LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Module Catalogue

Master's Programme: Geomaterials and Geochemistry

(Master of Science, M.Sc.)

(120 ECTS credits)

Based on the *Prüfungs- und Studienordnung* adopted by the Senate of Ludwig-Maximilians-Universität München on 25 July 2019

88/391/---/M0/H/2019

Issued on 30 September 2019

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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/module
P	mandatory course/module

1. The ECTS credits assigned in the Module Catalogue 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 Catalogue 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.

Module: P 1 Heterogeneous Systems

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	P 1.1 Heterogeneous Systems (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)
Exercise	P 1.2 Heterogeneous Systems (Exercise)	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. Including time for self-study, 180 hours have to be invested.

Module type	Mandatory module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	None
Entry requirements	None
Semester	Scheduled semester: 1
Duration	The completion of the module takes 1 semester.
Content	The module focusses on the understanding the principles of phase stability and phase transformations/reactions in heterogeneous systems. Lecture combined with exercise will elucidate the empirical description of heterogeneous systems with phase diagrams in temperature-stress -composition, eH, pH and time, highlight the fundamentals of the quantitative thermodynamic and kinetic background, and train the students in application of the principles and fundamentals of the experimental analytical methods to explore phase stability and phase reactions. A few hands-on examples for processing phase analytical and chemical-analytical data will be used for training in the exercises.
Learning outcomes	The goal of this module is to guide students into the modern approaches to the complex physico-chemical processes and states in/of Earth systems and in man-made materials systems. The students will acquire skills and competence in the theoretical, experimental, and analytical approach to multi-component- and multi-phase systems. Analytical tools will be taught only to the level of understand¬ding which analytical objectives can be reached by which method. To reach a certain level of proficiency in the various techniques

	is the goal of later, advanced and specialized courses and the thesis work.
Type of examination	Written exam
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Wolfgang W. Schmahl
Language(s)	English
Additional information	Grundlagen-Orientierungs-Prüfung (GOP) As mindset and the skills in approaching complex systems are of basic importance in the field of Geomaterials and Geochemistry, be it in industry or fundamental sciences. Thus the exam to this module serves as GOP.

Module: P 2 Petrophysics

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	P 2.1 Petrophysics (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)
Exercise	P 2.2 Petrophysics (Exercise)	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. Including time for self-study, 180 hours have to be invested.

Module type	Mandatory module with mandatory courses
Usability of the module in other Programmes	MSc Geophysics (PStO 2019), MSc Geology (PStO 2015)
Elective guidelines	None
Entry requirements	None
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	This module investigates the physical properties of rocks (and other geomaterials) such as for instance porosity, permeability, elastic and mechanical properties, thermal and electrical properties. P2.1 Petrophysics (Lecture) The students are introduced to the theoretical background of petrophysics. Petrophysical properties are explored in the light of the different rock types. The properties are discussed individual as well as against each other. Methods of measuring these properties (direct or indirect are discussed) are discussed and examples for the usage of petrophysical properties in different fields of geomaterials and geoscience are given. P2.1 Petrophysics (Exercise) The students will be introduced to some of the laboratory methods explained in P2.1 and will train to apply these methods in laboratory exercises; they will learn to interpret and discuss the results of their measurements.
Learning outcomes	At the end of the module the student are familiar with petrophysical properties of different rock types. The students will be able to understand or interpret petrophysical parameters of different geomaterials. The

	students can apply methods they learned in the practical part of the module.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	PD Dr. Bettina Scheu
Language(s)	English
Additional information	None

Module: P 3 Applied Mineralogy

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	P 3.1 Glass and Ceramics	WiSe	30 h (2 SWS)	60 h	(3)
Exercise	P 3.2 Polarisation Microscopy	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. Including time for self-study, 180 hours have to be invested.

Module type	Mandatory module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	None
Entry requirements	None
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	The module will focus on modern concepts and techniques in applied mineralogy with an emphasis on the properties of glass, ceramics and natural polyphase crystalline Geomaterials. These materials and techniques are of fundamental significance equally for materials processing technologies and various disciplines in several Geosciences. The lecture on Glass and Ceramics (P 3.1) will focus on the understanding of structure-property relations of glassy and polycrystalline inorganic non-metallic materials. Preparation of glass, i.e. reasons for suppressed crystallization in typical glass-forming systems, will be treated as well as the most important properties used in technical applications. Chemical aspects will be discussed using basic knowledge in thermodynamics and kinetics of phase transitions. In the broad field of ceramic materials, three main groups are presented: (i) traditional silicate ceramics like earthenware, stoneware and porcelain, (ii) oxide ceramic, and (iii) non-oxide ceramic materials. These advanced ceramics will be discussed in combination with their physical properties to be used in technical devices. Various kinds of sintering mechanisms are explained depending on the specific ceramic material. A short

	presentation of the science and technology of building materials is included at the end. In the exercise (P 3.2) advanced techniques of polarized light microscopy, using for example the compensator plate and an U-stage, will be introduced and applied to characterize the microfabric of mineralogical samples, including mineralogical, structural and textural characteristics. The exercise will build upon the basic knowledge already present from the Bachelor's degree and represents the link to the module P3 "high resolution microscopy" in the second semester. Students will be trained to use polarized light microscopy as a powerful, effective and cheap tool for the microfabric analysis, for example to judge grain parameters, porosities, the distribution and textural characteristics of mineralogical phases and to measure the 3D-orientation of planar elements and optical axes. The students will work project-oriented on specific samples.
Learning outcomes	The students will deepen their knowledge on the characteristic properties of glass and ceramic as well as the microscopic techniques to characterize the microfabric of mineralogical samples. The students will understand how structural properties of technical and natural materials determine their possible use in modern technology. The goal is to enable students to learn, understand and critically discuss the usage and limits of advanced techniques in polarized microscopy.
Type of examination	Written exam or oral examination or exercise portfolio
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Peter Gille
Language(s)	English
Additional information	None

Module: WP 1 Materials Science I

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 1.1 Fundamentals in Materials Science (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 1.2 Fundamentals in Materials Science (Exercise)	WiSe	15 h (1 SWS)	45 h	(2)

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

Module type	Compulsory elective module with mandatory courses.
Usability of the module in other Programmes	Master Physik, Master Chemie
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	Materials Science I is an interdisciplinary series of lecture units and exercises given or supervised by lecturers from different faculties of LMU, TUM, and local industry. The attending students likewise come from different fields (mainly geomaterials and geochemistry, chemistry, physics). The exercises are lab experiments and information research including patent information. Material Science I (winter semester) gives an overview into ancient and modern materials classes, covers fundamentals of structural, mechanical, magnetic, dielectric, transport, and thermal properties, and highlights important analytical techniques. Materials Science II (summer semester) discusses specific topics in a similar interdisciplinary way.
Learning outcomes	Getting an overview and fundamental skills and knowledge in materials science: material properties and their

	optimization by selection of appropriate chemical systems and processing techniques.
Type of examination	Exercise portfolio
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Wolfgang W. Schmahl
Language(s)	English
Additional information	None

