP 9 Critical Zone

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Exercise course	WP 9.0.1 Global Cycles: Tutorial	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 9.0.2 Introduction to Soil Science	WiSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 9.0.3 Geo- and Paleobiology	WiSe	60 h (4 SWS)	120 h	(6)
Exercise course	WP 9.0.4 Bioconstruction	WiSe	30 h (2 SWS)	60 h	(3)
Exercise course	WP 9.0.5 Soil Science Methods	WiSe	60 h (4 SWS)	120 h	(6)
Lecture	WP 9.0.6 Global Cycles: Lecture	WiSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours per week. Including time for self-study, 180 hours have to be invested per semester.

Module type	Compulsory elective module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	Two of the compulsory elective modules WP 6 – WP 9 must be taken. With regard to the compulsory elective courses WP 9.0.1 – WP 9.0.6, must be taken with a total value of 6 ECTS credits. Students who take the compulsory elective course WP 9.0.5 may not take the compulsory elective course P 11.0.9.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This module deals with the conditions at the interface between the Earth's surface and the atmosphere, addressing the complex interactions between parent rock, soil, water, air and organisms. *Global Cycles: Tutorial*. Basic concepts of data acquisition, calculation, and evaluation in geobiology. The students will use theoretical background and apply it to understand data acquisition and data analysis in geobiology. This enables them to apply these methods in the future and to critically understand and evaluate related scientific publications. This course should be taken in conjunction with Global

	Cycles: Lecture. In *Introduction to Soil Science* students will learn the principals of soils covering aspects as the definition of soil, soil mineralogy, soil biology and organic matter, soil chemistry and physics. *Geo- and Paleobiology* includes an interactive teaching of the evolution of life in the seas and on land during the Phanerozoic and of the principles of chronostratigraphy. It focuses on selected papers published in international journals that are appropriate to illustrate the state of the art on these topics. Students will gain insight in contemporary research on the interaction between processes of evolution and global or regional patterns of palaeoclimate and palaeogeography. The exercises include analysis of fossils in the context of the lectures. *Bioconstruction* covers all classic and modern aspects of carbonate sedimentology. Great value is set on current issues in carbonate sedimentology, e.g., cold-water carbonates, deep-water reefs, bioerosion, and cold seep carbonates. The topics will be (among others): basics of carbonate sedimentology, carbonate classification schemes, facies models, microfacies analysis of thin sections, diagenesis, staining of thin sections, seep carbonates, and bioerosion. In *Soil Science Methods* students learn how to describe soil properties. They will analyze chemical, physical, mineralogical, and microbial soil characteristics in the laboratory and learn how to interpret the results in terms of the soil pedogenesis, soil functions, and soil reservoir and puffer capabilities. *Global Cycles: Lecture*. Theoretical background on biogeochemical global cycles. Bio-available redox partners in space and time; share and imprint of biogeochemical guilds; Marine and continental biomes; basic concepts of data acquisition, calculation, and evaluation by land-, sea-, air-, or space-born investigations; plate tectonic control on marine circulation, humidity fluxes, and transport systems; imprint of alterations in recycled fluxes. At the end of the course students will be familiar with the most recent reviews on the global cycles of carbon, nitrogen, phosphorous, and silica. They will be able to discuss geobiological alterations resulting from modified pool sizes, and drifts in the magnitude of inputs or outputs.
Learning outcomes	The purpose of this module is for the students to acquire knowledge and understanding of the complexity of Earth surface systems and their interactions.
Type of examination	Written or oral exam. The definite exam modalities will be announced by the course instructor at the beginning of the semester.
Type of assessment	The successful completion of the module will be graded.
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.

Module coordinator	Prof. Dr. Miriam Dühnforth
Language(s)	English
Additional information	/

Module: P 13 Modern Geology IV

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	(Compulsory elective) course	Rotation	Contact hours	Self-study hours	ECTS
Seminar	P 13.0.1 Advanced Deformation and Transformation of Rocks 4	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 13.0.2 Advanced Surface Processes 4	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 13.0.3 Advanced Active Tectonics 4	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 13.0.4 Advanced Earth Magnetism 4	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 13.0.5 Advanced Isotope Geochemistry and Geochronology 4	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Mandatory module with compulsory elective courses.
Usability of the module in other Programmes	/
Elective guidelines	Two of the compulsory elective courses P 13.0.1 – P 13.0.5 must be taken.
Entry requirements	None
Semester	Recommended semester: 4
Duration	The completion of the module takes 1 semester.
Content	The seminars in this module deal with the latest research in the major areas of geology, and consists in reading, presenting and discussing current papers. This module is part of a series of four modules, one in each semester (P 6, P 7, P 12, P 13), that address the need for students to familiarize themselves with reading scientific literature by reading and discussing it on a regular basis.
Learning outcomes	The goal of this module is for students to critically analyze, and synthesize scholarly literature in the relevant field.
Type of examination	Presentation

Type of assessment	The successful completion of the module will not be graded (pass/fail).
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Dr. habil. Sara Carena
Language(s)	English
Additional information	/

Module: P 14 Communicating Science

Programme	Master's Programme: Geology (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Workshop	P 14.1 Scientific Writing	SoSe	30 h (2 SWS)	60 h	(3)
Workshop	P 14.2 Scientific Presentations	SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours per week. Including time for self-study, 180 hours have to be invested per semester.

Module type	Mandatory module with mandatory courses.
Usability of the module in other Programmes	/
Elective guidelines	None
Entry requirements	It is strongly recommended that students taking this module have already completed P 8, or have started P 10 in the third semester, so that they have sufficient material to work with during this course. Students who do not satisfy this requirement will need to generate realistic-looking scientific writing samples and presentation topics on their own, outside the class and individual study hours allotted for this module. The module addresses exclusively the improvement and presentation of scientific work that students have already produced, it does not address the conceiving and carrying out of a research project itself.
Semester	Recommended semester: 4
Duration	The completion of the module takes 1 semester.
Content	This module deals with various aspects of scientific writing and oral presentations in English, including topics like cultural differences in reader/writer relationship between English and other languages, and how to avoid plagiarism. The writing workshop component focuses on the proper structure and style for writing a variety of scientific texts, from abstracts to research papers. It will cover planning and preparation, strategies for dealing with English scientific writing, how to give proper acknowledgment and avoid plagiarism, how to deal with reviewers and editors. The scientific presentation workshop focuses on presentation skills for academic purposes (thesis defenses, conference presentations, seminars). It includes targeting of audience type, slide preparation and proper use of media and software, English usage, handling questions and answers.

Learning outcomes	The goal of this module is for students to acquire the necessary skills to communicate scientific ideas in a variety of formats to a diverse audience. The purpose of the writing workshop component is to give students the necessary tools to write their own Master's thesis, conference abstracts, scientific reports, proposals, or any other text that may be needed in their future career. The purpose of the scientific presentations component is to enable the student to independently prepare their oral presentations and to deliver them in the manner appropriate for the type of presentation and audience to be addressed.
Type of examination	Presentation and writing samples folder
Type of assessment	The successful completion of the module will not be graded (pass/fail).
Requirements for ECTS credits accrual	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Module coordinator	Dr. habil. Sara Carena
Language(s)	English
Additional information	Literature: R.L. Bates, *Writing in Earth Science*, AGI, 1988 edition; A. Wallwork, *English for Writing Research Papers*, Springer; A. Wallwork, *English for Presentation at International Conferences*, Springer.