EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

Studienführer und Modulhandbuch

Geowissenschaften
Master of Science

Wintersemester 2020/21

Mathematisch-Naturwissenschaftliche Fakultät
Fachbereich Geowissenschaften

Inhalt

1. Qualifikationsziele des Studiengangs

Der Masterstudiengang „Geowissenschaften“ richtet sich an fortgeschrittene Studierende, die ihre in einem geowissenschaftlich ausgerichteten Bachelorstudiengang erworbenen Kenntnisse ergänzen und vertiefen wollen.

Der forschungsorientierte Studiengang soll es den Studierenden ermöglichen, sowohl im Bereich der klassischen Grundlagenwissenschaften als auch der Angewandten Geodisziplinen Kontakt zu Spitzenforschung auf nationaler und internationaler Ebene herstellen zu können. Dies beinhaltet eine kritische Auseinandersetzung mit Zielen, Inhalten, Planung und Antragstellung, aber auch den Problemen der Forschung, sowie ein entsprechend hohes wissenschaftliches Niveau. Damit einhergehend werden in einem ersten Schritt unter Anleitung und in einem zweiten Schritt eigenständig Planungs-, Gelände- und Labormethoden erarbeitet und angewendet.

Der MSc Geowissenschaften in Tübingen bietet die größte Vielfalt an geowissenschaftlichen Fächern in Deutschland und erlaubt es daher den Studierenden, wie an keinem anderen Standort, die Fülle der geowissenschaftlichen Forschung von Angewandter Mineralogie, über Paläontologie, Strukturgeologie, Petrologie-Geochemie-Lagerstättenkunde, Geophysik bis zu Biogeologie kennenzulernen. Aufgrund der Breite des Fächerangebots am Standort Tübingen, der besonderen Struktur des Studiengangs und der sich daraus ergebenden großen Vielfalt an theoretischen und auch praktischen Wahlmöglichkeiten kann der individuelle Studienverlauf sehr unterschiedlich sein.

Seit dem Wintersemester 2018/19 bietet der Masterstudiengang Geowissenschaften Bewerbern ohne Deutschkenntnisse die Möglichkeit den Masterabschluss in der Vertiefungsrichtung International Track durch die in Englisch angebotenen Module zu erwerben. Für diese Studierenden steht ein eigenes Modulhandbuch in englischer Sprache zur Verfügung.

Zu beachten ist, dass eine spezielle Ausbildung in den angewandten Geowissenschaften (Hydrogeologie, Environmental Modeling ...) in diesem Studiengang nicht gewährleistet werden kann, so dass diesbezüglich interessierte Studierende auf den M.Sc-Studiengang "Applied & Environmental Geosciences" (AEG) verwiesen werden.

Durch die speziellen integrativen Arbeitsweisen der Geowissenschaften und die fundierte Ausbildung in fachspezifischen Inhalten und Kernkompetenzen sind die Studierenden bestens in der Lage, fachübergreifend und interdisziplinär zu arbeiten. Diese Fähigkeit macht sie für allgemeine Tätigkeitsfelder ebenso attraktiv, wie für facheigene Fragestellungen. Entsprechend der Breite des Lehrangebots sind auch die Berufsperspektiven sehr weit gefächert. Es bestehen Beschäftigungsmöglichkeiten bei Universitäten, Kommunal-, Landes- und Bundesbehörden, Museen, Industrieunternehmen, Versicherungen, Planungsinstituten und Consultingunternehmen mit folgenden Tätigkeitsfeldern:

- Alternative Energiegewinnung (Geothermie, Solarindustrie)
- Altlastenuntersuchung, -bewertung und -sanierung
- Analytikindustrie
- Baugrunduntersuchungen
- Baustoffindustrie (Steine und Erden)
- Bergbau und Aufbereitung geogener Rohstoffe
- Bodenschutz
- Chemische Industrie
- Denkmalschutz und -pflege

- Exploration von Öl-, Gas- und Erzlagerstätten
- Georessourcen-Management
- Grundwasser- und Trinkwasserschutz
- Journalismus
- Keramik-, Zement- und Glasindustrie
- Klimaschutz
- Materialwissenschaft und Analytikindustrie
- Rekultivierung und Renaturierung
- Risikofolgeabschätzungen (Erdbeben, Vulkanismus, Klima)
- Tourismus (Geo-).

Eine permanente intensive Kooperation und Zusammenarbeit zahlreicher Arbeitsgruppen mit der Industrie ermöglicht den Studierenden einen erfolgreichen Start in das Berufsleben, da schon während des Studiums wertvolle Kontakte geknüpft werden können.

2. Modulübersicht

Der Masterstudiengang Geowissenschaften ist auf eine Regelstudienzeit von zwei Jahren ausgelegt. Für einen erfolgreichen Studienabschluss erwerben Studierende 120 Leistungspunkte aus einem Programm von Pflichtmodulen (48 Leistungspunkte) und Wahlpflichtmodulen (72 Leistungspunkte). Dabei besteht die Möglichkeit, sich in 4 Bereichen (Mineralogie, Geodynamik, Biogeologie oder Exploration) zu vertiefen.

Pflicht – und Wahlpflichtprogramm

In den ersten beiden Semestern zeichnet sich der Studiengang durch weitgehende Wahlmöglichkeiten aus dem Lehrangebot der im Fachbereich Geowissenschaften vertretenen Forschungs- und Lehrrichtungen Mineralogie, Geodynamik, Biogeologie aus. Insgesamt sind aus dem Angebot an Mastermodulen zwölf Wahlpflichtmodule zu wählen.

In Abhängigkeit der persönlichen Studienausrichtung sind innerhalb des Wahlpflichtbereichs bestimmte festgelegte Kombinationen (bestehend aus je drei definierten sogenannten Kernmodulen) vorgeschrieben. Diese Kernmodule beinhalten grundlegende, für eine Vertiefung in den angebotenen Fachrichtungen

- Mineralogie ,
- Geodynamik,
- Biogeologie oder
- International Track

notwendigen Studieninhalte.

Kernmodule			
Bereich Mineralogie	Isotope Geochemistry	Sediment-geochemie	Materialwissen-schaften für Geowissen-schaftler (letztmals WiSe 20/21)
Bereich Geodynamik	Applied Tectonics & Surface Processes	Geländepraktika	Kartierkurs
Bereich Biogeologie	Palaeoecology of Marine Ecosystems	Palaeoecology of Terrestrial Ecosystems	Carbonate Facies Analysis
International Track (3 out of 5)	Hydrogeology	Applied Tectonics & Surface Processes	Advanced Structural Geology
	Isotope Geochemistry	MSc Field Mapping	

Verpflichtende Kernmodulkombinationen innerhalb des Wahlpflichtbereichs

Zum Studium gehört aber in jedem Fall die erfolgreiche Teilnahme an Geländetagen im Umfang von mindestens 6 ECTS-Punkten (entweder durch das Modul M 304 MSc Geländeübungen, oder das Modul M 305 MSc Kartierkurs). Im Bachelorstudium bereits absolvierte Geländetage können im Modul M 304 angerechnet werden, soweit sie nicht schon im vorherigen Bachelorstudium zur Anrechnung gekommen sind.

Die Wahl der restlichen Module ist beliebig möglich und ermöglicht sowohl eine weitreichende Spezialisierung als auch ein Studium der gesamten Breite der geowissenschaftlichen Forschung. Dabei sind, soweit ausreichend Platzkapazitäten zu Verfügung stehen, auch Module aus dem Bereich der Angewandten Geowissenschaften wählbar.

Auf Antrag können als Wahlpflichtmodule weitere Module aus dem geowissenschaftlich naturwissenschaftlichen Bereich zugelassen werden; die Entscheidung trifft der Vorsitzende des Prüfungsausschusses.

Die verpflichtenden Bestandteile für alle Studierenden des Masterstudiums bilden den Schwerpunkt des zweiten Studienabschnitts (3. und 4. Semester) und beinhalten neben der Masterarbeit die Module „Wissenschaftliches Arbeiten 1“, „Wissenschaftliches Arbeiten 2“ und „Wissenschaftliches Präsentieren“.

Alle drei Module sind darauf ausgelegt, es den Studierenden zu ermöglichen, praktische, fachübergreifende Schlüsselqualifikationen zu erwerben und sich in enger Zusammenarbeit mit den Mitarbeitern der universitären Arbeits- und Forschungsgruppen methodische, konzeptionelle sowie praktische Kompetenzen für wissenschaftliches Arbeiten anzueignen.

Das Modul **Wissenschaftliches Arbeiten 1**, das von den Studierenden individuell in Absprache mit einem Dozenten gestaltet wird, ermöglicht es

- Studierende frühzeitig in die Arbeitsgruppen zu integrieren, damit sie deren Forschungsbereiche kennen lernen.
- Studierenden, sich eigenständig in einen thematischen Bereich ihrer Wahl einzuarbeiten und begleitet von erfahrenen Betreuern einen ersten praktischen Einstieg und methodischen Zugang zu wissenschaftlichem Arbeiten zu erhalten.
- Orientierungshilfe für den weiteren Studienverlauf zu geben und die Integration der Studierenden aller Semester durch eine gemeinsame Seminarveranstaltung zu fördern.

Im Modul **Wissenschaftliches Arbeiten 2** durchlaufen Studierende anhand einer selbst gewählten beispielhaften Aufgabenstellung alle wichtigen Schritte einer Projektplanung. Ziel dieses Moduls ist es, wichtige praktische und methodische Kompetenzen bei der Konzeption, Arbeitsplanung und Umsetzung von wissenschaftlichen Forschungsprojekten zu vermitteln und diese im Rahmen eines Forschungsantrags schriftlich umzusetzen.

Das Modul **Wissenschaftliches Präsentieren** dient dem Erwerb von Kommunikations- und Präsentationskompetenz. Studierende lernen Forschungsergebnisse in verschiedenen Präsentationsformen aufzubereiten, inhaltlich vorzustellen und zu diskutieren. Es beinhaltet drei Teilleistungen: Eine Präsentation im Master-Seminar, im Rahmen eines Vortrags innerhalb der Arbeitsgruppe und das Erstellen eines Posters mit den Ergebnissen der Masterarbeit.

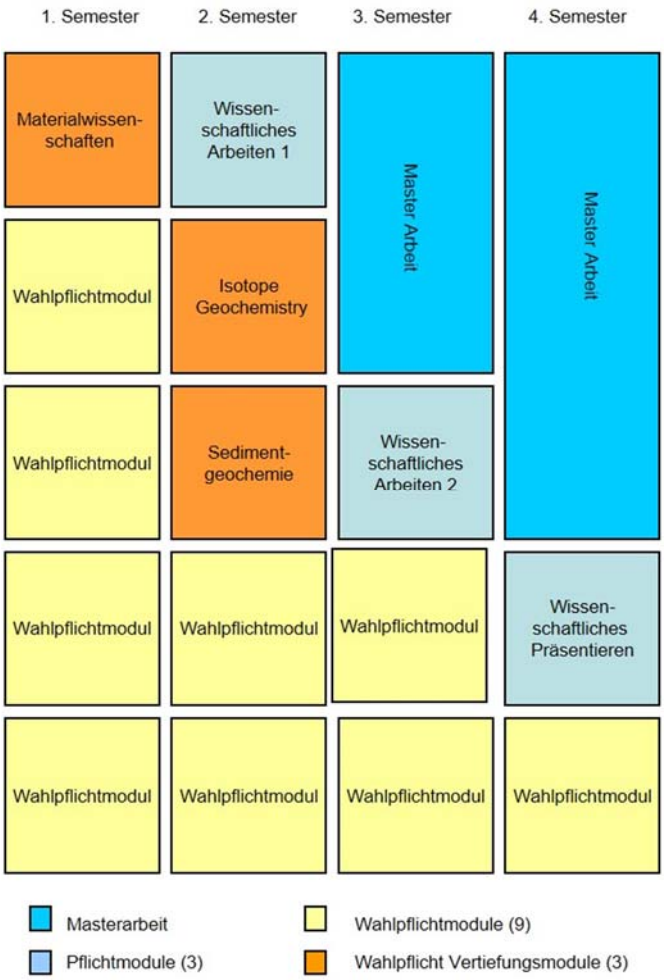
Modulübersicht und Vertiefungsrichtungen

Um Studierenden, die sich in einem der angebotenen Fachgebiete spezialisieren wollen, bei der Zusammenstellung eines individuellen Studienplans eine Hilfestellung zu geben, wurden von den Dozenten eine Reihe von Modulen identifiziert, die, über die geforderten Kernmodulkombinationen der jeweiligen Fachrichtungen hinaus, eine sinnvolle Ergänzung des Wahlpflichtprogramms darstellen können.

Modulübersicht Themenbereich Mineralogie (Beginn letztmalig SoSe 2020)

Die Vertiefungsrichtung Mineralogie konzentriert sich auf mineralogische, geochemische und petrologische Prozesse, die in und auf der Erde stattfinden und stattfanden. Die Analyse, Modellierung und Simulierung dieser Prozesse ist eine essentielle Aufgabe im Studium, um das System Erde zu erklären und Entwicklungen zu prognostizieren.

Da Mineralien die Grundbausteine aller Gesteine und somit der Erde darstellen, sind moderne mineralogische und petrologische Untersuchungen und Kenntnisse die Grundlage für das Verständnis dieser Prozesse und somit der Bildung und Veränderung der Erde und der Planeten mit der Zeit.



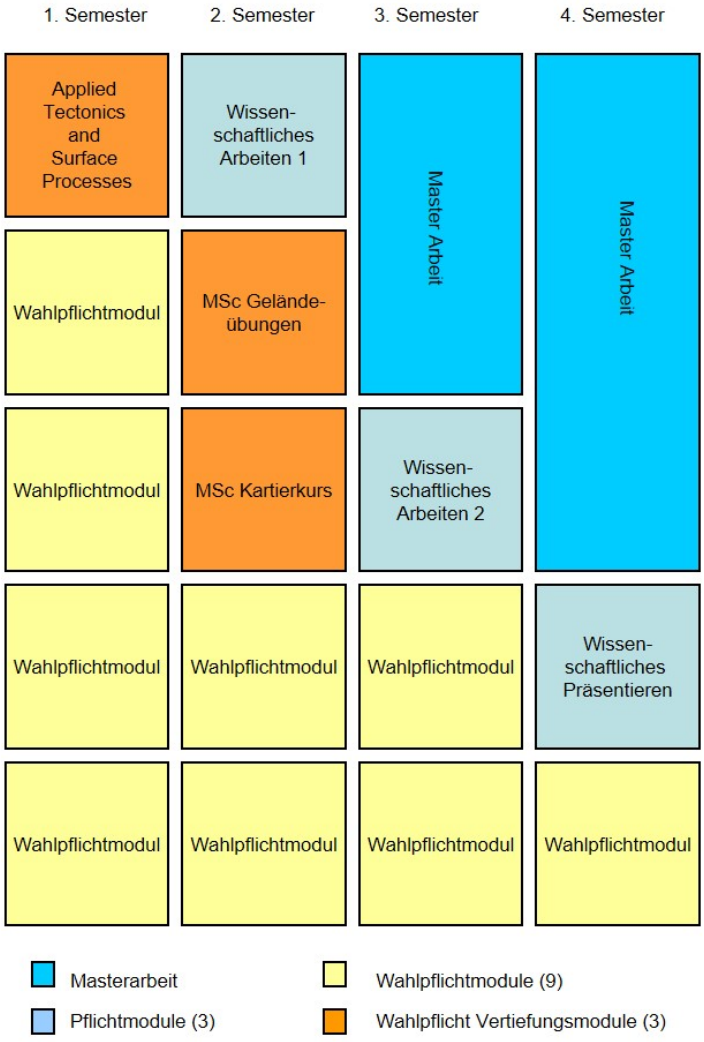
Die Vertiefungsrichtung Mineralogie kann nach dem Sommersemester 2020 nicht mehr angefangen werden.

Zusätzlich empfohlene Wahlpflichtmodule:

- Applied Tectonics and Surface Processes
- Applied Data Analysis and Models for Geoscientists
- MSc Geländeübungen
- MSc Kartierkurs 1&2
- Die Erde im Experiment
- Advanced Structural Geology
- Magmatische Prozesse
- Metamorphe Prozesse
- Economic Geology

Modulübersicht Themenbereich Geodynamik

Das Geodynamik Programm beschäftigt sich mit der Quantifizierung der Wechselwirkungen zwischen Klima, Tektonik und Prozessen auf der Erdoberfläche. Themen, die bearbeitet werden, beinhalten: [1] die Deformation und Struktur der Erde, [2] Modellierung von Gebirgsbildung und Erosion, [3] Techniken der geologische Altersbestimmung, [4] Klima und Paläoklima, [5] Geländearbeiten und [6] Computermodellierung von Gesteinsmechanik bis hin zu globaler Tektonik. Diese Forschung ist sehr interdisziplinär und konzentriert sich auf die Integration von Tiefen-, Oberflächen- und atmosphärischen Prozessen.