Module: WP 2 Advanced Structural Studies I

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 2.1 Structure Determination (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)
Exercise	WP 2.2 Structure Determination (Exercise)	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. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	WP 2.1 In this lecture the students learn the fundamental diffraction theory, the stepwise in conducting single crystal diffraction, followed by methods for structure determination and refinements. On this purpose, mathematical backgrounds are elucidated particularly for Fourier synthesis, Direct Method, and Least Square method. WP 2.2 The exercise contains sample preparation for single crystal diffraction, density determination, absorption corrections, data collection on a four-circle single crystal diffractometer, data reduction and structure analysis. The obtained structure model will be plotted and further discussed about structure properties.
Learning outcomes	WP 2.1 Students are able to comprehend the principle of diffraction from solid-state matter and how to collect

	intensities at 3-dimensional reciprocal lattice points, i.e. reflections. By mathematical deals with positions and intensities of reflections, the atomic arrangement in the real space is delivered. WP 2.2 Students can prepare and mount samples. They independently collect and correct single crystal diffraction data, followed by data evaluation. With the obtained model, they can predict and/or explain physical properties of the structure of interest.
Type of examination	Written exam
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Sohyun Park
Language(s)	English
Additional information	None

Module: WP 3 Volcanology I

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 3.1 Volcanology (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)
Exercise	WP 3.2 Volcanology (Exercise)	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. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	MSc Geology (PStO 2015)
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	This module investigates the concepts of magmatic processes holistically, starting from partial melting and magma movement to the plethora of dynamic processes during magma ascent, leading to the observed variability of eruptive phenomena. WP3.1 Volcanology (Lecture) The students are introduced to magmatic processes from the roots (partial melting) to the results (volcanic deposits). They will be shown how petrological, geochemical and petrographical analysis will shed light into mantle and crustal processes during melt formation (host rock, degree of partial melting) and magma migration (ascent velocity, ponding) as well as how to decipher eruptive as well as transport processes and environmental conditions via deposit analysis. Analytical methods are revised or introduced.

	WP3.2 Volcanology (Exercise) The students will be introduced to analogue laboratory experiments to mimic material properties relevant to magmatic processes (e.g. viscosity, rheology) as well as methods of investigation for volcanic deposits. This will base on the theory learned in P3.1 and increase the comprehension.
Learning outcomes	At the end of the module the students will be familiar with the plethora of boundary conditions affecting magmatism and volcanic activity as well as the related deposits.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Ulrich Küppers
Language(s)	English
Additional information	None

Module: WP 4 Geochemistry I

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 4.1 Isotope Geochemistry	WiSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 4.2 Geochronology	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. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	MSc Geology (PStO 2015)
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	This module introduces the principles of isotope geochemistry and emphasizes its cross-disciplinary range of applications within the earth sciences. WP 4.1 Isotope Geochemistry An introduction to the most important isotope systems to earth science with emphasis on theoretical principles and applications. This course explores the differences between traditional stable isotope (O, C, N, S, H) and non-traditional stable isotope (Mg, Fe, Ti, U, etc.) geochemistry and provides students an overview of which isotope system is best suited to trace specific geological processes throughout Earth`s major geochemical reservoirs. Selected

	case studies and seminal papers on low- and high-temperature isotope geochemistry are discussed in class. WP 4.2 Geochronology An introduction to the physical fundamentals of radiogenic isotope geochemistry including radioactive decay and how absolute ages can be retrieved from geological materials. The most important decay systems such as K-Ar-Ca, Rb-Sr, Sm-Nd, Lu-Hf, Re-Os and U-Th-Pb as well as commonly used cosmogenic nuclides are explored in depth.
Learning outcomes	Development of a comprehensive understanding of the most important isotope systems used in geochronology and stable isotope geochemistry. Students learn to critically evaluate and accurately process isotope geochemical data as well as to select the appropriate isotope system(s) to solve fundamental geological problems.
Type of examination	Written exam or oral examination or scientific draft
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Daniel Weidendorfer
Language(s)	English
Additional information	None

Module: WP 5 Recent Topics in Geosciences

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 5.1 Recent Topics in Geosciences (Seminar)	WiSe	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	Compulsory elective module with mandatory course
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	Students read scientific publications on hotly debated advanced topics in Geosciences with special focus on volcanically relevant processes and material sciences. The publications are chosen by the lecturers. The students regularly prepare written summaries and will thereby improve their experience in asking critical questions about papers. They will actively participate in and lead group discussions on case studies, which qualifies them to take part in scientific discussions and prepares them to defend their MSc thesis.
Learning outcomes	At the end of the module the students will be have a diverse insight into ongoing and cutting-edge research topics and will have increased their capacity to critically read scientific articles and compile coherent summaries.
Type of examination	Term paper or scientific draft

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Ulrich Küppers
Language(s)	English
Additional information	None

Module: WP 6 Advanced Geosciences I

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 6.1 Advanced Geosciences	WiSe	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	Compulsory elective module with mandatory course
Usability of the module in other Programmes	See Additional information
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	The module includes an integrated learning activity on topics in advanced geosciences. The course can be selected from the regular course programs of a variety of geoscience disciplines such as geology, hydrogeology, engineering geology, geophysics, paleontology, or geobiology. The content of the integrated learning activity depends on the specific topic of the selected course. The selected course focusses on methods or concepts, which are apt to provide complementary aspects to the topics of master program geomaterials and geochemistry.
Learning outcomes	The students will be able to understand important aspects of geology, hydrogeology, engineering geology, geophysics, paleontology, or geobiology. The aspects will complementary to the aspects of the master program geomaterials and geochemistry. Due to this complementarity, students will especially gain thorough interdisciplinary knowhow. The interdisciplinary cross-

	links will particularly contribute to a significant widening of knowledge that can be gained by the students.
Type of examination	Written exam or oral examination or term paper or scientifc draft
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Examination committee (current chair: Prof. Dr. Peter Gille)
Language(s)	English
Additional information	The following procedure applies: Students select a course from the offers of the various disciplines mentioned above. Approval of the selected course has to be requested from the examination committee. Eligible courses particularly strengthen the interdisciplinary cross-links between the advanced geosciences disciplines on the one hand and the various aspects of the master program geomaterials and geochemistry on the other hand.

