Geosciences of Basins and Lithosphere MSc

Vrije Universiteit Amsterdam - Fac. der Aard- en Levenswetenschappen - M Geosciences of Basins and Lith. (j.d.) - 2013-2014

The aim of the Master programme Geosciences of Basins and Lithosphere (GBL) is to impart to the student the knowledge, skills and insight required to

- operate as an independent professional within the field of geosciences of continental lithosphere, sedimentary basins and petroleum systems
- understand and predict the relative interplay of those geological processes that control the formation and evolution of sedimentary basins
- show an open-minded and internationally oriented attitude and to be a suitable candidate for a subsequent course of study leading to a research-career in academia or society.

The MSc programme Geosciences of Basins and Lithosphere (GBL) is a European research master's programme which participates in the European Basinmaster. When students finish the GBL programme they obtain two diplomas (Double-Degree) from universities in the GBL consortium.

The GBL courses, which can be followed at VU University Amsterdam and form themselves a complete Dutch degree programme are subdivided into three specialisations, each with their own educational programmes. The three specialisations are:

- Deep processes
- Petroleum systems and new energy resources
- Basin formation

The year schedule 2014 - 2015 can be found at the FALW-website .
Further information about the MSc programme Geosciences of Basins and Lithosphere.
A complete programme description can be found at the FALW-website .

Inhoudsopgave

Bergen vakken

Vakken:

Naam	Periode	Credits	Code
Advanced Petroleum Geology		5.0	AM_GEO364
Geodynamics and Basin Modelling		10.0	AM_GEO254
Integrated Interpretation of Seismic and		5.0	AM_GEO372
Master's Thesis in Geoscience		30.0	AM_GEO399
Palaeoclimatology		10.0	AM_GEO222
Reservoir Geophysics		10.0	AM_GEO274
Sequence Stratigraphy		10.0	AM_GEO361

Expired programme components GBL

Courses:

Name	Period	Credits	Code
Master Thesis Geosciences of Basins and Lithosphere	Semester 1	30.0	AM_450271
Petroleum Resources Module	Ac. Year (September)	2.0	AM_450281
Petro-Tecto Field Excursion		3.0	AM_450347
Sedi-Tecto Field Excursion	Period 1	3.0	AM_450348

MSc GBL- Basin Formation

Opleidingsdelen:

- MSc GBL, spec. Sedimentary Basins year 1
- MSc GBL, spec. Sedimentary Basins year 2

Vakken:

Naam	Periode	Credits	Code
Field Excursion Petroleum Systems / Basin Formation	Periode 1	3.0	AM_1035
Research Project GBL I	Ac. Jaar (september)	12.0	AM_1105

MSc GBL, spec. Sedimentary Basins year 1

Opleidingsdelen:

- compulsory courses sedimentary, yr 1
- MSc GBL, compulsory courses first year

compulsory courses sedimentary, yr 1

Vakken:

Naam	Periode	Credits	Code
Geothermal Energy	Periode 5	6.0	AM_450409
Magmatic Processes	Periode 4	6.0	AM_450189
Metamorphism and P-T Evolution	Periode 4	6.0	AM_450176
Reflection Seismic for Geologists	Periode 4	6.0	AM_450170

MSc GBL, compulsory courses first year

Vakken:

Naam	Periode	Credits	Code
From Source to Sink: Chemical and Physical Cycles	Periode 2	6.0	AM_450146
Introduction Field Excursion	Periode 1	3.0	AM_450229
Mantle Properties in Lithosphere Development	Periode 1	3.0	AM_450225
Orogenesis	Periode 3	6.0	AM_450190
Petroleum Systems and Regional Geology	Periode 1	3.0	AM_450179
Portfolio Geosciences of Basins and Lithosphere	Ac. Jaar (september)	3.0	AM_450193
Research Project GBL I	Ac. Jaar (september)	12.0	AM_1105
Sedimentary Basins	Periode 2	6.0	AM_450154

MSc GBL, spec. Sedimentary Basins year 2

Opleidingsdelen:

- optional courses sed. bas. year 2
- choose one

- MSc GBL, compulsory courses second year
- optional modules

optional courses sed. bas. year 2

Vakken:

Naam	Periode	Credits	Code
Petroleum Geology of the North Sea	Periode 2	7.0	AM_450317

choose one

Vakken:

Naam	Periode	Credits	Code
Petro-Tecto Field Excursion		3.0	AM_450347
Sedi-Tecto Field Excursion	Periode 1	3.0	AM_450348

MSc GBL, compulsory courses second year

Vakken:

Naam	Periode	Credits	Code
Field Research Project Geosciences of Basins and Lithosphere	Ac. Jaar (september)	24.0	AM_450195
Master Thesis Geosciences of Basins and Lithosphere	Semester 1	30.0	AM_450271

optional modules

Vakken:

Naam	Periode	Credits	Code
Advanced Geochronology	Periode 5	3.0	AM_450171
Advanced Inorganic Geochemistry	Periode 5	3.0	AM_450172
Capita Selecta Structural Geology and Tectonics	Periode 4	3.0	AM_450144
Diagenesis of Sedimentary Rocks	Periode 5	3.0	AM_450169
Historical Geography	Periode 1	6.0	AM_450292

Low Temperature Deformations of Rocks and Regions	Periode 5	3.0	AM_450180
Magmatic Processes	Periode 4	6.0	AM_450189
Metamorphism and P-T Evolution	Periode 4	6.0	AM_450176
Microstructures in Tectonites	Periode 4	6.0	AM_450158
Palaeo-ecology/Palynology	Periode 3	3.0	AM_450054
Planetary Science	Periode 1+2	6.0	AM_450273
Practical Subsurface Evaluation Workshop	Periode 3	2.0	AM_450277
Precambrian Geology	Periode 4	3.0	AM_450164
Reflection Seismic for Geologists	Periode 4	6.0	AM_450170
Sediment Petrography of Heavy Minerals	Periode 3	3.0	AM_450058
Sustainable Land Management	Periode 3	6.0	AM_1015
Unsaturated Zone and Near Surface Hydrological Processes	Periode 4	6.0	AM_450021
Volcanism	Periode 3	3.0	AM_450061

MSc GBL - Deep Processes

Opleidingsdelen:

- MSc GBL, spec. Continental lithosphere year 1
- MSc GBL, spec. Continental lithosphere year 2

Vakken:

Naam	Periode	Credits	Code
Field Excursion Deep Processes	Periode 1	3.0	AM_1034

MSc GBL, spec. Continental lithosphere year 1

Opleidingsdelen:

- compulsory courses continental, yr 1
- MSc GBL, compulsory courses first year

compulsory courses continental, yr 1

Vakken:

Naam	Periode	Credits	Code
Advanced Geochronology	Periode 5	3.0	AM_450171
Advanced Inorganic Geochemistry	Periode 5	3.0	AM_450172
Magmatic Processes	Periode 4	6.0	AM_450189
Metamorphism and P-T Evolution	Periode 4	6.0	AM_450176

MSc GBL, compulsory courses first year

Vakken:

Naam	Periode	Credits	Code
From Source to Sink: Chemical and Physical Cycles	Periode 2	6.0	AM_450146
Introduction Field Excursion	Periode 1	3.0	AM_450229
Mantle Properties in Lithosphere Development	Periode 1	3.0	AM_450225
Orogenesis	Periode 3	6.0	AM_450190
Petroleum Systems and Regional Geology	Periode 1	3.0	AM_450179
Portfolio Geosciences of Basins and Lithosphere	Ac. Jaar (september)	3.0	AM_450193
Research Project GBL I	Ac. Jaar (september)	12.0	AM_1105
Sedimentary Basins	Periode 2	6.0	AM_450154

MSc GBL, spec. Continental lithosphere year 2

Opleidingsdelen:

- compulsory courses continental, yr 2
- MSc GBL, compulsory courses second year
- optional modules

compulsory courses continental, yr 2

Vakken:

Naam	Periode	Credits	Code
Petro-Tecto Field Excursion		3.0	AM_450347

MSc GBL, compulsory courses second year

Vakken:

Naam	Periode	Credits	Code
Field Research Project Geosciences of Basins and Lithosphere	Ac. Jaar (september)	24.0	AM_450195
Master Thesis Geosciences of Basins and Lithosphere	Semester 1	30.0	AM_450271

optional modules

Vakken:

Naam	Periode	Credits	Code
Advanced Geochronology	Periode 5	3.0	AM_450171
Advanced Inorganic Geochemistry	Periode 5	3.0	AM_450172
Capita Selecta Structural Geology and Tectonics	Periode 4	3.0	AM_450144
Diagenesis of Sedimentary Rocks	Periode 5	3.0	AM_450169
Historical Geography	Periode 1	6.0	AM_450292
Low Temperature Deformations of Rocks and Regions	Periode 5	3.0	AM_450180
Magmatic Processes	Periode 4	6.0	AM_450189
Metamorphism and P-T Evolution	Periode 4	6.0	AM_450176
Microstructures in Tectonites	Periode 4	6.0	AM_450158
Palaeo-ecology/Palynology	Periode 3	3.0	AM_450054
Planetary Science	Periode 1+2	6.0	AM_450273
Practical Subsurface Evaluation Workshop	Periode 3	2.0	AM_450277
Precambrian Geology	Periode 4	3.0	AM_450164
Reflection Seismic for Geologists	Periode 4	6.0	AM_450170
Sediment Petrography of Heavy Minerals	Periode 3	3.0	AM_450058
Sustainable Land Management	Periode 3	6.0	AM_1015
Unsaturated Zone and Near Surface Hydrological Processes	Periode 4	6.0	AM_450021
Volcanism	Periode 3	3.0	AM_450061

MSc GBL - Petroleum Systems & New Energy

Opleidingsdelen:

- MSc GBL, spec. Petroleum Systems year 1
- MSc GBL, spec. Petroleum Systems year 2

MSc GBL, spec. Petroleum Systems year 1

Opleidingsdelen:

- optional courses petroleum, yr 1
- compulsory courses petroleum, yr 1
- MSc GBL, compulsory courses first year

optional courses petroleum, yr 1

Vakken:

Naam	Periode	Credits	Code
Geothermal Energy	Periode 5	6.0	AM_450409

compulsory courses petroleum, yr 1

Vakken:

Naam	Periode	Credits	Code
Diagenesis of Sedimentary Rocks	Periode 5	3.0	AM_450169
Low Temperature Deformations of Rocks and Regions	Periode 5	3.0	AM_450180
Petroleum Resources Module	Ac. Jaar (september)	2.0	AM_450281
Reflection Seismic for Geologists	Periode 4	6.0	AM_450170

MSc GBL, compulsory courses first year

Vakken:

Naam	Periode	Credits	Code

From Source to Sink: Chemical and Physical Cycles	Periode 2	6.0	AM_450146
Introduction Field Excursion	Periode 1	3.0	AM_450229
Mantle Properties in Lithosphere Development	Periode 1	3.0	AM_450225
Orogenesis	Periode 3	6.0	AM_450190
Petroleum Systems and Regional Geology	Periode 1	3.0	AM_450179
Portfolio Geosciences of Basins and Lithosphere	Ac. Jaar (september)	3.0	AM_450193
Research Project GBL I	Ac. Jaar (september)	12.0	AM_1105
Sedimentary Basins	Periode 2	6.0	AM_450154

MSc GBL, spec. Petroleum Systems year 2

Opleidingsdelen:

- optional courses petroleum, yr 2
- compulsory courses petroleum, yr 2
- MSc GBL, compulsory courses second year
- optional modules

optional courses petroleum, yr 2

Vakken:

Naam	Periode	Credits	Code
3D Seismic Interpretation and Production Geology	Periode 1	6.0	AM_450316
Petroleum Geology of the North Sea	Periode 2	7.0	AM_450317
Practical Subsurface Evaluation Workshop	Periode 3	2.0	AM_450277

compulsory courses petroleum, yr 2

Vakken:

Naam	Periode	Credits	Code
Petro-Tecto Field Excursion		3.0	AM_450347

MSc GBL, compulsory courses second year

Vakken:

Naam	Periode	Credits	Code
Field Research Project Geosciences of Basins and Lithosphere	Ac. Jaar (september)	24.0	AM_450195
Master Thesis Geosciences of Basins and Lithosphere	Semester 1	30.0	AM_450271

optional modules

Vakken:

Naam	Periode	Credits	Code
Advanced Geochronology	Periode 5	3.0	AM_450171
Advanced Inorganic Geochemistry	Periode 5	3.0	AM_450172
Capita Selecta Structural Geology and Tectonics	Periode 4	3.0	AM_450144
Diagenesis of Sedimentary Rocks	Periode 5	3.0	AM_450169
Historical Geography	Periode 1	6.0	AM_450292
Low Temperature Deformations of Rocks and Regions	Periode 5	3.0	AM_450180
Magmatic Processes	Periode 4	6.0	AM_450189
Metamorphism and P-T Evolution	Periode 4	6.0	AM_450176
Microstructures in Tectonites	Periode 4	6.0	AM_450158
Palaeo-ecology/Palynology	Periode 3	3.0	AM_450054
Planetary Science	Periode 1+2	6.0	AM_450273
Practical Subsurface Evaluation Workshop	Periode 3	2.0	AM_450277
Precambrian Geology	Periode 4	3.0	AM_450164
Reflection Seismic for Geologists	Periode 4	6.0	AM_450170
Sediment Petrography of Heavy Minerals	Periode 3	3.0	AM_450058
Sustainable Land Management	Periode 3	6.0	AM_1015
Unsaturated Zone and Near Surface Hydrological Processes	Periode 4	6.0	AM_450021
Volcanism	Periode 3	3.0	AM_450061

3D Seismic Interpretation and Production Geology

Vakcode	AM_450316 ()
Periode	Periode 1
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	prof. dr. J. de Jager
Docent(en)	dr. B.P. Zoetemeijer
Lesmethode(n)	Werkcollege

Doel vak
Introduce 3D Seismic interpretation as a subsurface exploration and production tool to find hydrocarbons. Give an overview of workflows in subsurface modelling and highlight dependencies between seismic interpretation and hydrocarbon production.

Inhoud vak
Introduction: seismic interpretation as a step in subsurface modelling for exploration and production of hydrocarbons / Fundamentals of the seismic method / Storage and display of seismic data / Introduction to Petrel software / Simple horizon interpretation
Volume attributes as aid in structural and stratigraphic interpretation / Structural styles / Interpretation of fault planes in 3D / Links to Framework Modelling / 3D visualisation techniques
Seismic resolution / Tying seismic and well data / Techniques for interpretation of continuous reflections / Jump correlation across faults / Techniques for improving interpretability
Large-scale depositional geometries and controlling processes / Interpretation techniques for unconformities and lap surfaces / Direct Hydrocarbon Indicators
Seismic attributes for prediction of reservoir quality and fluid fill / Depth conversion
Introduction to reservoir geology/core description/well correlation/facies interpretation
Building of a static reservoir model in Petrel/ horizon modelling/property modelling/geostatistics
Anatomy of a reservoir/static&dynamic modelling/ FDP/drilling a well

Onderwijsvorm
Lectures on specific topics
Hands-on 3D seismic interpretation using PC-based software
Feed-back sessions with presentations by participants
Exercises on numerical steps in interpretation

Toetsvorm
Written Examination 40%; oral presentation 20%; practical 40%

Overige informatie
Course will be given as a 3 week block course at Shell research in Rijswijk. Course has a limited capacity.

Advanced Geochronology

Vakcode	AM_450171 ()
Periode	Periode 5
Credits	3.0

Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	prof. dr. J.R. Wijbrans
Docent(en)	prof. dr. J.R. Wijbrans, prof. dr. P.A.M. Andriessen, dr. K.F. Kuiper
Lesmethode(n)	Werkcollege

Doel vak
Students who attended this course should have gained knowledge and understanding about
Current developments in high resolution geochronology as applied to
I. the Geological Timescale, and to
II. topography development
Analytical and methodological approaches to constrain these processes as well as the skills to
- Use the acquired knowledge to analyze, compare and explain distinct
- features of processes in which geochronological tools are required.
- Read and critically assess significant literature about these subjects
- Actively participate in group discussions

Inhoud vak
- Assessment of the literature, the rock types, mineral assemblages and their structural features, the isotopic data sets of one well understood orogen (Case history).
- the use of low- , medium and high-temperature thermochronometers
- Astronomical dating of cyclically bedded sediments.
- tephra chronology
- Intercalibration of the Geological Timescale by applying both.

The skills to use the acquired knowledge will be obtained using a case study of one orogen (from microscopic observation to the techniques required to constrain the T- t histories of various domains).

Onderwijsvorm
Lectures (6 * 3 u 45 min), assignments /self-study (6 * 4 hrs)

Toetsvorm
Essay – presentation – poster

Literatuur
Selection literature for individual essay and presentation projects to be announced on Blackboard.

Vereiste voorkennis
BSc Geology

Aanbevolen voorkennis
Petrology, structural geology, tectonics courses at the BSc level.

Doelgroep
1st year MSc Earth Science Solid Earths.

Overige informatie
Guest teachers include dr. J.M. O'Connor, University of Erlangen.

Advanced Inorganic Geochemistry

Vakcode	AM_450172 ()
Periode	Periode 5
Credits	3.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	prof. dr. G.R. Davies
Docent(en)	dr. P.Z. Vroon, prof. dr. G.R. Davies, prof. dr. W. van Westrenen, dr. L. Font Morales
Lesmethode(n)	Werkgroep

Doel vak
Our main aim is two-fold. First, to present an overview of the state-of-the-art in geochemical research. After this course you should be aware of the major problems that are being tackled right now by geochemists, the techniques they use, and some of the major advances that have been made in the areas discussed over the past couple of years.Second, to introduce you to the skill of reviewing and marking academic work.

Inhoud vak
Topics covered include planetary core formation, volatiles in subduction zones, geochemical tracing, and geochemical techniques applied to art history and renovation.

Onderwijsvorm
Most sessions consist of lectures introducing you to several ‘hot topics’ in advanced geochemistry. The information you receive in these lectures is meant to provide the background needed to understand and critically assess recent high-impact publications that we have selected in these active research areas. Lectures are generally relatively short, leaving sufficient time for discussion and self-study of these papers (and other relevant papers on the same topic that you find). The course also includes a visit to the laboratories of the Rijksmuseum.

In addition, at the start of the course students are divided into groups of two. Each group will be allowed to choose one of the topics covered in the course. Each member of each group has 10 days to individually prepare:(1) a 200-word abstract on the paper / topic (i.e. what is the problem or controversy; what data are used).(2) a 3-page essay on the topic that discusses the major arguments in the subject region.(3) a Powerpoint presentation on the topic (maximum length 15 minutes, maximum 15 slides).You will then provide feedback on the performance of your colleague, and jointly prepare a final presentation.

The work load of this course given in SBU is (1) 5 * 70 minutes lectures + museum visit = 18 SBU, (2) 5 * 2.5 hours reading and discussing publications = 30 SBU; Preparation of abstract, essay, presentation, and review of colleague’s work = 32 SBU. Total 80 SBU = 3 ECTS

Toetsvorm
The mark you obtain for this course consists of the following components: preparation of abstract (15%), essay (20%), and first draft of presentation (10%); your review of essay and presentation of a colleague (25%), and the final presentation (30%).

Literatuur

As we aim to discuss hot-off-the-press research, papers to be discussed are not known until the week before the start of the course.

Vereiste voorkennis
This is the highest level petrology- geochemistry course so a good understanding of petrology and particularly geochemistry is required. Completion of second and third year BSc. level petrology and geochemistry courses is required and it is strongly advised that "mantle properties in lithospheric development" and one of "magmatic process or metamorphic petrology" (or equivalents at other universities) have been completed successfully.

Aanbevolen voorkennis
The Mantle Properties in Lithosphere Development and Magmatic Processes courses provide useful backgrounds in isotope geochemistry.

Doelgroep
Second year MSc students in Earth Sciences.

Overige informatie
Guest lecturers include Dr. Robert van Langh (Rijksmuseum) and Dr. Gerard van der Peijl (Netherlands Forensics Institute). Additional lecturers from the VU may be involved, depending on the time of arrival of new postdoctoral researchers.

Advanced Petroleum Geology

Vakcode	AM_GEO364 ()
Credits	5.0
Faculteit	Fac. der Aard- en Levenswetenschappen

Capita Selecta Structural Geology and Tectonics

Vakcode	AM_450144 ()
Periode	Periode 4
Credits	3.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. B.P. Zoetemeijer
Docent(en)	dr. B.P. Zoetemeijer, dr. E. Willingshofer
Lesmethode(n)	Hoorcollege

Doel vak
To be able to link geological and geophysical data sets of various scales to viable concepts in Earth Sciences, thereby conveying the understanding of processes which are involved in the deformation of the lithosphere.

Inhoud vak
Students have to choose a topic for their self- study about which they have to hand in a written report and give a concise oral presentation. Topics are provided during the first session and cover certain aspects of a general theme, which may vary on a yearly basis. Themes may cover

aspects which are important for the tectonic evolution of particular regions like the Alps or may cope with process-oriented issues like different modes of extension etc. The results of the self studies will be presented and discussed in the group. A period of ~ 4 weeks is given for preparing the presentation and the report. Relevant literature will be partly provided.

Onderwijsvorm
Combined; presentation and discussion meetings (~5 x 3hrs), self study, written and oral presentations.

Toetsvorm
Student paper (50%) and oral presentation (50%)

Overige informatie
This course is not offered in 2013/2014.

Diagenesis of Sedimentary Rocks

Vakcode	AM_450169 ()
Periode	Periode 5
Credits	3.0
Voertaal	Engels
Coördinator	dr. H.B. Vonhof
Docent(en)	dr. H.B. Vonhof
Lesmethode(n)	Computerpracticum

Doel vak
• To recognize the diagenetic processes and products.
• To familiarize yourself with the most common analytical techniques that are relevant for the study of the diagenetic history and the fluid flow pattern of reservoir rocks.
• To understand the link between diagenesis and rock properties.
• To gain an overview of applications of diagenetic studies in oil industry.

At the end of this course, you should be able to:
• Characterize paleoenvironments during and just after the deposition of sediments.
• Understand sedimentary basin evolution (burial, fluids circulation) through time.
• Predict quality of carbonate reservoirs.

Inhoud vak
The course will cover carbonates and their diagenetic products and is concerned primarily with the preservation potential of the main carbonate and detrital phases under marine, meteoric and burial diagenetic settings. As a consequence, the porosity evolution in sedimentary rocks will be of relevance to this course. This has both fundamental and applied aspects. The course will involve theoretical knowledge as well as case studies.

Onderwijsvorm
Classes and microscope practical

Toetsvorm
Written exam (70%) report of prcatical (30%)

Literatuur
Course notes and handout

Vereiste voorkennis
Students are expected to have bachelor-level knowledge of:
• (carbonate) sedimentology
• stable isotope geochemistry
• petroleum geology

Field Excursion Deep Processes

Vakcode	AM_1034 ()
Periode	Periode 1
Credits	3.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	prof. dr. G.R. Davies

Field Excursion Petroleum Systems / Basin Formation

Vakcode	AM_1035 ()
Periode	Periode 1
Credits	3.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. G.V. Bertotti

Doel vak
The goal of this course to provide advanced and hands-on knowledge of how to read the sedimentological and structural record of outcropping rocks to produce a quantitative reconstruction of sedimentary basin formation and deformation.

Inhoud vak
The course takes place as a field excursion and is essentially organized in a limited number of "exercises" where the students are asked to solve a geological problem of general importance by gathering and interpreting data from the field. The "exercises" will take place in different geological parts of the same system allowing eventually for larger scale correlation and integration.

Onderwijsvorm
The course is composed of a 8-10 days excursion preceded by preparatory sessions.