Zusätzlich empfohlene Wahlpflichtmodule:

Vertiefung Erdsystem Dynamik:

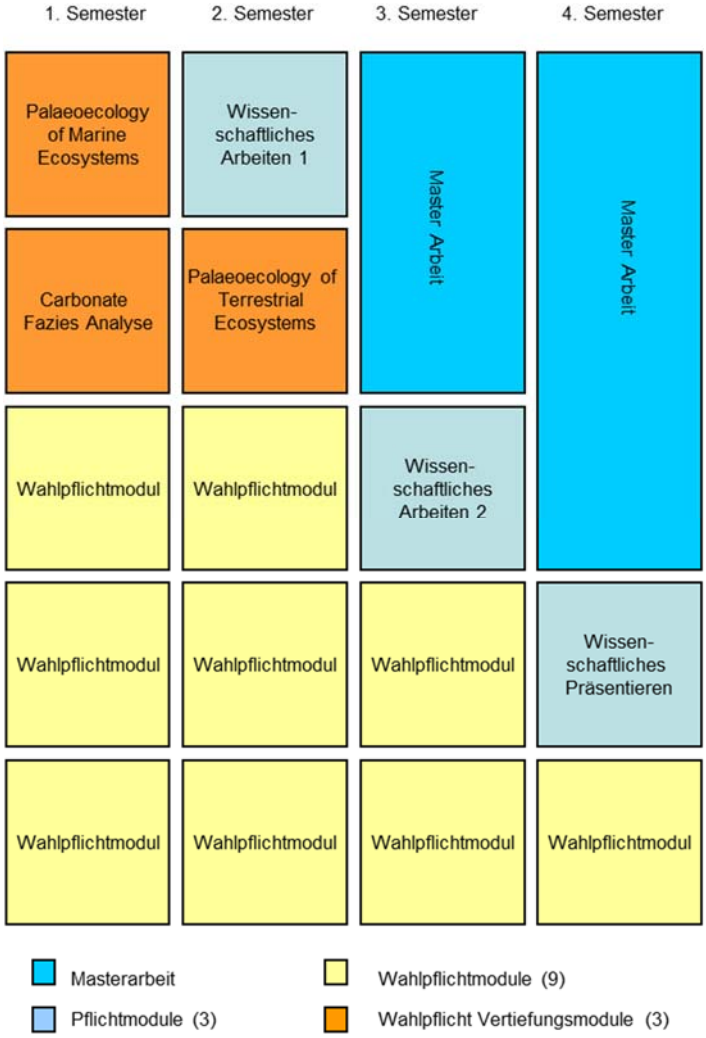
- Environmental Modeling 1
- GIS and Remote Sensing
- Isotope Geochemistry
- Paleoecology of Terrestrial Ecosystems
- Geotechnical Engineering
- Carbonate Facies Analysis
- MSc Kartierkurs 2
- Applied Data Analysis and Models for Geoscientists
- Climate Dynamics, Probability and Statistics
- Applied Thermochronology and Quaternary Dating: Techniques, Interpretation and Applications

Vertiefung Strukturgeologie:

- Hydrogeology
- Magmatische Prozesse
- Metamorphe Prozesse
- Economic Geology
- Explorations-Praxis (bis WiSe 20/21)
- Materialwissenschaften für Geowissenschaftler (bis WiSe 20/21)

Modulübersicht Themenbereich Biogeologie

Im Fokus der Vertiefungsrichtung Biogeologie (Paläontologie) stehen marine und kontinentale biologische Prozesse aus Vergangenheit und Gegenwart. Das Verständnis fossiler Organismengruppen (von Pflanzen bis Wirbeltieren) als Proxies sich verändernder Ökosysteme steht ebenso im Zentrum wie evolutive Prozesse, Klimadynamik und Faziesanalyse jeweils in enger Vernetzung zur Biologie. In einer objekt- und geländeorientierten Ausbildung vermitteln wir praxisnahe Kenntnisse in paläontologischen Labor- und Grabungstechniken.

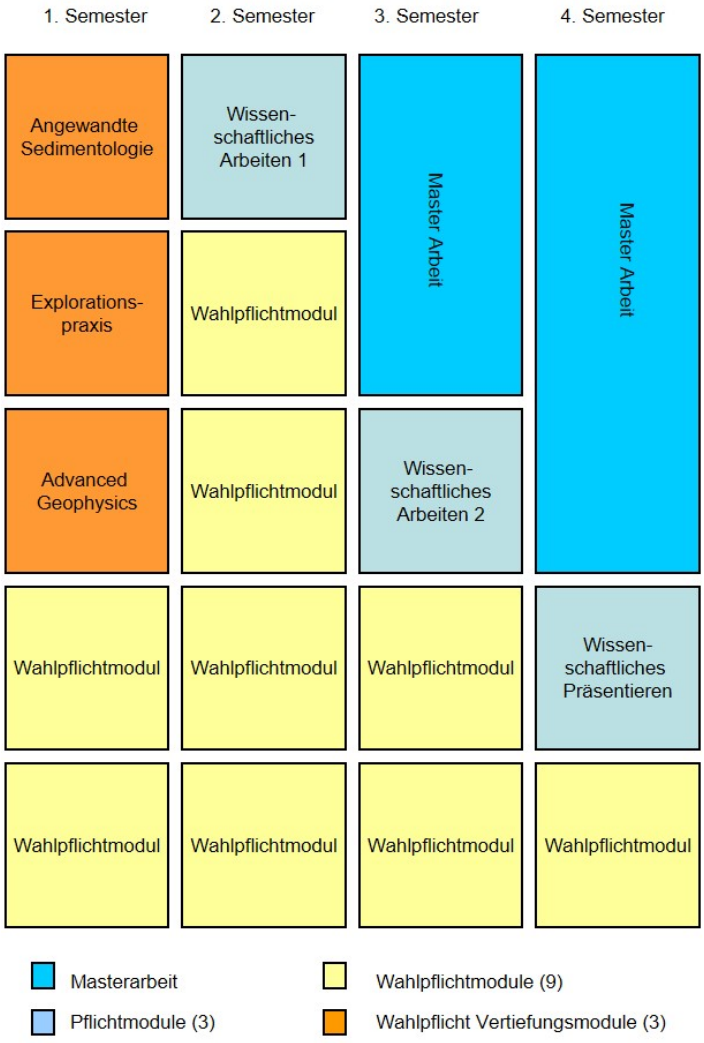


Zusätzlich empfohlene Wahlpflichtmodule:

- Marine Geology und Geochemistry
- Micropaleontology
- Wirbeltiere und Pflanzen des Känozoikums
- Terrestrische Ökosysteme – Grabungs- und Laborpraktikum
- Applied Tectonics and Surface Processes
- Isotope Geochemistry
- Environmental Isotope Chemistry
- Angewandte Sedimentgeologie
- MSc Kartierkurs 1&2
- MSc Geländeübungen
- Applied Data Analysis and Models for Geoscientists

Modulübersicht Themenbereich Exploration (Beginn letztmalig im WiSe 2019/20)

Ziel ist eine praxisnahe Ausbildung im Bereich der Exploration für sedimentäre Georessourcen mit Schwerpunkt Erdöl/Erdgas-Lagerstätten. Während die beteiligten Dozenten der Universität Tübingen die allgemeinen Grundlagen vermitteln, bieten verschiedene Gast-Dozenten aus der Industrie im Rahmen mehrerer Kompaktkurse Anwendungen aus der Praxis mit Übungsbeispielen an Original-Datensätzen.



Die Vertiefungsrichtung Eploration kann ab dem Wintersemester 2019/20 nicht mehr angefangen werden.

Zusätzlich empfohlene Wahlpflichtmodule:

- Micropaleontology
- Carbonate Facies Analysis
- Sedimentgeochemie (bis SoSe 20)
- Paleoecology of Marine Ecosystems
- Marine Geology und Geochemistry
- Applied Tectonics and Surface Processes
- MSc Kartierkurs 1&2
- MSc Geländeübungen
- Applied Data Analysis and Models for Geoscientists

Unterrichtssprache

Große Teile der Lehrveranstaltungen werden in englischer Sprache angeboten. Gute Kenntnisse der englischen Sprache werden vorausgesetzt.

3. Modulhandbuch MSc Geowissenschaften

Dieses Modulhandbuch dient als Einstiegshilfe und Übersicht für das Masterstudium der Geowissenschaften im Fachbereich Geowissenschaften der Mathematisch-Naturwissenschaftlichen Fakultät der Universität Tübingen. Inhalte der Module sowie Lehrende können Änderungen unterliegen. Für weitere Informationen und Fragen zu den einzelnen Modulen ist der jeweilige Modulkoordinator zuständig.

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

Pflichtmodule

Modulnummer Module Number	Modulname Module Title	Modul-koordinator Module Coordinator	LP / Credits	Semester	Studiengang 1 Geowiss 2 Geoöko 3 AEG P Pflicht W Wahl
M 101	Scientific Practice 1 / Wissenschaftliches Arbeiten 1	Merkel	6	WiSe/SoSe	P 1,2,3
M 102	Scientific Practice 2 / Wissenschaftliches Arbeiten 2	Merkel	6	WiSe/SoSe	P 1,2,3
M 103	Scientific Presentation /Wissenschaftliches Präsentieren	Bocherens	6	WiSe/SoSe	P 1,2,3
M 104	Master Thesis / Masterarbeit	-	30	WiSe/SoSe	P 1,2,3

Wahlpflichtmodule aus dem Fachbereich Geowissenschaften

Module Angewandte Geowissenschaften (Teilnahme bei freien Kapazitäten möglich)					
M 201	Hydrogeology	Cirpka	6	WiSe	W 1,2 / P 3
M 202	Applied Hydrogeology	Leven	6	SoSe	W,1,2,3
M 203	Environmental Modeling 1	Cirpka	6	WiSe	W 1,2 / P 3
M 204	Environmental Modeling 2	Cirpka	6	SoSe	W 1,2,3
M 205	Contaminant Hydrogeology	Grathwohl	6	SoSe	W 1,2,3
M 206	Case Studies in Environmental Geosciences	Cirpka	6	WiSe	W 1,2,3
M 207	Aquatic & Environmental Chemistry	Zarfl	6	WiSe	W 1,2 / P 3
M 208	Environmental Isotope Chemistry	Taubald	6	SoSe	W 1,2,3
M 209	Environmental Chemistry Lab	Haderlein	6	WiSe	W 1,2,3
M 210	Environmental Microbiology and Geomicrobiology	Kappler	6	SoSe	W 1,2,3
M 211	Geomicrobiology Lab	Kappler	6	SoSe	W 1,2,3
M 213	GIS and Remote Sensing	Schäuble, Lörcher	6	WiSe	W 1,2,3

M 214	Geotechnical Engineering	Leven	6	WiSe	W 1,2,3
M 216	Physics of the Atmospheric Boundary Layer	Bange	6	SoSe	W 1,3
M 218	Environmental Analytical Chemistry	Zwiener	6	WiSe	W 1,2,3
M 221	Environmental Risk Assessment	Escher	6	WiSe	W 1,2,3
M 222	Hydrogeochemical Modeling	Haderlein	6	SoSe	W 1,2,3
M 223	Advanced Topics in Flow and Transport	Cirpka	6	SoSe	W 1,2,3
M 224	Geostatistics	Haslauer	3	SoSe	W 1,2,3
M 227	Sustainable Environmental Biotechnology Systems 1	Angenent	6	SoSe (ab 20)	W 1,2,3
M 228	Sustainable Environmental Biotechnology Systems 2	Angenent	6	WiSe (ab 21/22)	W 1,2,3
M 603	Interactions of geomorphology, dams and flood hazards in fluvial systems	Lucía Vela	3	SoSe	W1,2,3
Module Mineralogie und Geologie					
M 301	Applied Tectonics and Surface Processes	Ehlers	6	WiSe	W 1,2,3
M 302	Metamorphe Prozesse	Markl	6	WiSe	W 1
M 303	Advanced Structural Geology	Bons	6	WiSe	W 1
M 304	MSc Geländeübungen	Bons	6	WiSe/SoSe	W 1
M 305	MSc Kartierkurs	Bons	6	WiSe/SoSe	W 1,3
M 306	Experiment Earth	Nowak	6	SoSe	W 1
M 307	Sedimentgeochemie (letztmalig SoSe 20)	Taubald	6	SoSe	W 1,2,3
M 308	Isotope Geochemistry	Schönberg	6	SoSe	W 1,2,3
M 310	Materialwissenschaften für Geowissenschaftler (letztmals WiSe 20/21)	Nickel	6	WiSe	W 1
M 311	Carbonate Facies Analysis (ab WiSe 20/21)	Nebelsick	6	WiSe	W 1,3
M 313	Explorationspraxis	Aigner	6	Letztmals WiSe 20/21	W 1,3
M 314	Magmatische Prozesse	Wenzel	6	SoSe	W 1

M 315	Glaciology	Weikusat	6	WiSe/SoSe	W 1,3
M 316	Geochemistry of the Mantle and Crust	Siebel	6	WiSe/SoSe	W 1
M 317	Applied Data Analysis and Models for Geoscientists	Drews	6	WiSe20/21	W 1,2,3
M 320	MSc Kartierkurs 2	Bons	6	WiSe/SoSe	W 1,3
M 321	Applied Thermochronology and Quaternary Dating: Techniques, Interpretation and Applications	Glotzbach	6	SoSe (ab 2019)/ jedes zweite Jahr	W 1,2,3
M 322	Climate Dynamics, Probability and Statistics	Mutz	6	SoSe (ab 2019)/ jedes zweite Jahr	W 1,2,3
M 323	Verwitterungsminerale in Erzlagerstätten	Markl	6	WiSe (unregelmäßig)	W 1
M 324	Economic Geology	Staude	6	SoSe (ab 2020)/ jedes zweite Jahr	W 1
M 602	Material Science and Archaeological Ceramics: Ceramic Petrography and Geochemistry	Amicone	6	WiSe	W 1
M 604	Material Science and Archaeological Ceramics: Ancient Pottery and its Pigments	Amicone	6	SoSe	W 1
M 606	Numerical Modelling in Geodynamics	Koptev	6	WiSe 20/21	W 1,3
Module Biogeologie					
M 401	Terrestrial Ecosystems – excavation and laboratory internship	Böhme	6	SoSe	W 1,2
M 403	Palaeoecology of Terrestrial Ecosystems	Bocherens	6	SoSe	W 1,2
M 404	Micropaleontology	Junginger	6	WiSe	W 1
M 405	Palaeoecology of Marine Ecosystems	Nebelsick	6	WiSe	W 1,2
M 408	Wirbeltiere und Pflanzen des Känozoikums	Böhme	6	WiSe	W 1,2
M 409	Marine Geology und Geochemistry	Schulz	6	WiSe	W 1,2,3
M 503	Paleobotany/Palynology	Bruch	6	WiSe 20/21	W 1

Einmalige Veranstaltungen / Teach @Tübingen / MSc Angebote anderer Lehreinheiten

T@T WiSe 20/21	Astrobiology: life in extreme environments	Samuels	3	WiSe 20/21	W 1,3
Bio-ZMBP	Applications of electron microscopy in cell biology, microbiology and virology	Fischer	6	WiSe	W 1,2,3
Wählbare Angebote anderer Lehreinheiten aus dem BSc Bereich					
	Umweltrecht I: Allgemeine Lehren und Immissionsschutzrecht	Saurer	6	WiSe	
	Umweltrecht II: Naturschutz-, Wasser- und Umweltenergierecht	Saurer	3	SoSe	
B 517	Umwelt- und Nachhaltigkeitsmanagement, (aus dem BSc Geoökologie und BSc Umweltnaturwissenschaften)	Kreeb	6	WiSe	

Auf Antrag können als Wahlpflichtmodule weitere Module aus dem geowissenschaftlich naturwissenschaftlichen Bereich zugelassen werden; die Entscheidung trifft der Vorsitzende des Prüfungsausschusses.

