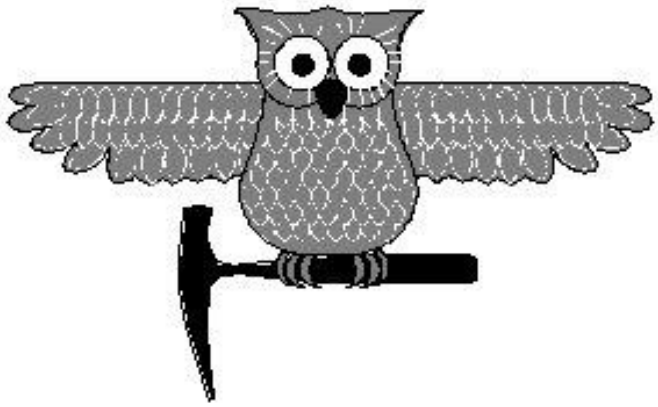
UNIVERSITY OF ZAGREB

FACULTY OF SCIENCE

DEPARTMENT OF GEOLOGY

Kralja Zvonimira 8, HR-10000 Zagreb

http://geol.gfz.hr/



GRADUATE STUDY OF ENVIRONMENTAL GEOLOGY

Zagreb, March 2005

1. INTRODUCTION

Department of Geology of the Faculty of Science intends to offer:

1. Undergraduate study program in **Geology,** and
   -Undergraduate study program in **Environmental Sciences** in collaboration with
   Departments of Biology and Geography of the Faculty of Science.

2. Graduate study program in :
   - **Geology (Geology and Paleontology** and **Mineralogy and Petrology)**
   - **Environmental Geology**
   - announce working on the program in Geoarheology in collaboration with the Faculty of Philosophy of the University of Zagreb;
3. Educational study program in **Geology/Geography** in collaboration with Department of Geography of the Faculty of Science.

Reason for setting the program

The reasons for change of existing study programs, and setting the new ones in undergraduate and graduate levels, we can find in demand for these studies in the market, both in public and private sector respectively.

Undergraduate study program

We intend to create undergraduate study program following the fundamental experiences from existing study programs having in mind to include the basic knowledge in geology into the other natural scientific branches and vice verse. The contemporaneousness of proposed study programs is reflected in similarities with programs of other universities. The proposed programs are comparable with programs of respectable universities in European Union, especially those in wider region. The aforesaid experiences we used as starting and comparable point when we set up our study program. The mentioned universities are: University of Vienna www.univie.ac.at/Geologie, Charles University Prague and University of Padova http://www.geol.unipd.it.

Graduate study programs

Graduate study programs continue on undergraduate programs and enable an additional specialized knowledge in geology. These are traditional but brought up to date graduate programs in **Geology and Paleontology, Mineralogy and Petrology.** Together with these traditional programs new graduate programs are offered from scientific disciplines which have risen in last decades like: **Environmental Geology, Geoarheology.**

Educational study program in Geology/Geography

This study program is designed as a replacement for former widely acclaimed study program for teachers in geology and geography at the Department of Geology and Department of Geography at the Faculty of Science. New proposal is based on modular approach in collaboration with Department of Geography of the Faculty of Science. In the same time, in a future this modular approach opens the possibility of combining of the geological modul with other natural science educational moduls.

Previous experiences of proposer

Department of Geology has taught basic geological programs in the high education system since 1874 y. New proposed studies are based on these experiences and previous experiences in scientific work and investigations of our staff which spent shorter or longer time on specialization at the eminent international scientific institutes and institutions of high education.

Possible collaborators

Possible collaborators for the study but not institutions in the high educational system are, as follows: Institute of Geology, Zagreb, Croatian Oil Company –INA, Croatian Natural History Museum, Ruđer Bošković Institute, Institute for oceanography and fisheries, National Parks, Croatian Water Management, PLIVA, etc.

Study openness

The study is based on modular principle and in accordance with ECTS system and enables vertical and horizontal mobility during the study having in mind that recommendation and supervision of coordinator or student mentor is provided.

Enclosure

Shematic outline of study program at Department of Geology of the Faculty of Science

2. GENERAL DESCRIPTION

2.1. Program title

a) Undergraduate study of Geology
b) Undergraduate study of Environmental science
c) Graduate study of Geology (Geology and Palaeontology)
d) Graduate study of Geology (Mineralogy and Petrology)
e) Graduate study of Environmental geology
f) Graduate study of Geoarhaeology – a collaboration with Faculty of Philosophy has been established, and program is in preparation
g) Educational study of Geology and Geography

2.2. Proposing institution:

University of Zagreb, Faculty of Science
Department of Geology

2.3. Duration

Undergraduate studies will last three years (6 semesters), and Graduate studies two years (4 semesters). Educational study will last continuously 5 years (10 semesters).

2.4. Admission requirements

Entrance examination will be required for all undergraduate studies as well as for educational study, for candidates with completed secondary (high school) education. After successful completion of the undergraduate study in Geology

(baccalaureate), candidate is allowed to enrol into graduate studies of Geology (Geology and Palaeontology, and Mineralogy and Petrology), Environmental geology, or Geoarhaeology, as well as into graduate studies in related disciplines (depending on admission requirements).

After successful completion of the undergraduate study in Environmental science (baccalaureate), candidate is allowed to enrol into following graduate studies: Environmental geology (Department of Geology, Faculty of Science), Environmental Biology (Department of Biology, Faculty of Science), Physical geography and geoecology (Department of Geography, Faculty of Science).

2.5. Undergraduate study

After successful completion of undergraduate studies the baccalaureus/ea is qualified for supporting and technical jobs in scientific, professional and educational institutions, governmental (local/central) agencies, industry, nature protected areas (national parks, nature parks…), etc. These include preparatory work for laboratory and field geological investigations, collection and analysis of samples, computer processing and data sorting, support to the specialists, simple professional-technical investigations, equipment maintenance etc.

Moreover, the baccalaureus/ea in Geology is allowed to enrol into graduate studies of Geology, Environmental geology, and Geoarhaeology, as well as into graduate studies in related disciplines, whereas the baccalaureus/ea in Environmental science is allowed to enrol into graduate studies of Environmental geology, Environmental Biology and Physical geography and geoecology.

In addition, after successful completion of undergraduate studies, the bacalaureus/ea is expected to be able to enrol into graduate studies offered on other faculties of the Zagreb University and/or abroad (e.g. Faculty of Mining, Geology and Petroleum Engineering, Faculties of Agriculture, Forestry, Philosophy, Tourism, Journalism, Traffic Engineering, Civil Engineering, Architecture etc.). We expect the mobility towards and from other European Universities, based on student mobility schemes and ECTS system.

2.6. Graduate studies

After successful completion of graduate study in Geology (Geology and Palaeontology, and Mineralogy and Petrology) and Environmental geology, the graduates are competent for scientific and research work in the fields of geology and environmental science, that require high degree of expert knowledge (management and use of natural resources – water, oil, metal and non-metal ores, control of technological processes in cement industry, ceramics, synthetic materials…). Moreover, graduates are expected to work in science and higher education in appropriate fields (both in basic and applied research) and environmentally-related jobs in industry and public sector. The acquired skills should be applicable in wider array of human activities.

After successful completion of graduate study in Geoarchaeology the graduates are competent for quantitative analysis of archaeological materials and other geoarchaeological research.

Undergraduate studies in veterinary medicine, agriculture, electric and mechanical engineering could be sufficient for graduate studies in Geology,

Environmental geology, and Geoarhaeology provided some additional requirements fulfilled, according to the decision of the Departmental council (*e.g*. supplementary courses in chemistry, biology, geology not completed during undergraduate study). Undergraduates in archaeology are allowed to enrol into graduate course in Geoarchaeology under the same conditions as the undergraduates in Geology.

After successful completion of educational study in Geology and Geography the graduates are competent for teaching in primary and secondary (high) schools. This includes also the competence to prepare and develop school curricula, textbooks, and other teaching materials. The skills obtained enable them to communicate science in the publics, and to develop geotourism.