Toetsvorm
The end result will be composed of three components, a presentation to be given during the excursion (15%), an assessment of the field book (40%) and a final exam carried out either during the last day of the excursion or immediately after (40%)

Doelgroep
Master students, 2nd year (or 1st year with permission of the organisers)

Field Research Project Geosciences of Basins and Lithosphere

Vakcode	AM_450195 (450003)
Periode	Ac. Jaar (september)
Credits	24.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. B.P. Zoetemeijer
Docent(en)	dr. B.P. Zoetemeijer
Lesmethode(n)	Bijeenkomst

Doel vak
Development, planning and carrying out fieldworkor scientific research and reporting the results. The main aim of fieldwork on the methodological side is to bring the students in a state where they are efficient managers of their field time. Because of its limited duration, an efficient use of fieldwork time is of crucial importance. An efficient fieldwork is one where the largest amount of relevant and good quality information is gathered. Both concepts of relevance and good quality cannot be defined in absolute terms and depend on the scientific problem being addressed. Only a thorough understanding of the tackled issues (academic or not) and its continuous update under the light of the new data being collected allows for identification of the relevant information to be obtained and the level of accuracy required.

Inhoud vak
The Field Research Project will allow students to develop their own scientific questions based on field observations into small- scale research projects. These projects will include the usual stages of planning and preliminary literature research (1 or 2 weeks), the fieldwork (2 or 4 weeks), the research itself (2 or 4 weeks) and reporting the results (2 or 4 weeks). The research topic can be in any of the Master's programme's disciplines and include numerical and laboratory analyses.

Onderwijsvorm
Fieldwork, laboratory work

Toetsvorm
Written report

Vereiste voorkennis
This course is only accessible to students who:
have earned their bachelor's degree, and;
have earned at least 12 EC in the master specialisation programme concerned, as registered by the student administration on March 1st. Otherwise, admission is possible only when granted by the Examination Board.

Overige informatie
The Field Research Project is subject to the school's Work placement and thesis regulations (stage- en scriptieregeling). These regulations require detailed written agreements between supervisor and student that specify the conditions for the research project. This agreement should be put forward to the master co-ordinator (dr B. P. Zoetemeijer) before the start of the project.

From Source to Sink: Chemical and Physical Cycles

Vakcode	AM_450146 ()
Periode	Periode 2
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. M. ter Voorde
Docent(en)	dr. M. ter Voorde
Lesmethode(n)	Werkcollege, Computerpracticum
Niveau	400

Doel vak
After having attended this course, the student should have gained knowledge and understanding about
- The interplay of (physical) mechanisms responsible for landscape evolution
- The relative importance and the mutual interaction between these processes
- The methods to put constraints on these processes from geological data, and the strength and limitations of these methods
as well as the skills to
- Read and critically assess significant literature about these subjects
- Actively participate in (oral) discussions about these subjects
- Judge research methods applied on this subject critically on their merits and weak points
- Compare and/or combine the results of different studies.

This implies that the course is not mainly focused on acquiring new knowledge, but especially on using, integrating and reflecting on the things you may have learned before.

Inhoud vak
This course deals with the parameters regulating the production, transfer and storage of sediments and solutes from their sources to their sinks, addressing short-term and long-term landscape evolution and sustainability. It covers the linked processes of tectonics, weathering, erosional systems (fluvial, glacial, marine) and climate changes, including ‘real-world’ examples on the SE Netherlands, the Ardennes, the Pyrenees and western Scandinavia, as well as the methods to constrain these processes (e.g. provenance studies and thermochronology). Lecturers from a variety of disciplines will teach the student how to view these topics from various backgrounds.

Onderwijsvorm
Lectures, exercises, literature study. A selected set of papers will be used for a 'PhD- defense'-role play. In addition, numerical modelling of

topography development will be carried out by the students.
Aantal contact-uren: 45 (inclusief tentamen)

Toetsvorm
Exam (45%), essay (20%), computer-practicum report (10%) PhD-defense-"game"(25%).

Literatuur
• Book:
Tectonic Geomorphology, D.W. Burbank and R.S. Anderson, 2nd edition, 2011. John Wiley & Sons, 320 pp.

Papers:
• Noller et al., Introduction to Quaternary geology
• Matenco et al., (2013) Quantifying the mass transfer from mountain ranges to deposition in sedimentary basins: Source to sink studies in the Danube Basin–Black Sea system (Global and Planetary Change)
• More papers, to be used for the exercises, will be made available via Blackboard

Doelgroep
Masterstudents GBL, Earth Sciences Solid Earth, Earth Sciences AEG, Earth Sciences Paleoclimate and Geo-ecosystems

Geodynamics and Basin Modelling

Vakcode	AM_GEO254 ()
Credits	10.0
Faculteit	Fac. der Aard- en Levenswetenschappen

Geothermal Energy

Vakcode	AM_450409 ()
Periode	Periode 5
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. M.P. Bokhorst
Lesmethode(n)	Hoorcollege, Computerpracticum
Niveau	400

Doel vak
• To provide students with an overview of the current status and future outlook of geothermal exploration and production (heat/cold and electricity)
• To assess its impact in the energy-transition challenge, being a major alternative source for renewable energy.
• To provide insight into the energetical and economical aspects of different ways to supply thermal energy to buildings and processes.
• To review main categories of operational geothermal systems, the governing processes and relevant boundary conditions, linking hydrogeology to subsurface understanding
• To assess exploration concepts of geothermal prospecting and see

how they can be applied to future subsurface analysis and energy supply prediction
An additional practical aim is to improve your communication and writing skills.

Inhoud vak
This course provides a comprehensive overview of existing systems that are used to supply thermal energy to buildings and/or industrial processes. The course starts with a general introduction to the history of geothermal exploration and production, what kind of geothermal systems exist, and how these are linked to particular subsurface and economical conditions. In addition it is explained what benefits of geothermal energy exist compared to other energy resources. Subsequently different aspects are explained in more detail. We will first
concentrate on the demand side, by showing how the heat and cold demand of a building can be provided by different types of energy systems and how the economical aspects of the different options relate. Later on we will focus on the hydrogeological parameters that contribute to successful geothermal systems. This is achieved through a review of several such systems, including borehole heat exchangers (closed loop systems), aquifer thermal energy storage (ATES or open loop systems) and systems for the production of deep geothermal heat for heating and/or electricity production (enhanced geothermal systems). Special emphasis is placed on the relation of subsurface conditions and operational excellence.
During the course the students are put in the role of consultants that have to choose an optimal solution for the customer. A business case is build in which different geothermal options have to be considered and compared to a conventional solution for climate control in the buildings concerned.

Onderwijsvorm
The course uses two different methods:
Oral lessons in the form of lectures and tutorials/seminars (distributed equally) where various topics are presented by the lecturer and discussed in common with the students. Students must be aware that the content of this course is difficult to find in one-two textbooks. Therefore, understanding the handouts is essential. Our advice is to attend the oral lessons during class hours. Further students are expected to read and present material from selected papers in a short presentation and abstract.
Practical lessons: this course includes a number of practical exercises and a few case studies. Exercises and case studies will be worked out individually and in small groups and discussed in class. The rule of thumb: this is individual work, unless otherwise specifically noted.

Toetsvorm
The final mark is made up of assignments (10%), a presentation, an excursion(10) and a 1-page abstract of relevant paper(s) (10%) and case studies (70%).
The practicals and case studies will cover the topics presented during the course.

Literatuur
All materials will be digitally provided through Blackboard

Vereiste voorkennis

To facilitate a rapid in- depth study at MSc level, students are required to know in advance basic notions of hydrogeology (groundwater flow, impact of wells on hydraulic head) which were already studied during their BSc curriculum. Furthermore sufficient knowledge of mathematics and MS Office (Excel) is required.

Overige informatie
Students are on a steep learning curve of integrated techno-economic-policy concepts. Mental alertness and the flexibility are therefore essential to gaining maximum benefit from the course!
Update (Sept 10 2013): This course is not offered in 2013/2014. The next opportunity to follow this course will be spring 2015.

Historical Geography

Vakcode	AM_450292 ()
Periode	Periode 1
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. A.M.J. de Kraker
Docent(en)	dr. A.M.J. de Kraker
Lesmethode(n)	Werkgroep, Excursie
Niveau	500

Doel vak
Student will be skilled in analysing the development of at least four different cultural landscapes over a longer time scale and assessing relevance of both the buried and still visible aspects of the cultural landscape today by giving four presentations and delivering one paper.

Inhoud vak
This master course deals with the interaction of man and his physical environment in the Low Countries (Belgium and the Netherlands) and adjacent countries on a time scale of the recent two thousand years. During this period man has had an impact on his environment by reclamation, various kinds of land use and changing its hydrology. At the same time natural conditions, such as geological, hydrological and paedological conditions, but also climate, continued to have an impact on the social, economic and political organization of local communities. How did societies of the past adapt to these changes and become resilient? As a consequence the natural landscape(s) evolved into several distinctive cultural landscapes.
During classes and two fieldtrips three distinctive landscapes of the Low Countries and adjacent European countries, their main characteristics and how they have evolved during the recent 2,000 years will be highlighted. These landscapes are: sandy soil region, clay soil region and the peat areas. A fourth landscape will be subject of self tuition and may be chosen from the Low Countries or from a wider European context in order to complete the masters.

Onderwijsvorm
Study group (8-10 h), working class (4 h), preparing four presentations (4x15 h), two whole day fieldtrips (16 h), writing paper (20 h) reading literature (40-50 h)

Toetsvorm
presentations (25%) and final paper (75%)

Literatuur
Reader's content: nrs. A-J are not compulsory

1. Zagwijn, W.H. (1994) Reconstruction of climate change during the Holocene in western and central Europe based on pollen records of indicator species. Vegetation History and Archaeobotany, 3, 65-88.
2. Bieleman, J. (1985) Rural change in the Dutch province of Drenthe in the seventeenth and eighteenth centuries. Agricultural History Review vol. 33, part II, 105-117.
3. Roessingh, H.K. (1979) Tobacco growing in Holland in the seventeenth and eighteenth centuries: a case study of the innovative spirit of Dutch peasants. Acta Historiae Neerlandica XI, 18-54.
4. Bieleman, Jan (1993) Dutch agriculture in the Golden Age, 1570-1660. In: Karel Davids & Leo Noordegraaf (eds) The Dutch economy in the Golden Age. Nine studies. Nederlandsch Economisch-Historisch Archief, Amsterdam, 159-183.
5. Dejongh, Guy and Erik Thoen (1999), Arable productivity and the former territory of Belgium in a long-term perspective (from the Middle Ages to the end of the Ancien Régime). In: Bavel, Bas J.P. van, & Erik Thoen (eds) Land productivity and agro-systems in the North Sea area (Middle Ages - 20th century). Elements for comparison. Comparative rural history of the North Sea area, vol. 2. Turnhout, 30-64.
6. Comet, Georges (1997), Technology and agricultural expansion in the middle ages, the example of France north of the Loire. In: Grenville Astill & John Langdon (eds) Medieval farming and technology. The impact of agricultural change in Northwest Europe, Leiden, 11-40.
7. Raepsaet, Georges (1997) The development of farming implements between the Seine and the Rhine from the second to the twelfth centuries. In: Grenville Astill & John Langdon (eds) Medieval farming and technology. The impact of agricultural change in Northwest Europe, Leiden , 41-68.
8. Thoen, Erik (1997) The birth of "the Flemish husbandry": agricultural technology in medieval Flanders. In: Grenville Astill & John Langdon (eds) Medieval farming and technology. The impact of agricultural change in Northwest Europe, Leiden, 69-88.
9. Hoppenbrouwers, Peter (1997), Agricultural production and technology in the Netherlands, c. 1000-1500. In: Grenville Astill & John Langdon (eds) Medieval farming and technology. The impact of agricultural change in Northwest Europe, Leiden, 89-115.
10. Uhlig, H. (1961) Old hamlets with infield and outfield systems in western and central Europe. Geografiska Annaler 43, 285-312.
11. Uhlig, Harald (1971) Field and field systems. In: R.H. Buchanan et all (eds) Man and his habitat. Essays presented to Emyr Estyn Evans. London, 93-125.
12. Thoen, Erik (2001), A Commercial survival economy in evolution. The Flemish countryside and the transition to capitalism (Middle Ages – 19th century)
13. Hoppenbrouwers, Peter and Jan Luiten van Zanden (2001), Peasants into farmers? The transformation of rural economy and society in the Low Countries (Middle Ages -19th century) in the light of the Brenner debate. Corn Publication Series 4. Brepols Turnhout.
14. Brenner, Robert P. (2001) The Low Countries in the transition to capitalism....
A) Ven, G.P. van de (ed)(1993) Man-made lowlands. History of water management and land reclamation in the Netherlands. Matrijs, Utrecht.