<table>
<tr><td>Module Number:
M 101</td><td colspan="8">Module Title:
Scientific Practice 1 / Wissenschaftliches Arbeiten 1</td><td>Type of Module:
MSc Compulsory</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="9">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="3">Workload:
180 h</td><td colspan="3">Contact Time:
variable depending on the activity</td><td colspan="3">Private Study:
variable depending on the activity</td></tr>
<tr><td>Duration of Module*
Module Coordinator</td><td colspan="5">1 Semester</td><td colspan="4">Merkel</td></tr>
<tr><td>Regular Cycle*</td><td colspan="9">Every semester (recommended in the 2nd semester)</td></tr>
<tr><td>Language</td><td colspan="9">English and German</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="9">Literature research and/or internship report, participation in the Master Seminar (min. 8 attendances at seminars)</td></tr>
<tr><td>Module Content*</td><td colspan="9">• Internship in one of the research groups at the Institute of Geoscience, participation in ongoing research projects and /or
• External internship in a company of the private sector or a different institution of the university (only after prior consultation and in agreement with the responsible supervisor) and/or
• Independent literature research on an individual topic in agreement with a responsible supervisor
• Participation in the lecture series 'Scientific Presentation'
• In agreement with the responsible supervisor combinations of the individual elements of the module (internships and literature research) are possible (e.g. 50% literature research, 50% internship)</td></tr>
<tr><td>Qualification Goals*</td><td colspan="9">• Students are, according to their personal interests, provided an insight in various research activities at the department, current research topics and are able to collect practical professional experience
• The module offers the opportunity to collect hands-on experience in special scientific research fields and provides an overview and orientation on possible fields of specialization for the Master Thesis
• The mandatory participation in the Master Seminar exposes students to a comprehensive overview of current Master projects of prior semesters from the various research groups and provides insights into various topics of environmental geoscience</td></tr>
<tr><td rowspan="3">Prerequisites for the allocation of credits / grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Scientific Practice 1</td><td>S</td><td>c</td><td>1</td><td>1</td><td>-</td><td>-</td><td>ng</td><td>-</td></tr>
<tr><td>PR</td><td>c</td><td>-</td><td>5</td><td>A</td><td>-</td><td>ng</td><td>-</td></tr>
<tr><td>Applicability*</td><td colspan="9">MSc Applied & Environmental Geoscience, MSc Geowissenschaften, MSc Geoökologie</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="9"></td></tr>
</table>

Module Number: **M 102**	**Module Title:** **Scientific Practice 2 / Wissenschaftliches Arbeiten 2**								**Type of Module:** MSc Compulsory
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: Approx. 20 h				Private Study: 160 h			
Duration of Module* **Module Coordinator**	1 Semester				Merkel				
Regular Cycle*	Every semester (recommended in the 3rd semester)								
Language	English and German								
Learning- / Teaching Forms*	Individual guidance by supervisor, scientific papers								
Module Content*	• Compilation of an example research proposal of an individually selected topic in agreement and under supervision of a responsible supervisor • Independent studies in the selected topic including literature research • Formulation of an appropriate problem set, analysis of relevant processes, presentation of the research outline, the required methodologies and the research goals • Set-up of a research schedule including the individual milestones • Writing of the research proposal								
Qualification Goals*	• In addition to well-founded professional competence, successful scientific work also requires conceptual and planning competences before and during a research project. In setting up an exemplary research proposal students will collect experiences in all important steps of planning a research project. • Preparing a research proposal in a written report helps students to acquire important methodological expertise to become acquainted with new fields of research, to identify and discuss relevant problem scenarios, to develop feasible methodological approaches and to present them in an appropriate written form.								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Scientific Practice 2	*PR*	*c*	*1*	*6*	*A*	*-*	*ng*	*-*
Applicability*	MSc Applied & Environmental Geoscience, MSc Geowissenschaften, MSc Geoökologie								
Participation Prerequisites*	Scientific Practice 1								

Module Number: **M 103**	**Module Title:** **Scientific Presentation / Wissenschaftliches Präsentieren**								**Type of Module:** MSc Compulsory
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: 30h /2 SWS				Private Study: 150 h			
Duration of Module* **Module Coordinator**	1 Semester				Bocherens				
Regular Cycle*	Every Semester (recommended in the 4th semester)								
Language	English								
Learning- / Teaching Forms*	Oral seminar presentations and poster								
Module Content*	• Preparation and presentation of a poster on a scientific topic of personal choice (e.g. MSc topic) • Oral presentation in the Master Seminar • A presentation of the results of the Master Thesis in the respective research group								
Qualification Goals*	A professional presentation of scientific research projects and their results is a fundamental prerequisite of a successful career both in scientific as well as in the economic world. Students are able to present their research projects in various forms (oral presentation and poster) and acquire in communication skills and presentation competence through oral presentation and discussion with a competent audience.								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Scientific Presentation	*S*	*c*	*2*	*6*	*R*	-	-	-
	Poster Project	*PR*	*c*			*A*	-	-	-
	Presentation of the MSc thesis in the Research Group	*PR*	*c*			*R*	-	-	-
Applicability*	MSc Geowissenschaften, MSc Geoökologie, MSc Applied & Environmental Geoscience; Seminar attendance (8 times) as part of the module Scientific Practice 1								
Participation Prerequisites*	Scientific Practice 1 & 2								

Module Number: **M 104**	**Module Title:** **Master Thesis / Masterarbeit**								**Type of Module:** MSc Compulsory
Credits (ECTS)*	30								
Workload* **- Contact Time** **- Private Study**	Workload: 900 h	Contact Time: variable depending on the activity							Private Study: variable depending on the activity
Duration of Module* **Module Coordinator**	1 Semester				Respective supervisors				
Regular Cycle*	Every semester								
Language	German or English (for AEG only in English)								
Learning- / Teaching Forms*	Independent research project under supervision (100%)								
Module Content*	Literature research, field and/or laboratory tasks preparation of a scientific essay								
Qualification Goals*	• Students independently prepare a research outline and perform a scientific study • Preparation of a scientific essay								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Master Thesis	*PR*	*c*	*-*	*30*	*A*	*6 Months*	*g*	*1*
Applicability*	MSc Applied & Environmental Geoscience, MSc Geowissenschaften, MSc Geoökologie								
Participation Prerequisites*	Completion of all required courses								

Module Number: **M 201**	**Module Title:** **Hydrogeology**		**Type of Module:** MSc Compulsory / Elective
Credits (ECTS)*	6		
Workload* **- Contact Time** **- Private Study**	Workload: 180	Contact Time: 90 h / 6 SWS	Private Study: 90 h
Duration of Module* **Module Coordinator**	1 Semester	Cirpka	
Regular Cycle*	Every winter semester (1st semester)		
Language	English		
Learning- / Teaching Forms*	Ex-cathedra lecture sessions are accompanied by exercise tutorials in which problem examples and regular homework are discussed in small groups.		
Module Content*	The module gives an introduction in the science of groundwater. The course has a strong emphasis on physical hydrogeology and the quantitative description of groundwater flow and solute transport. Topics include: • Characterization of aquifers • Concept of the porous medium • Vadose zone (hydrostatics and steady-state flow) • Derivation of conservation laws for water, solute mass, and heat in porous media • Groundwater flow with analytical solutions for different geometries • Well hydraulics • Groundwater transport with analytical solutions in one and multiple dimensions		
Qualification Goals*	Students know the basic concepts of quantitative subsurface hydrology in different geological environments and acquire general competences in the basic physical principles of groundwater flow and solute transport in the saturated and unsaturated zone. They can calculate groundwater flow and solute transport for simple geometries and are aware of the underlying assumptions. With practical experience in groundwater resource development they can address standard hydrogeological problems.		

Prerequisites for the allocation of credits / grades (if necessary weighting)*

Courses	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
Hydrogeology	*L*	*c*	*4*	*4*	*WE*	*90*	*g*	*1*
	E	*c*	*2*	*2*				

Applicability*	MSc Applied & Environmental Geoscience, MSc Geowissenschaften, MSc Geoökologie
Participation Prerequisites*	Students have a firm background in mathematics and physics corresponding to the competences acquired in the BSc modules Mathematik für Naturwissenschaftler and Physik.

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

Module Number: **M 203**	**Module Title:** **Environmental Modeling 1**		**Type of Module:** MSc Compulsory / Elective
Credits (ECTS)*	6		
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: 90 h / 6 SWS	Private Study: 90 h
Duration of Module* **Module Coordinator**	1 semester	Cirpka	
Regular Cycle*	Every winter semester (1st semester)		
Language	English		
Learning- / Teaching Forms*	Theoretical aspects of basic environmental modeling are taught in ex-cathedra lecture sessions. In computer exercises and homework students obtain practical modeling skills.		
Module Content*	The module introduces important basic concepts including: • Principles of parameter identification and • Interpolation of spatial data Modeling water balance is key aspect of the module and involves the topics: • Water and energy balance at the land surface (precipitation, infiltration, evapotranspiration, surface runoff) • Modeling of groundwater flow [main focus] • Modeling of open-channel flow		
Qualification Goals*	Students know basic modeling principles in Environmental Geosciences. They understand relevant modeling parameters and necessary data handling and processing procedures. They are acquainted with important surface processes in the hydrologic cycle and are able select and apply adequate environmental models, their discretization and parameterization. The students know how to set up a computer model for groundwater flow and how to calibrate it. Practical experience in environmental modeling of various systems and scales, with a focus on groundwater modeling provides them with necessary key competences needed to tackle standard hydrogeological problems and enables them to use professional standard software packages.		

Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Environmental Modeling 1	*L*	*c*	*2*	*3*	*WE*	*180*	*g*	*1*
		E	*c*	*2*	*2*	*A*	*-*	*-*	*-*
	Matlab	*E*	*c*	*2*	*1*	*A*	*-*	*-*	*-*

Applicability*	MSc Applied & Environmental Geoscience (MSc Geowissenschaften, MSc Geoökologie
Participation Prerequisites*	Students have a firm background in mathematics and physics corresponding to the competences acquired in the BSc modules mathematics for scientists and physics.

<table>
<tr><td>Module Number:
M 204</td><td colspan="8">Module Title:
Environmental Modeling 2</td><td>Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="9">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="3">Workload:
180 h</td><td colspan="3">Contact Time:
90 h / 6 SWS</td><td colspan="3">Private Study:
90 h</td></tr>
<tr><td>Duration of Module*
Module Coordinator</td><td colspan="4">1 semester</td><td colspan="5">Cirpka</td></tr>
<tr><td>Regular Cycle*</td><td colspan="9">Every summer semester (recommended 2nd semester)</td></tr>
<tr><td>Language</td><td colspan="9">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="9">Theoretical aspects of basic environmental modeling are taught in ex-cathedra lecture sessions. Extensive computer exercise tutorials provide students with ‘hands on’ experiences in modeling various environmentally relevant scenarios.</td></tr>
<tr><td>Module Content*</td><td colspan="9">Contents of the advanced environmental modeling module are:
• Modeling of energy and mass balance in mixed systems (e.g. temperature model of a lake)
• Modeling of conservative transport in porous media and open channels
• Modeling of reactive transport
• Coupling to mass transfer
• Coupling to (bio)chemical transformations</td></tr>
<tr><td>Qualification Goals*</td><td colspan="9">Based on their firm understanding of conservation principles students are able to set up mathematical models to determine transport, fate and behavior of aqueous-phase compounds in groundwater. They are experienced in addressing the behavior of relevant contaminant groups and apply modeling principles to practical examples of solute transport. They are able to understand and interpret the interactions between transport processes, inter-phase mass transfer, and chemical transformation processes in environmental systems, mainly in porous media.</td></tr>
<tr><td rowspan="3">Prerequisites for the allocation of credits / grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Environmental Modeling 2</td><td>L</td><td>c</td><td>4</td><td>4</td><td rowspan="2">WE</td><td rowspan="2">180</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>E</td><td>c</td><td>2</td><td>2</td></tr>
<tr><td>Applicability*</td><td colspan="9">MSc Applied & Environmental Geoscience, MSc Geowissenschaften, MSc Geoökologie</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="9">Students have competences corresponding to those of MSc Modules Hydrogeology and Environmental Modeling 1, Aquatic and Environmental Chemistry.</td></tr>
</table>

Module Number: **M 205**	**Module Title:** **Contaminant Hydrogeology**								**Type of Module:** MSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 60 h / 4 SWS						Private Study: 120 h
Duration of Module* **Module Coordinator**	1 Semester			Grathwohl					
Regular Cycle*	Every summer semester (recommended in the 3rd semester)								
Language	English								
Learning- / Teaching Forms*	Lectures are followed by tutorial sessions in which practical problems are quantitatively addressed.								
Module Content*	• Subsurface contaminant distribution • Non aqueous phase liquids in porous media (NAPLs): Behavior and dissolution kinetics • Dissolved compounds: Transport in groundwater • Site investigation and sampling strategies • Integral pumping tests • In situ and ex situ source zone remediation technologies • Plume remediation: Natural attenuation, permeable reactive barriers, pump-and-treat • Remediation technology selection: Technical, economical and environmental aspects • Integrated contaminated land management								
Qualification Goals*	Students learn to address real case scenarios of contaminated sites and to interpret the inherent contamination characteristics due to subsurface conditions and the compounds under consideration. The comprehensive overview on practical aspects of contaminant hydrogeology involves building of conceptual models of a contaminated site, assessing potential risks and developing solution strategies for subsurface contaminations, a key competence of environmental geoscientists.								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Contaminant Hydrogeology	*L*	*c*	*2*	*3*	*R*	*-*	*g*	*1*
		E	*c*	*2*	*3*				
Applicability*	MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften								
Participation Prerequisites*	MSc modules Hydrogeology, Aquatic & Environmental Chemistry or equivalent competences								

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

Module Number: **M 207**	**Module Title:** **Aquatic & Environmental Chemistry (Environmental Chemistry 1)**								**Type of Module:** MSc Compulsory / Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: 90 h / 6 SWS							Private Study: 90 h
Duration of Module* **Module coordinator**	1 semester				Zarfl				
Regular Cycle*	Every winter semester								
Language	English								
Learning- / Teaching Forms*	Lectures, Exercises, Tutorial, Team work								
Module Content*	• Chemical thermodynamics in aqueous systems • Sorption and partitioning processes of organic and inorganic compounds • Sorption kinetics • Practical applications and case studies								
Qualification Goals*	• Role of particles as sorbents, vectors and reactants for contaminants • Quantitative understanding of partitioning and sorption mechanisms of organic and inorganic compounds in the hydrosphere • Knowledge of sorption QSARs for various classes of contaminants • Sorption kinetics and retarded diffusion in porous media • Assessment of contaminant release and cleanup strategies at contaminated sites								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Aquatic & Environmental Chemistry Lecture	*L*	*c*	*2*	*6*	*WE*	*120*	*g*	*1*
	Aquatic & Environmental Chemistry Exercises	*E*	*c*	*2*					
	Aquatic & Environmental Chemistry Tutorials	*E*	*op*	*2*					
Applicability*	MSc Applied & Environmental Geoscience (c), MSc Geoökologie (e), MSc Geo-wissenschaften (e)								
Participation Prerequisites*	Basic knowledge in Chemistry, Physics, Hydrogeology								

<table>
<tr><td>Module Number:
M 208</td><td colspan="8">Module Title:
Environmental Isotope Chemistry (Environmental Chemistry 2)</td><td>Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="9">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="3">Workload:
180 h</td><td colspan="3">Contact Time:
90 h / 6 SWS</td><td colspan="3">Private Study:
90 h</td></tr>
<tr><td>Duration of Module*
Module coordinator</td><td colspan="5">1 semester</td><td colspan="4">Taubald</td></tr>
<tr><td>Regular Cycle*</td><td colspan="9">Every summer semester</td></tr>
<tr><td>Language</td><td colspan="9">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="9">Lectures, exercises, team work, presentations</td></tr>
<tr><td>Module Content*</td><td colspan="9">• Basic principles of isotope chemistry
• Relevant isotope systems for the hydrosphere (esp. C, H, O, N, S)
• Compound-specific organic isotope chemistry
• Application of isotope systems for dating, forensic and process identification purposes
• Principles of isotope analysis
• Applications and case studies</td></tr>
<tr><td>Qualification Goals*</td><td colspan="9">• Knowledge of prospects, limitations and applications of isotope methods in environmental chemistry
• Knowledge of theory and interpretation of isotope fractionation processes
• Knowledge of basic principles and applications of core methods for isotope analysis
• Application of isotope methods in the context of contaminant hydrology (natural attenuation and tracer studies)</td></tr>
<tr><td rowspan="5">Prerequisites for the allocation of credits /grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Inorganic Environmental Isotope Chemistry</td><td>L</td><td>c</td><td>2</td><td rowspan="2">3</td><td rowspan="2">WE</td><td rowspan="2">120</td><td rowspan="2">g</td><td rowspan="2">0,5</td></tr>
<tr><td>Inorganic Environmental Isotope Chemistry Exercises</td><td>E</td><td>c</td><td>1</td></tr>
<tr><td>Organic Environmental Isotope Chemistry</td><td>L</td><td>c</td><td>2</td><td rowspan="2">3</td><td rowspan="2">WE</td><td rowspan="2">120</td><td rowspan="2">g</td><td rowspan="2">0,5</td></tr>
<tr><td>Organic Environmental Isotope Chemistry Exercises</td><td>E</td><td>c</td><td>1</td></tr>
<tr><td>Applicability*</td><td colspan="9">MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="9">Basic knowledge in chemistry and physics for geoscientists</td></tr>
</table>

Module Number: **M 209**	**Module Title:** **Environmental Chemistry Lab (Environmental Chemistry 3)**		**Type of Module:** MSc Elective
Credits (ECTS)*	6		
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: 90 h / 6 SWS	Private Study: 90 h
Duration of Module* **Module coordinator**	1 semester	Haderlein	
Regular Cycle*	Every winter semester		
Language	English		
Learning- / Teaching Forms*	Lab experiments under supervision, accompanying seminar		
Module Content*	• Analytical methods for organic & inorganic contaminants in environmental samples • Concepts and methods for the quantification of contaminants and degradation processes • Participation in current research projects in the field of environmental chemistry & microbiology		
Qualification Goals*	• Practical application of key lab techniques in environmental analytics (Extraction- & Enrichment techniques, basics of chromatography (GC, HPLC) & Mass spectrometry) • The students learn to determine experimentally analysis data as well as to evaluate and interpret them quantitatively • Knowledge of current research in environmental chemistry & microbiology		

Prerequisites for the allocation of credits /grades (if necessary weighting)*

Courses	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
Environmental Chemistry Lab	*E*	*c*	*5*	*6*	*SP*	-	*g*	*0,5*
	S	*c*	*1*		*LP*	-	*g*	*0,5*
	Grading is based on the lab performance during the course and lab protocols, no final exam.							