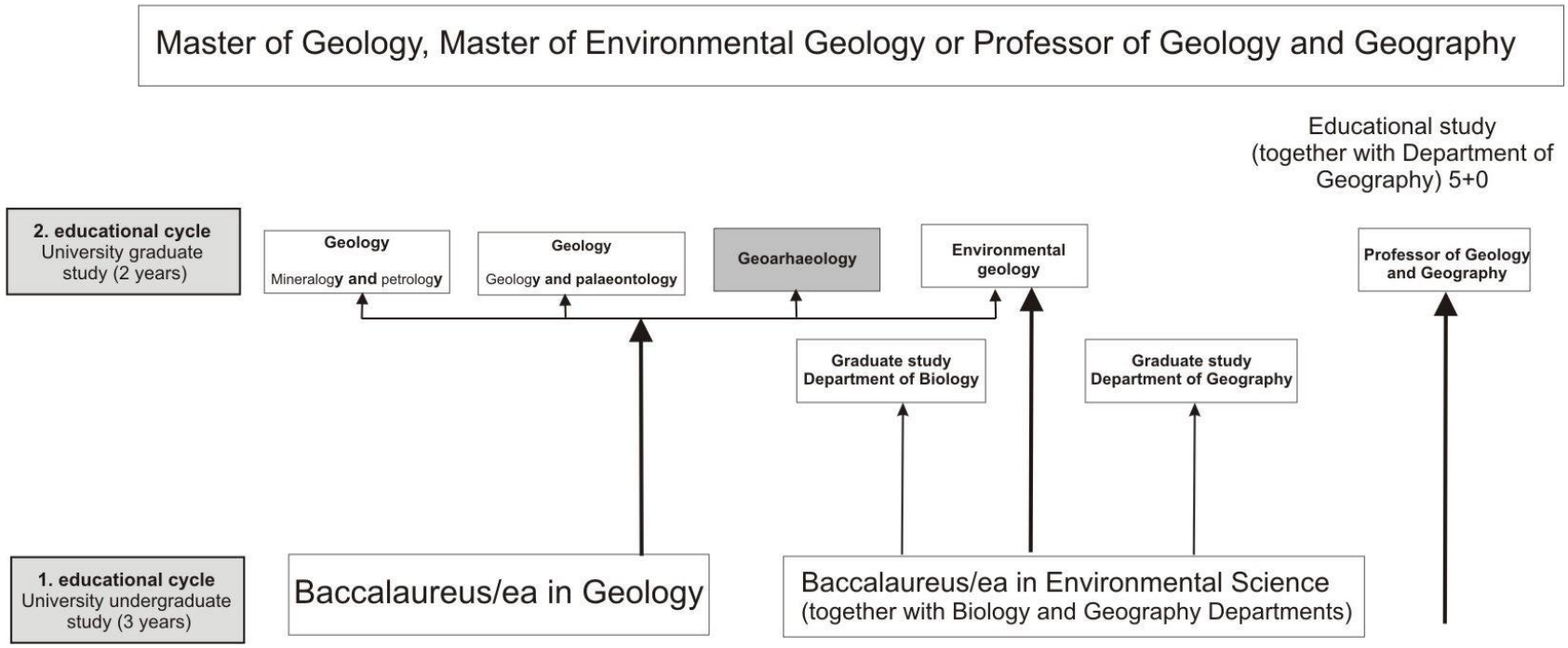
2.7. Only educational programs have unified undergraduate and graduate degrees, due to juditional restrictions.

2.8. After successful completion of undergraduate study the candidates are awarded academic degrees:
Baccalaureus/ea in Geology and **Baccalaureus/ea in Environmental Science**

After successful completion of graduate study the candidates are awarded academic degrees: **Master of Geology**, **Master of Environmental Geology**, and **Master of Geoarchaeology.**

After successful completion of graduate educational study the candidates are awarded academic degree: **Professor of Geology and Geography**

Study flow chart
Department of Geology
Faculty of Science
3+2 model



Graduate study of environmental geology – Learning outcomes

Underlying basis in geology

- Advanced knowledge and understanding of the principles of geology.
- Deeper knowledge of a chosen specialisation.
- Critical awareness of the forefront of their specialisation.
- Advanced understanding of Earth system relevant to their specialisation.
- Appreciation of the learning capacity needed to progress to independent research.

Analysis, design and implementation

- Ability to specify and complete geological tasks that are complex, incompletely defined or unfamiliar.
- Some ability to formulate and solve problems in new and emerging areas of their discipline.
- Ability to apply state of the art or innovative methods in problem solving, possibly involving use of other disciplines.
- Ability to think creatively to develop new and original approaches and methods.

Technological, Methodological and Transferable Skills

- Ability to design appropriate experiments, to analyse and interpret data and draw conclusions integrating knowledge from different disciplines, and handling complexity.
- Ability to use advanced, and develop customised, quantitative methods.
- Comprehensive understanding of applicable techniques and methods for a particular specialisation, and of their limits.
- Awareness of the limits of current knowledge and the practical application of the state-of-the-art technology.
- Knowledge and understanding of geology to create geological models of complex systems and processes.
- Basic ability to contribute to the further development of geology in practice and research.

Other professional competences

- Ability to produce independent work in their professional and scientific fields.
- Ability to manage and work effectively as leader of teams that may be composed of different disciplines and levels.
- Basic ability to work effectively and communicate in national and international contexts.
- Appreciation of the role of geology in the development of knowledge, wealth creation and improving quality of life.
- Ability to evaluate performance as an individual and a team member.
- Ability to identify individual and collective goals and responsibilities and to perform in a manner appropriate to these roles.
- Ability to evaluate critically professional and research papers.
- Ability to plan and appropriate programme of continuing professional development

3. STUDY PROGRAMME AND COURSE LIST

3.1. COURSE LIST

Up to 120 ECTS from optional course list for 4. i 5. year.

4.YEAR

	7. semester		**ECTS**		**8. semester**		**ECTS**
Mrinjek	Plate tectonics	2+0	3	Medunić	Geostatistics	2+1	4
Sremac Halamić	Geology of Croatia	2+0	2		Compulsory - elective course		6
Palinkaš	Quantitative and isotope geochemistry	3+2	7		*Elective course*		5
	Compulsory - elective course		6		*Elective course*		5
	Elective course		5		*Elective course*		5
	Elective course		5		Field course in Geology IV	75 sati	5
	Seminar IV	0+2	2				
			30				**30**

5.YEAR

	9. semester		**ECTS**		**10. semester**		**ECTS**
Marjanac	Elements of scientific work	2+1	5				
	Elective course		5				
	Elective course		5		*Elective course*		5
	Seminar V	0+3	3		Seminar		5
	Individual field project	0+7	12		Thesis		20
			30				**30**

OPTIONAL COURSE LIST (Elective course list)

Elective course 3 hrs/week, obligatory 6 ECTS credits, others 5 ECTS credits.

Marjanac	Karst geology	obligatory for GEOLOGY AND PALAEONTOLOGY
Ćosović	Paleoecology	obligatory for GEOLOGY AND PALAEONTOLOGY
Balen	Petrogenesis	obligatory for MINERALOGY AND PETROLOGY
Tibljaš	Crystallography	obligatory for MINERALOGY AND PETROLOGY
Juračić	Environmental Geology	obligatory for ENVIRONMENTAL GEOLOGY
Marjanac	Geohazards	obligatory for ENVIRONMENTAL GEOLOGY

GEOLOGY AND PALAEONTOLOGY

Bajraktarević	Selected topics of vertebrates paleontology	Moro	Selected chapters form invertebrate paleontology
Ćosović,	Geology and geochemistry of crude oil	Marjanac	Glaciology
Cvetko Tešović, Pezelj	Micropaleontology II	Marjanac	Field work in glaciology
Ćosović	Methods in paleontology	Marjanac	Methods of remote sensing in geology
Juračić	History of geology	Saftić	Geology of Fossil Fuels
Mezga	Paleontological aspects of evolution	Sremac	Palaeobotany
Juračić	Marine Geology	Miracle	Zooarcheology
	Applied geophysics		

MINERALOGY AND PETROLOGY

Balen	Rock Microstructure	Palinkaš	Interpretation of geochemical data
Balen	Microtectonics	Tibljaš, Prohić	Phase and elemental analysis
Bermanec	Silicate mineralogy	Tomašić	Universal stage methods
Bermanec	Non-silicate mineralogy	Medunić	Geochemistry of sedimentary rocks
Kniewald, Bermanec	Gemmology		Field techniques *MP*
Bermanec	Mineral associations		

ENVIRONMENTAL GEOLOGY

Bermanec,	Environmental mineralogy	Prohić	Environmental geochemistry
Bermanec	Instrumental metods in environmental analysis	Prohić	Environmental law
Kapelj	Hydrogeochemistry and groundwater protection	Tibljaš	Clay mineralogy
Palinkaš	Geological aspects of waste disposals	Ahel	Organic geochemistry of pollutants
Medunić	Geochemical metodhs of environmental investigation	Sraka	Basics of pedology
Jüttner, Nuić	Introduction to geotechnology	Romić	Biogeochemistry
Marjanac	Methods of remote sensing in geology	Miracle	Zooarcheology