(available in O-442)
B) Lambert, Audry M. (1985) The making of the Dutch landscape. An historical geography of the Netherlands. Academic Press. London etc. 2nd ed. (available in some photocopies in O-442)
15. Roessingh, H.K. (1970) Village and hamlet in a sandy region of the Netherlands in the middle of the 18th century. An application of the Guttman scalogram technique to socio-historical research. Acta Historiae Neerlandica IV, 105-129.
16. Smeerdijk, Dirk G. van, Theo Spek & Marja J. Kooistra (1995) Anthropogenic soil formation and agricultural history of the open fields of Valthe (Drenthe, the Netherlands) in mediaeval and early modern times. Mededelingen Rijks Geologische Dienst 52, 451-479.
17. Spek, Theo (1992) The age of plaggen soils. An evaluation of dating methods for plaggen soils in the Netherlands an Northern Germany. In: A. Verhoeve & J.A.J. Vervloet (eds) The transformation of the European rural landscape. Brussel, 72-91. Also published as Wageningen Studies in Historical Geography 1, Report 66, 72-130. Wageningen.
17a. Spek, Theo (2004) Het Drentse esdorpenlandschap. Een historisch-geografische studie. Stichting Matrijs-Utrecht, 3 vols, only the summary.
18. Spek, Theo Interactions between Humans and Woodland in Prehistoric and Medieval Drenthe (The Netherlands): an Interdisciplinary Approach. In: Kirby K.J. and C. Atkins (eds), The Ecological History of European Forests, 81- 95.
19. Heidinga, H.A. (1987): Kootwijk and his neighbours: settlement territories on the Veluwe since the Early Middle Ages. In: Medieval Settlement and Economy North of the Lower Rhine. Archeology and history of Kootwijk and the Veluwe (the Netherlands). Cingula 9. Van Gorcum, Assen/Maastricht, 153-174.
20. Slicher van Bath, B.H. (1965) The economic and social conditions in the Frisian districts from 900 to 1500. In: A.A.G. Bijdragen, Wageningen, no. 13, 97-134.
21. Behre, Karl-Ernst (2004) Coastal development, sea-level change and settlement history during the later Holocene in the Clay District of Lower Saxony (Niedersachsen), northern Germany. In: Quaternary Journal, 112, 37-53.
C) Vollmer, Manfred, Mette Guldberg, Matthias Maluck, Dré van Marrewijk & Gregor Schlickbier (2001) Lancewad. Landscape and Cultural Heritage in the Wadden Sea Region. Project Report. Wadden Sea Ecosystem No. 12. Common Wadden Sea Secretariat, Wilhelmshaven. (available at VU library)
D) Fokkens, Harry (1998) Drowned landscape. The occupation of the western part of the Frisian-Drentian Plateau, 4400 BC - AD 500. Assen/Amersfoort. (available in O-442)
22. Geel, B. van, D.P. Hallewas and J.P. Plas (1982/1983) A Late Holocene deposit under the Westfriese Zeedijk near Enkhuizen (Prov. of Noord-Holland, The Netherlands) Palaeoecological and Archaeological aspect. In Review of Palaeobotany and Palynology, 38, 269-335.
23. Geel, B. van and G.J. Borger (2005), Evidence for medieval salt/making by burning Eel-grass [Zostera marina L.] in the Netherlands. In: Netherlands Journal of Geosciences, 84-1, 43-49.
24. Ervynck, Anton, Cecile Baeteman e.a. (1999) Human occupation because of a regression, or the cause of a transgression? A critical review of the interaction between geological events and human occupation in the Belgian coastal plain during the first millennium AD. Probleme der Küstenforschung im südlichen Nordseegebiet 26, 97-121.
25. Baeteman, Cecile (2005) How the subsoil morphology and erodibility influence the origin and pattern of late Holocene tidal channels: case studies from the Belgian coastal lowlands. In: Quaternary Science

Reviews, 24, 2146-2162.
E) Vos, P.C., & R.M. van Heeringen (1997) Holocene geology and occupation history of the Province of Zeeland. In: M.M. Fischer (ed) Holocene evolution of Zeeland (SW Netherlands), Haarlem, 5-109. (available in photo copy in O-442)
26. Bult, E.J., & D.P. Hallewas (1990) Archaeological evidence for the early-medieval settlement around the Meuse and Rhine deltas up to ca AD 1000. In: J.C. Besteman e.a. (eds) Medieval archaeology in the Netherlands. Assen, 71-90.
27. Ven, Gerard van de (1996), The Netherlands and its rivers. In: Tijdschrift voor economische en sociale geografie, 87, 364-370.
F) Hesselink, Annika.W (2002), History makes a river. Morphological changes and human interference in the river Rhine. The Netherlands. Netherlands Geographical Studies no. 292. Dissertation Utrecht. (available in O-442)
28. Pons, L.J. (1992) Holocene peat formation in the lower parts of the Netherlands. In: J.T.A. Verhoeven (ed) Fens and bogs in the Netherlands: vegetation, history, nutrient dynamics and conservation. Geobotany 18, 7-79.
29. Borger, G.J. (1992) Draining-digging-dredging; the creation of a new landscape in the peat areas of the Low Countries. In: J.T.A. Verhoeven (ed) Fens and bogs in the Netherlands: vegetation, history, nutrient dynamics and conservation. Geobotany 18, 131-171.
30. Londen, Heleen van (2001) Landscape and water management: Midden-Delfland, a region south of the Limes. In: Thomas Grünewald (ed) Germania inferior. Besiedlung, Gesellschaft und Wirtschaft an der Grenze der römisch-germanischen Welt, Berlin/New York, 169-184.
G) TeBrake, William H. (1985) Medieval frontier. Culture and ecology in Rijnland. Texas A&M University Press. (available in O-442)

31. Besteman, J.C. (1990) North Holland AD 400-1200: turning tide or tide turned? In: J.C. Besteman e.a. (eds) Medieval archaeology in the Netherlands. Assen, 91-120.
32. Hallewas, D.P. (1981) Archaeological cartography between Marsdiep and IJ. In: Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek 31, 219-272.
H) Henderikx, Peter A. (1988) The lower delta of the Rhine and the Maas: landscape and habitation from the Roman period to c. 1000. In: Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek 36, 1986, 447-599. (available in O-442)
33. Dam, Petra J.E.M. (2001) Sinking Peat Bogs. Environmental Change in Holland, 1350-1550 In: Environmental History, vol. 6. 1. 32-46.
34. Engelen, A.F.V., J. Buisman and P. IJnsen (2001), A millennium of weather, winds and water in the Low Countries. In: P.D. Jones, A.E.J. Ogilvie, T.D. Davies and K.R. Briffa, History and Climate. Memories of the Future? Kluwer Academic/Plenum Publishers, New York, Boston, Dordrecht, London, Moscow, 101-124.
35. Pfister, Chr. and Rudolf Brázdil (1999), Climate variability in sixteenth century Europe and its social dimensions. A Synthesis. In: Climatic Change, 43, 5-53.
36. Kraker, A.M.J. de (1999), A method to assess the impact of high tides, storms and storm surges as vital elements in climatic history. The case of stormy weather and dikes in the northern part of Flanders, 1488 to 1609. In: Climatic Change, 43, 287-302.
37. Ogilvie, Astrid and Graham Farmer (1997), Documenting the medieval climate. In: Mike Hulm and Elaine Barrow (eds.) Climates of the British Isles, Routledge London and New York, 112-134.
I) Crone, G.R. (1978) Maps and their makers: an introduction to the history of cartography. Haarlem.

J) Tooley, R.V. (1978) Maps and map-makers. London.

Aanbevolen voorkennis
Bachelor Earth and Life Sciences / Bachelor Aarde & Economie, Bachelor Archeaology

Integrated Interpretation of Seismic and

Vakcode	AM_GEO372 ()
Credits	5.0
Faculteit	Fac. der Aard- en Levenswetenschappen

Introduction Field Excursion

Vakcode	AM_450229 ()
Periode	Periode 1
Credits	3.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	prof. dr. J.J.G. Reijmer
Docent(en)	dr. G.V. Bertotti, dr. F.M. Brouwer, prof. dr. J.J.G. Reijmer
Lesmethode(n)	Veldwerk

Doel vak
The aim of this course is to familiarise students with the multidisciplinary aspects of studying geological processes, using different kinds of local observations that can be synthesised to generate larger scale insights. This approach is illustrated by looking at the coupling between orogenic cores and sedimentary basins as part of the dynamic lithosphere.
Another objective of the course is to orient students in tackling phenomenological observations derived from particular natural laboratories. It is the aim to make students familiar with the principles of 'problem-based learning techniques' by making field observations.

Inhoud vak
The excursion follows a transect through the Eastern Alps. The excursion addresses a range of inter-related tectonic, petrological and sedimentary processes. Students will consider these processes directly in front of the outcrops, and through extended discussions during the evenings. The students learn to understand the nature, structure and evolution of the Eastern Alps and train critical thinking and communication skills in group discussions and individual presentations.

Onderwijsvorm
7-day field programme and evening sessions

Toetsvorm
Active participation in the field surveys and discussions / presentations during the evening sessions Information written down in the field note books will be evaluated and their overall evaluation will be part of the exam (20%). A written examination is scheduled after our

return to Amsterdam.

Literatuur
Excursion guide and possibly selected additional publications from the scientific literature

Doelgroep
Compulsory for students starting MSc Geosciences of Basins and Lithosphere and MSc Earth Sciences - Solid Earth stream

Overige informatie
Admission is only granted to bachelor students who have earned at least 150 EC in the bachelor's programme. Admission requirements are checked by the examination board on July 1st. Participants should register in time (before July 1st) using VUnet and should notify the responsible staff by e-mail. Rules concerning the deadline for subscription and having proper mountain equipment will be strictly enforced. Due to field logistics, the excursion may start a few days earlier than the official start of the academic year. The final dates will be announced before May 1st.

Low Temperature Deformations of Rocks and Regions

Vakcode	AM_450180 ()
Periode	Periode 5
Credits	3.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. G.V. Bertotti
Docent(en)	dr. G.V. Bertotti
Lesmethode(n)	Werkcollege

Doel vak
The course focuses on the deformation of rocks and regions in the Earth's upper crust, that is, in the brittle domain.

The main goal of the course is to provide students the skills to interpret relevant data and use them to predict deformation patterns at various scales and establish relations with causative stress fields.

Students are expected to acquire the following skills
- Predict stress fields of regions and specific structures such as folds and faults given specific boundary conditions and data points;
- Predict patterns of deformations in various domains at different spatial scales;
- Interpret the geological record to derive stress- strain conditions during deformation;
- Use observation to derive predictions for the deformation and general physical properties of larger regions.

Inhoud vak
The course is organized in four blocks dedicated to four different topics, together covering the most important issues of low temperature deformation of rocks and regions. The blocks focuses on:
- The structural geology, architecture and mechanics of faults

- Folding and fracturing
- Geometry, kinematics and mechanics of large scale contractional structures
- An issue with societal relevance such as, for instance, the earthquakes associated with the extraction of hydrocarbons or other.
In a further session, the results of the practical works are presented and discussed.
In all these components, a special attention will be dedicated to connections between small scale observations and large scale tectonics

Contact hours:
Lectures: 3 hours
Practicals: 12 hours

Onderwijsvorm
The course will have a "hands-on" approach typically starting with the analysis of real world data and then deriving general knowledge. Following a short introduction, the students will split in small groups and work through the practicals following a road-map prepared by the lecturer. At the end, they are required to prepare a schematic report of the results they have reached.