Applicability*	MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften
Participation Prerequisites*	Physics, Chemistry, Biology for geoscientists BSc Module Biogeochemie and/or Aquatic & Environmental Chemistry

<table>
<tr><td>Module Number:
M 210</td><td colspan="8">Module Title:
Environmental Microbiology and Geomicrobiology</td><td>Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="9">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="3">Workload:
180 h</td><td colspan="3">Contact Time:
60 h / 4 SWS</td><td colspan="3">Private Study:
120 h</td></tr>
<tr><td>Duration of Module*
Module coordinator</td><td colspan="4">1 semester</td><td colspan="5">Kappler</td></tr>
<tr><td>Regular Cycle*</td><td colspan="9">Every summer semester</td></tr>
<tr><td>Language</td><td colspan="9">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="9">Lecture and seminar (student presentations)</td></tr>
<tr><td>Module Content*</td><td colspan="9">• General environmental microbiology and geomicrobiology
• Microbial degradation of pollutants
• Redox zonation, thermodynamics
• Microbe-mineral interactions
• Bioremediation
• Biogeochemical cycles</td></tr>
<tr><td>Qualification Goals*</td><td colspan="9">The students
• can read and evaluate current literature about various topics in Environmental Microbiology and Geomicrobiology and can present these topics to an inter-disciplinary audience of students
• obtain an advanced and detailed understanding of current topics Geomicrobiology and Environmental Microbiology
• understand the kinetics and energetics of microbially catalyzed processes and the consequences of these processes for the environment
• know about the contribution role of microbial processes for biogeochemical cycling (C, N, S, Fe, Si, P)
• know about environmental behavior and microbial transformation of selected organic and inorganic pollutants
• understand the interactions of microorganisms with solid substrates (minerals and surfaces)</td></tr>
<tr><td rowspan="2">Prerequisites for the allocation of credits / grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Environmental Microbiology and Geomicrobiology</td><td>L,S</td><td>c</td><td>4</td><td>6</td><td>R</td><td>45</td><td>g</td><td>1</td></tr>
<tr><td>Applicability*</td><td colspan="9">MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="9">Geomicrobiology; basic knowledge in microbial physiology and in microbial ecology</td></tr>
</table>

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

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

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

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

Prerequisites forthe allocation of credits / grades (if necessary weighting)*

Courses	*Type ofLecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Require-*	*Duration of Exam*	*Grading System*	*Weighting*
Physics of the Atmospheric Boundary Layer	*L*	*c*	*2*	*3*	*WE*	*120*	*g*	*1*
	E	*c*	*1*	*2*	*A*	-	-	-
	S	*c*	*1*	*1*	-	-	-	-

Applicability*	The module is an elective module in the MSc program Applied & Environmental Geosciences and a prerequisite for its specialization in Environmental Physics and Environmental Modeling.

Participation Prerequisites*	Lectures on mathematics and physics of a BSc study completed by lectures on thermodynamics, atmospheric physics and basics in flow mechanics (UWP1 and UWP2 of the BSc Umweltnaturwissenschaften)

<table>
<tr><td>Module Number:
M 218</td><td colspan="4">Module Title:
Environmental Analytical Chemistry</td><td colspan="4">Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="8">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="3">Contact Time:
90 h / 6 SWS</td><td colspan="4">Private Study:
90 h</td></tr>
<tr><td>Duration of Module*
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="5">Zwiener</td></tr>
<tr><td>Regular Cycle*</td><td colspan="8">Every winter semester (recommended for the 1st semester)</td></tr>
<tr><td>Language</td><td colspan="8">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="8">The module combines classroom lectures and exercises with a one week laboratory practical course, which allows students to apply their theoretical classroom knowledge and gain practical laboratory skills. Regular homework and lab presentations give feedback on individual study progress.</td></tr>
<tr><td>Module Content*</td><td colspan="8">The module focuses on:
• Analysis of new emerging and polar compounds in environmental media
• Basic principles of atmospheric pressure ionization techniques and mass spectrometry
• Advanced applications of instrumental analytical techniques with liquid chromatography-mass spectrometry
• Special approaches for ultratrace analysis</td></tr>
<tr><td>Qualification Goals*</td><td colspan="8">Students understand the properties of polar compounds. They acquire the theoretical competence to select appropriate problem-oriented analytical methods for environmental pollutants.
At the same time the acquired practical skills allow them to handle sophisticated analytical instruments and to develop suitable analytical methods for variable contamination scenarios on demand.
Both, the theoretical knowledge and the practical laboratory skills are key competences for environmental scientists.</td></tr>
<tr><td rowspan="3">Prerequisites for the allocation of credits /grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Environmental Analytical Chemistry</td><td>L</td><td>c</td><td>3</td><td>3</td><td>WE</td><td>120</td><td>g</td><td>0,5</td></tr>
<tr><td>LC</td><td>c</td><td>3</td><td>3</td><td>LP</td><td>-</td><td>g</td><td>0,5</td></tr>
<tr><td>Applicability*</td><td colspan="8">The module is an elective module in the MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="8">Basic knowledge in chemistry, environmental analytics and statistics.</td></tr>
</table>

Module Number: **M 221**	**Module Title:** **Environmental Risk Assessment**		**Type of Module:** MSc Elective
Credits (ECTS)*	6		
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: 60 h / 4 SWS	Private Study: 120 h
Duration of Module* **Module Coordinator**	1 semester	Escher	
Regular Cycle*	Every winter semester		
Language	English		
Learning- / Teaching Forms*	Lecture and accompanying seminar (exercises, presentations) Groups of three students conduct a comprehensive risk assessment for one selected chemical each according to the European regulation for industrial chemicals. The risk assessment is performed stepwise in the exercises and then compiled into a written technical report that will be graded. In addition, each student presents a paper in the seminar on a specialized topic in environmental risk assessment.		
Module Content*	• Regulatory methods for environmental risk assessment of chemicals (industrial chemicals, pesticides, pharmaceuticals), European regulation REACH, human vs. ecological risk assessment • Exposure analysis: emission patterns, multimedia fate and transport models for quantifying environmental exposure, persistence and long-range transport, predicted and measured exposure concentration • Effect analysis: estimation of hazard potential, tests for ecotoxicity and human health, dose-effect relationships, extrapolation methods, classification of chemicals according to modes of toxic action, prediction methods (QSARs and integrated testing strategy) • Risk assessment methods (deterministic vs. probabilistic), risk assessment vs. hazard assessment PBT assessment (persistence, bioaccumulation, toxicity), uncertainty and sensitivity analyses, precautionary principle • Site specific risk assessment and management, water quality assessment • Specific topics: risk assessment of mixtures, risk assessment of transformation products, dynamic exposure and effect assessment		
Qualification Goals*	The students are familiar with regulatory approaches to environmental risk assessment of chemicals and can perform a regulatory risk assessment for an industrial chemical. They are aware of pitfalls and challenges and know about new approaches to risk assessment that are still in the research stage.		

Prerequisites for the allocation of credits /grades (if necessary weighting)*

Courses	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
Environmental Risk Assessment	*L*	*c*	*2*	*4*	*WE*	*90*	*g*	*1*
	S	*c*	*2*	*1*	*R*	-	-	-
				1	*A*	-	-	-

Applicability*	MSc Applied & Environmental Geoscience, MSc Geowissenschaften, MSc Geoökologie.
Participation Prereq-uisites*	

<table>
<tr><td>Module Number:
M 222</td><td colspan="4">Module Title:
Hydrogeochemical Modeling (Environmental Chemistry 4)</td><td colspan="4">Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="8">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="2">Workload:
180 h</td><td colspan="3">Contact Time:
60 h / 4SWS</td><td colspan="3">Private Study:
135 h</td></tr>
<tr><td>Duration of Module*
Module coordinator</td><td colspan="4">1 semester</td><td colspan="4">Haderlein</td></tr>
<tr><td>Regular Cycle*</td><td colspan="8">Every summer semester</td></tr>
<tr><td>Language</td><td colspan="8">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="8">Lectures, exercises, tutorial, team work</td></tr>
<tr><td>Module Content*</td><td colspan="8">• Chemical thermodynamics in aqueous systems
• Chemical speciation modelling (quantitative hydrochemistry)
• Sorption and Partitioning processes of organic and inorganic compounds in the hydrosphere
• Practical case studies</td></tr>
<tr><td>Qualification Goals*</td><td colspan="8">• Knowledge of basic principles and features of chemical speciation software codes
• Quantitative understanding and prediction of aqueous speciation, dissolution of and complex formation at minerals, redox using chemical modelling software
• Informed application of PHREQC software</td></tr>
<tr><td rowspan="4">Prerequisites for the allocation of credits /grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="3">Hydrogeochemical Modeling</td><td>E</td><td>o</td><td rowspan="2">3</td><td rowspan="3">6</td><td>WE</td><td>120</td><td>g</td><td>0,5</td></tr>
<tr><td>E</td><td>o</td><td>SP</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>S, PR</td><td>o</td><td>1</td><td>A</td><td>-</td><td>g</td><td>0,5</td></tr>
<tr><td>Applicability*</td><td colspan="8">MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="8">Physics, Chemistry, Biology for geoscientists
BSc Module Biogeochemie and/or Environmental Chemistry 1</td></tr>
</table>

<table>
<tr><td>Module Number:
M 223</td><td colspan="8">Module Title:
Advanced Topics in Flow and Transport</td><td>Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="9">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="3">Workload:
180 h</td><td colspan="3">Contact Time:
60 h / 4 SWS</td><td colspan="3">Private Study:
120 h</td></tr>
<tr><td>Duration of Module*
Module Coordinator</td><td colspan="4">1 semester</td><td colspan="5">Cirpka</td></tr>
<tr><td>Regular Cycle*</td><td colspan="9">Every summer semester</td></tr>
<tr><td>Language</td><td colspan="9">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="9">Lectures are accompanied by exercises, literature studies, and computer tutorials.</td></tr>
<tr><td>Module Content*</td><td colspan="9">Yearly changing topics covering aspects of mathematical modeling of flow and solute transport in rivers, soils, and aquifers. Potential topics may include:
Conformal mapping and other analytical methods for potential flows
Laplace-transform ad Fourier-transform techniques for transport
Calculation of sensitivities
Uncertainty quantification
Dispersion theories
Unsaturated and multi-phase flow in porous media
Simulation of groundwater-induced land subsidence
Finite Element Methods
Solving ordinary differential equations
Linearization of large systems of equations
Numerical methods of parameter estimation</td></tr>
<tr><td>Qualification Goals*</td><td colspan="9">Students understand and can apply advanced analytical and numerical techniques used in the simulation of flow and transport in terrestrial aquatic systems. They are able to choose appropriate schemes for particular applications and implement smaller self-developed codes.</td></tr>
<tr><td rowspan="3">Prerequisites for the allocation of credits / grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Advanced Topics in Flow and Transport</td><td>L</td><td>c</td><td>3</td><td>2</td><td rowspan="2">A</td><td rowspan="2">-</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>PR</td><td>c</td><td>1</td><td>4</td></tr>
<tr><td>Applicability*</td><td colspan="9">MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="9">Students have successfully participated in Environmental Modeling 1 and Hydrogeology.</td></tr>
</table>

<table>
<tr><td>Module Number:
M 224</td><td colspan="4">Module Title:
Geostatistics</td><td colspan="4">Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="8">3</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="2">Workload:
90 h</td><td colspan="3">Contact Time:
45 h / 3 SWS</td><td colspan="3">Private Study:
45 h</td></tr>
<tr><td>Duration of Module*
Module Coordinator</td><td colspan="3">1 semester</td><td colspan="5">Haslauer</td></tr>
<tr><td>Regular Cycle*</td><td colspan="8">Winter semester 20/21</td></tr>
<tr><td>Language</td><td colspan="8">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="8">general: fundamental concepts will be provided in lectures; these concepts are discussed in more detail using computer exercises that are interspersed with the lecture;
extras: presentations related to specific topics are prepared by students; key part of the preparation is scientific code that is discussed, applied, and potentially improved with the class; at the end of the class students have access to a toolbox of relevant computer codes for their use.</td></tr>
<tr><td>Module Content*</td><td colspan="8">Detailed, physically based hydro-geo-logical models need data in fine spatial and temporal resolution. This requires the interpolation and extrapolation of the data that are usually measured in smaller resolution due to the cost of measurement network maintenance. The topic of the course “geostatistics” are methods relevant for hydro-geo-logy that can be used for:
spatial interpolation and simulation based on discrete data;
the estimation of the parameters of geostatistical models;
planning of measurement networks;
improved uncertainty quantification of relevant dependent processes (e.g. solute transport behavior);</td></tr>
<tr><td>Qualification Goals*</td><td colspan="8">Students understand and can apply basic tools for statistical interpolation and simulation spatially distributed parameters (e.g. groundwater quality, hydraulic conductivity, precipitation intensities, air pollution). The students will be able to choose appropriate schemes for particular applications and implement smaller self-developed codes.</td></tr>
<tr><td rowspan="3">Prerequisites for the allocation of credits / grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Geostatistics</td><td>L</td><td>c</td><td>1.5</td><td>1.5</td><td rowspan="2">A& WE</td><td rowspan="2">60</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>E</td><td>c</td><td>1.5</td><td>1.5</td></tr>
<tr><td>Applicability*</td><td colspan="8">MSc Applied & Environmental Geoscience;
interested quantitatively and statistically inclined students</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="8">Basic statistics</td></tr>
</table>

Module Number: **M 227**	**Module Title:** **Sustainable Environmental Biotechnology Systems 1**								**Type of Module:** Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 90 h (6 SWS)						Private Studies: 90 h
Duration of Module* **Module Coordinator**	1 Semester				Angenent				
Regular Cycle *	Every Summer Semester (starting SoSe 21)								
Language	English								
Learning- /Teaching Forms*	The module combines class room lectures and field trips.								
Module Content*	This course will offer a systems approach to understand energy systems that include a bioprocessing step, such as anaerobic digestion, anaerobic fermentation, microbial fuel cells, and photobioreactors with algae. In general, this course focuses on biomass-to-bioenergy conversion, including introduction to major treatment steps, such as pretreatment steps, fermentation steps, and product separation steps. The course integrates physics, engineering, environmental impacts, economics, and sustainable development. Different energy generation technologies will be compared to gain an understanding of the advantages and limitations of these technologies. Students are expected to be interested in and appreciate the need for quantitative aspects of energy systems. An emphasis of this course is technical and economic analysis of large-scale energy systems and their conceptual design.								
Qualification Goals*	This course is intended to students to gain the capabilities to: 1. Use a systems approach to design renewable bioenergy systems. 2. Explain the energy conversion processes for biomass systems. 3. Evaluate the advantages and limitations of renewable bioenergy systems. 4. Assess a system by using nontechnical factors (environmental impacts, economics, and sustainable development) during the design phase. 5. Identify which information is missing during the design phase.								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	Sustainable Environmental Biotechnology Systems 1	*L*	*c*	*3*	*6*	*A*	*-*	*g*	*0,5*
		E	*c*	*3*		*A*	*-*	*g*	*0,5*
Applicability*	MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften, MSc Biology								
Participation Prerequisites*	Basic knowledge in microbiology or chemistry or physics or geosciences or engineering								

Module Number: **M 228**	**Module Title:** **Sustainable Environmental Biotechnology Systems 2**		**Type of Module:** Elective
Credits (ECTS)*	6		
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: 90 h (6 SWS)	Private Studies: 90 h
Duration of Module* **Module Coordinator**	1 Semester	Angenent	
Regular Cycle *	Every Winter Semester (starting 2021/22)		
Language	English		
Learning- /Teaching Forms*	The module combines class room lectures and a group design project.		
Module Content*	This course will offer a systems approach to understand energy systems that include a bioprocessing step, such as anaerobic digestion, anaerobic fermentation, microbial fuel cells, and photobioreactors with algae. In general, this course focuses on biomass-to-bioenergy conversion, including introduction to major treatment steps, such as pretreatment steps, fermentation steps, and product separation steps. The course integrates physics, engineering, environmental impacts, economics, and sustainable development. Different energy generation technologies will be compared to gain an understanding of the advantages and limitations of these technologies. Students are expected to be interested in and appreciate the need for quantitative aspects of energy systems. An emphasis of this course is technical and economic analysis of large-scale energy systems and their conceptual design.		
Qualification Goals*	This course is intended to students to use the capabilities from Sustainable Environmental Biotechnology Systems 1 to: 1. Excel in a team-oriented design experience, focused on the application of renewable bioenergy technologies. 2. Design a “real life” renewable bioenergy system.		

Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	Sustainable Environmental Biotechnology Systems 2	*L*	*c*	*2*	*6*	*A*	*-*	*g*	*1*
		E	*c*	*4*					

Applicability*	MSc Applied & Environmental Geoscience, MSc Geoökologie, MSc Geowissenschaften, MSc Biology
Participation Prerequisites*	Basic knowledge in microbiology or chemistry or physics or geosciences or engineering, Sustainable Environmental Biotechnology Systems 1

Module Number: **M 603**	**Module Title:** **Interactions of geomorphology, dams and flood hazards in fluvial systems**								**Type of Module:** MSc Elective
Credits (ECTS)*	3								
Workload* **- Contact Time** **- Private Study**	Workload: 90 h		Contact Times: 40 h/ 3 SWS						Private Study: 50 h
Duration of Module* **Module Coordinator**	1 Semester				Lucía				
Regular Cycle*	Summer semester 2020 and 2021								
Language	English								
Learning- / Teaching Forms*	Seminar (student presentations)								
Module Content*	This course is designed to introduce students to the interactions between hydrological, geomorphological and anthropogenic factors in fluvial systems with a strong focus on fluvial geomorphology as well as sediment and wood transport. Students will learn about the effects that increasing pressures have on river systems, ranging from floods increasing in frequency and magnitude to a boom in hydropower dam construction. This will be complemented by knowledge on current attempts to mitigate the undesired effects, e.g. through flood hazard mapping and engineering measures, as well as river restoration. The course will be complemented with 1-day fieldtrip to Braunsbach, where a flash flood occurred in 2016.								
Qualification Goals*	By the end of the course, students will be able to (i) understand the interactions between severe floods and dam construction and fluvial geomorphology (ii) know about different alternatives to mitigate flood hazard risk and restore river channels.								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Interactions of geomorphology, dams and flood hazards in fluvial systems	*S*	*c*	*3*	*3*	*R*	*45*	*g*	*1*
Applicability*	The module is an elective module in the MSc programs of "Geowissenschaften" and Applied Environmental Geosciences and complements competences acquired in both programs.								
Participation Prerequisites*									

Module Number: M 301	Module Title: Applied Tectonics and Surface Processes								Type of Module: MSc Elective
Credits (ECTS)*	6								
Workload* - **Contact Time** - **Private Study**	Workload: 180 h		Contact Time: 90 h / 6SWS						Private Study: 180 h
Duration of Module* **Module Coordinator**	1 semester			Ehlers					
Regular Cycle*	Every winter semester								
Language	English								
Learning- / Teaching Forms*	This module includes a combination of lectures and exercises where the exercises include either computer exercises or scientific paper discussions related to the lecture topics.								
Module Content*	This course highlights current methods used to quantify how tectonics and surface processes interact to form Earth's topography and sedimentary basins. Emphasis is placed on understanding how different geologic, geophysical, and geochemical tools can be used to understand mountain building processes and the evolution of Earth's surface. Specific topics addressed in lectures include: • How and why tectonics, topography, and climate interact over short and long (million year) timescales. • Physical and mathematical approaches for understanding erosion and sedimentation by rivers, hillslopes, and glacial processes. • Geochemical and other dating techniques for quantifying tectonic and surface processes, including thermochronology and cosmogenic isotopes. • Examples of how the previous methods have been applied to different mountain ranges around the world. Topics addressed in the exercises and discussion include: • Computer exercises using Matlab and other software to investigate physical and geochemical processes discussed in lectures. • Group discussions on scientific papers that provide examples of how different techniques discussed in class are applied to geoscience studies.								
Qualification Goals*	Goals of this class center around enabling students to: • Apply different geologic, geochemical, and geophysical data sets to understand tectonic and surface processes in different settings. • Apply different computer software tools to investigate physical and geochemical processes associated with mountain building. • Develop skills in critically reading scientific literature.								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Applied Tectonics and Surface Processes	*L*	*c*	*4*	*4*	*-*	*-*	*-*	*-*
		LC	*c*	*2*	*2*	*A*		*g*	*1*
Applicability*	This module compliments other geoscience modules in structural geology, isotope geochemistry, geophysics, and sedimentology by providing a regional context for the driving mechanisms of mountain building, basin formation, and topographic development. It also compliments modules in physical geography by providing a quantitative understanding of surface processes and paleoclimate.								
Participation Prerequisites*	Introductory geology								

Modulnummer: **M 302**	**Modultitel:** **Metamorphe Prozesse**								**Art des Moduls:** MSc Wahlpflicht
ECTS-Punkte*	6								
Arbeitsaufwand* **- Kontaktzeit** **- Selbststudium**	Arbeitsaufwand: 180 h		Kontaktzeit: 60 h / 4 SWS						Selbststudium: 120 h
Moduldauer* **Modulkoordinator**	1 Semester				Markl				
Häufigkeit des Angebots*	Jedes Wintersemester								
Unterrichtssprache	Deutsch								
Lehr- /Lernformen*	Das Modul wird als Blockveranstaltung angeboten und beinhaltet Vorlesungs- und betreute Mikroskopie-Übungen (7 Tage) und eigenständiges Mikroskopieren an ausgesuchten Proben (3 Tage) mit anschließender Interpretation.								
Modulinhalt*	Behandelt werden Aspekte der Metamorphose verschiedenartiger Ausgangsgesteine in Abhängigkeit von den P-T-Bedingungen und vom jeweiligen plattentektonischen Milieu. Dazu werden insbesondere die polarisationsmikroskopische Identifizierung metamorpher Texturen und Mineralparagenesen sowie die Interpretation von Phasendiagrammen herangezogen.								
Qualifikationsziele*	Hauptqualifikationsziel des Moduls ist ein grundlegendes Verständnis der Gesetzmäßigkeiten und Rahmenbedingungen für die Bildung metamorpher Gesteine. Studierende sind in der Lage, unbekannte Vorkommen metamorpher Gesteine zu analysieren sowie genetisch zu interpretieren und dadurch einen Beitrag zur Rekonstruktion (paläo)tektonischer Milieus zu liefern. Durch umfangreiche Übungen bei Interpretation von Gleichgewichts- und Reaktionstexturen im Dünnschliff erlangen sie fortgeschrittene praktisch-methodische Kompetenzen für die eigenständige Bearbeitung von Gesteinsproben.								
Voraussetzung für die Vergabe von Leistungspunkten/ Benotung (ggf. Gewichtung)*	*Lehrveranstaltungen*	*Art der Lehrform*	*Status*	*SWS*	*LP*	*Prüfungsform / Studienleistung*	*Prüfungsdauer*	*Benotungssystem*	*Gewichtung*
	Metamorphe Prozesse	*V*	*o*	*2*	*4*	*K*	*90*	*b*	*1*
		Ü	*o*	*2*	*2*	*ET/ R*	*-*	*ub*	*-*
Verwendbarkeit*	Das Modul „Metamorphe Prozesse“ steht in engem Zusammenhang mit den Modulen „Magmatische Prozesse“ und „Advanced Structural Geology". Beide untersuchen mit Polarisationsmikroskopie Gefüge, die dann für die Interpretation geologischer Prozesse verwendet werden.								
Teilnahme-voraussetzungen*	Voraussetzungen für die Teilnahme am Modul „Metamorphe Prozesse“ sind grundlegende Kenntnisse der Polarisationsmikroskopie, der Mineralogie und der Anwendung von Phasendiagrammen auf geologische Probleme.								

Module Number: **M 303**	**Module Title:** **Advanced Structural Geology**								**Type of Module:** MSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Study: 90 h
Duration of Module* **Module Coordinator**	1 semester				Bons				
Regular Cycle*	Every winter semester								
Language	English and/or German								
Learning- / Teaching Forms*	Lectures and practicals (microscopy, computer exercises)								
Module Content*	The module comprises two courses, each highlighting two aspects of advanced structural geological interpretation and modelling. 1. Microtectonics deals with the interpretation of rock deformation structures, focusing on the microstructure as observed in thin sections. Various processes and rock deformation mechanisms will be treated, discussing background theory and the resulting (micro-) structures visible in hand specimen and thin section (practicals). Main topics are: brittle structures, such as fractures and veins, ductile deformation mechanisms (pressure solution, stylolites, dislocation creep), foliations and lineations, high strain structures and shear zones, and the interaction between metamorphism and tectonics. 2. Structural geological modelling treats the 3D modelling of geological structures, in particular on the map scale. It covers theory of faulting and folding and the techniques of constructing models and reconstructions (such as dip-panel method, circular arc method, balancing cross sections). The practical mostly deals with computer-based constructing of 3D models from maps and cross sections, currently with the software MOVE.								
Qualification Goals*	Main aim of the module is to make students acquainted with the main methods of structural geological analysis. This includes being able to: • recognize deformation structures; • interpret the processes that produced these structures; • infer conditions of deformation from these structures • use the main techniques of modern structural analysis • visualize structural relationships in 3 dimensions and structural cross sections In the end, the students will have gained the necessary skills to work as a geologist in academic research, as well as in ore or hydrocarbon exploration, and other geoscientific environments that deal with field studies.								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Microtectonics	*L, LC*	*c*	*3*	*3*	*A*	*-*	*g*	*0,5*
	Structural Geological Modeling	*LC*	*c*	*3*	*3*	*A*	*-*	*g*	*0,5*

Applicability*	The module provides advanced skills of structural analysis and interpretation. These are a necessary prerequisite of any field based-study, from basin analysis to the study of high-grade metamorphic or igneous complexes. The module is thus of direct practical relevance to all geoscience students, no matter whether they intend to pursue and academic or industrial career.
Participation Prerequisites*	• BSc-module "Introduction to Structural Geology", including maps and cross sections, or equivalent courses. • At least one bedrock mapping course in MSc or previous BSc. • Optical mineralogy/microscopy • English (read & write)

Modulnummer: **M 304**	**Modultitel:** **MSc Geländeübungen**								**Art des Moduls:** MSc Wahlpflicht
ECTS-Punkte*	6								
Arbeitsaufwand* **- Kontaktzeit** **- Selbststudium**	Arbeitsaufwand: 180 h		Kontaktzeit: 18 Geländetage						Selbststudium: 36 h
Moduldauer* Modulkoordinator	18 Tage, verteilt über 4 Semester.				Bons				
Häufigkeit des Angebots*	Üblicherweise im Sommersemester und nach Angebot im WS								
Unterrichtssprache	Deutsch und/oder Englisch								
Lehr- /Lernformen*	Exkursionen und Geländeübungen								
Modulinhalt*	Insgesamt müssen 18 Geländetage absolviert werden. Diese können beinhalten: • Besuche von Aufschlüssen im Gelände, Steinbrüchen, Ausgrabungen, geowissenschaftsrelevanten Museen, Forschungseinrichtungen, Betrieben, etc. • Ein- oder mehrtägige fortgeschrittene Übungen Geländetage aus Kartierkursen werden nur in Ausnahmefällen und nach vorheriger Absprache als Exkursionstage angerechnet (max. 7 Tage).								
Qualifikationsziele*	Aufbauend auf den im BSc erlangten Kompetenzen für die raumbezogene Erfassung von geologischen, bodenkundlichen, ingenieurgeologischen oder anderer geowissenschaftlicher Daten im Gelände, werden in weiteren Geländeaufenthalten sowohl die praktisch-methodischen Kenntnisse vertieft, als auch durch die Betrachtung unterschiedlicher Gebiete bzw. geologischer Formationen die Kenntnis über die regionale Geologie deutlich erweitert.								
Voraussetzung für die Vergabe von Leistungspunkten/ Benotung (ggf. Gewichtung)*	*Lehrveranstaltungen*	*Art der Lehrform*	*Status*	*SWS*	*LP*	*Prüfungsform / Studienleistung*	*Prüfungsdauer*	*Benotungssystem*	*Gewichtung*
	18 Geländetage aus dem Angebot des Fachbereichs	*GÜ*	*o*	*10*	*6*	*H**	*-*	*ub*	*-*
	**Dozenten können für die erfolgreiche Teilnahme an einer Geländeveranstaltung Leistungsnachweise z.B. in Form von Protokollen, Berichten verlangen.*								
Verwendbarkeit*	MSc Geowissenschaften. Teilnahme von Studierenden aus anderen Studiengängen insbesondere aus dem FB Geowissenschaften möglich.								
Teilnahmevoraussetzungen*	In der Regel keine Teilnahmevoraussetzungen. In Abhängigkeit der Thematik können Dozenten jedoch Teilnahmevoraussetzungen definieren. Spezielle Geländepraktika (z.B. im Hochgebirge) setzen die erforderliche körperliche Fitness voraus.								

Modulnummer: **M 305**	**Modultitel:** **MSc Kartierkurs**								**Art des Moduls:** MSc Wahlpflicht
ECTS-Punkte*	6								
Arbeitsaufwand* - Kontaktzeit - Selbststudium	Arbeitsaufwand: 180 h		Kontaktzeit: 14-18 Geländetage						Selbststudium: 0-40 h
Moduldauer* Modulkoordinator	Blockkurs: 14-18 Geländetage			Bons					
Häufigkeit des Angebots*	Jährlich								
Unterrichtssprache	Deutsch und/oder Englisch								
Lehr- /Lernformen*	Betreute Geländeübung in Kleingruppen. Geologische Datenaufnahme im Gelände und textliche und graphische Aufbereitung der Daten in Berichtsform.								
Modulinhalt*	Ein 14-tägiger Kartierkurs beinhaltet: • Die geologische Kartierung eines Gebietes, individuell oder in kleinen Gruppen • die Erstellung einer geologischen Karte, Erfassung und grafische Darstellung der geologischen Schichtenfolge (z.B. Profilschnitte durch das Kartiergebiet, Konstruktion von stratigraphischen Profilen, etc.) • die Zusammenfassung und Interpretation der Ergebnisse in einem Bericht In Abhängigkeit der Dauer eines Kartierkurses kann die Vergabe der Leistungspunkte an weitere Zusatzleistungen geknüpft werden. Diese werden im Vorfeld der Kartierung vom Dozenten bekannt gegeben und können in Form von an die Kartierung anschließenden Geländetagen, der Teilnahme an Vorbereitungsseminaren, Hausarbeiten oder Projektarbeiten erbracht werden.								
Qualifikationsziele*	Die Studierenden wenden selbstständig geowissenschaftliche Arbeitsmethoden im Gelände an und sammeln erste praktische Erfahrungen bei der geologischen Bearbeitung eines unbekannten Gebietes. Sie nehmen Messungen vor, beschreiben und dokumentieren die angetroffenen Gesteinsschichten und stellen diese in einen räumlichen Zusammenhang. Die sichere Anwendung geologischer Geländemethoden, besonderes zur Herstellung von geologischen Karten, Geländeschnitten und Profilen stellt eine Kernkompetenz von Geowissenschaftlern dar.								
Voraussetzung für die Vergabe von Leistungspunkten/ Benotung (ggf. Gewichtung)*	*Lehrveranstaltungen*	*Art der Lehrform*	*Status*	*SWS*	*LP*	*Prüfungsform / Studienleistung*	*Prüfungsdauer*	*Benotungssystem*	*Gewichtung*
	MSc Kartierkurs	*GÜ*	*o*	*6*	*6*	*H*	*-*	*b*	*1*
Verwendbarkeit*	Wahlpflichtmodul im MSc Geowissenschaften								
Teilnahmevoraussetzungen*	Abgeschlossenes BSc Studium Geowissenschaften								

Module Number: **M 306**	**Module Title:** **Experiment Earth**								**Type of Module:** MSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 90 h/ 6 SWS						Private Study: 90 h
Duration of Module* **Module Coordinator**	1 Semester				Nowak				
Regular Cycle*	Every summer semester								
Language	English								
Learning- / Teaching Forms*	The module consists of lectures, seminars and exercises								
Module Content*	Instruction of theoretical and practical basics of experimental approaches to simulate dynamic processes of the Earth's interior (e.g. magmatic differentiation processes, explosive volcanism, fluid-rock interactions) in combination with space-resolved analytical methods and data handling.								
Qualification Goals*	Experimental high pressure-high temperature techniques and their application in simulation of magmatic and metamorphic processes in the lab are a key competence in mineralogy and petrology. Safe working procedures and quantitative space-resolved analytical techniques in combination with data analysis, error propagation and interpretation enable students to perform independent research-oriented activities in the field of mineralogy and petrology.								
Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Experiment Earth	*L,S*	*c*	*3*	*3*	*R*	*-*	*g*	*1*
		E	*c*	*3*	*3*	*H*	*-*	*-*	*-*
Applicability*	The module is closely related to the modules *Magmatische Prozesse* and *Isotope Geochemistry* and a key to understanding physicochemical models for the quantification of magmatic and metamorphic processes.								
Participation Prerequisites*	Successful participation in the BSc elective module *Mineralogische Analysemethoden* or comparable qualifications, basic knowledge in anorganic and physical chemistry.								

Modulnummer: **M 307**	**Modultitel:** **Sedimentgeochemie**		**Art des Moduls:** MSc Wahlpflicht
ECTS-Punkte*	6 LP		
Arbeitsaufwand* - Kontaktzeit - Selbststudium	Arbeitsaufwand: 180 h	Kontaktzeit: 90 h / 6 SWS	Selbststudium: 90 h
Moduldauer* Modulkoordinator	1 Semester	Taubald	
Häufigkeit des Angebots*	Jedes Sommersemester **(letztmalig SoSe 20)**		
Unterrichtssprache	Deutsch		
Lehr- /Lernformen*	Vorlesung und Übung		
Modulinhalt*	Das Modul besteht aus zwei Veranstaltungen: a) Sedimentpetrographie (Grundlagen der Sedimentpetrologie; Tonmineralogie, Aufbereitung und Analytik in der Sedimentpetrographie, röntgenographische Methoden) b) Umweltgeochemie (Anwendung und Einsatz von Isotopensystemen aller Art (leichte stabile, schwere stabile, radiogene, radioaktive, kosmogene, anthropogene) in den Umweltgeowissenschaften und Tone als Barrieresysteme. Die Veranstaltungen sind so konzipiert, dass die Studierenden einen umfassenden Einblick in geowissenschaftlich relevante Niedrigtemperaturphänomene erhalten, die an der Erdoberfläche ablaufen. Dazu gehören sedimentbildende Prozesse ebenso wie die Interaktion von Atmo/Geo/Bio- und Hydrosphäre. In der Sedimentpetrographie liegt ein Schwerpunkt auf Charakterisierung und Analytik von Tonen und Tonmineralen. Dies schafft die Verbindung zu Environmental Isotope Chemistry I, wo Tone und Tonminerale als Barrieresysteme bei der Ausbreitung von Schadstoffen besprochen werden. Bei der Beschreibung deren Migration durch die Barrieren spielen Isotopensysteme wiederum eine entscheidende Rolle. Sie bilden ebenso das entscheidende Werkzeug um Oberflächenprozesse zu beschreiben und quantifizieren.		
Qualifikationsziele*	Die Studierenden, am Ende des Moduls: • kennen die wichtigsten Sedimente und sedimentären Minerale, sowie Isotopenmethoden und deren Anwendung in den umweltrelevanten Geowissenschaften • verfügen über Wissen in den Bereichen Sedimentanalytik, Isotopensystematik und Isotopenfraktionierung • können Sedimentanalysen und Isotopendiagramme interpretieren und Zusammenhänge bei der Bildung von Sedimenten und der Interaktion der oberflächennahen Sphären verstehen. • ihr Wissen auf neue Projekte, Problemfälle und Isotopensysteme anwenden • sich in neue Fragestellungen der Niedrigtemperaturprozesse auf der Erde selbständig einarbeiten		

Voraussetzung für die Vergabe von Leistungspunkten/ Benotung (ggf. Gewichtung)*

Lehrveranstaltungen	*Art der Lehrform*	*Status*	*SWS*	*LP*	*Prüfungsform / Studienleistung*	*Prüfungsdauer*	*Benotungssystem*	*Gewichtung*
Sedimentpetrographie	*V/Ü*	*o*	*3*	*3*	*K*	*90*	*b*	*0,5*
Umweltgeochemie	*V/Ü*	*o*	*3*	*3*	*K*	*90*	*b*	*0,5*

Verwendbarkeit*	MSc Geowissenschaften
Teilnahmevoraussetzungen*	Grundlagen zur Charakterisierung von Gesteinen und Isotopensystemen sollten vorhanden sein. Dies ist üblicherweise gegeben, wenn die Studierenden ein BSc Studium der Geowissenschaften oder sonstiger geonaher Studiengänge in Deutschland oder der EU erfolgreich absolviert haben.