3.2. STUDY PROGRAMME

7. SEMESTER

<table>
<tr><td colspan="3">COURSE TITLE: Plate tectonics</td></tr>
<tr><td colspan="3">COURSE TEACHER/TEACHERS: PhD. Ervin Mrinjek, assistant professor, Faculty of Science</td></tr>
<tr><td colspan="3">STUDY PROGRAMME: Graduate study of geology and Graduate study of environmental geology</td></tr>
<tr><td colspan="3">YEAR OF STUDY: 1</td></tr>
<tr><td colspan="3">SEMESTER: 1</td></tr>
<tr><td>TEACHING METHODS</td><td>CONTACT HRS PER WEEK</td><td>DELIVERED BY (professor or assistant)</td></tr>
<tr><td>Lectures</td><td>2</td><td>professor</td></tr>
<tr><td>Exercises</td><td>1</td><td>professor</td></tr>
<tr><td>Seminars</td><td></td><td></td></tr>
<tr><td colspan="3">ECTS credits: 3</td></tr>
<tr><td colspan="3">DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS:
Basic knowledge on plate dynamics (on plane and sphere), basic knowledge on magnetostratigraphy and Earth magnetism, basic knowledge on seismology and plate dynamics.</td></tr>
<tr><td colspan="3">LEARNING OUTCOMES:
Basic knowledge and understanding of the Earth’s layers and interior processes.
Basic knowledge on tectonic plates, their boundaries, sedimentary and magmatic processes in boundary areas.
Representing the tectonic plates as a plane and representing their move on a plane.
Ability to use techniques needed for drawing circles movements on a sphere.
Understanding the tectonic plate’s moving on the sphere.
Understanding the link between plate motions and earthquakes.
Understanding paleomagnetism and its connection to plate motions.</td></tr>
<tr><td colspan="3">DESCRIPTION OF THE COURSE:
1) Crust, mantle, core and plate structure.
2) Plate geometry and velocity.
3) Euler poles.</td></tr>
</table>

4) Isochrones and velocities.

5) Ridges and rifting, trenches and subduction, transform faults and fracture zones.

6) "Triple junctions" and their stability

7) Plate motion and velocity on sphere.

8) Earthquakes and plates.

9) Earthquakes at transfom faults, trenches and ridges.

10) Magnetism and isochrones, Earth,s magnetic field, rocks magnetization.

11) Reversals of the magnetic field.

12) Magnetostratigraphy.

13) Polar wandering and plate motion.

14) "What drives the plates"

STUDENT OBLIGATIONS DURING THE COURSE:

Class attendance.

METHODS TO EVALUATE STUDENT PERFORMANCE:

EXAMINATION METHODS:

Exercises, written exam and oral exam.

COURSE(s) NEEDED FOR THIS COURSE:

Physical geology Structural geology and tectonics, petrological courses.

COMPULSORY LITERATURE:

Kearey, P., Kleipes, K. A. & Vine, F. J. (2008): Global Tectonics. Wlley-Blackwel.

Cox, A. & Hart, R. B. (1986): Plate Tectonics –How It Works. Blackwell Publishing.

ADDITIONAL READING:

COURSE TITLE: Geology of Croatia		
COURSE TEACHER/TEACHERS: PhD. Jasenka Sremac, associate professor, PhD. Josip Halamić, associate professor, Faculty of Science		
STUDY PROGRAMME: Graduate studa of geology and Graduate study of environmental geology		
YEAR OF STUDY: 1		
SEMESTER: 1		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	-	-
Seminars		
ECTS credits: 2		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Synthesis and upgrade of previous knowledge in tectonics, biostratigraphy and paleogeography for the purpose of future ability of a graduate student to work in any region of Croatia.		
LEARNING OUTCOMES: Knowledge of the complex geologic, paleogeographic and geotectonic history of Croatian regions. Synthesis of sedimentological and paleontological features of deposits from different geological periods. Knowledge of the development of earth sciences and improvement of geological knowledge in Croatia. Knowledge about the lithostratigraphic units with their potential concerning the investigation and exploration of raw materials and energetic resources.		
DESCRIPTION OF THE COURSE: 1. Geotectonic history of Croatia and the main structural units. 2. Karst Dinarides - early history and beginnings of development of carbonate platform (Carboniferous-Permian) 3. Karst Dinarides - stressful events at the end of the Paleozoic era, the great extinction at Permian / Triassic boundary and slow recovery during the Triassic. 4. Karst Dinarides during the Jurassic and Cretaceous - a platform type of deposition. 5. Karst Dinarides in Cenozoic era - from tropics to the glacial period.		

6. Internal Dinarides - the edge of the platform and its specificity.

7. Northern Croatia during the Palaeozoic era.

8. Triassic events in Northern Croatia.

9. Geological events during the Jurassic and Cretaceous in Northern Croatia.

10. Cenozoic in Northern Croatia. Formation of Paratethys and its evolution.

11. Croatia during the Pleistocene and Holocene.

12. History of geological explorations in Croatia.

STUDENT OBLIGATIONS DURING THE COURSE:

Class attendance.

METHODS TO EVALUATE STUDENT PERFORMANCE:

Regular attendance of lectures, seminar essays, tests.

EXAMINATION METHODS:

Seminar essays, tests.

COURSE(s) NEEDED FOR THIS COURSE:

Finished undergraduate study of geology at the Faculty of Science or Faculty of Mining, Geology and Petroleum Engineering

or Finished courses in Historical (Stratigraphic) geology, Geological mapping and Structural geology with tectonics.

COMPULSORY LITERATURE:

Basic geological map 1:100 000 with 74 sheets and explanatory text. Croatian Geological Survey.

Croatian Geological Map 1: 300 000 with explanatory text. Croatian Geological Survey (2009). http://www.hgi-cgs.hr/osnovna-geoloska-karta.htm

Goričan, Š.; Halamić, J.; Grgasović, T. & Kolar-Jurkovšek, T. (2005): Stratigraphic evolution of Triassic arc-backarc system in northwestern Croatia. // Bulletin de la Société géologique de France. 176 (2005) , 1; 3-22.

Pamić, J. (1997): Vulkanske stijene savsko-dravskog međuriječja i Baranje (Hrvatska). // Nafta, 1-192, Zagreb.

Pamić, J. & Jurković, I. (2002): Paleozoic tectonostratigraphic units of the northhwest and central Dinarides and the adjoining South Tisia. J.Earth Sci. (Geol. Rundschau), 91, 538-554.

Vozarova,A.; Ebner,F.; Kovacs,S.; Kräutner, H.-G.; Szederkenyi, T.; Krstić,B.; Sremac, J.; Aljinović,D.; Novak,M. & Skaberne,D. (2009): Late Variscan (Carboniferous to Permian) environments in the Circum Pannonian Region. // Geologica Carpathica, 60/1, 71-104.

ADDITIONAL READING:

Scientific and professional articles by Croatian and other authors concerning geology of Croatia, available in libraries of Faculty of Science and/or Croatian Geological Survey.

COURSE TITLE: Quantitative and isotope geochemistry		
COURSE TEACHER/TEACHERS: prof.dr. Ladislav Palinkaš		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 4.		
SEMESTER: 7.		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	3	professor
Exercises	2	assistent
Seminars		assistent
ECTS credits: 7		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Knowledge of quantitative modelling of geochemical processes including isotopes is the major goal of the course. It enables students to apply geochemistry in variety of geological branches.		
LEARNING OUTCOMES: Study of quantitative and isotope geochemistry requires basic knowledge of physics, chemistry, mineralogy and petrology. According to the past experience int he frame of Bologna process, the fundamental knowledge is elaborated, but students skills in solving geochemical problems by use of mathematical tools is not adequate. In the progress of the course acquried skill is significantly improved by satisfactory time devoted to students practice. Laboratory exercise would be another way to improve understanding of complex subjects, and their application in the field of economic geology, petrology and geochemistry of environment. Study program intensively uses Internet, great choice of text books and scientific journals.		
DESCRIPTION OF THE COURSE: 1.Chemical equilibrium, 2. Acids and basis, buffers, (carbonate equilibrium, sea water as buffer, ion activity), 3. Carbonate sediments (hydrolysis, carst phenomena, carbonate deposition, tuffa), 4. Kinetics (chemical weathering, catalysis, complexation), 5. Structural chemistry (bond types, isomorphism, polymorphism), 6.Colloids, (organic, silica, Fe-Mn hydroxides, stability), 7.Clay minerals and soil, 8.Thermodynamic equilibria (phase rule, thermodynamic lows and functions), 9.Eh-pH diagrams, 10.Organic matter in sediments (diagenesis, epigenesis, maturation, genesis of oil and gas), 11. Magma (Nernst coef. of distribution, REE, ionic potential,		