During these activities, students are accompanied by the lecturer who will also take the opportunity of presenting specific theoretical issues.

Toetsvorm
Students will work in small groups to tackle specific topics and/or case studies. Reports on the practical works are compulsory. Results will be presented and subjected to general discussion. Reports will be graded. The final grade results from these reports. The possibility of a final exam (oral or written) is kept open and will be decided at the beginning of the course.

Literatuur
Structural Geology by H. Fossen – Cambridge University Press

Material in the form of a comprehensive hand-outs and selected publications will be provided on Blackboard.

Magmatic Processes

Vakcode	AM_450189 ()
Periode	Periode 4
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	prof. dr. G.R. Davies
Docent(en)	dr. P.Z. Vroon, prof. dr. G.R. Davies, prof. dr. W. van Westrenen, dr. J.M. Koornneef
Lesmethode(n)	Werkcollege

Doel vak
The main aim of the course is to provide an overview of the geochemical structure and evolution of the Earth’s interior. After this course you

are able to (1) understand the interaction between physical and chemical processes in the Earth’s interior,(2) select geochemical tools to solve problems regarding melting and chemical evolution of the Earth’s interior, (3) understand why and how trace elements are fractionated between mantle minerals and melt,(4) describe how different mantle components evolved isotopically over time. An emphasis will be placed on improving data handling using Excel, scientific writing, oral presentation, and critical assessment.

Inhoud vak
Distribution of major and trace elements between solid and liquid phases; geochemical modeling of magmatic differentiation processes. Radiogenic and stable isotopes as tracers of magmatic processes: geochemical and temporal evolution of crust and mantle. The physics of magmatic processes: source, transport, emplacement/eruption. Characteristics of the principal geodynamic environments and their effects on magmatic processes.

Onderwijsvorm
Lectures with associated class and home work exercises; preparation of a student paper and its oral presentation, including critical interaction between staff and students. The course counts for 6 ECTS = 160 SBU which are divided between the different components of this course in the following way (1) 12 * 3 hour lectures = 108 SBU, Presentation and essay = 28 SBU, Homework exercises = 24 SBU, Total 160 SBU = 6 ECTS

Toetsvorm
The mark you obtain for this course consists of the following components:Homework exercises (20%), Paper and its presentation (40%), Written exam (40%)

Literatuur
Selected specialist literature papers include Blundy J, Wood B (1994) Nature 372, 452-454.

Blundy J, Wood B (2003) Earth and Planetary Science Letters 210, 383-397. A full list of literature required for the preparation of essays and presentation will be provided at the start of the course.

Vereiste voorkennis
The Mantle Properties in Lithosphere Development course (code AM_450156) is mandatory for the Magmatic Processes course.

Aanbevolen voorkennis
The BSc Earth Science course "Inleiding in de Anorganische Geochemie" (AB_450336) is not required, but contains a broad overview of many of the basic isotopic systems which will be discussed in the Magmatic Processes course. If you are not familiar with the contents of the BSc course "Inleiding in de Anorganische geochemie", then you should read the handouts provided on Blackboard.

Doelgroep
First year MSc students in Earth Sciences

Mantle Properties in Lithosphere Development

Vakcode	AM_450225 ()

Periode	Periode 1
Credits	3.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	prof. dr. W. van Westrenen
Docent(en)	prof. dr. G.R. Davies
Lesmethode(n)	Werkcollege

Doel vak
The main aim of this course is to make you appreciate that heat and its transport provide a fundamental link between processes at the Earth's surface (such as large-scale deformation, orogenesis, basin and lithosphere formation, and rifting), and processes in the deeper parts of the Earth (such as convection and partial melting). An additional practical aim is to improve your communication and writing skills.

Inhoud vak
In this course we will (1) Provide you with an up-to-date overview of what seismology, petrology, and mineral physics tell us about the properties of and processes in the Earth's interior. (2) Clarify the links between heat, pressure, mineral properties, density variations, and observed seismic structure of the mantle. (3) Discuss the role of these and the importance of water in lithosphere-mantle interactions (specifically at rifting and subduction zones).

Onderwijsvorm
Lectures with associated class and home work exercises; preparation of a student paper and its oral presentation wherein a critical assessment of two competing models is discussed. The course counts for 3 ECTS = 80 SBU, which are divided between the different components of this course in the following way (1) 6 * 3 hour lectures = 54 SBU, (2) Preparing resentation and 1-page abstract = 16 SBU (3) Two homework exercises = 10 SBU, total 80 SBU = 3 ECTS

Toetsvorm
The final mark you are given for this course consists of the following components: (1) Two homework exercises (25%); Presentation and 1-page abstract (35%); Written exam (40%)

Literatuur
Literature references that are required background reading will be provided on Blackboard at the start of the course.

Aanbevolen voorkennis
Students should have a basic understanding of global geophysics, mineralogy and petrology, as presented in the textbook of Klein and Philpotts (2013) Earth Materials.

Doelgroep
First year MSc students Earth Sciences, tracks Solid Earth, and First year MSc students GBL

Master Thesis Geosciences of Basins and Lithosphere

Vakcode	AM_450271 ()

Periode	Semester 1
Credits	30.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. B.P. Zoetemeijer

Doel vak
Improvement of scientific research skills, reporting results

Inhoud vak
As in the Field Research Project (450195), the student will be enabled to independently perform scientific research, either at VU University or at another university. Alternatively, the Master Thesis can be used as a work placement at a company in the field of basin research.

Onderwijsvorm
The Master Thesis is a research project or work placement in research-oriented industry, or public, or private sector.

Toetsvorm
The master programme will be concluded with a Master thesis, which consists of a written report, in the style of an international journal article.

Vereiste voorkennis
This course is only accessible to students who:
have earned their bachelor's degree, and;
have earned at least 36 EC in the master specialisation programme concerned, as registered by the student administration on March 1st. Otherwise, admission is possible only when granted by the examination board.

Overige informatie
The Master Thesis is subject to the school's Work placement and thesis regulations (stage- en scriptieregeling). These regulations require detailed written agreements between supervisor and student that specify the conditions for the Master thesis work placement or research project. This agreement should be put forward to the examination board (mrs. M. Wolters) before the start of the work placement or research project.
The master thesis work placement or research project may be extended by a volume of 6 EC using the optional subject 'Extension Master Thesis GBL' (450272).
Information on Master thesis projects is provided by departmental lecturers and is made available on the departmental pages of the Faculty website.

Master's Thesis in Geoscience

Vakcode	AM_GEO399 ()
Credits	30.0
Faculteit	Fac. der Aard- en Levenswetenschappen

Metamorphism and P-T Evolution

Vakcode	AM_450176 ()
Periode	Periode 4
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. F.M. Brouwer
Docent(en)	prof. dr. J.R. Wijbrans, dr. F.M. Brouwer
Lesmethode(n)	Werkcollege

Doel vak
Gain a sufficient understanding of the theoretical basis of metamorphism (i.e. chemical thermodynamics) for the calculation of phase equilibria in open and closed systems for common non-metamorphic protoliths. This approach will be the basis for critically assessing PTt paths and; hence deriving the implications for geodynamic processes preserved in metamorphic rocks. Learning the basics of phase equilibrium modelling using Thermocalc, TheriakDomino and/or Perple_X. Expand skills in optical microscopy as applied to metamorphic rocks.

Inhoud vak
Metamorphic phase equilibria, their variance and calculation; theoretical (chemographic) analysis of assemblages and reactions; element distribution between minerals; recognition of stable assemblages and of reactions in rocks. Role of fluid phases. Metamorphism of pelitic sediments, carbonate rocks and mafic (igneous) rocks. Geothermobarometry and PT- paths. Diffusion mechanisms and the concept of closure temperature as pertaining to geochronology of metamorphic processes. Critical assessment of PTt- data. Relation between PTt- paths and geodynamic processes.

Onderwijsvorm
Lectures with associated class- and homework and tutorial seminars. Three 15- to 30-minute written tests to help keep track of your progress. Practicals: microscopy, chemographic analysis, calculation of phase equilibria, geothermobarometric calculations, online assignment closure temperature. Written student paper on a selected subject and accompanying presentation.
Contact hours: 12 half-day classes made up of lectures and practical exercises. One half day class of student presentations and one written examination (2.5 hours).

Toetsvorm
All practical assignments must be completed; together they make up 30% of the final mark. The three written tests together count for 5% of the final mark. The student paper and presentation each make up 12.5% of the final mark whilst the remaining 40% is for the written examination.

Literatuur
Textbook: Winter (2010) An introduction to igneous and metamorphic petrology, Prentice Hall. Or the 1st edition from 2001.

Some chapters from Bucher & Grapes (2011) Petrogenesis of metamorphic rocks, 8th ed., Springer, which may be copied from the teacher or the library.

Papers to be used as background reading for lectures will be listed on

the Blackboard-site at the start of the course. The list of papers that serve as topics for the presentations is made available in the first week of the course.

Doelgroep
First year MSc Earth Sciences students in the Solid Earth track.

Overige informatie
This course fits well within the lithosphere orientation of Solid Earth, together with courses like Magmatic Processes, Advanced Inorganic Geochemistry and Advanced Geochronology. It builds on Mantle Properties and Orogenesis, as well as courses in petrology, chemistry and tectonics at the BSc level.

Microstructures in Tectonites

Vakcode	AM_450158 ()
Periode	Periode 4
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. H. Stel
Docent(en)	dr. H. Stel
Lesmethode(n)	Practicum

Doel vak
To provide the students a guide to microstructures in rocks induced by deformation

Inhoud vak
During the course, the main mechanism of deformation of minerals and rocks will be discussed and it will be shown by practical work how these mechanisms left their imprint on mesoscopic and microscopic scale. Topics of interest are a.o.: pressure solution, dislocation glide and climb; recovery recrystallization and the formation of mylonites. Information that is derived from microscopic observations will be compared with general models of rock deformation such as derived from experimental work. Special attention will be given to microstructures that yield information between deformation-induced foliations and the growth of metamorphic minerals.

Onderwijsvorm
During the course, the main mechanism of deformation of minerals and rocks will be discussed and it will be shown by practical work how these mechanisms left their imprint on mesoscopic and microscopic scale. Topics of interest are a.o.: pressure solution, dislocation glide and climb; recovery recrystallization and the formation of mylonites. Information that is derived from microscopic observations will be compared with general models of rock deformation such as derived from experimental work. Special attention will be given to microstructures that yield information between deformation-induced foliations and the growth of metamorphic minerals.

Toetsvorm

Written exam

Literatuur
Reader: a guide to the practicals

Doelgroep
Master students Solid earth

Orogenesis

Vakcode	AM_450190 ()
Periode	Periode 3
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	prof. dr. J.R. Wijbrans
Docent(en)	prof. dr. J.R. Wijbrans
Lesmethode(n)	Werkcollege, Computerpracticum

Doel vak
Students attending this course will gain knowledge and understanding about mountain building processes (subduction, accretion, collision), their consequences (metamorphism, syn- orogenic magmatism, and sedimentary basin formation, etc.), and the methods constraining those processes such as microscopic analysis, thermochronology or numerical modelling.
Mutual relationships and feed- back relations of orogenic processes in space and time are illustrated for different segments of orogens ranging from the external to the core zones.
Furthermore, students will develop skills (1) to analyse, compare and explain distinct features of orogenic structures, (2) to apply numerical modelling as a tool to tackle orogenic processes quantitatively, and to (3) critically assess and discuss relevant literature as well as numerical modelling results.

Inhoud vak
Key aspects of mountain building are discussed in the context of natural examples like the Alpine mountain chain in Europe and in across-disciplinary manner.
Specific topics are:
- The anatomy, tectonic development, and thermal evolution of convergent continental margins, subduction and continental collision zones;
- Deformation, metamorphism and magmatism in axial zones;
- PTt- paths: observation, interpretation and numerical modeling;
- The interaction between orogens and sedimentary basins in internal and external zones of orogens;
- The late stage evolution of orogens: modes of syn- orogenic extension, orogenic collapse, and exhumation mechanisms;
- Real-world examples; European Alps, Andes, Himalaya.