<table>
<tr><td>Module Number:
M 308</td><td colspan="5">Module Title:
Isotope Geochemistry</td><td colspan="4">Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="9">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="3">Workload:
180 h</td><td colspan="3">Contact Time:
90 h / 6 SWS</td><td colspan="3">Private Study:
90 h</td></tr>
<tr><td>Duration of Module*
Module Coordinator</td><td colspan="4">1 semester</td><td colspan="5">Schönberg</td></tr>
<tr><td>Regular Cycle*</td><td colspan="9">Every summer semester</td></tr>
<tr><td>Language</td><td colspan="9">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="9">Lectures, exercises, oral and written presentations</td></tr>
<tr><td>Module Content*</td><td colspan="9">The module consists of 3 main parts:
1. Theory of isotope geochemistry: Detailed view on applications of radiogenic isotope systems as geochemical indicators for assimilation and fractionated crystallization (AFC). U-Th disequilibrium dating and its applications. Heavy ‘non-traditional’ stable isotope systems (e.g. Cr, Fe, Mo) and their applications.
2. Theory of Mass spectrometry: Basic instrumental set-up of various mass spectrometers, focusing on systems used to determine isotope ratios. Isotope dilution for exact quantitative element concentration analysis.
3. Literature study: The experience gained during parts 1&2 of this module are applied to isotope geochemical literature. Papers published in international journals will be summarized in oral and written presentations.</td></tr>
<tr><td>Qualification Goals*</td><td colspan="9">Upon completion of the module students:
• have detailed knowledge how radiogenic isotope ratios can be used for the identification and quantification of magmatic processes
• understand how the U-Th disequilibrium can be used in dating young rocks/minerals and those in turn allow statement about changes in climate and bioproductivity understand how stable isotope variations of heavy elements (transition metals) allow statements on the formation mineral deposits as well as in the field of environmental geochemistry can be used to identify sources of contamination
• know the basic set-up of a mass spectrometer, the methodological differences with respect to other analytical techniques
• will be able to assess the quality of published isotope data and the interpretations drawn from those</td></tr>
<tr><td rowspan="4">Prerequisites for the allocation of credits / grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td>Isotope Geochemistry</td><td>L, E</td><td>c</td><td>3</td><td>3</td><td rowspan="2">WE</td><td rowspan="2">120</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>Mass Spectrometry</td><td>L,E</td><td>c</td><td>2</td><td>2</td></tr>
<tr><td>Literature Study</td><td>E</td><td>c</td><td>1</td><td>1</td><td>R</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Applicability*</td><td colspan="9">Elective module in the MSc Geosciences, key module in the specializations Mineralogy and General Geosciences</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="9">Basic knowledge from the BSc Geowissenschaften or from a comparable BSc degree</td></tr>
</table>

Modulnummer: **M 310**	**Modultitel:** **Materialwissenschaften für Geowissenschaftler**		**Art des Moduls:** MSc Wahlpflicht
ECTS-Punkte*	6		
Arbeitsaufwand* **- Kontaktzeit** **- Selbststudium**	Arbeitsaufwand: 180 h	Kontaktzeit: 90 h / 6 SWS	Selbststudium: 90 h
Moduldauer* Modulkoordinator	1 Semester	Nickel	
Häufigkeit des Angebots*	jedes Wintersemester (**letztmals im WiSe 20/21)**		
Unterrichtssprache	Deutsch		
Lehr- /Lernformen*	Vorlesung & Übungen		
Modulinhalt*	Überblick über die nichtmetallisch-anorganischer Werkstoffe: Herstellung (Rohstoffe, Aufbereitung, Konsolidierung) und Eigenschaften (mechanische, chemische, elektrische, biologische), Deformationsmechnismen und Fließverhalten (insbesondere natürlicher) Materialien		
Qualifikationsziele*	Die Absolventen können die wichtigsten Darstellungsmethoden der Rohstoffe, Aufbereitungs- und Formgebungs- und Konsolidierungsprozesse benennen und interpretieren. Sie können die Eigenschaften von Materialien an Hand von Kennzahlen beurteilen und einschätzen. Insbesondere können sie mechanische Eigenschaften wie Festigkeiten, Zuverlässigkeiten und rheologisches Verhalten auch quantitativ interpretieren, grundlegende Formeln hierzu anwenden und dadurch Materialverhalten unter äußeren Einwirkungen beurteilen.		

Voraussetzung für die Vergabe von Leistungspunkten/ Benotung (ggf. Gewichtung)*

Lehrveranstaltungen	*Art der Lehrform*	*Status*	*SWS*	*LP*	*Prüfungsform / Studienleistung*	*Prüfungsdauer*	*Benotungssystem*	*Gewichtung*
Rheologie	*V*	*o*	*0,5*	*0,5*	*K*	*30*	*b*	*0,1*
	Ü	*o*	*0,5*	*0,5*		*30*	*b*	*0,1*
Nichtmetallische-anorganische Materialien	*V*	*o*	*2,5*	*2,5*		*80*	*b*	*0,4*
	Ü	*o*	*2,5*	*2,5*		*100*	*b*	*0,4*

Verwendbarkeit*	Das Modul ist für Personen mit Interesse für angewandte Geowissenschaften geeignet.
Teilnahmevoraussetzungen*	Mineralogische Grundkenntnisse werden benötigt: Erfolgreiche Teilnahme an "Minerale und Gesteine" und "Chemie für Geowissenschaftler II" ist Pflicht, Teilnahme an "Anwendungen und Methoden der Mineralogie" erwünscht. Teilnehmer sollten auch das Modul "Analytische Methoden" nehmen.

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

Modulnummer: **M 311**	**Modultitel:** **Faziesanalyse**		**Art des Moduls:** MSc Wahlpflicht
ECTS-Punkte*	6		
Arbeitsaufwand* **- Kontaktzeit** **- Selbststudium**	Arbeitsaufwand: 180 h	Kontaktzeit: 90 h / 6 SWS	Selbststudium: 90 h
Moduldauer* / Modulkoordinator	1 Semester	Nebelsick	
Häufigkeit des Angebots*	Jedes Wintersemester		
Unterrichtssprache	Deutsch		
Lehr- /Lernformen*	Die Vermittlung der theoretischen Grundlagen erfolgt über Vorlesungsanteile die mit praktischen Übungen verbunden sind. Neben Arbeitsblättern für einzelne Themenbereiche, gehören vor allem Übungen an Dünnschliffen, z.T. auch Bohrkernen zur methodisch-praktischen Ausbildung.		
Modulinhalt*	Die Rekonstruktion von ehemaligen sedimentären Ablagerungsräumen spielt eine zentrale Rolle in der Paläo-Umweltforschung sowie bei der Suche und Erschließung von fossilen Rohstofflagerstätten. Das Modul, das aus 2 Einzelveranstaltungen besteht, gibt eine Einführung in • die wichtigsten Faziesräume und ihre Charakteristika • die Prinzipien der Fazies- und Sequenzanalyse sowie Sequenzstratigraphie • die Arbeitsmethoden und Anwendungen von Mikro- und Biofazies-Analyse (besonders Karbonate) • die physische und biotische Steuerung siliziklastischer und karbonatischer Sedimentsysteme.		
Qualifikationsziele*	Die Studierenden können die Sedimentationsgeschichte, die räumliche Ausdehnung und den Aufbau eines Ablagerungsraumes rekonstruieren und in einen regional-geologischen Kontext stellen. Unter Zuhilfenahme unterschiedlichster Methoden (Mikroskopie-Geophysik) auf verschiedenen Skalen (Mikroskala-regionale Skala) können sie ein schlüssiges Gesamtbild eines Ablagerungssystems erstellen sowie praktische Bezüge herstellen.		

Voraussetzung für die Vergabe von Leistungspunkten/ Benotung (ggf. Gewichtung)*	*Lehrveranstaltungen*	*Art der Lehrform*	*Status*	*SWS*	*LP*	*Prüfungsform / Studienleistung*	*Prüfungsdauer*	*Benotungssystem*	*Gewichtung*
	Karbonate	*V/Ü*	*o*	*3*	*3*	*K*	*90*	*b*	*0,5*
	Fazies- und Sequenzanalyse	*V/Ü*	*o*	*3*	*3*				*0,5*

Verwendbarkeit*	MSc Geowissenschaften
Teilnahmevoraussetzungen*	Kenntnisse vergleichbar mit denen aus den BSc Modulen Erdgeschichte, Sedimente & Stratigraphie, Paläontologie.

Modulnummer: **M 312**	**Modultitel:** **Angewandte Sedimentgeologie**		**Art des Moduls:** MSc Wahlpflicht
ECTS-Punkte*	6		
Arbeitsaufwand* **- Kontaktzeit** **- Selbststudium**	Arbeitsaufwand: 180 h	Kontaktzeit: 90 h / 6 SWS	Selbststudium: 90 h
Moduldauer* **Modulkoordinator**	1 Semester	Aigner	
Häufigkeit des Angebots*	2-semestrig im Wintersemester (empfohlen im 3. Semester MSc Geowissenschaften)		
Unterrichtssprache	Deutsch		
Lehr- /Lernformen*	Angewandte Sedimentgeologie verbindet Vorlesungsanteile mit praktischen Fortgeschrittenen Übungen (meist als Blockveranstaltungen angeboten). In einem Seminar können aktuelle Forschungsergebnisse oder methodische Prinzipien diskutiert und in Referaten vorgestellt, oder auch Inhalte im Gelände umgesetzt werden. Spezielle Themen und aktuelle Forschungen werden ins Modul eingebunden (z.B. kann bei Bohrkernanalysen auf das umfangreiche Bohrkernarchiv des Fachbereichs zurückgegriffen werden).		
Modulinhalt*	Das Modul widmet sich der praktischen Bedeutung der sedimentären Geologie, z.B. im Rohstoff- und Umweltbereich, wobei die Einzelthemen wechseln können. Ein Fokus liegt z.B. in Beschreibung, Charakterisierung und Modellierung von Speichergesteinen (z.B. Karbonate). Neben der Vermittlung grundlegender methodisch-praktischer Fähigkeiten auf verschiedenen Skalen ist die Modellierung ein Thema des Moduls. Die spezifischen Inhalte des Moduls können, z.B. bedingt durch aktuelle Forschungsthemen wechseln.		
Qualifikationsziele*	Studierende sind in der Lage Daten aus einer Vielzahl von Erkundungsmethoden und Analyseansätzen zu sichten, zu analysieren und zu bewerten. Sie beherrschen die wissenschaftlichen Grundlagen und besitzen fortgeschrittene Fähigkeiten die auf verschiedenen Skalen erhobenen Daten in ein Modell zu integrieren und in einen zeitlich-räumlichen Zusammenhang zu stellen.		

Voraussetzung für die Vergabe von Leistungspunkten/ Benotung (ggf. Gewichtung)*

Lehrveranstaltungen	*Art der Lehrform*	*Status*	*SWS*	*LP*	*Prüfungsform / Studienleistung*	*Prüfungsdauer*	*Benotungssystem*	*Gewichtung*
Angewandte Sedimentgeologie	*V*	*o*	*2*	*2*	*K*	*60*	*b*	*0,5*
Angewandte Sedimentgeologie	*S*	*o*	*2*	*2*			*ub*	
Spezielle Themen (Block)	*V/Ü*	*o*	*2*	*2*	*H*	*-*	*b*	*0,5*

Verwendbarkeit*	Das Modul vermittelt fortgeschrittene Kompetenzen, z.B. für die Vertiefungsrichtung Exploration im MSc Geowissenschaften und ist Voraussetzung für die Teilnahme im Modul Explorationspraxis.
Teilnahmevoraussetzungen*	Grundlage für die Teilnahme sind grundlegende Kenntnisse in Sedimentgeologie vergleichbar mit Kompetenzen des BSc Moduls Sedimente und Stratigraphie, sowie Faziesanalyse.

Modulnummer: **M 313**	**Modultitel:** **Explorationspraxis (Letztmalig im WiSe 20/21)**								**Art des Moduls:** MSc Wahlpflicht
ECTS-Punkte*	6								
Arbeitsaufwand* **- Kontaktzeit** **- Selbststudium**	Arbeitsaufwand: 180 h		Kontaktzeit: 150 h / 10 SWS						Selbststudium: 30 h
Moduldauer* **Modulkoordinator**	1 Semester				Aigner				
Häufigkeit des Angebots*	Letztmalig im WiSe 20/21								
Unterrichtssprache	Deutsch und Englisch								
Lehr- /Lernformen*	Das Modul besteht im Wesentlichen aus praxisorientierten Vorlesungen und Übungen. Wechselnde Blockveranstaltungen zu Spezialthemen aus dem Bereich Erdöl/Erdgas Exploration werden von externer Spezialisten aus der Erdölindustrie vorgestellt: Neben umfangreichen Übungen an Original-Datensätzen aus der Explorationspraxis, kommt neuste 3D Modellierungssoftware zum Einsatz. Praktische Projektarbeiten sowie Industriepraktika können in diesem Modul integriert werden.								
Modulinhalt*	Das Modul befasst sich mit sedimentären Lagerstätten mit einem Fokus auf Erdöl-Erdgas-Exploration (Petroleumgeologie). Die wichtigsten Methoden in der Erdölexploration werden vorgestellt und praktisch eingeübt. Behandelte Themenbereiche sind z.B. Erdölgeologie, Seismische Interpretation, Strukturelle Interpretation, Seismische Stratigraphie, Well-Log-Interpretation, Beckenanalyse und –modellierung. Die angebotenen Einzelveranstaltungen bieten eine direkten Einblick in ‚State of the Art' Entwicklungen und können daher in ihren Inhalten von Jahr zu Jahr variieren.								
Qualifikationsziele*	Studierende kennen die Grundzüge der Lagerstätten-Exploration/Erkundung, im Bereich Erdöl-Erdgas. Sie verfügen über umfangreiches Wissen zum aktuellen Stand der Forschung und sind in der Lage selbstständig Informationen der wichtigsten Explorationsmethoden zu sichten, analysieren und interpretieren. Aus einer Vielzahl der unterschiedlichen Daten sind sie in der Lage komplexe Strukturmodelle zu erstellen, die die Grundlage für das Auffinden von potentiellen Erdöl/Erdgaslagerstätten sind.								
Voraussetzung für die Vergabe von Leistungspunkten/ Benotung (ggf. Gewichtung)*	*Lehrveranstaltungen*	*Art der Lehrform*	*Status*	*SWS*	*LP*	*Prüfungsform / Studienleistung*	*Prüfungsdauer*	*Benotungssystem*	*Gewichtung*
	Explorationspraxis wechselnde Blockveranstaltungen von externen Dozenten	*V,Ü*	*o*	*10*	*6*	*A*	*-*	*b*	*1*
Verwendbarkeit*	Das Modul vermittelt fortgeschrittene Kompetenzen für die Vertiefungsrichtung Exploration								
Teilnahmevoraussetzungen*	Grundlage für die Teilnahme ist die erfolgreiche Teilnahme an den MSc Modulen Modul Fazies-Analyse und Angewandte Sedimentgeologie.								

Modulnummer: **M 314**	**Modultitel:** **Magmatische Prozesse**								**Art des Moduls:** MSc Wahlpflicht
ECTS-Punkte*	6								
Arbeitsaufwand* **- Kontaktzeit** **- Selbststudium**	Arbeitsaufwand: 180 h		Kontaktzeit: 90 h / 6 SWS						Selbststudium: 90 h
Moduldauer* **Modulkoordinator**	1 Semester				Wenzel				
Häufigkeit des Angebots*	Jedes Sommersemester								
Unterrichtssprache	Deutsch								
Lehr- /Lernformen*	Das Modul besteht aus Vorlesungen und Übungen sowie einem Seminarvortrag.								
Modulinhalt*	Behandelt werden Hintergründe für die Entstehung, Entwicklung und Modifizierung von Magmen in ihrem jeweiligen plattentektonischen Kontext. Dazu werden insbesondere die polarisationsmikroskopische Untersuchung magmatischer Gesteine, die Interpretation von Phasendiagrammen sowie computergestützte Modellierungen magmatischer Prozesse auf der Grundlage geochemischer Daten herangezogen. Die vertiefte Behandlung vulkanischer Prozesse ist ein weiterer wesentlicher Bestandteil des Moduls.								
Qualifikationsziele*	Hauptqualifikationsziel des Moduls ist ein grundlegendes Verständnis der Bildungsursachen und der Differentiationsprozesse von Magmen. Auf dieser Grundlage sind die Absolventen in der Lage, unbekannte Vorkommen magmatischer Gesteine zu analysieren sowie genetisch zu interpretieren, und dadurch einen Beitrag zur Rekonstruktion (paläo)tektonischer Milieus zu liefern.								
Voraussetzung für die Vergabe von Leistungspunkten/ Benotung (ggf. Gewichtung)*	*Lehrveranstaltungen*	*Art der Lehrform*	*Status*	*SWS*	*LP*	*Prüfungsform / Studienleistung*	*Prüfungsdauer*	*Benotungssystem*	*Gewichtung*
	Magmatische Prozesse	*VL*	*o*	*4*	*4*	*K*	*90*	*b*	*1*
		Ü	*o*	*2*	*2*	*ET*	*-*	*-*	*-*
Verwendbarkeit*	Das Modul „Magmatische Prozesse“ steht in engem Zusammenhang mit den Modulen „Metamorphe Prozesse“ und „Die Erde im Experiment“ sowie "Erzlagerstättenkunde". In all diesen Modulen spielen Polarisationsmikroskopie und die Interpretation von Phasendiagrammen eine große Rolle und somit greifen diese Module nahtlos ineinander.								
Teilnahmevoraussetzungen*	Voraussetzungen für die Teilnahme sind grundlegende Kenntnisse in der Polarisationsmikroskopie, der Geochemie, der Mineralogie sowie in der Anwendung von Phasendiagrammen auf geologische Probleme.								