phase diagrams), 12. Stabile isotopes, C,O,S,H, geothermometry, 13. Radiogenic isotopes Rb/Sr, K/Ar, Ar/Ar, U-Th-Pb, Sm-Nd, ^{14C}, geochronology, 14. Historical geochemistry.
STUDENT OBLIGATIONS DURING THE COURSE: Obligatory lecture audience and successful lab assignments,
METHODS TO EVALUATE STUDENT PERFORMANCE: colloquies, seminars, mid-term exam are prerequisite for recognition of attendance.
EXAMINATION METHODS: After fulfilling of the course obligation the overall mark is formed by the final exam, written and oral.
COURSE(s) NEEDED FOR THIS COURSE:General mineralogy, Systematic mineralogy, Petrology of igneous and metamorphic rocks, Geochemistry.
COMPULSORY LITERATURE: 1. Richardson, S.M. & McSween, Jr., H.Y.: Geochemistry, pathways and processes. Prentice Hall, 1989., str. 488. 2. Prohić, E.: Geokemija, Targa, 1998., str. 554.
ADDITIONAL READING: White, W.M.: Geochemistry, 2001., http://www.geo.cornell.edu./geology/classes/geo455/Chapters.HTML Rollinson, H.: Using geochemical dana: evaluation, presentation, interpretation, Longman group, 1995., str.350.

8. SEMESTER

<table>
<tr><td colspan="3">COURSE TITLE: Geostatistics</td></tr>
<tr><td colspan="3">COURSE TEACHER/TEACHERS: Research assisstant, dr. sc. Gordana Medunić, Faculty of Science, Department of geology</td></tr>
<tr><td colspan="3">STUDY PROGRAMME: Graduate study Geology</td></tr>
<tr><td colspan="3">YEAR OF STUDY: 4</td></tr>
<tr><td colspan="3">SEMESTER: 8</td></tr>
<tr><td>TEACHING METHODS</td><td>CONTACT HRS PER WEEK</td><td>DELIVERED BY (professor or assistant)</td></tr>
<tr><td>Lectures</td><td>2</td><td>assisstant</td></tr>
<tr><td>Exercises</td><td>1</td><td>assisstant</td></tr>
<tr><td>Seminars</td><td></td><td></td></tr>
<tr><td colspan="3">ECTS credits: 4</td></tr>
<tr><td colspan="3">DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: A student should be able to explain spatial variations of geological features on the basis of the quantitative methods of analysis of geological data. In addition to that, they should recognize patterns (models) and structures in population on the basis of available samples. They are expected to interprete geologic phenomena, as well as to exercise control over the sampling procedures.</td></tr>
<tr><td colspan="3">LEARNING OUTCOMES:
Knowledge and understanding the spatial variations of geological features on the basis of the quantitative methods of analysis of geological data.
Ability to recognise the models and structures in population on the basis of available samples. Ability to interprete geological phenomena.
Ability to devise the sampling procedures.</td></tr>
<tr><td colspan="3">DESCRIPTION OF THE COURSE:
1. Basic concepts in statistics: relevance of geostatistics, measuring scales
2. Definition of a set of data: population, sample, sampling frame, problems with geochemical data (censored values, outliers)
3. Theory of probability: basic concepts (probability laws, Bayes's theorem, conditional probability)
4. Measures of central tendency: arithmetic mean, mode, median, quantiles
5. Measures of variability: range of variation, interquartile, mean deviation,</td></tr>
</table>

variance, standard deviation, coefficient of variation

6. Testing normal populations: central limits theorem, Shapiro-Wilk W test
7. Correlation analysis: Pearson's coefficient of correlation, simple and multiple linear correlation, partial correlation, rank correlation coefficients
8. Regression analysis: simple and multiple regression, scatter diagram, least-squares method, regression diagnostics
9. Sampling design: a concept and size of a sample, a hierarchical sampling design based on an unbalanced sampling scheme
10. Analysis of variance: F-test, post-hoc tests (Scheffe, HSD for unequal N)
11. R-mode factor analysis: vector space model, problem of the number of possible factors, interpretation of factor loadings' joint behaviour towards variables
12. Cluster analysis: R-mode (classification of variables) and Q-mode (classification of samples) based on hierarchical clustering, construction of dendrogram
13. Formulating conclusions in statistics: accepting or rejecting of null-hypothesis, level of significance
14. Parametric and nonparametric statistics: Wald-Wolfowitz, Kolmogorov-Smirnov and Mann-Whitney U tests

STUDENT OBLIGATIONS DURING THE COURSE: Regular attendance of all class lectures and especially exercises, solving homework problems (calculations, worked examples, data treatment of variables with the STATISTICA software).

METHODS TO EVALUATE STUDENT PERFORMANCE: Absence from exercises must be less than 20% of the total time-table, and homework results should be presented in written/electronic form.

EXAMINATION METHODS: A short written exam followed by an oral exam.

COURSE(s) NEEDED FOR THIS COURSE: Mathematics I i II, Physical geology, Geochemistry.

COMPULSORY LITERATURE:

Petz, B. (2004) : Osnovne statističke metode za nematematičare (Basic statistical methods for nonmathematical people). Naklada Slap, Jastrebarsko, 384 pp.

Šošić, I. & Serdar, V. (1995) : Uvod u statistiku (Introductory statistics). Školska knjiga, Zagreb, 363 pp.

ADDITIONAL READING:

Davis, J. C. (1986): Statistics and data analysis in geology. John Wiley & sons, New York, 646 pp.

StatSoft, Inc. (2003): STATISTICA (data analysis software system), version 6.1,

www.statsoft.com.

9. SEMESTER

COURSE TITLE: Elements of scientific work		
COURSE PROFESSOR/PROFESSORS: Prof. dr. sc. Ljubomir Babić, Faculty of Science		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 5.		
SEMESTER: 9.		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	Professor
Exercises	1	Professor
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Students become aware of the fundamental features of scientific work as to be able to find and use scientific results successfully. The course aims at showing the vital role of science in modern society. Modern students should know how science works and how it is organized. The course is also intended to help students understand the interrelationship between science, university and their own studies, as well as make them better oriented as professionals, be it in science, education or industry.		
LEARNING OUTCOMES: Achievement of specific knowledge on the subject and competences which are necessary for: 1) participation in scientific research, 2) writing research project proposals, formulating a hypothesis, 3) gathering and evaluating literature data, usage of data bases, 4) writing reports and research papers, editing, 5) presentation of research results at meetings, 6) successful evaluation of research data, 7) learning hierarchy in science, and understanding of science policies.		
DESCRIPTION OF THE COURSE: Knowledge and scientific research. Information. Motives. Creativity and freedom. Scientific publications. Organization of a scientific paper. Primary and other publications. Bibliographic reference. How to find scientific information. The character of the observation. Recording observations. Role of experience and school. The necessity of being informed of the most recent publications. Critical reading. Why publish? Producing a manuscript for a scientific paper. Review process. Revision. Oral presentation. Poster presentation. Induction and deduction. Problem, hypothesis, theory. Paradigm and normal science. Falsification. Anarchistic theory. Historical, social and personal factors.		

Specific aspects of scientific approach in geosciences.
Conditions for scientific work. Evaluation in science. Competence, elite, democracy. Industry and science. Ph. D. Thesis. Scientific project. Scientific policy.

STUDENT OBLIGATIONS DURING THE COURSE:

Activity during discussions, regular completion of exercises and essays.

METHODS TO EVALUATE STUDENT PERFORMANCE:

Activity during discussions, regular completion of exercises and essays.

EXAMINATION METHODS:

Oral; an important part of the grade is based on in class activity

COURSE(s) NEEDED FOR THIS COURSE:

None

COMPULSORY LITERATURE:

Schumm, S. A.: To interpret the Earth. Ten ways to be wrong. Cambridge University Press, Cambridge, 1991.
Silobrčić, V.: Kako sastaviti, objaviti i ocijeniti znanstveno djelo. 4th ed. Medicinska naklada, Zagreb, 1998.