The skills to use the acquired knowledge will be obtained using a case study of one orogen (from microscopic observation to the techniques required to constrain the T- t histories of various domains).

Onderwijsvorm
tuition Lectures (9 * 3 u 45 min), computer practical (4 * 3 hrs 45min), assignments /self-study (12 * 3 hrs)

Toetsvorm
Exam (50%), Reports (20%), Essay – presentation – poster (20%)

Literatuur
The course will be based on chapters from:
- "Geodynamics of the Lithosphere", 2nd ed. Kurt Stüwe, Springer 2007.
- "An introduction to igneous and metamorphic petrology", 2nd ed., Winter, Prentice Hall 2010. (available through GeoVUsie)
- Global Tectonics, 3rd ed., P. Kearey and F. Vine, Blackwell 2008.
- Orogenesis, 1st edition, M.R.W. Johnson, S.L. Harley, Cambridge 2012.

Selection literature for individual essay and presentation projects to be announced on Blackboard.

Vereiste voorkennis
BSc Geology

Aanbevolen voorkennis
Petrology, structural geology, tectonics courses at the BSc level.

Doelgroep
1st year MSc Earth Science Solid Earths

Overige informatie
Guest teachers include B. Petri (MSc) University of Strasbourg and VU University.

Palaeoclimatology

Vakcode	AM_GEO222 ()
Credits	10.0
Faculteit	Fac. der Aard- en Levenswetenschappen

Palaeo-ecology/Palynology

Vakcode	AM_450054 ()
Periode	Periode 3
Credits	3.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. S.J.P. Bohncke
Docent(en)	dr. S.J.P. Bohncke
Lesmethode(n)	Werkcollege
Niveau	500

Doel vak
The student can independently read and interpret and apply palynological literature. The student must be able to integrate palynological evidence in his or her research or thesis. He or she is able to handle the

specific terminology that is needed to start his or her own palynological analyses.

Inhoud vak
The basal principles of palynology and applications in Quaternary geology such as climate reconstructions and paleoenvironmental reconstructions and human impact on vegetation.

Onderwijsvorm
Lectures: on pollen dispersion, deposition and preservation. How to construct a pollen diagram. How to interpret a pollen diagram, the local and regional signal. The relation between pollen assemblage and paleovegetation. Quaternary vegetation- and climate history of NW Europe.
Palynological characteristics of glacial, interglacial and interstadial pollen records, biostrigraphy. Anthropogenic impact as recorded in pollen diagrams. Landscape reconstructions applying pollen en macrobotanical data. Raised bogs as paleoclimatic archieves in the Holocene.
Literature study: on specific articles concerning the application of palynology in Quaternary studies.
Practical: the study of pollen morphological features using a microscope, the practical collection and the digital photo database. Different fossil pollen assemblages will be studied ranging from glacial to interglacial. Together the students work on pollen slides from one specific core and will make and interpret a pollen diagram.

Toetsvorm
Written examination on theory; essay on the practical part.

Aanbevolen voorkennis
Geobotanie AB_1062

Petroleum Geology of the North Sea

Vakcode	AM_450317 ()
Periode	Periode 2
Credits	7.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. B.P. Zoetemeijer
Docent(en)	prof. dr. J. de Jager
Lesmethode(n)	Hoorcollege

Doel vak
The objective of this course is to give students a detailed understanding of the geology of the wider North Sea area and Northwest European petroleum provinces as an excellent example of a very rich and varied petroleum province. The course will provide an in-depth and comprehensive review of the many aspects of exploration and development as they are applied to one of the World's classic and most important petroleum provinces about which much detailed information is available. It provides excellent examples of how petroleum systems work and how oil and gas are trapped in a range of different settings spanning a considerable period of the geological time scale. Emphasis is placed on

the impact of the geological history the occurrence and distribution of hydrocarbons.

Inhoud vak
Different lecturers from the university of Utrecht and the VU University Amsterdam will address the many aspects of the petroleum geology of the wider North Sea area, including the Norwegian Atlantic margin. Several staff actively working in the petroleum industry will present aspects of the petroleum geology of the North Sea from their practical perspectives.
The course will start with a regional overview of the geological development of the area. In this module, the geology, structural setting and basin fill through time of the North Sea will be discussed. The aspects of the geological development of the North Sea relevant to the presence and distribution of hydrocarbons, such as traps, reservoirs, seal and source rocks will be highlighted. The multiple reservoir levels developed in the area and their properties and characteristics will be reviewed in some detail. Attention will be paid, through reference to several example fields, to many of the practical problems faced by exploration and development geologists in evaluating the uncertainties related to volume and productivity evaluation. The petroleum fields of the area will be placed in their petroleum system context and an analysis of the
"plays" (families of similar fields) present will be proposed and presented for discussion and review by the students. Several specific aspects of the geology of the wider North Sea area, such as structural inversion, halokinesis and overpressure development, will be presented and their impact on the petroleum geology will be discussed.
A field Study-trip to S.W. England is part of the course. During this short trip, students will be shown outcrops of many of the most important source and reservoir formations of the area, as well as some of the structural styles represented. This will provide an opportunity to experience the 3-dimensional geometry of the rock types first-hand.

Onderwijsvorm
Lectures, project work, student presentation, and field study.

Toetsvorm
Evaluation of project work, student presentation and written examination.

Literatuur
The lecturers will make extensive literature lists available.

Overige informatie
This course is only accessible to graduate students (with bachelor's degree).

Petroleum Resources Module

Vakcode	AM_450281 ()
Periode	Ac. Jaar (september)
Credits	2.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. B.P. Zoetemeijer

Docent(en)	dr. B.P. Zoetemeijer
Lesmethode(n)	Werkcollege

Doel vak
Building on the Petroleum Systems and Regional Geology course, to teach the basic principles of petroleum accumulation and of prospect evaluation and risking.

Inhoud vak
The course demonstrates the workflow of prospect evaluation starting with the regional setting of petroleum reservoirs, followed by principles of source rock geochemistry and hydrocarbon charge analysis, reservoir prediction and analysis, trap analysis and concluding with prospect evaluation and risking. For each of the parts an introduction of the principles, followed by a regional scale and a prospect scale application will be given. The student gets the opportunity of practising principles of each of the parts by hands- on exercises. On the final day, dealing with prospect evaluation, the parts will be brought together into a prospect and risk assessment of the real life prospect.

Onderwijsvorm
The course will be a combination of classroom lectures and hands-on exercises on actual field data, through presentations from practising industry professional specialists.

Toetsvorm
Evaluation of project work.

Literatuur
Literature lists will be provided by the lecturers.

Vereiste voorkennis
This course is only accessible to graduate students (with bachelor's degree) who attended the MSc course Petroleum Systems and Regional Geology.

Petroleum Systems and Regional Geology

Vakcode	AM_450179 ()
Periode	Periode 1
Credits	3.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	prof. dr. J. de Jager
Docent(en)	prof. dr. H. Doust
Lesmethode(n)	Werkcollege

Doel vak
1) To give students a good understanding of the geological concepts that control the occurrence of petroleum (oil and gas) accumulations.
2) To review some of the world’s main geological settings with significant petroleum resources, and to pick out the main lessons they provide.

4) To review the concepts of petroleum systems and plays and see how they relate to sedimentary basin evolution.
5) To study how these concepts can be applied to subsurface analysis for prediction of as of yet undiscovered oil and gas fields (exploration) and for production of petroleum resources.
6) To provide students with a good idea of worldwide impact of petroleum (oil and gas) exploration and production and what it means to society.

Inhoud vak
This course reviews a number of issues, technical and otherwise, that impact on exploration for hydrocarbons worldwide. Emphasis is placed on the need to be able to study subsurface issues from the most regional to the most local and to integrate data and concepts from all sorts of different disciplines. The main objective of the course is to teach students to appreciate the overall application of basin studies to the evaluation of petroleum resources. The strong link between basin tectonics and stratigraphy at all scales, as well as the importance of taking an integrated view through developing regional geologic skills are emphasized.

The course commences with a general introduction to what hydrocarbons are, what they are used for and discusses current and expected future supply and demand scenarios. This part of the course is directed towards an appreciation of petroleum exploration in its societal and management context, making a link to important and controversial issues facing global development. Much of the course deals with the geological parameters that contribute to some of the most important and successful petroleum systems in the world. Different geological settings with rich petroleum resources will be discussed such as: deltaic settings, rift basins, epeiric platform areas, carbonate reef settings, deep-water fold belts, etc. Specific examples from these settings will be presented from petroleum provinces around the globe: Middle East, Asia-Pacific, Southern Atlantic, North Sea, etc. Several exercises will be included based on data from these areas. Other issues discussed include the tools and technologies applied in exploration and how exploration is carried out in practice. The concepts of risk and volume assessment as applied in Petroleum Industry for undrilled potential petroleum fields will be introduced with examples and exercises. The course also includes an introduction to important elements of oil and gas field development, as well as a module on so-called Unconventional Gas (Shale Gas, Basin Centre Gas and Coalbed Methane).

Onderwijsvorm
Lectures, practical examples worked by students.

Toetsvorm
Question paper on the subject matter, including practical examples of analysis of plays and petroleum systems.

Literatuur
Syllabus can be obtained from the lecturer. Powerpoint presentation material is posted on Blackboard.

Overige informatie
Students are carried on a rollercoaster of integrated geologic concepts and swept in a short time from place to place across the globe to look at the local geology from an explorers' perspective. Mental alertness and the flexibility to follow these rapid changes are therefore essential to gaining maximum benefit.

Petro-Tecto Field Excursion

Vakcode	AM_450347 ()
Credits	3.0
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	prof. dr. G.R. Davies
Docent(en)	dr. G.V. Bertotti, prof. dr. G.R. Davies
Lesmethode(n)	Excursie

Doel vak
The objective of this course is to study the complex feedback mechanisms that lead to formation of lithosphere with emphasis on the interplay between sedimentation and tectonics. We aim to enhance the ability of the participants to use a multidisciplinary and multi-scalar approach to reach a quantitative understanding of geological problems of different type and nature. The accent is set on the development of a common language among the different disciplines represented by the participants so that the entire spectrum of geological methods can be used. The multi-scale approach of the course aims to make the students able to integrate the different scales of observations from that of the sample to that of the entire lithosphere.

Inhoud vak
The field course will take place either in Cyprus, The Alps, Pyrenees or Oman and undertakes a traverse through the entire oceanic/continental lithosphere examining the tectonic control of mantle melting, magma injection into the crust, hydrothermal activity, uplift, deformation and sedimentation. The magnitude of the different uplift and deformation events determined from field observations are put into a regional plate tectonic context. This approach emphasises how an interdisciplinary approach is required to gain full understanding of a particular field area.

Onderwijsvorm
Week long field course.

Toetsvorm
Field note books and active participation to the excursion will count for 40% and 60% in a written exam.

Literatuur
A field guide will be supplied

Vereiste voorkennis
Admission to this field course is only granted to students registered in the master's programme AND who have at least completed 12 stp. of the compulsory/ core optional part of the MSc programme including the Introduction Field Excursion (450229) AND who have not yet participated the field course 450348.

Doelgroep
Second year MSc students Earth Sciences, tracks Solid Earth, and Second year MSc students GBL

Overige informatie
Registration takes place in March 2011. Students have to contact the programme secretariat (room C118, W&N building) personally for registration.

Planetary Science

Vakcode	AM_450273 ()
Periode	Periode 1+2
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	prof. dr. W. van Westrenen
Docent(en)	dr. P.Z. Vroon, prof. dr. G.R. Davies, prof. dr. W. van Westrenen, dr. W.F.M. Roling, prof. dr. B.H. Foing
Lesmethode(n)	Werkcollege

Doel vak
The main aim of this course is to provide an overview of current knowledge about the formation and evolution of the large and small bodies in our solar system. This overview serves to compare and contrast processes that are important on Earth with processes active on other planetary bodies.