Module: WP 7 Microthermometry

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 7.1 Introduction to Microthermometry	WiSe	15 h (1 SWS)	45 h	(2)
Exercise	WP 7.2 Microthermometry (Exercise)	WiSe	15 h (1 SWS)	15 h	(1)

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	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	TUM Master Ingenieur- und Hydrogeologie
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	The course covers the petrographic and thermodynamic foundations of fluid inclusion research and provides a practical introduction to microthermometry. The main topics are mechanisms of fluid inclusion formation, microscopic description and evaluation of fluid inclusions, isochoric-isoplethic behaviour of fluids during heating and freezing, fluid phase equilibria of geologically important unary (H2O, CO2), binary (CO2-CH4, H2O-NaCl, H2O-CO2) and ternary fluid systems (H2O-NaCl-CaCl2, H2O-NaCl-KCl, H2O-NaCl-CO2), equations of state, and an practical aspects of microthermometry and other analytical techniques.
Learning outcomes	At the end of the module, students are able to understand fluid phase equilibria, to conduct microthermometric measurements, to apply the newest computer programs, to

	analyze the phase changes and to evaluate the results in terms of fluid composition and conditions of entrapment.
Type of examination	Scientific report
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. H. Albert Gilg
Language(s)	English
Additional information	s. TUM, Introductory course to polarizing microscopy required

Module: WP 8 Selected Topics in Natural Sciences

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 8.1 Complementary Natural Sciences	WiSe	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	Compulsory elective module with mandatory course
Usability of the module in other Programmes	s. Additional information
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	The module includes an integrated learning activity on topics in natural sciences. The course can be selected from the regular course programs of a variety of natural science disciplines such as physics, chemistry, biology, materials sciences, or mathematics. The content of the integrated learning activity depends on the specific topic of the selected course. The selected course focusses on methods or concepts, which are apt to provide complementary aspects to the topics of master program geomaterials and geochemistry.
Learning outcomes	The students will be able to understand important aspects of physics, chemistry, biology, materials sciences, or mathematics. The aspects will complementary to the aspects of the master program geomaterials and geochemistry. Due to this complementarity, students will especially gain thorough interdisciplinary knowhow. The interdisciplinary cross-links will particularly contribute to a

	significant widening of knowledge that can be gained by the students.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Examination committee (current chair: Prof. Dr. Peter Gille)
Language(s)	English
Additional information	The following procedure applies: Students select a course from the offers of the various disciplines mentioned above. Approval of the selected course has to be requested from the examination committee. Eligible courses particularly strengthen the interdisciplinary cross-links between the general natural science disciplines on the one hand and the various aspects of the master program geomaterials and geochemistry on the other hand.

Module: P 4 High Resolution Microscopy

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	P 4.1 High Resolution Microscopy (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)
Exercise	P 4.2 High Resolution Microscopy (Exercise)	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. Including time for self-study, 180 hours have to be invested.

Module type	Mandatory module with mandatory courses
Usability of the module in other Programmes	MSc Geology (PStO 2015)
Elective guidelines	None
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The module focusses on high resolution electron microscopic techniques applied to the characterization of the microfabric of Geomaterials, including chemical, structural and textural characteristics. These techniques are of fundamental significance in several Earth, biological and environmental science disciplines as well as for material design and material processing technologies. The techniques represent the link between science and technology of materials. Students are introduced into state-of-the-art microanalytical techniques performed in a scanning electron microscope (SEM), including secondary electron (SE)-, backscattered electron (BSE)- and cathodoluminescence (CL)- imaging as well as Energy Dispersive Spectroscopy (EDS), EBSD (Electron Backscatter Diffraction) and scanning transmission electron microcopy (STEM). Students are also introduced into the application of transmission electron microscopy in Geosciences. In exercises students will get hands-on experience on a modern analytical SEM and will be trained to characterize the microfabric on various different Geomaterials, including the determination of grain parameters, chemical

	composition, spatial distribution of phases, crystallographic and structural relationships between grains as well as intragranular misorientation. The primary goal is to enable students to apply modern microanalytical techniques to acquire, judge and evaluate crucial data on the microfabric (chemical, structural and textural) characteristics of Geomaterials.
Learning outcomes	The goal of this module is for students to acquire knowledge on state-of-the-art microanalytical techniques for the characterization of microfabrics of Geomaterials. It is also to enable students to learn, understand and critically discuss the significance of the data as well as the limits of the specific techniques. The students will be trained to apply their knowledge on the techniques of high resolution microscopy for solving scientific problems in view of the characterization of microfabrics of Geomaterials.
Type of examination	Written exam or oral examination or written report or presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Claudia Trepmann
Language(s)	English
Additional information	None

Module: P 5 Analytical Methods in Geochemistry

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	P 5.1 Introduction to Geochemical Analytics	SoSe	15 h (1 SWS)	45 h	(2)
Integrated learning activity	P 5.2 Applied Geochemical Analytics	SoSe	45 h (3 SWS)	75 h	(4)

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

Module type	Mandatory module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	None
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	This Module covers the range between classic wet-chemical analytical methods to a selection of modern instrumental techniques and their applications. Although, classic wet-chemical methods lose more and more their classic applications, a fundamental knowledge about this classic analytical field and involved simple trial tests guarantee a rock-solid foundation for first information of composition of samples in the field. Classic analytical methods allow the quantitative determination of any sample material with unprecedented accuracy and precision, and need no external standard to do so. No modern analytical method can compete in this respect. Some analytical methods are still based on classic methods like the determination of the Fe2+-content of a sample by dichromatometry, a standard method for the determination of the Fe2+-Fe3+-ratio in combination with electron microprobe analysis. A deeper view into modern instrumental-analytical methods like Atomic- (AAS, AES), molecular- (IR, RAMAN) and Fluorescence-Spectroscopy (AES, RFA) demonstrate the capabilities and limitations of modern instrumental techniques and their daily application in analytical life.

Learning outcomes	Fundamental skills in classic wet chemical analysis as a standard-less, quantitative tool and a series of simple tests for daily analytical life are explained and shown. Modern analytical tools which are all reference based are introduced and applications and limitations are demonstrated. The students will learn to decide which merthod will give the best results for his scientific question.
Type of examination	Written exam or scientific draft or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Werner Ertel-Ingrisch
Language(s)	English
Additional information	None

Module: WP 9 Materials Science II

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 9.1 Functional Materials (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 9.2 Functional Materials (Exercise)	SoSe	15 h (1 SWS)	45 h	(2)

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

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	Master Physik, Master Chemie
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	Materials Science II is an interdisciplinary series of lecture units and exercises given or supervised by lecturers from different faculties of LMU, TUM, and local industry. The attending students likewise come from different fields (mainly geomaterials and geochemistry, chemistry, physics). The exercises are lab experiments. Material Science II discusses specific topics of materials classes and their specific field of application, and/or specific analytical techniques. Typical themes covered, for example, are high-performance alloys, shape memory, biomaterials, engineering ceramics, glasses and rheology of melts, organic semiconductors and photovoltaics, ionic conductors and battery materials, ferroelectrics, liquid crystals, polymers, block-copolymers, neutron scattering and radiography, super-resolution optical microscopy, STM and AFM.