ADDITIONAL READING:

Kuhn, T. S.: The Structure of Scientific Revolutions. University of Chicago Press, Chicago, 1962.
Oliver, J. E.: The Incomplete Guide to the Art of Discovery. Columbia University Press, New York, 1991.
Sindermann, C. J.: Winning the Games Scientists Play. Plenum Press, New York, 1982.
Popper, K.: The Logic of Scientific Discovery. Hutchinson, London, 1959.
Feyerabend, P.: Against Method: Outline on an Anarchistic Theory of Knowledge. New Left Books, London, 1959.
Lelas, S.: Promišljanje znanosti. Hrvatsko filozofsko društvo, Zagreb, 1990.
Petrović, G.: Logika. Školska knjiga, Zagreb, 1987.
Ravetz, J. R.: Scientific Knowledge and its Social Problems. 2nd ed. Transaction Publications, New Brunswick, 1996.
+ selected articles from various publications

COURSE TITLE: Individual field project

COURSE TEACHER/TEACHERS: PhD. Tihomir Marjanac, associate professor; PhD. Marijan Kovačić, associate professor, Faculty of Science

STUDY PROGRAMME: Graduate study of geology and Graduate study of environmental geology

YEAR OF STUDY: 2

SEMESTER: 3

TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures		
Exercises	7	professor
Seminars		

ECTS credits: 12

DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS:

Mastering field and laboratory research techniques in geology, authoring a geological map and explanatory notes.

LEARNING OUTCOMES:

Mastering skills for recognition and interpretation of lithologies in the field, measurement of tectonical elements and recognition of geological structures. Mastering skills and knowledge for analysis and lithological and stratigraphical interpretation of collected rock and fossil samples. Achieving competences for preparation of field geological map, geological sections and column, and preparation of a manuscript geological map and related explanatory report.

DESCRIPTION OF THE COURSE:

1) Students individually perform preparation for the field research, study appropriate literature.

2) Students individually map given territory.

3) Students individually describe and analyse collected samples, study thin sections under the microscope, determine lithology of the sampled rocks, determine collected fossils and their age.

4) Students individually prepare a manuscript geological map of the studied area.

5) Students individuallly write a comprehensive report.

STUDENT OBLIGATIONS DURING THE COURSE:

Individual work in the field, obeying safety in field work, periodic reporting of work progress to dedicated mentor, obeying work and deadline schedule.

METHODS TO EVALUATE STUDENT PERFORMANCE:
EXAMINATION METHODS: Monitoring individual work phases, review of field performance and map, review of written report, grading of final report and geological map.
COURSE(s) NEEDED FOR THIS COURSE: Geological mapping I and II course, Field courses in geology.
COMPULSORY LITERATURE: Bahun, S.: Geološko kartiranje. Školska knjiga, Zagreb,1993. Barnes, J.W. & Lisle, R.J: Basic Geological Mapping (fourth edition). John Wiley & Sons, Ltd, England, 2004. Powell, D.: Interpretation of Geological Structures Trough Maps (an introductory practical manual). Longman Scientific & Technical, Group UK Ltd., 1994. Dimitrijević, M.: Geološko kartiranje. ICS, Beograd, 1978.
ADDITIONAL READING: Explanatory notes of Basic geological maps, geological publications on Medvednica and Samoborsko gorje.

GRADUATE STUDY OF GEOLOGY (GEOLOGY AND PALAEONTOLOGY, MINERALOGY AND PETROLOGY)

Obligatory course list for graduate studies

<table>
<tr><td colspan="3">COURSE TITLE: Karst Geology</td></tr>
<tr><td colspan="3">COURSE TEACHER/TEACHERS: Prof. Mladen Juračić, PMF</td></tr>
<tr><td colspan="3">STUDY PROGRAMME: Graduate study Geology</td></tr>
<tr><td colspan="3">YEAR OF STUDY: 4</td></tr>
<tr><td colspan="3">SEMESTER: 7</td></tr>
<tr><td>TEACHING METHODS</td><td>CONTACT HRS PER WEEK</td><td>DELIVERED BY (professor or assistant)</td></tr>
<tr><td>Lectures</td><td>2</td><td>professor</td></tr>
<tr><td>Exercises</td><td>1</td><td>assistant</td></tr>
<tr><td>Seminars</td><td></td><td></td></tr>
<tr><td colspan="3">ECTS credits: 6</td></tr>
<tr><td colspan="3">DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: To introduce students with geological background of karst development. To teach them of the complexity of water circulation in karst, based mainly on examples from Dinaric karst. Emphasize the dependence of the karstification process on the geological structures and lithology.</td></tr>
<tr><td colspan="3">LEARNING OUTCOMES:
Achievement of specific knowledge on the subject and competences which are necessary for: 1) field study of karst, 2) study of water dynamics in karst, 3) protection of waters in karst, 4) successfully interpret the evolution of karst regions, individual karst phenomena in particular.</td></tr>
<tr><td colspan="3">DESCRIPTION OF THE COURSE: History of karst research. Different approaches to the karst studies (speleologic, descriptive, genetic). Tectogenetic karst classification (orogenic, epiorogenic). Water in karst (geochemical and hydrologic aspect). Karst areas in the world. Dinaric karst (lithostratigraphi, tectonics, kastification timeframe), Morphologic evolution of karst.</td></tr>
<tr><td colspan="3">STUDENT OBLIGATIONS DURING THE COURSE: Lectures and practical exercises (optional – field work: hydrogeological phenomena, barrier types)</td></tr>
<tr><td colspan="3">METHODS TO EVALUATE STUDENT PERFORMANCE:</td></tr>
<tr><td colspan="3">EXAMINATION METHODS: Preliminary exams during practical exercises,</td></tr>
</table>

midtermwritten exam, final oral exam
COURSE(s) NEEDED FOR THIS COURSE: chemistry, general geology
COMPULSORY LITERATURE: 1. Bahun, S. Juračić, M. (2002): Geologija krša. Internal skripta. PMF 2. Ford, D., Williams, P. (1992): Karst geomorphology and hydrology. Chapmann & Hall, London
ADDITIONAL READING: Herak, M., Stringfield, V.T. (1972): Karst. Important karst regions of the northern hemisphere. Elsevier, Amsterdam. Bonacci, O. (1987): Karst hydrology with special reference to the Dinaric Karst. Springer Verlag, Berlin, pp. 184.

COURSE TITLE: Paleoecology		
COURSE TEACHER/TEACHERS: Prof. dr. Vlasta Ćosović		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 5		
SEMESTER: 2		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	professor
Seminars	1	professor
ECTS credits: 6		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Through paleoecological rules make an picture about evolution of biosphere, with determination of cosequences of cological changes which happend today, and use them in predicting future.		
LEARNING OUTCOMES: Basic knowledge and understanding of the key aspects and concepts of paleoecology. Knowledge and and understanding of the complex nature of interactions within the past biosphere. Ability to integrate field and laboratory evidence with theory following the sequence from observation to recognition, synthesis and paleoecological modeling. Basic ability to combine theory and practice to complete paleoecological reconstruction. Ability to use simple quantitative methods and to apply them to paleoecological and paleogeographical problems. Ability to critically evaluate paleoecological analyses in the literature.		

DESCRIPTION OF THE COURSE: (1) History of Biosphere: Marine and Terrestrial environments, Life modes and trophic strategies, Global changes in atmosphere, hydrosphere and lithosphere, Geophysiology. (2) Environmental control on biotic distribution: the structure of biosphere, Limiting factors on the distribution of organisms (light, nutrients, oxygen, temperature, salinity, substrate composition). (3) Taphonomy: preservation potential (the fidelity of fossils assemblages), destruction (chemical, biological and physical) on sediment surface and below the sediment surface, Fossil lagersttaten, the taphonomy of plants and vertebrates. (4) Adaptive morphology: terminology, growth strategies, investigative methods (paradigm approach, experimental palaeoautoecology, computer simulation), Adaptation, Morphology and environments (Pre - Vendian, Vendian, Tommotian, Cambrian, Paleozoic and modern biotas). (5) Trace fossils: Preservation and taxonomy of ichnofossils, Marine and marginal marine trace fossils, Bioerosion, Terrestrial ichnofacies, Evolution of trace fossils. (6) Fossils as environmental indicators: Clastic shelves, Carbonate environments, Oxygen deficient environments, Environment with high and low salinity, Firmness of substrate. (7) Populations and communities: Types and dynamics of populations, Variations in populations, Spatial distribution, Opportunist and equilibrium species, Community structure, Numerical analysis of community, Community organization, Species diversity through time. (8) Paleobiogeography: Modern biogeography, Definitions of paleobiogeography, Controls on biogeography (Dispersal vs. Vicariance biogeography), faunal province through time, Paleoclimatology, Biogeography and evolution and extinction. (9) Evolutionary paleoecology of the marine biosphere: Diversification event in Earth history (the origin of life, the earliest prokaryote, appearance of eukaryote and metazoan, the Ediacara fauna, Cambrian fauna and three great evolutionary faunas), Extinction (pattern, causes and recoveries). (10) Fossil terrestrial ecosystems: initial adaptation s and earliest fossil record of animals and plants, terrestrial ecosystem through time.