Inhoud vak
A series of lectures will examine the bodies that make up our solar system, how they differentiated and over what timescale they were geologically active. Contrast will be made between styles of volcanism and types of atmospheres on the different planets and moons. The role of water in shaping both internal and external structures of planetary bodies will be examined. The course will include a discussion of astrobiology and exoplanetary science. The course will conclude with a visit to ESTEC where there will be presentations to and from ESTEC staff.

Onderwijsvorm
Lectures plus a day long visit to ESTEC where each student will make a critical review of a recent paper and groups will present a Space mission concept developed during the course. The course counts for 6 ECTS = 160 SBU, which are divided between the different components of this course in the following way (1) 13 * 3 hour lectures = 117 SBU, (2) Background reading and preparation of ESTEC presentations = 33 SBU (3) Excursion to ESTEC = 10 SBU, total 160 ECTS = 6 ECTS

Toetsvorm
The final mark for this course consists of the following components: Active participation and homework (20%), Written exam (40%), Poster preparation and mini-talks at ESTEC (40%).

Literatuur
Peter Bond – Exploring the solar system, augmented with recent scientific papers that will be made available at the start of the course.

Aanbevolen voorkennis
A solid background in geology and geochemistry is recommended but not essential.

Doelgroep
Second year MSc students with a natural science background

Overige informatie
Guest lectures are provided by Dr. Inge Loes ten Kate (Utrecht University), dr. Arie van den Berg (Utrecht University), dr. Bert Vermeersen (TU Delft), dr. Daphne Stam (TU Delft), and Prof. dr. Christoph Keller (Leiden University).

Portfolio Geosciences of Basins and Lithosphere

Vakcode	AM_450193 ()
Periode	Ac. Jaar (september)
Credits	3.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. B.P. Zoetemeijer
Docent(en)	dr. M. ter Voorde
Lesmethode(n)	Computerpracticum, Hoorcollege

Inhoud vak
To be announced

Practical Subsurface Evaluation Workshop

Vakcode	AM_450277 ()
Periode	Periode 3
Credits	2.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	prof. dr. J. de Jager
Docent(en)	prof. dr. H. Doust
Lesmethode(n)	Werkcollege

Doel vak
The course is intended to enable students to acquire and practice subsurface interpretation skills in a realistic, real-world environment. They will have the opportunity to work in teams on the kind of projects they could expect to carry out as practising petroleum geoscientists. The practical exercises use real data. The course represents a summing up of the Petroleum specialisation of Geosciences of basins and Lithosphere.

Inhoud vak
The course is organised into practical exercises, each taking a few days. Use is made of real data from real situations, and the participants work in small teams to come up with reasonable answers to such questions as: Should we proceed with exploration or appraisal of

this prospect? What are the risks versus rewards of continuing? How can this field be best developed?
A very important aspect of the exercises is the opportunity they give to work co-operatively in teams, sharing tasks and integrating each other's skills, in a general competitive atmosphere. Regular reporting of results to the whole group gives the opportunity to polish up participants' presentation skills.
The course is constructed around the so-called "Goonybird" exercise. Data from a hydrocarbon field in the North Sea is used to evaluate a discovery in 3 stages through early appraisal. As more data comes available, teams of participants can see how their interpretations and thoughts have to be modified, whilst becoming more precise. Task to be carried out include: interpretation of a grid of seismic profiles to construct a depth map of the field; geological correlation of wells and construction of a reservoir model; calculation of potential volumes of hydrocarbons with ranges of uncertainty; and prognosis of results of future wells.
If logistically feasible, and desired by participants, an option to view the cores at TNO's core laboratory may be added. Normally an industry representative, who is actively involved in the development and production of the field on which the exercise is based, is present at the final student presentations, and will give the company's latest view of the field and its volumes.

Onderwijsvorm
A full week of practical exercises with real subsurface seismic and well data, which is made available in batches, simulating a real field appraisal programme. Students work in small groups, and give regular presentations.

Toetsvorm
Continuous evaluation of results and presentations by lectures, quality of material delivered.

Overige informatie
This course is only accessible to second year graduate students (with bachelor's degree) who attended MSc courses like Petroleum Systems and Reflection Seismics.

Precambrian Geology

Vakcode	AM_450164 ()
Periode	Periode 4
Credits	3.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	prof. dr. J.R. Wijbrans
Docent(en)	prof. dr. J.R. Wijbrans, dr. P.Z. Vroon, dr. H.B. Vonhof
Lesmethode(n)	Werkcollege

Doel vak
The Precambrian (Archean and Proterozic) comprises the immensely long time periods between the initial formation of the planet Earth and the earliest Paleozoic radiation of life forms with endo- or extra-skeletons. This course intends to summarize the Precambrian Geology in a

general and interdisciplinary manner covering the evolution of the lithosphere, the hydrosphere, the atmosphere and the biosphere.

Inhoud vak
The course covers four main fields of Precambrian Geology: A) Earliest Precambrian planetary evolution; B) Evolution of the Precambrian lithosphere (genesis, petrology, tectonics and geochemistry); C) Evolution of the Precambrian atmosphere (e. g., evidence for free oxygen in the atmosphere); D) Surface processes (early sediments, earliest life forms).

Onderwijsvorm
Lectures (8 * 3 u 45 min), assignments /self-study (8 * 2 hrs).

Toetsvorm
Essay – presentation – poster

Literatuur
H.R. Rollinson, Early Earth Systems A Geochemical Approach, Wiley Blackwell, 1st edition 296 pp. Selection literature for individual essay and presentation projects to be announced on Blackboard.

Vereiste voorkennis
BSc Geology

Aanbevolen voorkennis
Petrology, sedimentology, structural geology courses.at the BSc level.

Doelgroep
2nd year MSc Earth Sciences.

Overige informatie
Guest teachers include Prof. Dr. C.W. Passchier (University of Mainz), prof. Dr. R. Hengeveld (emeritus professor Animal Ecology, VU University), dr. P.Mason (Utrecht University).

Reflection Seismic for Geologists

Vakcode	AM_450170 ()
Periode	Periode 4
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. B.P. Zoetemeijer
Examinator	dr. B.P. Zoetemeijer
Docent(en)	dr. B.P. Zoetemeijer
Lesmethode(n)	Werkcollege, Computerpracticum

Doel vak
The participant is expected to collect sufficient understanding of the fundamentals and the limitations of the applications of reflection seismology as a tool to predict the structure and geology in the shallow to deeper (100's to 1000's of metres) subsurface. The aim is to derive the evolution of sedimentary basins and underlying crust by using seismostratigraphic and structural interpretation of seismic

lines. In particular, the participant will learn:
the application of technical and methodological principles of reflection seismology to real situations;
the basic principles linking geology and reflection seismology, including an introduction to petrophysics;
seismic workstation skills for seismic interpretation, and
how to extract reliable information on sequence stratigraphy and structure from seismic reflection and well log data.

Inhoud vak
Assuming a basic knowledge of the principles of reflection seismology, this course provides a modular programme with hands-on experience on interpreting seismic lines and integrating data from well logs, principles and interpretation of reflection seismic data and geology. Special attention will be paid to pitfalls in data acquisition, processing and interpretation. The course will use in part similar methodologies used in hydrocarbon exploration and development.
The course is constructed in 5 parts:
Part 1 Introduction to seismics. The introduction will cover the technical and methodological broadband principles of reflection seismology. Note that this section will build on already existing Applied Geophysics course knowledge;
Part 2 Introduction to interpretation. Students will learn how to interpret basic geological features, such as strata relationships, faults and folds as well as the reliability of seismic interpretation at various scales;
Part 3 Seismic sequence stratigraphy. Learning seismostratigraphy will mean in practice how to extract stratigraphic, sedimentological and basin evolution information from seismic data. This information is used as a tool in exploration and basin analysis to derive regional analysis of sedimentary basin-fills with a view towards constructing models for gross lithology prediction. It is recommended that students remind themselves the principles and methodology of sequence stratigraphy, already acquired during their BSc courses;
Part 4 Seismic structural interpretation. This section will provide students with the knowledge of interpreting deformation structures at various scales;
Part 5 Interpretation on workstation. This section gives the students the opportunity to work on case studies by using standard workstation methodologies for seismic interpretation. Students will learn how to handle, visualize and interpret 2D and 3D seismic data using a standard industrial software package;
Part 6 Integrating wells with seismics for seismostratigraphy, deriving basin evolution. The section will give students the chance to start from reflection seismic and correlative well interpretation to derive the evolution of sedimentary basins at local and regional scale.;
Part 7 Advanced seismic interpretation This section will give students the opportunity to work with advanced methodologies of seismic interpretation specific for petroleum exploration.

Onderwijsvorm
The course uses two different methods:
Oral lessons, where the lecturer presents various topics. Students must be aware that the content of this course is difficult to find in one-two textbooks. Therefore, understanding the handouts is essential. Our advice is to attend the oral lessons during class hours.
Practical lesson; the bulk of this course is made up by a large number of practical exercises and a few case studies. You will have to hand in at the end of the course a part of these for evaluation

purposes, as noted by the staff. Make sure you understand which are those exercises and case studies needed for evaluation. The thumb rule: this is individual work, unless otherwise specifically noted.

Toetsvorm
The final mark is made up by 50% the practical exercises and case studies handed in at the end of the course and 50% the final examination. The practical exercises and case studies must be handed in no later than one day prior to the final examination. The exam will cover the topics presented during course. It is typically organized in blocks of questions from every part of the course AND 2 - 5 data sets (seismic lines) which you will be asked to interpret in terms of specific issues.

Literatuur
All materials will be digitally provided through Blackboard.

Overige informatie
Teaching staff: John Verbeek

Research Project GBL I

Vakcode	AM_1105 ()
Periode	Ac. Jaar (september)
Credits	12.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen

Reservoir Geophysics

Vakcode	AM_GEO274 ()
Credits	10.0
Faculteit	Fac. der Aard- en Levenswetenschappen

Sediment Petrography of Heavy Minerals

Vakcode	AM_450058 ()
Periode	Periode 3
Credits	3.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. C. Kasse
Docent(en)	dr. C. Kasse
Lesmethode(n)	Werkcollege
Niveau	400

Doel vak
Study of heavy minerals as a tool to establish the Quaternary lithostratigraphy of the Netherlands and abroad and to establish the provenance of the sediments.

Inhoud vak
The study of optical characteristics of heavy minerals under the microscope. The study of the heavy mineral characteristics (relief, color, pleochroism, etc.) in slides from the mono-mineral collection. Recognition and determination of heavy minerals from unconsolidated deposits. Interpretation of heavy mineral assemblages regarding the provenance of the sediment and the Quaternary lithostratigraphy of the Netherlands.

Onderwijsvorm
Lectures and practical courses

Toetsvorm
Oral examination and determination of a heavy mineral sample by the student

Literatuur
Mange, M.A. & H.F.W. Maurer 1992 Heavy minerals in colour. Chapman & Hall, London, 147 pp.

Boenigk, 1983 Schwermineralanalyse, Ferdinand Enke Publishers, Stuttgart, 158 pp.

Overige informatie
This optional course is offered every two years. The next course takes place in 2013 - 2014.

Sedimentary Basins

Vakcode	AM_450154 ()
Periode	Periode 2
Credits	6.0
Voertaal	Engels
Coördinator	dr. G.V. Bertotti
Docent(en)	dr. G.V. Bertotti, dr. B.P. Zoetemeijer, prof. dr. J.J.G. Reijmer
Lesmethode(n)	Computerpracticum, Hoorcollege

Doel vak
The main goal of the course is to provide students the skills to analyze and interpret data on sedimentary basins and derive quantitative reconstruction of their tectono-sedimentary evolution. In order to do so, the student should be able to:
• Combine different data sets to understand tecto-sedimentary processes controlling the evolution of sedimentary basins.
• Combine class material with significant, compiled literature material.
• To use quantitative computer models to assess the importance of factors controlling basin forming processes
• To work in small interdisciplinary groups.
• To present the results of his/her work in oral and written form.