Learning outcomes	With the example of specific materials or techniques students get an overview on how certain materials properties can be achieved and optimized, or which specific and less-well-known methods are available to achieve certain objectives in materials research. The lab exercises provide the students with a certain degree of proficiency in analytical methods.
Type of examination	Exercise portfolio
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Wolfgang W. Schmahl
Language(s)	English
Additional information	None

Module: WP 10 Crystal Physics

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 10.1 Crystal Physics (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)
Exercise	WP 10.2 Crystal Physics (Exercise)	SoSe	15 h (1 SWS)	15 h	(1)
Lecture	WP 10.3 Thermodynamics of Crystals	SoSe	15 h (1 SWS)	45 h	(2)

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

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The module includes a lecture and a lab excercise on linear physical properties of crystals as well as a lecture on thermodynamics of crystals. In detail, the courses include the following contents: WP 10.1 Crystal Physics: Lecture Basic concepts of tensors and representation quadrics and their relation to crystal symmetry are presented. The concepts are subsequently applied to strain, deformation, stress, piezoelectricity and elasticity as examples for tensors ranging from second to fourth rank. WP 10.2 Crystal Physics: Exercise Using an experimental setup, tensor components of an anisotropic crystal property are measured quantitatively.

	WP 10.3 Thermodynamics of Crystals: Lecture The lecture covers (i) fundamental models of the theory of heat capacity in relation to electrons and lattice vibrations, (ii) briefly introduces thermodynamics of defects, and (iii) discusses cooperative phase transitions in crystals and demonstrates the use of Landau theory for their description.
Learning outcomes	The students will be able to understand fundamental models of thermodynamical quantities and will be able to treat the ansiotropy of physical properties of crystals numerically. Furthermore, the students will gain knowledge on how to measure anisotropic crystal properties and how to interpret published data of crystal properties.
Type of examination	Written exam
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Guntram Jordan
Language(s)	English
Additional information	None

Module: WP 11 Petrology

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 11.1 Petrology (Lecture)	SoSe	30 h (2 SWS)	60 h	(3)
Exercise	WP 11.2 Petrology (Exercise)	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. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	MSc Geology (PStO 2015)
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	This module aims to significantly expand the students knowledgeon the petrology of igneous and metamorphic rocks. Lectures combined with excersises will elucidate the petrology of the Earths' crust and mantle. Petrological processes will be placed in regional and global tectonic context. The relationship between major elements as well as trace elements of for instance igneous rocks with the tectonic setting will be introduced or deepened. Methods and principles of modern igneous and metamorphic petrology will be introduced and discussed.
Learning outcomes	At the end of this module students should have complemented and expanded their knowledge about igneous and metamorphic petrology. The students should be capable to understand and critically discuss usage and limits of petrological concepts and data in the scientific literature.

Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Donald B. Dingwell
Language(s)	English
Additional information	None

Module: WP 12 Geochemistry II

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 12.1 Geochemical Cycles	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 12.2 Experimental Geochemistry	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. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	MSc Geology (PStO 2015)
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	This module focuses on geochemical exchange dynamics between Earth´s major reservoirs and introduces high-pressure / high-temperature experimental techniques for investigating phase equilibria and thermodynamic properties of rocks and their constituents. WP 12.1 Geochemical Cycles Chemical and physical properties of elements and molecules control large-scale exchange dynamics between the Earth´s core, mantle, crust and atmosphere. This course deals with geochemical cycling of geologically important tracer elements through the dynamic Earth.

	WP 12.2 Experimental Geochemistry This course introduces experimental techniques covering a range of geologically relevant pressures and temperatures that allow for investigation of physical and chemical properties of Earth materials as well as geochemical processes in the Earth and other planetary bodies. A selection of the most common experimental methods will be introduced including 1atm gas mixing furnaces and the principle concept of oxygen fugacity, internally and externally heated pressure vessels for investigation of crustal magmatic systems, piston cylinders, multi anvil presses and diamond anvil cells for geochemical and geophysical research applications at upper- and lower mantle P-T conditions.
Learning outcomes	Students learn to link observations obtained from geochemistry, petrology, geophysics, and atmospheric sciences that altogether form the basis for constructing large-scale geodynamic models. The experimental geochemistry course also focuses on how experimental projects are designed in practice by discussing the pros and cons as well as the technical limitations of each of the covered experimental techniques. The aim is to train students how experimental geochemistry and -geophysics can improve our understanding of how the Earth and other planets have formed and differentiated.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Daniel Weidendorfer
Language(s)	English
Additional information	None

Module: WP 13 Advanced Geosciences II

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 13.1 Theory in Advanced Geosciences	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 13.2 Applied Advanced Geosciences	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. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	s. Additional information
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The module includes two integrated learning activities in the areas of advanced geosciences. The courses can be selected from the regular course programs of a variety of geoscience disciplines such as geology, hydrogeology, engineering geology, geophysics, paleontology, or geobiology. The contents of the integrated learning activities depend on the specific topics of the selected courses. The selected courses focus on theoretical as well as applied concepts, which both are apt to provide complementary aspects to the topics of master program geomaterials and geochemistry.
Learning outcomes	The students will be able to understand important theoretical and applied aspects of geology, hydrogeology, engineering geology, geophysics, paleontology, or

	geobiology. The aspects will be complementary to the aspects of the master program geomaterials and geochemistry. Due to this complementarity, students will especially gain thorough interdisciplinary knowhow. The interdisciplinary cross-links will particularly contribute to a significant widening of knowledge that can be gained by the students.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Examination committee (current chair: Prof. Dr. Peter Gille)
Language(s)	English
Additional information	Students select a module from the offers of the various disciplines mentioned above. Approval of the selected course has to be requested from the examination committee. Eligible courses particularly focus on theoretical and applied aspects and strengthen the interdisciplinary cross-links between the advanced geosciences disciplines on the one hand and the various different aspects of the master program geomaterials and geochemistry on the other hand.

Module: WP 14 Industrial Minerals

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 14.1 Introduction to Industrial Minerals	SoSe	30 h (2 SWS)	60 h	(3)
Exercise	WP 14.2 Analysis of Nonmetallic Raw Materials	SoSe	15 h (1 SWS)	15 h	(1)
Field exercise	WP 14.3 Field exercise to Industrial Minerals	SoSe	-	60 h	(2)

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

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	TUM Master Ingenieur- und Hydrogeologie
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	WP14.1 Introduction to Industrial Minerals: Definitions, economic and societal importance, occurrence, genesis, mineral law and mining access, exploration and exploitation concessions, mining methods, processing, quality criteria, medical and environmental aspects, applications. The following commodities are explored in detail: aggregates, cementitious materials, carbonates, gypsum, anhydrite, salt, graphite, perlite, quartz, diatomite, refractories, talc, pyrophyllite, zeolites, kaolin, bentonite, fine ceramic clays and heavy clays.