STUDENT OBLIGATIONS DURING THE COURSE: Essay, project type of individual work, exercises.

METHODS TO EVALUATE STUDENT PERFORMANCE: Succesfully resolve project tasks, active participation on exercises.

EXAMINATION METHODS: Oral exam.

COURSE(s) NEEDED FOR THIS COURSE:

COMPULSORY LITERATURE: Brenchley, P.J. & Harper, D.A.T., 1998, Palaeoecology, Ecosystems, Environments and evolution, Champan & Hall, London

Prothero, D.R., 1998, Bringing fossils to life, An Introduction to Paleobiology, McGraw-Hill

ADDITIONAL READING: Lieberman, B.S., 2000, Paleobiogeography, Using fossils to study global change, plate tectonics and evolution, Kluwer Acad. Press.

Internet izvori:
http://www.utexas.edu/cc/vislab/gallery/index.html
http://members.aol.com/macops/Raup.html
http://www.paleo.geol.vt.edu/geos3604/labs/EXERCISES/PALEOECOLOGY/paleo.html

http://www.notam02.no/~oyvindha/compal.html

COURSE TITLE: Petrogenesis		
COURSE TEACHER/TEACHERS: Dr. Dražen Balen, assistant professor, Department of Geology, Faculty of Science, University of Zagreb		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 5		
SEMESTER: 8		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	professor
Seminars		
ECTS credits: 6		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Advanced level of igneous and metamorphic petrology with emphasis on regime of rock genesis in the different geotectonic settings. Students achieve knowledge needed for research and work in laboratory and field on master of geology level. After course students should be able to read scientific literature and have basics for interpretation of petrologic data.		
LEARNING OUTCOMES: Advanced knowledge and understanding of the natural processes underlying the study of geology and igneous and metamorphic rocks genesis. An awareness of the wider spectrum of geological disciplines. Ability to create simple geological models. Knowledge of appropriate solution patterns for geological problems. Ability to integrate field and laboratory evidence with theory following the sequence from observation to recognition, synthesis and modelling. Basic ability to combine theory and practice to complete geological tasks. Ability to undertake literature searches, and to use data bases and other sources of information. Basic ability to solve numerical problems using computer and non-computer based techniques. Basic ability to work effectively and communicate in national and international contexts. Ability to evaluate performance as an individual and a team member. Ability to identify individual and collective goals and responsibilities and to perform in a manner appropriate to these roles. Ability to evaluate critically professional and research papers. Ability to plan and appropriate programme of continuing professional development.		

DESCRIPTION OF THE COURSE:
1. Importance of phase and chemical composition and microstructures in the genesis of igneous and metamorphic rocks.
2. Importance of trace elements and isotopes in the genesis of igneous and metamorphic rocks.
3. Role of accessory minerals in the genesis of igneous and metamorphic rocks.
4. Petrochemical and geochemical calculations - reasons, applicability, constraints, limits.
5. Norms - approach and use in the igneous and metamorphic petrology.
6. Specific software in the igneous and metamorphic petrology. Construction and interpretation of various petrologic, phase, variation and discrimination diagrams.
7. Petrochemical calculations in the metamorphic petrology. AFM, ACF i A´KF diagrams
8. Metamorphism and deformation. Growth and importance of pretectonic, intertectonic, sintectonic and post-tectonic porphyroblasts.
9. Microtectonics. Geometry and crystallography vs. optical elements. Necessity of 3rd dimension in thin section.
10. Geothermobarometry basics.
11. Age of igneous and metamorphic rocks - principles, basics and methods.
12. P-T-t-D-X reaction paths, ideas, basics.
13. Igneous and metamorphic rocks in the area (Pannonian Basin, Tisia, Alps, Carpathians, Dinarides).
14. Volcanism in the area, potential hazard.
15. The "granite problem" - ideas, evolution, state of the art.

STUDENT OBLIGATIONS DURING THE COURSE: seminar

METHODS TO EVALUATE STUDENT PERFORMANCE: seminar

EXAMINATION METHODS: short written exams after each lecture block, seminar, oral

COURSE(s) NEEDED FOR THIS COURSE: Igneous and metamorphic petrology

COMPULSORY LITERATURE:
Hibbard, M. J. (1995): Petrography to Petrogenesis. Prentice Hall, New Jersey, 587 pp.

Bucher, K. & Frey, M (2002): Petrogenesis of Metamorphic rocks. Springer Verlag, 341 pp.

ADDITIONAL READING:
Best, M.G. (2003): Igneous and metamorphic petrology.- Blackwell Publishing, 729 pp.
Hyndman, D. W. (1985): Petrology of Igneous and Metamorphic Rocks. Mc Graw Hill Inc., N. Y.
Brown, M. (2001): From microscope to mountain belt: 150 years of petrology and its contribution to understanding geodynamics, particularly the tectonics of orogens. Journal of Geodynamics, 32, 115-164.

COURSE TITLE: CRYSTALLOGRAPHY		
COURSE TEACHER/TEACHERS: Associate professor, DARKO TIBLJAŠ, Faculty of Science		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: IV		
SEMESTER: VII		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	1	professor
Exercises	2	professor
Seminars		
ECTS credits: 6		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Gaining of complementary knowledge, to that obtained from General mineralogy, for better understanding of crystallographic principles		
LEARNING OUTCOMES: Knowledge of main properties of stereographic and gnomonic projection and capability of their drawing; Capability of crystal indexing by using gnomonic projection; Knowledge and understanding of point and space group symbols; Capability of determination of possible crystal forms for all point groups; Understanding of space group inferring; Capability of using point group data from International Tables for Crystallography; Capability of mathematical defining of operations with Euclidian vectors, colinearity, complanarity and coordinates; Capability of performing operations with Euclidian vectors and checking relations between objects in space using coordinates in general oblique coordinate systems; Capability of determining order and generators of point group by using stereographic projection of symmetry elements and point in general position; Capability of interpreting crystallographic concepts (lattice planes, Miller indices and Weiss parameters, zones and forms, symmetry, direct and reciprocal space and lattice, point and space groups) in mathematical way;		

DESCRIPTION OF THE COURSE: 1.-2. Derivation of point groups and possible crystal forms

3.-6. Crystallometry (two-circle reflection goniometer), gnomonic, stereographic and parallel-perspective projections

7. Spherical trigonometry

8.-9. Bravais lattices and space groups – principles of derivation

10.-12. Reciprocal lattice, explanation of X-ray diffraction

13.-15. Principles of matrix algebra

STUDENT OBLIGATIONS DURING THE COURSE: attending classes, preliminary exams, homework assignments

METHODS TO EVALUATE STUDENT PERFORMANCE: fulfilled obligations

EXAMINATION METHODS: written exam, final grade includes also results of prelim and homework assignments

COURSE(s) NEEDED FOR THIS COURSE: General mineralogy

COMPULSORY LITERATURE: Borchardt-Ott, W. (1995): Crystallography, Springer Verlag, Berlin, 307 pp.

Rousseau, J.-J. (1998): Basic crystallography, John Wiley & Sons, New York, 414 pp.

Klein, C. (2002): Mineral Science, John Wiley & Sons, New York, 641 pp.

Nesse, W.D. (2000): Introduction to mineralogy, Oxford University Press, Oxford, 442 pp.

ADDITIONAL READING: Giacovazzo, C. (ed.) (2002): Fundamentals of crystallography, International Union of Crystallography, Oxford University Press, Oxford, 844 pp.