Module Number: **M 315**	**Module Title:** **Glaciology**								**Type of Module:** MSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 90 h / 6 SWS						Private Studies: 90 h
Duration of Module* **Module Coordinator**	1 Semester				Weikusat				
Regular Cycle*	Every summer semester								
Language	English/German (can be held in German depending on students)								
Learning- / Teaching Forms*	Two weeks block course including lectures, tutorials and exercises. Poster presentations								
Module Content*	Topics covered in lectures and exercises: • Components of the earth's cryosphere in recent and palaeo-time scales • Cryosphere and climate (sea level) • Ice cores (palaeo-climate records) • Material ice (modifications, crystal structure, defects, physical properties) • Micro-dynamics of ice (deformation and recrystallization mechanisms) • Formation processes of natural ice (e.g. meteoric glacial ice, sea ice, ice shelf ice, marine ice) • Mass balance of glaciers and ice sheets (ablation and accumulation measurements and processes, e.g. melting, calving) • Ice dynamics (stress and strain, deformation modes, flow features, flow law) Poster session on hot topics in glaciological research (exam): • basics poster preparation and presentation techniques • present a topic / recent research paper on a poster and a 5 min. oral presentation and 5 min questions / discussion								
Qualification Goals*	During the course the students will: • Gather general knowledge of the field about the cryosphere and the related glaciological subtopics • Develop an understanding of the physical processes relevant for the cryosphere • Acquire an up to date overview of current glaciological research topics and being able to evaluate conclusions in a critical way • Acquire expertise in assessing cryosphere related information with respect to modern climate change discussions • Gather practical experience in simple ice core data processing and ice dynamic modelling (exercises and tutorials).								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Require-*	*Duration of Exam*	*Grading System*	*Weighting*
	Glaciology	*L*	*c*	*4*	*4*	*R*	*-*	*g*	*1*
		E	*c*	*1*	*1*				
		S	*c*	*1*	*1*				

Applicability*	Elective module in the MSc program Geowissenschaften. The glaciology module covers topics related to the material of the core modules mineralogy, geodynamics and applied geosciences.
Participation Prerequisites*	Fundamentals in geology/mineralogy and physics

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

Module Number: **M 317**	**Module Title:** **Applied Data Analysis and Modeling for Geoscientists**		**Type of Module:** MSc Elective
Credits (ECTS)*	6		
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: 60 h / 4SWS	Private Study: 120h
Duration of Module* **Module Coordinator**	1 semester	Drews	
Regular Cycle*	WiSe 2020/21		
Language	English		
Learning- / Teaching Forms*	Lectures and computer exercises for data analysis and modelling.		
Module Content*	This lecture teaches universal mathematical concepts and applies them to a wide range of geologic, geoecology, and applied geology problems ranging from analysis of satellite displacement fields, to landscape evolution and isotope records of climate change. Topics include: • Which function fits my data? ✓ Linear/non-linear regression and curve fitting ✓ Statistical metrics and error analysis • What signals are in my data? ✓ Time series analysis and Fourier Transform ✓ Signal processing (e.g. bandpass-pass filtering, deconvolution) ✓ Principal Component Analysis ✓ Denoising and invariants in raster data • Modelling the real world, but how? ✓ Differential equations with finite-differences/finite-element modelling • Which model best describes my data? ✓ Inverse modelling for data integration		
Qualification Goals*	• Numerical programming in Matlab and/or Python • Application of universal mathematical concepts (calculus, linear algebra, differential equations) for geoscientific problems using computers.		

Prerequisites for the allocation of credits /grades (if necessary weighting)*

Courses	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
Applied Data Analysis and Modeling for Geoscientists	*L*	*c*	*2*	*6*	*R*	*25*	*g*	*100*
	E	*c*	*2*					

Applicability*	This module compliments many other geology, geoecology, and applied geology courses (e.g. geophysics, geochemistry, climatology and ecosystems, applied tectonics and surface processes, remote-sensing) by providing a toolbox for quantitative data analysis and modelling. It provides a good baseline for students who want to go further in certain topics in their respective projects.
Participation Prerequisites*	Calculus, linear algebra and ODEs, although some concepts will be reviewed in class. Prior knowledge of programming is helpful but not a hard prerequisite.

Modulnummer: **M 320**	**Modultitel:** **MSc Kartierkurs 2**								**Art des Moduls:** MSc Wahlpflicht
ECTS-Punkte*	6								
Arbeitsaufwand* - Kontaktzeit - Selbststudium	Arbeitsaufwand: 180 h		Kontaktzeit: 14-18 Geländetage						Selbststudium: 0-40 h
Moduldauer* Modulkoordinator	Blockkurs: 14-18 Geländetage			Bons					
Häufigkeit des Angebots*	Jährlich								
Unterrichtssprache	Deutsch und/oder Englisch								
Lehr- /Lernformen*	Betreute Geländeübung in Kleingruppen. Geologische Datenaufnahme im Gelände und textliche und graphische Aufbereitung der Daten in Berichtsform.								
Modulinhalt*	Ein Kartierkurs beinhaltet: • Die geologische Kartierung eines Gebietes, individuell oder in kleinen Gruppen • die Erstellung einer geologischen Karte, Erfassung und grafische Darstellung der geologischen Schichtenfolge (z.B. Profilschnitte durch das Kartiergebiet, Konstruktion von stratigraphischen Profilen, etc.) • die Zusammenfassung und Interpretation der Ergebnisse in einem Bericht In Abhängigkeit der Dauer eines Kartierkurses kann die Vergabe der Leistungspunkte an weitere Zusatzleistungen geknüpft werden. Diese werden im Vorfeld der Kartierung vom Dozenten bekannt gegeben und können in Form von an die Kartierung anschließenden Geländetagen, der Teilnahme an Vorbereitungsseminaren, Hausarbeiten oder Projektarbeiten erbracht werden.								
Qualifikationsziele*	Die Studierenden wenden selbstständig geowissenschaftliche Arbeitsmethoden im Gelände an und sammeln erste praktische Erfahrungen bei der geologischen Bearbeitung eines unbekannten Gebietes. Sie nehmen Messungen vor, beschreiben und dokumentieren die angetroffenen Gesteinsschichten und stellen diese in einen räumlichen Zusammenhang. Die sichere Anwendung geologischer Geländemethoden, besonderes zur Herstellung von geologischen Karten, Geländeschnitten und Profilen stellt eine Kernkompetenz von Geowissenschaftlern dar.								
Voraussetzung für die Vergabe von Leistungspunkten/ Benotung (ggf. Gewichtung)*	*Lehrveranstaltungen*	*Art der Lehrform*	*Status*	*SWS*	*LP*	*Prüfungsform / Studienleistung*	*Prüfungsdauer*	*Benotungssystem*	*Gewichtung*
	MSc Kartierkurs	*GÜ*	*o*	*6*	*6*	*H*	*-*	*b*	*1*
Verwendbarkeit*	Wahlpflichtmodul im MSc Geowissenschaften								
Teilnahmevoraussetzungen*	Abgeschlossenes BSc Studium Geowissenschaften und erfolgreiche Teilnahme am MSc-Modul Kartierkurs. Teilnahme nur bei ausreichender Kapazität und mit Einverständnis des/der Kursleiters/in.								

Module Number: **M 321**	**Module Title:** **Applied Thermochronology and Quaternary Dating: Techniques, Interpretation and Applications**								**Type of Module:** Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 90 h (6 SWS)						Private Studies: 90 h
Duration of Module* **Module Coordinator**	1 Semester				Glotzbach				
Regular Cycle *	Every other year on odd numbered years starting SS 2019, 2 week block course (10 days).								
Language	English								
Learning- /Teaching Forms*	Two weeks block course including lectures (in the morning), tutorials and exercises (in the afternoon).								
Module Content*	In this block course the following topics will be lectured and practically learned: - General principles of absolute and relative dates - Radiometric dating methods - Cosmogenic radionuclide dating - Optical- and thermo-stimulated luminescence dating - Heat transport in the crust - Low-temperature thermochronology - Fission track dating method - (U-Th)/He dating method - Detrital thermochronology data interpretation - Thermal history modelling - Thermo-kinematic modelling								
Qualification Goals*	After this block course the students: - Know the theoretical basis of different dating techniques - Have acquired practical (laboratory) experience in thermochronology - Use computer skills to quantitatively interpret thermochronological data - Gain expertise in deriving geodynamic models from data through case studies								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	Applied Thermochronology and Quaternary Dating	*LE*	*c*	*6*	*6*	*R*	*-*	*g*	*1*
Applicability*	MSc Geowissenschaften, Geoecology, Applied & Environmental Geoscience also open for interested MSc students from other institutions if capacity allows								
Participation Prerequisites*	Introductory Geology								

Module Number: **M 322**	**Module Title:** **Climate Dynamics, Probability and Statistics**		**Type of Module:** MSc Elective
Credits (ECTS)*	6		
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: 60 h / 4 SWS	Private Study: 120 h
Duration of Module* **Module Coordinator**	1 semester	Mutz	
Regular Cycle*	Every other summer semester		
Language	English		
Learning- / Teaching Forms*	Lectures introduce fundamental concepts of statistics, probability theory and the processes governing the climate system on different space and time scales. In computer exercises, specific empirical-analytical methods are described in more detail. In class, these are applied to describe, explain and predict different elements of the climate system. Students prepare presentations on how they applied a taught method to a specific (palaeo)climatological problem.		
Module Content*	This module offers an introduction to atmospheric processes and climate change of the past, present and future. Furthermore, it teaches theoretical and practical knowledge of probability theory, and basic to advanced methods from descriptive and inferential statistics, which are required for the description, explanation and prediction of climate and other Earth systems. Module core content includes: • processes governing the climate system on different scales; • climate change of the past, present and future; • physics- and statistics-based modelling of the atmosphere; • concepts of frequentist and Bayesian probabilities and statistics; • data handling: from high dimensionality to sparse records; • synoptic statistical tools for (palaeo)climatology and geoscience; • detection and explanation of patterns in large datasets; • intelligent, self-improving models: letting models learn from new data.		
Qualification Goals*	Students have a basic understanding of the processes governing climate and climate change and are able to understand and apply basic and advanced tools of descriptive and inferential statistics to typical problems in climatology and geoscience. The students will be able to implement these tools as self-developed (Python or other) programming code.		

Prerequisites for the allocation of credits / grades (if necessary weighting)*

Courses	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
Climate Dynamics, Probability and Statistics	*L*	*c*	*2*	*2*	*R*	*25*	*g*	*1*
	E	*c*	*2*	*2*				

Applicability*	MSc Geoscience, MSc Applied & Environmental Geoscience, MSc Geoecology.
Participation Prerequisites*	Basic knowledge of statistics and programming is useful, but not required.

Modulnummer: **M 323**	**Modultitel:** **Verwitterungsminerale in Erzlagerstätten**								**Art des Moduls:** Wahlpflicht
ECTS-Punkte*	6 LP								
Arbeitsaufwand* - Kontaktzeit - Selbststudium	Arbeitsaufwand: 180 h		Kontaktzeit: 90 h				Selbststudium: 90 h		
Moduldauer* / Modulkoordinator	1 Semester			Markl					
Häufigkeit des Angebots*	Jedes SoSe								
Unterrichtssprache	Deutsch								
Lehr- /Lernformen*	Frontalunterricht, Seminar mit Vorträgen der Studierenden, Mikroskopieübungen, Analytikübungen an div. Geräten								
Modulinhalt*	2-wöchiger Blockkurs in der vorlesungsfreien Zeit. Teil A: Frontalunterricht und Mikroskopieübungen (2 Tage) Teil B: Seminar (Vorträge der Studierenden, 1 Tag) Teil C: Analytikübungen an Mikro-XRD, Mikro-Raman, Mikro-RFA (2 Tage, mit C. Berthold,) Teil D: Analytikübungen am Tisch-REM (2 Tage) Teil E: Bestimmungsübungen an Handstücken und mit dem Mikroskop (3 Tage)								
Qualifikationsziele*	- Grundlegende Informationen über verschiedene Klassen von Verwitterungsmineralen in Erzlagerstätten, insgesamt rund 150-200 Mineralarten - Kristallchemie, Mischkristallbildungen dieser Phasen - Thermodynamik dieser Phasen, Probleme mit Kinetik bei der Verwitterung - Methodik der Bestimmung und chemischen Analyse mittels Optik, XRD, Raman, REM, RFA - Selbstständiges Erkennen der wichtigsten 150 Sekundärminerale in Erzlagerstätten								
Voraussetzung für die Vergabe von Leistungspunkten/ Benotung (ggf. Gewichtung)*	*Lehrveranstaltungen*	*Art der Lehrform*	*Status*	*SWS*	*LP*	*Prüfungsform/ Studienleistung*	*Prüfungsdauer*	*Benotungssystem*	*Gewichtung*
	Vorlesung, Seminar	*V,S*	*o*		*2*	*R*	*90*	*g*	*50%*
	Analytikübungen	*Ü*	*o*		*1*	*MP*	*30*	*g*	*50%*
	Bestimmungsübungen	*Ü*	*o*		*3*				
Verwendbarkeit*	Als Wahlpflichtmodul im MSc-Studiengang Geowissenschaften								
Teilnahmevoraussetzungen*	Voraussetzung sind die MSc Module Erzlagerstätten und Applied Economic Geology sowie die Module Minerale und Gesteine und Mineralogische Analysemethoden des BSc-Studiengangs Geowissenschaften.								

Module Number: M 324	Module Title: Economic Geology		Type of Module: MSc Elective
Credits (ECTS)*	6		
Workload* - **Contact Time** - **Private Time**	Workload: 180 h	Contact times: 90 h / 6 SWS	Private Studies: 90 h
Duration of Module* **Module Coordinator**	1 Semester	Staude	
Regular Cycle*	Every second summer semester (starting 2020)		
Language	English / German (can be held in German depending on students)		
Learning- /Teaching Forms*	The module consists of lectures, complemented by exercises, and reflected light microscopy practice		
Module Content*	This module gives insights into the exploration and mining practices used by geologists in the mineral and metal mining sector. The lecture will cover initial theoretical exploration praxis to practical greenfield and brownfield exploration, mining development stages, and mining geology. The focus is set on drilling (methods, planning, supervising, logging), data handling (databases, QAQC – Quality Assurance Quality Control, modelling) and data reporting (JORC code). The practical part focusses on ore textures and their interpretation and the identification of ore and gangue minerals and frequent mineral assemblages by reflected light microscopy.		
Qualification Goals*	In this module the students learn the methods and procedures of the international exploration and mining industry, independently of the commodity. A main aim is to learn the importance of data quality and data management throughout the exploration and mining stages. Graduates will be able to analyse ore minerals and their textures to establish genetic interpretations and identify economic and ecologic impacts.		

Prerequisites for the allocation of credits / grades (if necessary weighting)*

Courses	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
Applied Economic Geology	*L*	*c*	*3*	*3*	*WE*	*120*	*g*	*0.5*
Ore Petrology and Reflected Light Microscopy	*L*	*c*	*1*	*3*				*0.5*
	E	*c*	*2*					

Applicability*	The module ‘Economic Geology‘ is in close context to the module "Magmatische Prozesse".
Participation Prerequisites*	The completion of the module ‘Georessourcen’ (or similar lecture, including basics in reflected light microscopy) is required.