	WP 14.2 Analysis of Nonmetallic Raw Materials: The students learn to prepare sample for X-ray powder diffraction analysis, especially of clayey materials. They will conduct qualitative mineral identification studies and quantitative phase analysis of complex mineral mixtures using the Rietveld method. The use of portable X-ray fluorescence analysis will be demonstrated. WP14.3 Field Exercise to Industrial Minerals: A focus of the field exercise will be a visit of actively mined industrial mineral deposits in Central Europe. The students will learn the adopted exploration and mining methods, questions of mineral ownership, processing and refinements and environmental issues. The students learn representative sampling of raw materials for quality control.
Learning outcomes	After the module the students can - remember the most important industrial and construction minerals, their deposits, geological setting and formational processes, properties and applications - develop appropriate exploration and processing methods - evaluate the relationships between raw material quality and geological processes in deposit formation - recognize the economic raw materials and their enclosing host rocks in the field - assess possible substitutional materials - understand appropriate authorization procedures for exploration and mining - design useful mining and restoration procedures - evaluate meaningful sampling and sample processing steps for raw materials - develop and evaluate qualitative and quantitative phase analytical methods
Type of examination	Oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.

Responsible contact	Prof. Dr. H. Albert Gilg
Language(s)	English
Additional information	s. TUM

Module: WP 15 Complementary Natural Sciences I

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 15.1 Theory in Complementary Natural Sciences 1	SoSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 15.2 Applied Complementary Natural Sciences 1	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. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	s. Additional information
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The module includes two integrated learning activities in the areas of complementary natural sciences. The courses can be selected from the regular course programs of a variety of natural science disciplines such as physics, chemistry, biology, materials sciences, or mathematics. The contents of the integrated learning activities depend on the specific topics of the selected courses. The selected courses focus on theoretical as well as applied concepts, which both are apt to provide complementary aspects to the topics of master program geomaterials and geochemistry.
Learning outcomes	The students will be able to understand important theoretical and applied aspects of physics, chemistry, biology, materials sciences, or mathematics. The aspects

	will be complementary to the aspects of the master program geomaterials and geochemistry. Due to this complementarity, students will especially gain thorough interdisciplinary knowhow. The interdisciplinary cross-links will particularly contribute to a significant widening of knowledge that can be gained by the students.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Examination committee (current chair: Prof. Dr. Peter Gille)
Language(s)	English
Additional information	Students select a module from the offers of the various disciplines mentioned above. Approval of the selected course has to be requested from the examination committee. Eligible courses particularly focus on applied aspects and strengthen the interdisciplinary cross-links between the general natural science disciplines on the one hand and the various different aspects of the master program geomaterials and geochemistry on the other hand.

Module: WP 16 Materials Science III

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 16.1 Nano Structures	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	Compulsory elective module with mandatory course
Usability of the module in other Programmes	Master Physik, Master Chemie
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	-fundamental differences between macroscopic and nanoscopic objects -microscopy of nanostructures (limitations and basic principles) -bottom-up vs. top down approaches for the fabrication of nanostructures -thin film preparation: physical vapor deposition (PVD) vs. molecular beam epitaxy (MBE) -fabrication and properties of GaAs-AlGaAs heterostructures -basic principles, fundamentals, and implications of quantum mechanics

	-synthesis, properties, and applications of carbon nanomaterials: fullerenes, graphene, and single wall vs. multi wall carbon nanotubes -metal & semiconductor nanoparticles: synthesis, functionalization, size-selection, and properties & applications -self-assembly: basic mechanisms and selected examples
Learning outcomes	actively attending students: -acquire an overview over the vast variety of prevalent nanostructures that are relevant for applications and / or provided fundamental insights -are able to categorize various and partly complementary approaches for the synthesis and fabrication of nanostructures -become familiar with the concepts and the implications of size and shape dependent material properties -are able to assess principal differences when matter approaches nanoscopic dimensions
Type of examination	Written exam
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Markus Lackinger
Language(s)	English
Additional information	None

Module: WP 17 Advanced Structural Studies II

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 17.1 Powder Diffraction (Lecture)	SoSe	15 h (1 SWS)	45 h	(2)
Exercise	WP 17.2 Powder Diffraction (Exercise)	SoSe	15 h (1 SWS)	15 h	(1)

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	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	WP 17.1 Powder Diffraction (Lecture) In this lecture the fundamental diffraction theory will be extended to understand diffraction from fine crystalline and disordered phases. Rietveld analysis is introduced to refine the present structure models with powder diffraction data. Mathematical backgrounds for microstructure analyses and quantitative phase analyses are introduced for X-ray and neutron powder diffraction techniques. WP 17.2 Powder Diffraction (Exercise) Sample preparation, data collection on X-ray powder diffractometers in three different geometries. Data evaluation is executed on via Rietveld analyses on computer. Refined structure models will be graphically presented to discuss about details of local configurations

	of structural building units and draw the entire topology. In addition, the amount of each phases within a powder sample, as well as their apparent domain sizes and strain coefficients are analysed.
Learning outcomes	WP 17.1 Powder Diffraction (Lecture) Students understand different radiation sources and geometries in powder diffraction and enable to use this technique for quantitative phase and microstructure analyses. WP 17.2 Powder Diffraction (Exercise) Students are able to work on powder diffractometers in both transmission and reflection geometries. Using powder diffraction data collected by themselves, all phases present in the sample are quantitatively determine phases along with relevant microstructures of each phase.
Type of examination	Written exam or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Sohyun Park
Language(s)	English
Additional information	None

Module: WP 18 Volcanology II

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 18.1 Physics of Volcanoes	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	Compulsory elective module with mandatory course
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	This module includes a significant expansion of the students' knowledge of physics of various volcanic processes such as for example magma properties, magma ascent, multiphase rheology, magma fragmentation, plume dynamics. Theoretical models, modern concepts and methods will be developed and discussed and with active involvement of the students in the form of this integrated learning activity.
Learning outcomes	At the end of this module students should have complemented and expanded their knowledge about physical concepts in volcanology. The students should be capable to understand and critically interpret theoretical aspects of volcanology as found in scientific publications. The students should be able to actively apply physical principles to volcanological questions.