COURSE TITLE: Environmental Geology		
COURSE TEACHER/TEACHERS: Prof. Mladen Juračić, PMF		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 4		
SEMESTER: 7		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	assistant
Seminars		
ECTS credits: 6		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Students gain knowledge on geological component in environmental protection (geological hazards, groundwater, location and design of landfills).		
LEARNING OUTCOMES: Awareness of the applications and responsibilities of Geology and its role in society including its environmental aspects. Knowledge and understanding of the complex nature of interactions within the geosphere . Knowledge of the range of applications of Geology Understanding the need of a rational use of earth resources. Some understanding of the complexity of geological problems and the feasibility of their solution. Basic ability to communicate effectively in written and verbal form with colleagues, other professionals, customers and the general public about substantive issues and problems related to their chosen specialisation		
DESCRIPTION OF THE COURSE: The role of geology in environmental protection. Basic concepts: environment, environmental protection, contamination-pollution. Interdicilinarity in environmental protection. Geological Hazards. Hydrological cycle, groundwater and its quality. Waste disposal and landfills. Erosion, floods, suspended matter and its sedimentation. Marine pollution and eutrophication (Adriatic Sea). Geomaterials and protection of geological heritage. The role of geology in physical planning. Environmental protection strategies and sustainable development.		

STUDENT OBLIGATIONS DURING THE COURSE: Lectures and practical exercises (optional – field work: sediment landfill, piesometric field)

METHODS TO EVALUATE STUDENT PERFORMANCE:

EXAMINATION METHODS: Preliminary exams during practical exercises, midterm written exam, final oral exam

COURSE(s) NEEDED FOR THIS COURSE: chemistry, general geology

COMPULSORY LITERATURE:

3. Juračić, M.: Geologija zaštite okoliša (http://geol.gfz.hr/Juracic/predavanja/index.html)
4. Bell (1998): Environmental geology, principles and practice, Blackwell Science, pp. 594.
5. Chamley, H. (2003): Geosciences, environment and man. Developments in Earth & Environmental Sciences 1, Elsevier, pp. 527.

ADDITIONAL READING:

Mayer, D.: Kvaliteta i zaštita podzemnih voda. IV + 146. Hrvatsko društvo za zaštitu voda i mora, Zagreb, 1993.

Montgomery, C.W. (1995): Environmental geology, Wm.C. Brown Communications, Inc., pp.496

COURSE TITLE: Geohazards

COURSE TEACHER/TEACHERS:

Prof. dr. sc. Ljubomir Babić, Faculty of Science

STUDY PROGRAMME: Graduate study Geology

YEAR OF STUDY: 4./5.

SEMESTER: 7./8./9./10.

TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	professor & assistant
Seminars		

ECTS credits: 6

DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS:

The course examines what are hazardous geological processes and how they influence humans and their activities in the world which is increasingly faced with complex environmental problems. Students will become aware of the consequences of geological hazards for human property and lives, as well as for socio-economic consequences. The influence of man on inducing hazardous processes is explained. The cooperation with scientists and experts in other fields in designing the approaches to assessment and solving of hazards and risk problems is considered. The exercises, a project and the field project will give the opportunity to study and obtain practical skills with real life examples of hazardous processes and features.

The course has an emphasis on the nature of various hazardous geological processes with which students receive a good knowledge base needed in many commonly used practices today such as Hazard Management, Environmental Impact Assessment and Land-Use Planning.

LEARNING OUTCOMES:

Achievement of specific knowledge on the subject and competences which are necessary for: 1) the understanding of causes and physics of individual geological hazard processes, 2) the understanding of effects of individual geological hazard processes, 3) the evaluation of risk associated with individual geological hazards, 4) design of hazard mitigation procedures and recommendations of safety measures.

DESCRIPTION OF THE COURSE:

Hazard and risk. Natural and technological hazards. Hazard parameters. Vulnerability. Prevention, defense, mitigation, recovery, management. Recurrence. Importance

of secondary hazards including socio-economic ones. Human factor. The role of scientists.
The aspects mentioned above are discussed for each individual hazard type listed below.
Volcanism. Processes, products, and consequences. Secondary hazards: mass movements, lahars, torrents, floods, fires, hydrographic changes.
Earthquakes. Processes. Role of geology of the area. Recognition of active faults. Secondary effects: liquefaction, groundwater, mass movement, floods, fires, tsunamis. Mapping types.
Mass movements. Fall, creep, sliding, sediment gravity flows, and combinations. Recognizing activity of mass movements. Morphological changes. Mapping mass movements. Snow and ice hazards. Subsidence.
Running water. River types and evolution. River parameters. Erosion and accumulation. Sediment movement. Morphological changes. Floods and alluviation.
Wind. Deflation. Transport and accumulation of sand and dust. Sources of sediment.
Coastal hazards. Waves, currents and tides. Cliffs and beaches. Erosion and accumulation. Effects of storms. River mouths. Morphological changes.
The influence of global changes.
Environmental impact assessment.
Field project on active slides.

STUDENT OBLIGATIONS DURING THE COURSE:

Active participation in the solving of exercises, discussions and fieldwork; Regular completion of all assigned work, including exercises, quizzes, essays, small classroom projects, and field project.

METHODS TO EVALUATE STUDENT PERFORMANCE:

Active participation in the solving of exercises, discussions and fieldwork; Regular completion of all assigned work, including exercises, quizzes, essays, small classroom projects, and field project.

EXAMINATION METHODS:

Oral; an important part of the grade is based on in class activity

COURSE(s) NEEDED FOR THIS COURSE:

Physical Geology

COMPULSORY LITERATURE:

Smith, K.: Environmental Hazards: Assessing Risk and Reducing Disaster. 3rd ed. Routledge, London, 2001.
Bell, F.G. Geological hazards. Spon Press, 1999.

ADDITIONAL READING:

Maund, J. G. & Eddleston, M. (eds.): Geohazards in Engineering Geology. Geological Society, London, 1998.
Keller, A.E.: Environmental Geology. 8th ed. Prentice Hall, Upper Saddle River, 2000.
Haughton, J.: Global Warming. 3rd ed. Cambridge Univesity Press, Cambridge, 2004.

Bolt, B.A., Horn, W.L., Macdonald, G.A., Scott, R.F.: Geological Hazards. Springer-Verlag, Berlin, 1975.
Allen, P. A., Earth Surface Processes. Blackwell, Oxford, 1997.
Bobrowsky, P. T. (ed.): Geoenvironmental Mapping. Balkema, Lisse, 2002.
Morris, P. & Therivel, R. (eds.): Methods of Environmental Impact Assessment. 2nd ed. Spon Press, London, 2001.

Internet sources:
http://www.usgs.gov/science.html (U. S. Geological Survey)
http://www.consrv.ca.gov/CGS/ (California Geological Survey)
http://www.fema.org/hazards/ (Federal Emergency Managment Agency, U. S.)
http://www.volcano.si.edu/ (Smithsonian, National Museum of Natural History)
http://www.ga.gov.au/urban/ (Geoscience Australia)
http://yosemite.epa.gov/oar/globalwarming.nsf/content/index.html (U. S. Environmental Agency)
http://www.elnino.noaa.gov/ (National Oceanic and Atmospheric Administration, U. S.)
http://www.eurosion.org/index.html (EUrosion, European Commission)

Optional course list Geology (Geology and Palaeontology)

<table>
<tr><td colspan="3">COURSE TITLE: Selected topics of vertebrates paleontology</td></tr>
<tr><td colspan="3">COURSE TEACHER/TEACHERS: Prof. Dr. Zlatan Bajraktarević, PMF</td></tr>
<tr><td colspan="3">STUDY PROGRAMME: Graduate study Geology</td></tr>
<tr><td colspan="3">YEAR OF STUDY: IV or V</td></tr>
<tr><td colspan="3">SEMESTER: VII or IX</td></tr>
<tr><td>TEACHING METHODS</td><td>CONTACT HRS PER WEEK</td><td>DELIVERED BY (professor or assistant)</td></tr>
<tr><td>Lectures</td><td>2</td><td>PROFESSOR</td></tr>
<tr><td>Exercises</td><td>1</td><td>ASSISTENT</td></tr>
<tr><td>Seminars</td><td></td><td></td></tr>
<tr><td colspan="3">ECTS credits: 5</td></tr>
<tr><td colspan="3">DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Structures of selected groups of vertebrates, studying of their anatomy, their narration in the perspective of evolution, biostratigraphy and paleogeogeography</td></tr>
<tr><td colspan="3">LEARNING OUTCOMES:
Proficiency and understanding of osteological fossil features important for the evolution of life.
Fundamental knowledge and basic aspects of evolution of the fossil vertebrates.
Ability to recognize individual osteological findings of the most frequent fossil vertebrates.
Ability to interpret field and laboratory evidences for paleoecological interpretation.
Ability of self-determining of unknown parts of fossils with the help of literatures.</td></tr>
<tr><td colspan="3">DESCRIPTION OF THE COURSE: The fossil foundings and fossilization of selected groups of the vertebrates (according to the interest of students). Comparative anatomy and selection of the most topic literature from the relevant world and domestic journals.</td></tr>
<tr><td colspan="3">STUDENT OBLIGATIONS DURING THE COURSE: Alongside lectures and systematic introduction with the selected topic and materia, setting the exact assignments, essays and leading a discussion.</td></tr>
<tr><td colspan="3">METHODS TO EVALUATE STUDENT PERFORMANCE: Ordinary attendance of the lectures and practise aswell as ordinary participating in discussions of the given</td></tr>
</table>

assignments and essays.
EXAMINATION METHODS: in writting and oral examination of the knowledge acuired
COURSE(s) NEEDED FOR THIS COURSE: basic paleontological and biological courses. A possibility of hearing, except for the students of geology and paleontology and students of biology and veterinary medicine. According to mentioned, recognizing of related paleontological and biological courses.
COMPULSORY LITERATURE: Carrol, F.L.: Vertebrate paleontology and evolution. W.H. Freeman & Co., New York, 1998.
ADDITIONAL READING: Selection of the selected topic scientific articles from the world's and domestic journals and Internet sites.