<table>
<tr><td>Module Number:
M 602</td><td colspan="4">Module Title:
Material Science and Archaeological Ceramics: Ceramic Petrography and Geochemistry</td><td>Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="5">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td>Workload:
180 h</td><td colspan="2">Contact Times:
60 h/ 4 SWS</td><td colspan="2">Private Study:
120 h</td></tr>
<tr><td>Duration of Module*
Module Coordinator</td><td colspan="2">1 Semester</td><td colspan="3">Silvia Rita Amicone</td></tr>
<tr><td>Regular Cycle*</td><td colspan="5">Winter Semester</td></tr>
<tr><td>Language</td><td colspan="5">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="5">Lectures and Exercises</td></tr>
<tr><td>Module Content*</td><td colspan="5">• This course provides a broad introduction to the technological study of ceramics in archaeology through a material science approach and demonstrates their role in interpreting various aspects of past societies.
• The first module provides in depth training in the principles of thin section ceramic petrography its role alongside instrumental geochemistry in the interpretation of pottery provenance and manufacturing technology.</td></tr>
<tr><td>Qualification Goals*</td><td colspan="5">At the end of the course the students will have:
• Good understanding of the foundations of the most established archaeometric techniques employed to analyse ceramic.
• Practical experience of ceramic petrography and instrumental geochemistry and their application and data processing.
• Ability to design research projects that employ instrumental analyses to address archaeological questions.</td></tr>
<tr><td rowspan="3">Prerequisites for the allocation of credits /grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Material Science And Archaeological Ceramics: Ceramic Petrography and Geochemistry</td><td>L</td><td>c</td><td>2</td><td>3</td><td rowspan="2">R/ WE</td><td rowspan="2">90</td><td rowspan="2">g</td><td rowspan="2"></td></tr>
<tr><td>E</td><td>c</td><td>2</td><td>3</td></tr>
<tr><td>Applicability*</td><td colspan="5">The module is an elective module in the MSc program of “Geowissenschaften” and Naturwissenschaftliche Archäologie / Ur- und Frühgeschichte. It complements competences acquired in both programs.</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="5">Fundamentals in basics of physical analytics and geosciences</td></tr>
</table>

Module Number: **M 604**	**Module Title:** **Material Science and Archaeological Ceramics: Ancient Pottery and its Pigments**								**Type of Module:** MSc Elective
Credits (ECTS)*	6								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Times: 60 h/ 4 SWS						Private Study: 120 h
Duration of Module* **Module Coordinator**	1 Semester				Silvia Rita Amicone				
Regular Cycle*	WiSe block course and 2 day field exercises								
Language	English								
Learning- / Teaching Forms*	Lectures and Exercises								
Module Content*	• This course provides a broad introduction to the technological study of pigments and decoration in archaeological ceramics, through a material science approach. • This module provides training in the principles of 3D Video microscopes, Laser Scanning Microscopy (LSM), Scanning Electron Microscopy (SEM), X-Ray Diffraction (XRD) and Raman Spectroscopy in the interpretation of pottery decoration techniques.								
Qualification Goals*	At the end of the course the students will have: • A good understanding of the foundations of the most established archaeometric techniques employed in the study of different types of pottery pigments and decoration • Practical experience of archaeometric techniques and their application to the study of pottery pigments and decoration • An ability to design research projects that employ instrumental analyses to address archaeological questions								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Material Science and Archaeological Ceramics: Ancient Pottery and its Pigments	*L*	*c*	*1*	*3*	*R/ WE*	*90*	*g*	
		E	*c*	*2*	*3*				
Applicability*	The module is an elective module in the MSc program of “Geowissenschaften” and Naturwissenschaftliche Archäologie / Ur- und Frühgeschichte. It complements competences acquired in both programs.								
Participation Prerequisites*	Fundamentals in basics of physical analytics and geosciences								

Module Number: **M 606**	**Module Title:** **Numerical Modelling in Geodynamics**		**Type of Module:** MSc Elective
Credits (ECTS)*	6		
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: 60 h / 4 SWS	Private Study: 120 h
Duration of Module* **Module Coordinator**	1 Semester	Koptev	
Regular Cycle*	Winter semester 2020/21		
Language	English		
Learning- / Teaching Forms*	This module includes a combination of lectures and computer exercises (MatLab) related to the lecture topics.		
Module Content*	Numerical modeling of geodynamic processes is an area of frontier research in integrated solid Earth science. This course provides an introduction of the underlying principles and essential elements in numerical geodynamic models, covering the following particular topics: - 1D steady-state thermal structure of the lithosphere: the role of radiogenic heating in the crust and the effect "thermal blanketing" by the sedimentary cover. - 1D rheological structure of the lithosphere: viscous and brittle (plastic) rheologies assigned by a Christmas tree-like criterion, lithospheric strength and effective elastic thickness. - 2D modelling of non-steady-state temperature field: an explicit finite-difference numerical scheme to solve diffusion equation. - 2D modelling of local and regional isostasy: a flexural response of the lithosphere subjected to surface loading/unloading. - 3D modelling of landscape evolution: stream power law river incision combined to diffusional hillslope processes. - 3D coupling of the landscape evolution model with the isostatic rebound of the lithosphere.		
Qualification Goals*	The major goal of this class centers on enabling students to understand the fundamental and intrinsic link between the evolution of surface topography, thermo-rheological structure of the lithosphere and geodynamic processes operating in the Earth interiors. At the same time the acquired technical skills allow students: - to estimate quantitatively the principal mechanical characteristics of the lithosphere (integrated strength, flexural rigidity, effective elastic thickness) based on its composition, thermal state and rheological properties; - to handle the basic principles of discretization of differential equations and to address numerically the key issues in geodynamics and geomorphology; - to develop coupled numerical models of the thermal diffusion in the crust and upper mantle, local or regional isostatic adjustment of the lithosphere and differential fluvial erosion on the surface. The students will be able to perform the quantitative estimates and to design the modelling experiments using self-developed (MatLab) programming scripts.		

Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Numerical Modelling in Geodynamics	*L*	*c*	2	6	*A*	-	*g*	*1*
		E	*c*	2					
Applicability*	MSc Geoscience, MSc Applied & Environmental Geoscience								
Participation Prerequisites*	Introductory geology. Basic knowledge of programming is useful, but not required.								

Module Biogeologie

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

Module Number: **M 403**	**Module Title** **Palaeoecology of Terrestrial Ecosystems**		**Type of Module:** MSc Elective
Credits (ECTS)*	6		
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: 90h /6 SWS	Private Study: 90 h
Duration of Module* **Module Coordinator**	1 Semester	Bocherens	
Regular Cycle*	Every summer semester		
Language	English		
Learning- / Teaching Forms*	A wide range of teaching methods are used. Subject specific theoretical and practical skills are presented during lectures and in exercise sessions. Seminar sessions introduce presentation and reporting elements which address generic communication and presentation skills.		
Module Content*	• Important characteristics of terrestrial ecosystems nowadays and in the past • Description of the main approaches (autoecology, synecology, geochemical tracers) • Taphonomy, diagenesis and palaeoecology of terrestrial ecosystems • Initial adaptations and the early terrestrial record • Terrestrial ecosystems through time • The role of biotic and abiotic factors in the evolution of terrestrial ecosystems • The impact of mass extinctions on terrestrial ecosystems • Changes in terrestrial ecosystems and human evolution		
Qualification Goals*	• Students are familiar with the history of life on land and can apply the methods used to reconstruct this history. • They have the ability to critically assess specialized literature related to this field and to appropriately present research topics in written and oral form.		

Prerequisites for the allocation of credits / grades (if necessary weighting)*

Courses	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
Paleoecology of Terrestrial Ecosystems	*L*	*o*	*3*	*3*	*WE*	*120*	*g*	*1*
	S	*o*	*2*	*2*	*R*	-	-	-
	E	*o*	*1*	*1*	*A*	-	-	-

Applicability	This course is one of the obligatory courses for the Orientierungsrichtung: Paläoökologie und Paläoklima in the MSc program Geoökologie.
Participation Prerequisites*	Bachelor courses „History of the Earth“, „Palaeontology“, „Palaeobiology“ or equivalent.

<table>
<tr><td>Module Number:
M 404</td><td colspan="5">Module Title:
Micropaleontology</td><td colspan="4">Type of Module:
MSc Elective</td></tr>
<tr><td>Credits (ECTS)*</td><td colspan="9">6</td></tr>
<tr><td>Workload*
- Contact Time
- Private Study</td><td colspan="3">Workload:
180 h</td><td colspan="3">Contact Time:
60 h / 4 SWS</td><td colspan="3">Private Studies:
120 h</td></tr>
<tr><td>Duration of Module*
Module Coordinator</td><td colspan="4">1 Semester</td><td colspan="5">Junginger</td></tr>
<tr><td>Regular Cycle*</td><td colspan="9">Every winter semester</td></tr>
<tr><td>Language</td><td colspan="9">English</td></tr>
<tr><td>Learning- / Teaching Forms*</td><td colspan="9">Lectures are accompanied by practical laboratory and microscopy exercises.</td></tr>
<tr><td>Module Content*</td><td colspan="9">The module introduces the biology, ecology, morphology and geological significance and evolution of important microfossil groups. The role of microfossils as paleoenvironmental indicators and in industrial micropalaeontology and biostratigraphy is discussed. Students learn the practical skills of processing and analyzing micropaleontological samples.</td></tr>
<tr><td>Qualification Goals*</td><td colspan="9">Students are familiar with the process of identification and classification of microfossils and understand the evolutionary history and geological significance of microfossil-producing organisms. They are able to independently carry out paleoenvironmental analyses and age determinations with microfossils and are able to critically evaluate micropaleontological data.
Practical skills in processing of micropaleontological material from sampling to interpretation and the understanding of the potential industrial applications of micropalaeontology are a key competence needed exploration of oil and gas reservoirs.</td></tr>
<tr><td rowspan="3">Prerequisites for the allocation of credits / grades (if necessary weighting)*</td><td>Courses</td><td>Type of Lecture</td><td>Status</td><td>CH</td><td>CR</td><td>Type of Exam / Study Requirement</td><td>Duration of Exam</td><td>Grading System</td><td>Weighting</td></tr>
<tr><td rowspan="2">Micropaleontology</td><td>L</td><td>c</td><td>2</td><td>3</td><td rowspan="2">WE</td><td rowspan="2">90</td><td rowspan="2">g</td><td rowspan="2">1</td></tr>
<tr><td>E</td><td>c</td><td>2</td><td>3</td></tr>
<tr><td>Applicability*</td><td colspan="9">Elective module in the MSc program Geowissenschaften. The module covers topics related the fields of sedimentology and stratigraphy</td></tr>
<tr><td>Participation Prerequisites*</td><td colspan="9">BSc Modules Erdgeschichte, Sedimente & Stratigraphie, Paläontologie (or equivalent)</td></tr>
</table>

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

Modulnummer: **M 408**	**Modultitel:** **Wirbeltiere und Pflanzen des Känozoikums**								**Art des Moduls:** MSc Wahlpflicht
ECTS-Punkte*	6								
Arbeitsaufwand* **- Kontaktzeit** **- Selbststudium**	Arbeitsaufwand: 180 h		Kontaktzeit: 90 h / 6 SWS						Selbststudium: 90 h
Moduldauer* Modulkoordinator	1 Semester				Böhme				
Häufigkeit des Angebots*	Jedes Wintersemester								
Unterrichtssprache	Deutsch								
Lehr- /Lernformen*	Vorlesungen werden kombiniert mit Übungsanteilen unter Nutzung der umfangreichen paläontologischen Lehr- und Übungssammlung.								
Modulinhalt*	• Prinzipien und Grundlagen terrestrischer Stratigraphie (insb. Biostratigraphie) und Taphonomie • Pflanzen als Vegetations-, Klima- und Umweltproxies • Wirbeltiere als Klima und Umweltproxies • Pflanzenmorphologie und botanische Taxonomie • Grundlagen der Osteologie und Evolution kontinentaler Wirbeltiere des Känozoikums • Aktuelle Themen kontinentaler Paläobiologie und Paläoklimatologie • Übungen zur Bestimmung känozoischer Wirbeltiere und Makrofloren								
Qualifikationsziele*	• Verständnis der Wechselwirkungsmechanismen kontinentaler Prozesse • Grundlagen der Morphologie und Evolution von känozoischen Wirbeltieren und Pflanzen • Einsicht in die Vielfalt von Rekonstruktionsmethoden (Klima, Umwelt, Vegetation) • Erfahrungen im Bestimmen kontinentaler Fossilien (Wirbeltiere, Pflanzen)								
Voraussetzung für die Vergabe von Leistungspunkten/ Benotung (ggf. Gewichtung)*	*Lehrveranstaltungen*	*Art der Lehrform*	*Status*	*SWS*	*LP*	*Prüfungsform / Studienleistung*	*Prüfungsdauer*	*Benotungssystem*	*Gewichtung*
	Wirbeltiere und Pflanzen des Känozoikums	*V*	*o*	*3*	*3*	*MP*	*30*	*b*	*1*
		Ü	*o*	*3*	*3*				
Verwendbarkeit*	MSc Geowissenschaften								
Teilnahmevoraussetzungen*	Grundlagen der Paläontologie								

Module Number: **M 409**	**Module Title:** **Marine Geology and Geochemistry**								**Type of Module:** MSc Elective
Credits (ECTS)*	6 Credits.								
Workload* **- Contact Time** **- Private Study**	Workload: 180 h		Contact Time: 90 h (6 SWS)						Private Studies: 90 h
Duration of Module* **Module Coordinator**	1 Semester				Dr. Hartmut Schulz				
Regular Cycle *	Every Winter Semester								
Language	English								
Learning- /Teaching Forms*	Teacher-centered teaching; studying literature on the subject, talk/exposé, handouts, laboratory practice.								
Module Content*	• Evolution and structure of ocean basins and –margins • Marine sedimentation and –accumulation • Marine natural resources • Ocean circulation/effects of currents and waves • Chemical evolution of the ocean system • Natural and anthropogenic tracers • Methods of survey and sampling								
Qualification Goals*	Students will understand the marine-geological processes between the ocean floor, sedimentation, ocean circulation and the biogeochemical cycles. Candidates learn to analyse and interpret the modern depositional facies, and how to describe elemental fluxes and –fractionations of the oceans. Laboratory and methodological practice on sediment processing and -characterization will provide skills and competence using the large variety of sediment core profiles from the Tübingen repository.								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirements*	*Duration of Exam*	*Grading System*	*Weighting*
	Marine Geochemistry	*L,S*	*c*		*2*	*R*	*-*	*g*	*1*
	Marine Geology	*L,S*	*c*		*2*				
	Marine Geology	*E*	*c*		*2*				
Applicability*	Elective module in MSc Geowissenschaften and MSc Geoökologie. Related modules are Paleoecology of Marine Systems, Isotope Geochemistry, Sedimentgeochemie and Faziesanalyse.								
Participation Prerequisites*	BSc-modules of Dynamics of the Earth (Dynamik der Erde), Earth History (Erdgeschichte), Sediments and Stratigraphy (Sedimente und Stratigraphie), Paläontologie (Paleontology), Course limited to 14 students.								

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

Einmalige Veranstaltungen / Teach@Tübingen /Angebote anderer Lehreinheiten

Module Number: **M T@T WiSe 20/21**	**Module Title:** **Astrobiology: life in extreme environments**								**Type of Module:** Elective
Credits (ECTS)*	3								
Workload* **- Contact Time** **- Private Study**	Workload: 90 h		Contact Times: 30 h/ 2 SWS						Private Study: 60 h
Duration of Module* **Module Coordinator**	1 Semester				Toby Samuels				
Regular Cycle*	One time offer WiSe 2020/21								
Language	English								
Learning- / Teaching Forms*	Lectures, exercises, journal club discussions and a group project								
Module Content*	• This course introduces astrobiology, with a particular focus on microbial life in extreme environments and space exploration. • Topics covered include origin of life theories, habitability, experiments in low-Earth orbit and human health in space. • Students will undertake a group project in which they select a future landing site for a speculative mission to Mars, based upon their analyses of provided data.								
Qualification Goals*	At the end of the course students will have: • An appreciation for the numerous methodological and conceptual approaches required to address fundamental questions in an interdisciplinary field. • An understanding of how knowledge acquired in extreme environments on Earth informs our search for life elsewhere. • An ability to critically analyze data published in scientific literature. • An ability to manipulate, analyze and present data relevant to planetary exploration.								
Prerequisites for the allocation of credits /grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
	Astrobiology: life in extreme environments	*L,S, E*	*c*	*2*	*3*	*R*		*g*	*1*
Applicability*	The module adresses students from various fields of Geosciences taught by a T@T lecturer and complements competences acquired in these programs. Applicants from outside these programs interesting in taking the course should contact the module coordinator to determine suitability.								
Participation Prerequisites*	A bachelor's degree in a scientific discipline (biology, chemistry, geosciences, physics). Undergraduate-level knowledge of microbiology will be useful but is not essential.								

Module Number: **Bio-ZMBP (Modul aus der Biologie)**	**Module Title:** **Applications of electron microscopy in cell biology, microbiology and virology / Anwendung der Elektronenmikroskopie in Zellbiologie, Mikrobiologie und Virologie**		**Type of Module:** MSc Elective
Credits (ECTS)*	6		
Workload* **- Contact Time** **- Private Study**	Workload: 180 h	Contact Time: 90 h / 6 SWS	Private Study: 90 h
Duration of Module* **Module Coordinator**	1 Semester	Fischer	
Regular Cycle*	Winter semester		
Language	English		
Learning- / Teaching Forms*	Lecture, exercise/tutorial, seminar		
Module Content*	The aim of the practical is to give participants a comprehensive and critical overview of the possibilities of electron microscopy in biological research based on their own preparative experience on selected objects in different institutes (University, University clinics, MPI, NMI): Preparation of bacterial cells, viruses and proteins: negative contrasting, plunge freezing for cryo-transmission electron microscopy. Preparation of cells, tissues, organisms: chemical fixation, cryofixation, embedding for ultramicrotomy, ultra-thin section technique, freeze-drying and freeze-breaking, critical point drying; methods of immunolabelling for electron microscopy, correlative light and electron microscopy, cryo-scanning electron microscopy, sample processing with focused ion beam (FIB) in scanning electron microscope, energy dispersive X-ray spectroscopy (EDX). Design and function of various microscopes: fluorescence and confocal laser scanning microscopes, (cryo)transmission and (cryo)scanning electron microscopes. Image analysis: Image montages, analysis and evaluation (addressing typical artifacts) of SEM & TEM image material using Open Source Software packages		
Qualification Goals*	- Introduction to independent microscopic work - Knowledge of fluorescence microscopy (basics) and transmission and scanning electron microscopic imaging techniques and important preparation methods - Analysis and interpretation of microscopic images - Documenting and communicating the results of examinations - Knowledge of the advantages and disadvantages of the respective techniques and methods - Critical work and development of a sound professional judgement - Ability to work in a team - Presentation of results in English language		

Prerequisites for the allocation of credits / grades (if necessary weighting)*	*Courses*	*Type of Lecture*	*Status*	*CH*	*CR*	*Type of Exam / Study Requirement*	*Duration of Exam*	*Grading System*	*Weighting*
		L	*c*	*1*	*1*	*LP*	*-*	*g*	*1*
		E	*c*	*4*	*4*				

		S	*c*	*1*	*1*				
Applicability*	MSc Applied & Environmental Geoscience, MSc Geowissenschaften, MSc Geoökologie								
Participation Pre-requisites*	none								