Inhoud vak
This course focuses on the origin and evolution of sedimentary basins in space and time. The main topics addressed are:
• the tectonic processes controlling vertical movements (subsidence

in particular);
• the phenomena taking place in the source areas where clastic sediments are produced;
• the sediment production and transport patterns within carbonate sedimentary systems and
• the physical processes controlling the transport and 3D distribution, deposition, and preservation of these sediments in the basin.
• Principles of sequences stratigraphy

A limited number of real-world sedimentary basins (siliciclastic and carbonate settings) from various tectonic settings will be addressed and used to test in practice the theoretical knowledge.

Onderwijsvorm
Combination teaching, practical projects and self-study of publications.
Contact hours:
Lectures: 30
Practicals: 24
Total: 54

Toetsvorm
Assessment will take place on the basis of results from the exam and from the practicals. The tectonic and sedimentological parts count 50% each.
Within the tectonic part, the exam counts for 50%, the two practicals for 25% each.
The sedimentological part the exam counts for 50% and the five practicals for 10% each.

Literatuur
Allen, P.A. and Allen, J.R. (2004). Basin Analysis. Blackwell Publishing. ISBN: 978-0-632-05207-3

Schlager, W. (2005). Carbonate Sedimentology and Sequence Stratigraphy, SEPM, Concepts in Sedimentology and Paleontology, v. 8. ISBN: 1-56576-116-2.

James, N.P. & Dalrymple, R.W. (2010). Facies Models 4. Geological Association of Canada; ISBN-13: 978-1-897095-50-8; ISSN: 1208-2260, 586 pages, full colour.

Other relevant literature will be provided on Blackboard

Sedi-Tecto Field Excursion

Vakcode	AM_450348 ()
Periode	Periode 1
Credits	3.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. G.V. Bertotti
Lesmethode(n)	Excursie

Doel vak
The objective of this course is to enhance the ability of the participants to use a multidisciplinary and multi-scale approach to reach a quantitative understanding of geological problems of different type and nature. The accent is set on the development of a common language among the different disciplines represented by the participants so that the entire spectrum of geological methods can be used. The multi-scale approach of the course aims to make the students able to integrate the different scales of observations from that of the sample to that of the entire lithosphere.
The sedi-tecto excursion focuses on the interactions between tectonic and sedimentary processes in forming and deforming sedimentary successions. Indeed, sedimentary basins host the largest proportion of resources such as energy and water. At the same time, the excursions have a strong regional character with attention being paid to the tectono-sedimentary evolution of the system object of the excursion.

Inhoud vak
The excursion will take place either in the Pyrenees or in the Eastern Alps. Both are world-class natural laboratories.

Onderwijsvorm
Work excursion

Toetsvorm
Active participation, on site seminars and on site written examination

Literatuur
Articles and field guide

Vereiste voorkennis
Admission to this field course is only granted to students registered in the master's programme AND who have at least completed 12 EC of the compulsory/ core optional part of the MSc programme including the Introduction Field Excursion (450229) AND who have not yet participated the field course 450347.

Overige informatie
Registration takes place before the end of May. Students have to contact the programme secretariat (room C118) personally for registration.

Sequence Stratigraphy

Vakcode	AM_GEO361 ()
Credits	10.0
Faculteit	Fac. der Aard- en Levenswetenschappen

Sustainable Land Management

Vakcode	AM_1015 ()
Periode	Periode 3
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen

Coördinator	drs. W.A.M. Tuijp
Docent(en)	dr. W.R.S. Critchley
Lesmethode(n)	Werkcollege
Niveau	400

Doel vak
What are the enabling and limiting factors to sustainable land management? How can smallholder farmers in the developing world adapt to climate change? What can farmers in developing countries – and especially Africa – do to improve their food security? Can organic agriculture help feeding the world? Are biofuels the solution for our energy needs of tomorrow?
These and many other questions will be discussed during this interdisciplinary course. Its main focus is on what can be done about the problems of soil erosion and land degradation, and their relevance to climate change and poverty reduction. "Sustainable Land Management" is a new approach that involves both people and technical issues. The course spans a wide range of topics, including environmental problems, history of approaches, conservation technologies in the field, indigenous knowledge, working with local people, and skills in research and development in the tropics. There is a combination of theory and practice, with a strong emphasis on illustrated case studies from over 20 countries.

Inhoud vak
Environmental degradation and rural poverty: processes and impact. History of conservation: from failed approaches to new concepts in rural development; principles and practices of Sustainable Land Management (SLM). Agriculture in Development. SLM technologies: humid areas/dry areas. International environmental protocols and their impact on rural development programs. Socio-economic factors including population/land tenure/gender/incentives/marketing and labeling. Energy and biofuels; biodiversity, genetic modification and organic production. ICTs in rural development. Indigenous knowledge and local innovation, Participatory learning and action, including research methodology).

Onderwijsvorm
Interactive lectures (about 38 hours in total) with illustrated case studies supplemented by group work activities; conducted and examined in English.

Toetsvorm
One topic will be chosen by each student for a paper of 3.000 words based on further reading (50% mark). There will also be a final examination (50% mark).

Literatuur
"Where the land is greener" WOCAT, Eds Liniger and Critchley, plus additional supporting literature.
https://www.wocat.net/en/knowledge-base/documentation-analysis/global-overview-book.html

Doelgroep
Aimed at Master’s students with environmental and developmental interests: especially those with some geography/earth science/hydrological/biological/ecological/environmental background, but social scientists can also benefit from this course.

Overige informatie
Comments from former students:
"I think this course gives a good overview and helps students with a non environmental background to understand essential issues."
"Good job, keep on going! Continue to be part of the ERM programme."
"Whereas other courses focus on scientific dimension of environmental problems SLM is also about the human dimension of environmental solutions. It is one of the few courses that gives a positive perspective for practical solutions. Whereas other courses try to inject "knowledge" theoretical problems and solutions."
"The course was a great launch pad for my thesis research. "
"This should be a specialization track! Sustainable Land Management 2 would be very interesting and give students more time to learn about the topics."

For more information please contact Wendelien Tuyp (w.a.m.tuijp@vu.nl)

Unsaturated Zone and Near Surface Hydrological Processes

Vakcode	AM_450021 ()
Periode	Periode 4
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. H.J. van Meerveld
Docent(en)	dr. H.J. van Meerveld
Lesmethode(n)	Computerpracticum, Werkcollege
Niveau	400

Doel vak
The main objective of this course is to provide basic insight into the hydrological processes operating within the unsaturated zone as a whole, and near the surface in particular. This hydrological knowledge forms the basis for determining recharge rates, plant available water, runoff ratios, etc. It requires fundamental theoretical and practical knowledge on soil properties and the physics of soil water movement.

At the end of this course students should be able to:
• Discuss soil characteristics in relation to soil water movement and storage
• Discuss the processes that determine the storage and movement of water in the unsaturated zone, and how this affects and is affected by other hydrological processes
• Describe the various measurement techniques to determine the storage and movement of water in and through the unsaturated zone
• Produce a simple hydrological model to analyse and describe the movement of water through the unsaturated zone and analyse how this is affected by soil properties
• Discuss the objectives, advantages and limitations of hydrological models for the unsaturated zone
• Present the results of a small hydrological modelling study in a clear and concise way
• Have obtained an awareness of how vegetation and land management affect soil erosion and water quality

The Unsaturated Zone and Near-Surface Hydrological Processes course contributes to the final attainment levels defined for the hydrology master's:
• Knowledge and understanding – knowledge and insight into the subject is obtained through studying the theory as provided during the lectures, in the text books, and through self-study of scientific papers
• Application of knowledge and understanding – analysis of data during lectures and workshops provides the skills and understanding required to process and analyse hydrological data
• Critical judgment – the student is encouraged to critically judge his/her work during the modelling workshops and the preparation of the report
• Communication – the presentation of the modelling results (structure, readability, etc.), as well as oral communication and discussion skills during the lectures

Inhoud vak
The course focuses on the following topics: hydraulic potential theory; soil water retention aspects; measurement techniques for soil water content and matric potential; stationary and non- stationary unsaturated flow (hydraulics); infiltration during conditions of ponding; determining saturated and unsaturated soil hydraulic conductivities; macropore vs. matrix flow; surface erosion processes (splash, wash and rill erosion) and governing factors.

Onderwijsvorm
The course consists of ten lectures and three computer practicals. The number of contact hours is in the order of 40.

Toetsvorm
Written examination.

Literatuur
Books:
• Koorevaar et al. (1983) Elements of Soil Physics. Elsevier, ISBN 0-444-42242-0 (selected chapters)
• Hillel D (1998) Environmental Soil Physics. Academic Press, ISBN 0-12-348525-8 (selected chapters)
• Morgan, R.P.C. (2005) Soil Erosion and Conservation, 3rd edition. Blackwell Publishing, Oxford, ISBN 978-1405117814 (selected chapters)

Articles:
• Anderson, A., Weiler, M., Alila, Y., and Hudson, R. O., 2009 Dye staining and excavation of a lateral preferential flow network, Hydrology and Earth Systems Science 13, 935-944.
• Bengtsson, L., R.K. Saxena, and Z. Dressie (1987) Soil water movement estimated from isotope tracers, Hydrological Sciences Journal 32:497-520.
• Horton, J.H. and R.H. Hawkins (1965) Flow Path of Rain From the Soil Surface to the Water Table, Soil Science. 100(6):377-383.
• Hoogmoed, W. B., and J. Bouma, (1980) A Simulation Model for Predicting Infiltration into Cracked Clay Soil, Soil Sci. Soc. Am. J. 44: 458–461
• Tricker, A.S. (1981), Spatial and temporal patterns of infiltration, Journal of Hydrology 49: 261-277.
• Western and Grayson. 2000. Soil Moisture and Runoff Processes at Tarrawarra, in: Grayson and Bloschl, Spatial Patterns in Catchment Hydrology: Observations and Modelling, Cambridge University Press.

Vereiste voorkennis
Participants are advised to follow the course on Groundwater Hydraulics (450009) first.

Doelgroep
First-year M.Sc. Hydrology students, students from Earth Sciences, Earth and Economy or Natural Sciences M.Sc. programmes.

Volcanism

Vakcode	AM_450061 ()
Periode	Periode 3
Credits	3.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. P.Z. Vroon
Docent(en)	dr. P.Z. Vroon
Lesmethode(n)	Werkcollege, Computerpracticum

Doel vak
Modern volcanology is balanced between the descriptive and quantitative, and both of these aspects of the science will be emphasized in this course. There are three basic goals for this class:
(1) We want to understand how volcanoes work: the process part;
(2) We want to be able to reconstruct unseen volcanic eruptions from the deposits they leave in the field;
(3) We will want to know as much as possible about the hazards volcanoes form to people.

An additional practical aim of this course is to improve your computer skills with Microsoft Excel. To this end I have designed some exercises which will show you how to use Microsoft Excel in it’s most powerful form: visual basic for applications (VBA). This will be a practical during the third lecture.

Inhoud vak
Introduction to volcanic explosions and their products; Magma properties: viscosity, density and volatiles; Non-explosive volcanic eruptions; Magmatic fragmentation and pyroclastic textures; Eruption columns and the interpretation of pyroclastic deposits; Volcanic hazards.

Onderwijsvorm
This course consists of 7 lectures in which several subjects related to volcanology will be discussed. Each lecture is accompanied by a review paper or chapter from a book that gives an overview of the topics discussed – you will get more out of the lectures if you read these papers beforehand.
In addition to following the lectures you will be asked to complete homework exercises. These should be handed in before the start of the exam. These exercises are designed to clarify aspects of the lecture topics, and are also meant to provide a link between the different lectures. During Lecture 3, the use of Microsoft Visual Basic for Applications is explained, which is required for some of the exercises

Toetsvorm
The final mark for this course consists of the following components: (1) homework exercises (25%); written exam (75%).

Literatuur
Encyclopedia of Volcanoes (Sigurdsson et al., 2000). Academic Press, ISBN 0-12-643140-X.)

Doelgroep
Second year MSc students Earth Sciences, tracks Solid Earth, and Second year MSc students GBL.