Type of examination	Oral examination or scientific draft
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	PD Dr. Bettina Scheu
Language(s)	English
Additional information	None

Module: WP 19 Rock-Fluid-Interactions

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 19.1 Rock-Fluid-Interactions (Lecture)	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	Compulsory elective module with mandatory course
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	This module comprises basic concepts of physical and chemical interaction between rocks and fluids, different types of hydrothermal systems, different types of alteration.
Learning outcomes	At the end of this module students should have complemented and expanded their knowledge about basic concepts physical and chemical interactions between rocks and fluids, different types of hydrothermal systems and their alteration characteristics. The students should be capable to understand and interpret fundamental principles of rock-fluid interaction as found in scientific publications.
Type of examination	Written exam or oral examination or scientific draft
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	PD Dr. Bettina Scheu
Language(s)	English
Additional information	None

Module: WP 20 Dynamic Processes in Igneous Systems

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 20.1 Dynamic Igneous Processes	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	Compulsory elective module with mandatory course
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	High-temperature geochemistry of chemically complex igneous systems with special emphasis on interaction dynamics between melts, minerals and fluids.
Learning outcomes	Igneous processes are of particular importance to our understanding of how the Earth has chemically evolved over time. Yet, a majority of geochemical and geophysical observations of mantle and lithospheric igneous processes build on snapshots in pressure – temperature – composition space. This course traces the pressure – temperature pathways of volatile-bearing mantle melts from the source to (potentially) the Earth surface. Chemical disequilibrium dynamics in the upper mantle and in open-system crustal igneous systems are discussed in depth by linking experimental and computational petrology / geochemistry with field-based volcanological and geophysical observations.

Type of examination	Written exam or oral examination or term paper or scientific draft
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Daniel Weidendorfer
Language(s)	English
Additional information	None

Module: WP 21 Advanced Geosciences III

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 21.1 Advanced Earth Sciences	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	Compulsory elective module with mandatory course
Usability of the module in other Programmes	s. Additional information
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The module includes an integrated learning activity in the areas of advanced Earth sciences. The course can be selected from the regular course programs of a variety of Earth science disciplines such as geology, hydrogeology, engineering geology, geophysics, paleontology, or geobiology. The content of the integrated learning activity depends on the specific topics of the selected course. The selected course focusses on concepts of Earth sciences, which are apt to provide complementary aspects to the topics of master program geomaterials and geochemistry.
Learning outcomes	The students will be able to understand important advanced aspects of Earth sciences such as geology, hydrogeology, engineering geology, geophysics, paleontology, or geobiology. The aspects will be complementary to the aspects of the master program geomaterials and geochemistry. Due to this complementarity, students will especially gain thorough

	interdisciplinary knowhow. The interdisciplinary cross-links will particularly contribute to a significant widening of knowledge that can be gained by the students.
Type of examination	Written exam or oral examination or term paper or scientific draft
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Examination committee (current chair: Prof. Dr. Peter Gille)
Language(s)	English
Additional information	Students select a course from the offers of the various disciplines mentioned above. Approval of the selected course has to be requested from the examination committee. Eligible courses particularly strengthen the interdisciplinary cross-links between advanced Earth sciences on the one hand and the various different aspects of the master program geomaterials and geochemistry on the other hand.

Module: P 6 Research Project

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Practical course	P 6.1 Individual Research Project	WiSe	45 h (3 SWS)	75 h	(4)
Seminar	P 6.2 Research Project (Seminar)	WiSe	15 h (1 SWS)	45 h	(2)

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

Module type	Mandatory module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	None
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	Students design and subsequently conduct a medium sized independent research project. The students will summarize the research project in a scientific document and present their project (for instance as poster or oral contribution). The principal project idea will usually be suggested by the lab advisor, but should be developed further by the student.
Learning outcomes	Students learn to independently develop, structure and conduct research projects under aspects of time, budget, methodology and feasibility and to present the project in form of a written document, and a poster or oral presentation. After having completed the module, students will be able to plan, structure and conduct larger research projects as their Master Thesis.
Type of examination	Scientific draft
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Examination committee (currend chair Prof. Dr. Peter Gille)
Language(s)	English
Additional information	None

Module: P 7 Rheology and Thermal Analysis of Melts

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	P 7.1 Theory of Physics and Chemistry of Melts	WiSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	P 7.2 Applied Physics and Chemistry of Melts	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. Including time for self-study, 180 hours have to be invested.

Module type	Mandatory module with mandatory courses
Usability of the module in other Programmes	MSc Geophysics (PStO 2019), MSc Geology (PStO 2015)
Elective guidelines	None
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This module conciliates knowledge of the central role that silicate melts play in both nature and technology and the potential of glass as a monitor of the processes involved. P 7.1 Theory of Physics and Chemistry of Melts The lecture will focus on geo-scientifically and technologically important properties of natural and synthetic glasses, melts and magma. Methods to measure rheologic and thermodynamic properties like the glass transition, volume, density, enthalpy and derivative properties like heat capacity and thermal expansivity are introduced. The effect of temperature, pressure and composition on these properties is analysed. Finally recent models for prediction are discussed and case studies are presented. P 7.2 Applied Physics and Chemistry of Melts The course deepens the contents of the accompanying lecture and serves the practice of the techniques presented there.

Learning outcomes	At the end of the module the students have acquired a deeper understanding of the basic nature of the molten and glassy state of silicates and the description of their petrogenetically and technologically relevant properties and processes.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Kai-Uwe Hess
Language(s)	English
Additional information	None

Module: WP 22 Synthesis and Processing

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 22.1 Synthesis and Processing (Lecture)	WiSe	30 h (2 SWS)	60 h	(3)
Exercise	WP 22.2 Synthesis and Processing (Exercise)	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. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The module gives a general overview of crystal growth theory and methods from the most important source phases: vapour, melt and solution. In the lecture (WP 22.1), atomistic models of crystal growth kinetics based on thermodynamic concepts will be presented. Different growth mechanisms depending on interface conditions are discussed with respect to the resulting growth laws. The most frequently used crystal growth methods are discussed with respect to advantages and specific problems. Growth-dependent crystal defect formation is a special issue. Exercises (WP 22.2) accompanying the content of the lecture are organized as paper discussions of high-impact original publications. In most cases the very first papers on new models or suggested crystal growth methods serve as the starting point presented by individual students

	followed by discussions of present-day developments and applications in science and industry.
Learning outcomes	At the end of this module students should have expanded knowledge about the formation of crystalline phases and presently accepted theories of crystal growth. They should have an overview of the most important crystal growth methods and should be capable – based on thermodynamic and technical arguments - to select the best-suited technique to prepare a specific crystalline phase.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Peter Gille
Language(s)	English
Additional information	None

Module: WP 23 Mineral Surfaces and Reactivity

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 23.1 Surfaces and Interfaces	WiSe	15 h (1 SWS)	45 h	(2)
Integrated learning activity	WP 23.2 Surface Analysis	WiSe	45 h (3 SWS)	75 h	(4)

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

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The module includes a lecture on mineral surfaces and interfaces as well as an ILA on methods analyzing surface morphology and reactivity in high resolution. In detail, the courses include the following contents: WP 23.1 Surfaces and Interfaces: Lecture The lecture presents the different types of surfaces and interfaces as well as the most important aspects related to surfaces and interfaces (e.g. structure, energy, sorption, charge, morphology, wetting, coatings, growth, reactivity, analyses).

	WP 23.2 Surface Analysis: ILA Based on the lecture in WP 23.1, the ILA focusses on the various techniques within the family of scanning probe microscopy methods, which belong to the most important tools in surface analysis. The ILA starts with a presentation of the theory and the technical aspects of different scanning probe methods. Subsequently, the students will be in the surfaces analysis laboratory in small groups. There, the students will learn how to operate an atomic force microscope on various mineral surfaces directly at the microscope. Then, they will perform measurements under various different conditions and will discuss their experimental results with respect to data available from literature.
Learning outcomes	The students will be able to understand the most important aspects of mineral surfaces and interfaces. They will know various important surface analytical methods. The students will obtain detailed knowledge of surface probe microscopy and will be able to apply an atomic force microscope independently in order to measure the reactivity of mineral surfaces in high resolution.
Type of examination	Written exam or scientific draft
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Guntram Jordan
Language(s)	English
Additional information	None

Module: WP 24 Thermodynamical Phase Equilibria

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 24.1 Theory of Thermodynamical Phase Equilibria	WiSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 24.2 Application of Thermodynamical Phase Equilibria	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. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The module introduces the thermodynamic calculation of univariate curves in the P-T field of homogeneous and heterogeneous equilibria of petrologically significant phases under the conditions of the earth's crust and mantle. In detail, the courses include the following contents: WP 24.1 Theory of Thermodynamical Phase Equilibria (Lecture) The course teaches students the pressure and temperature dependencies of Gibbs' free enthalpies of solids and gases and allows them to calculate equilibrium constants for dehydration and decarbonation reactions.

	WP 24.2 Application of Thermodynamical Phase Equilibria (Exercise) The course deepens the contents of the corresponding lecture and serves to practice the techniques presented there. Relevant software will be introduced and applied by the students.
Learning outcomes	The students will be familiar with the thermodynamic calculation of phase equilibria. They will be able to apply the gained knowledge for own research questions and to critically evaluate published data.
Type of examination	Written exam or scientific draft
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Donald B. Dingwell
Language(s)	English
Additional information	None

Module: WP 25 Deformation and Transformation

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 25.1 Rheology of Rocks	WiSe	30 h (2 SWS)	60 h	(3)
Exercise	WP 25.2 Rheology of Rocks (Laboratory)	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. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	MSc Geology (PStO 2015)
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester(s).
Content	The module presents modern concepts of deformation and transformation processes in rocks of the Earth's interior. The students will learn how to use the microfabric of rocks to infer the deformation mechanisms, transformation processes and conditions. Flow laws and paleopiezometers derived from deformation experiments are discussed and applied to specific microfabrics to obtain quantitative data on the stress and strain rate history. These topics will be addressed by a combination of lectures, exercises and microscopy. The primary goal is to enable students to use the grain-scale microstructural record of metamorphic rocks to obtain information on the deformation and stress history and to relate this to the large-scale rheological behaviour of the lithosphere.

Learning outcomes	The goal of this module is for students to acquire advanced knowledge and to connect theory and practice in interpreting geological events on the base of the deformation and transformation record of rocks. It is also to enable students to learn, understand and critically discuss the microstructural record, limits and terminology that define the fields of deformation and transformation of rocks, as well as to apply this knowledge in solving specific problems on the rheology of rocks.
Type of examination	Written exam or oral examination or written report or presentation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Claudia Trepmann
Language(s)	English
Additional information	None

Module: WP 26 Field Practical

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Field exercise	WP 26.1 Field Exercise	WiSe	-	120 h	(4)
Seminar	WP 26.2 Field Exercise (Seminar)	WiSe	15 h (1 SWS)	45 h	(2)

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.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This module investigates the concepts of analysing volcanic processes through a thorough analysis of the related deposits, allowing for physical and quantitative analysis of unobservable phenomena or explain unobserved processes and eruptions. WP 26.1 Field Exercise Methods of fieldwork to describe and interpret volcanic deposits, including geological, sedimentological, petrographical and volcanological methods in exemplary geological settings; e.g.: Recognizing and describing of the local facies and the underlying processes of magma priming, eruption and emplacement processes, geological history of the study area, analytical field methods, mapping and logging.

	WP 26.2 Field exercise (Seminar) The students will read about and present one topic or study area relevant for the field exercise (mandatory for participation in WP 26.1).
Learning outcomes	Students will remember geological, sedimentological, petrographical and volcanological basics from previous lectures in order to describe and interpret selected examples in the field. After the module, students will be able to understand and apply field methods for own research questions, e.g., in a research project or the Master Thesis.
Type of examination	Scientific draft
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Ulrich Küppers
Language(s)	English
Additional information	Duration Field Exercise: 10 days

Module: WP 27 Complementary Natural Sciences II

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 27.1 Theory in Complementary Natural Sciences 2	WiSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 27.2 Applied Complementary Natural Sciences 2	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. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	s. Additional information
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The module includes a lecture and an integrated learning activity in the areas of complementary natural sciences. The courses can be selected from the regular course programs of a variety of natural science disciplines such as physics, chemistry, biology, materials sciences, or mathematics. The contents of the lecture and the integrated learning activity depend on the specific topics of the selected courses. The selected courses focus on theoretical as well as applied concepts, which both are apt to provide complementary aspects to the topics of master program geomaterials and geochemistry.
Learning outcomes	The students will be able to understand important theoretical and applied aspects of natural sciences such as physics, chemistry, biology, materials sciences, or

	mathematics. The aspects will be complementary to the aspects of the master program geomaterials and geochemistry. Due to this complementarity, students will especially gain thorough interdisciplinary knowhow. The interdisciplinary cross-links will particularly contribute to a significant widening of knowledge that can be gained by the students.
Type of examination	Written exam or oral examination or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Examination committee (current chair: Prof. Dr. Peter Gille)
Language(s)	English
Additional information	Students select a module from the offers of the various disciplines mentioned above. Approval of the selected course has to be requested from the examination committee. Eligible courses particularly focus on theoretical and applied aspects and strengthen the interdisciplinary cross-links between the general natural science disciplines on the one hand and the various different aspects of the master program geomaterials and geochemistry on the other hand.

Module: WP 28 Advanced Materials Science

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 28.1 Theory in Advanced Materials Science	WiSe	30 h (2 SWS)	60 h	(3)
Integrated learning activity	WP 28.2 Applied Advanced Materials Science	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. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This is a meta module intended for the students to gain advanced experience in neighboring subjects offered within or without our faculty, LMU as well as TUM. E.g. geo-related materials science (waste treatment, deposition, recovery, rheology of rocks , rock or mineral physics, etc.), solid state chemistry, electrochemistry, solid state physics, engineering of structural or functional materials such as alloys, ceramics, composites, biomedical materials, ferroics, semiconductors, photovoltaics, catalysis, superconductors, etc. This module can contain lectures, exercises, seminars, excursions/field trips or internships.
Learning outcomes	Obtain complementary, interdisciplinary experience/skill in materials science or materials-science-related engineering. Important aims are to increase the abilities of self-guided learning and independent organization, as well as to train

	communication skills with colleagues from different and various science/engineering disciplines, who use different professional philosophy and terminology, in future career.
Type of examination	Written exam or oral examination or term papert
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Wolfgang W. Schmahl
Language(s)	English
Additional information	None

Module: WP 29 Concepts of Biomineralization

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 29.1 Concepts of Biomineralization: Lecture	WiSe	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	Compulsory elective module with mandatory course
Usability of the module in other Programmes	MSc Geobiology and Paleobiology (WP 6, PStO 2017)
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	oncepts of Biomineralization is an interdisciplinary lecture run jointly by lecturers from geobiology/paleontology, and geomaterials/geochemistry. Fundamentals and current research on biomineralization are highlighted from paleontological, molecular-biological, geochemical, crystallographic, and biomedical points of view. The lecture covers the most important biominerals (i.e., calcium carbonate, calcium phosphate, and silica mineral-organic composites) and their function in various organisms, structure-function relationships, the physiology of biomineralization processes, recording of environmental signatures in biominerals, biocompatible, bioactive or biomimetic materials, including those of medical relevance (e.g., prostheses, bone replacements), the evolution of biomineralization throughout geological time, feedback between mineralizing organisms (populations) and environmental changes, genetic and genomic aspects of biomineralization processes in deep time.
Learning outcomes	Understanding the interconnection of the world of organisms and the inorganic "mineral" world in geosystems, and the

	related feedback processes between genomes, organisms, the biomineral products they produce and global change, all related to earth processes and their analytical reconstruction, as well as to biomechanical/biochemical/biomedical issues. Learning of critical thinking and preparation for independent research in a modern, highly interdisciplinary and active field.
Type of examination	Written exam
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Wolfgang W. Schmahl
Language(s)	English
Additional information	None

Module: WP 30 Scientific Working

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 30.1 Techniques of Scientific Working	WiSe	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	Compulsory elective module with mandatory course
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The module comprises practical guidelines to scientific working in general, including the preparation and presentation of scientific contributions: Students will train for instance the preparation of written scientific contributions, the preparation presentation of oral scientific presentations as well as poster presentations and learn the different aspects of scientific discussions. They learn how to write the different parts of a scientific document, and deepen their knowledge how to work with literature (search, incorporation, discussion).
Learning outcomes	Students will learn how to design scientific documents (e.g. research articles, conference abstracts, poster presentations) and how to present oral contributions:

	Furthermore, the students will know the principles of writing scientific documents and are able to conduct a literature search.
Type of examination	Scientific draft or presentation or term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	PD Dr. Bettina Scheu
Language(s)	English
Additional information	None

Module: WP 31 Spectroscopic Methods

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Integrated learning activity	WP 31.1 Methods of Spectroscopy	WiSe	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	Compulsory elective module with mandatory course
Usability of the module in other Programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	Modern instrumental analytical techniques are the essential parts of daily analytical works. A fundamental understanding is necessary to apply these techniques successfully and obtaining high quality and publishable results. In this module, students are introduced into atomic and molecular physics, the interaction between electromagnetic radiation and matter, the analytical processes and settings within the applied method or technique. The aim is to critically train students to enable them to choose the right method for the scientific question and to cope with the potential of each single analytical method as well as with their limitations. The module contains in the first place a fundamental training in the atomic and molecular structure of matter, the interaction of matter with electromagnetic radiation and a detailed introduction into AAS/AES, IR/RAMAN, XRF, potentially

	NMR, and a series of other spectroscopic and spectrometric (Mass spectrometry) methods.
Learning outcomes	Students should learn which analytical methods is most suitable for their analytical task and the involved scientific questions. Applicability as well as physical limitations of each method will be learned.
Type of examination	Written exam or oral examination
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Dr. Werner Ertel-Ingrisch
Language(s)	English
Additional information	None

Module: WP 32 Reflected-Light Microscopy

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Exercise	WP 32.1 Reflected-Light Microscopy (Exercise)	WiSe	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	Compulsory elective module with mandatory course
Usability of the module in other Programmes	MSc Geology (PStO 2015)
Elective guidelines	The module can be chosen in compliance with the following rules: With regard to the compulsory electve modules WP 1 – WP 32, compulsory electives with a total of 48 ECTS credits must be taken. In doing so, compulsory elective modules with a total of 12 ECTS credits should be taken in the first semester and compulsory elective modules with a total of 18 ECTS credits each should be taken in the second and in the third semester.
Entry requirements	None
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The exercise is an introduction to the fundamentals of reflected-light microscopy. It deals with the design and use of the polarization microscope, the investigation of optical properties of opaque minerals and substances in bright and dark fields, reporting of observations, and systematic identification of opaque minerals. The course also impart basic knowledge about typical ore textures and their interpretation.
Learning outcomes	Use of the reflected-light microscope; systematic identification of opaque minerals, knowledge about characteristics of common ore minerals, selected ore mineral associations and ore textures
Type of examination	Written exam
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Prof. Dr. Robert Marschik
Language(s)	English
Additional information	None

Module: P 8 Final Module

Programme	Master's Programme: Geomaterials and Geochemistry (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Master's Thesis	P 8.1 Master's Thesis	SoSe	-	870 h	(29)
Disputation	P 8.2 Disputation	SoSe	-	30 h	(1)

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
Usability of the module in other Programmes	None
Elective guidelines	None
Entry requirements	None
Semester	Recommended semester: 4
Duration	The completion of the module takes 1 semester.
Content	This module consists of two parts. In the first part students are expected to perform independent scientific research on a complex problem of geomaterials and/or geochemistry under the guidance of one or multiple advisors and to develop a new solution to the problem. In the second part the results of this research must adequately be presented by writing a scientific work and giving an oral presentation as well as discussing the results obtained with colleagues and scientists from the field of gematerials and geochemistry.
Learning outcomes	Students learn to transfer their advanced and technical knowledge in geomaterials and geochemisty as well as their scientific competences in geomaterials and geochemistry to a scientific research problem. They are able to solve a complex scientific problem independently, create, evaluate and interpret scientific data sets and write a scientific report. Students are in the position to discuss and present their results in front of a critical scientific audience.
Type of examination	Master's thesis and disputation
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsary module parts) has/have been completed successfully.
Responsible contact	Examination committee (current chair Prof. Dr. Peter Gille)
Language(s)	English
Additional information	None