COURSE TITLE: Geology and geochemistry of crude oil		
COURSE TEACHER/TEACHERS: Prof. dr. Vlasta Ćosović, Prof. dr. Anđa Alajbeg		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 5		
SEMESTER: 2		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	professor
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: To teach students how to evaluate sedimentary basins as possible carriers of crude oil and gas.		
LEARNING OUTCOMES: Knowledge and understanding of the sedimentological properties of reservoir and source rocks and their identification in logs, seismic profiles and cores. Basic knowledge and understanding of genesis of crude oil and gas and how they are related to tectonic, stratigraphic characteristics of depo- centers. Basic knowledge of thermal/maturation modeling. Ability to define source rock facies, palaeoenvironments and geochemical signatures. Ability to do geochemical evaluation.		
DESCRIPTION OF THE COURSE: (1) Basic considerations about crude oil and gas (geophysical methods, environments in which crue oil and gas appear, porosity, traps) _Exercises: determination of structural characteristics if seismic profiles, calculation of porosity) (2) Biosrtratigraphy and sequence stratigraphy in exploration of crude oil and gas – Exercises: how to use polen, nanoalgae, and forams in reconstruction of environments in which crude oil and gas could be formed. (3) Models of sequence stratigraphy for carbonate platforms- Exercies: Analysis of edimentary space from geophysical profiles.		
STUDENT OBLIGATIONS DURING THE COURSE: Colloquium after every lecture unit. Resolving of tasks from sequence stratigraphy		

METHODS TO EVALUATE STUDENT PERFORMANCE: Succesfully resolve all tasks, active participation on exercises.
EXAMINATION METHODS: writing exam.
COURSE(s) NEEDED FOR THIS COURSE: Physical geology, Historical geology I and II, Chemistry I and II.
COMPULSORY LITERATURE: Emery, D. & Myers, K.J. (ur), 1996, Sequence Stratigraphy. Blackwell Science, 297 str., Oxford. Miall, A.D., 1997, The geology of stratigraphic sequences. Spriinger Verlag, 433 str., Berlin.
ADDITIONAL READING: Ercegovac, M.D., 2002, Geologija nafte. RGNF, 463 str., Beograd

COURSE TITLE: Micropaleontology II		
COURSE TEACHER/TEACHERS: Prof. dr. Vlasta Ćosović		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 5		
SEMESTER: 2		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	1	professor
Exercises	2	professor
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Role of microfossil in paleoecology, paleooceanology, paleoclimatology and biostratigraphy.		
LEARNING OUTCOMES: Students will be able: Knowledge and understanding the role of microfossils in paleoecology, paleoceanography, paleoclimatology and biostratigraphy. Apply knowledge of taxonomy and ecology to analyse the evolution of foraminifera. Apply statistical methods and relate the fossil record of foraminifera to its chronostratigraphic and palaeoenvironmental context. Recognize various types of microfossils in unknown sample and use them to reconstruct and interpret the history of the area. Ability to become familiar with advanced micropaleontological methods.		
DESCRIPTION OF THE COURSE: (1) Foraminifers (Lifestyle aspects of foraminifers, techniques of sampling that are pertinent to consolidate and unconsolidated sediments; laboratory processing of samples, systemtics). (2) Environmental applications of deep sea benthic foraminifers. (3) Benthic foraminifers as indicators of environmental change: marginal – marine – shelf - upperslope environments. (4) Intertidal forminifers as environmental indicators. (5) Environmental applications of marine and freshwater ostracods. (6) Paleoceanographic applications of planktonic foraminifers and radiolarians. (7 - 10) Environmental applications of diatoms, . calcareous nannoplankton, dinoflagellate and pollen. (11) Application of ecologically based statistics to micropaleontology.		

STUDENT OBLIGATIONS DURING THE COURSE: Colloquium after every lecture unit.

Seminar work using articles form micropaleontology are which dealing with Adriatic Sea

METHODS TO EVALUATE STUDENT PERFORMANCE: Succesfully resolve all tasks ans seminar work, active participation on exercises.

EXAMINATION METHODS: Oral exam.

COURSE(s) NEEDED FOR THIS COURSE:

COMPULSORY LITERATURE: Haq, B.U. & Boersma, A., 1998, Introduction to Marine Micropaleontology. Elsevier

Brasier, M.D., 1985, Microfossils. George Allen & Unwin

Haslett, S.K. (ed), 2002. Quaternary Environmental Micropaleontology, Arnold/Oxford Univ. Press publ.

ADDITIONAL READING: Martin, R.E. (ed), 2000, Environmental Micropaleontology: The Application of Microfossils to Environmental geology. Kluwer Academic/Plenum Publishers.

Molina E. (ed), 2002, Micropaleontologia. Coleccion Textos Docentes, no. 93, 634 str., Prensas Universitarias de Zaragoza.
Scott, D.B., Medioli, F.S. & Schafer, C.T., 2001, Monitoring in Coastal Environments Using Foraminifera and Thecamoebian Indicators. Cambridge University Press.
Sen Gupta, B.K. (ed), 1999, Modern foraminifera. Kluwer Academic Publishers.
Internet sources
www.nmnh.si.edu/paleo/foram
www.UCMP.Berkeley.EDU/fosrec

http://earthguide.ucsd.edu/eyh/links.html

COURSE TITLE: Methods in paleontology		
COURSE TEACHER/TEACHERS: Prof. dr. Vlasta Ćosović		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 5		
SEMESTER: 1		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	1	professor
Exercises	2	professor
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: To teach students how to make fenethic tree, how to define biozones, how ans when use biostatistics, and how to use some laboratory techincs		
LEARNING OUTCOMES: Basic ability in the formalisation and specification of problems whose solution involves the use of paleontological methods. Knowledge of appropriate solution patterns for stratigraphical and paleontological problems. Ability to integrate field and laboratory evidence with theory following the sequence from observation to recognition, synthesis and paleoecological modeling. Appreciation of issues concerning paleontological sample selection, accuracy, precision and analysis of data in the field and laboratory. Ability to undertake literature searches, and to use data bases and other sources of information for paleontological interpretation (taxonomy, paleoclimatology, paleoecology, paleogeography). Ability to interpret standard paleontological charts and plots (biostratigraphic range charts; phylogenies and cladograms; diversity analyses; etc.)		

DESCRIPTION OF THE COURSE:

(1) Systematic Paleontology (Exercise: An example of the Formal description of selected species); (2) Systematics II (Exrecise: Indentify selected species, an example of benthic foraminifera); (3) Phenetic vs. Cladistic Classifications (Exrecise: How to make cladograms and phenetic three); (4) Biostratigraphy and biostratigraphic smpling, Reolution, Precision and Accurancy (Exercises: Correlations of geologicl logs based on index fossils and the global biotratigraphic standard, and qunatitative biotratigraphy); (5) Biostatitics and Diversity Indexes (Exercises: Multivar analysis: indexes, clusters); (6) Functional Morphology (Exrecises: Testing Raup's Functional Hypothesis, and anlysis of structural elements of larger foraminiferal tests); (7) Paleoecological interpretation (Exrecise: from selected sample rich in foraminifers interpret ecologic conditions); (8) Research Project on selected sample

STUDENT OBLIGATIONS DURING THE COURSE: During semester student resolve wo tasks for each lecture-one of them with assistance of teacher and another one as homework whic will be evaluated.

METHODS TO EVALUATE STUDENT PERFORMANCE: Succesfully resolve all tasks

EXAMINATION METHODS: Evaluation of every task together with evaluation of oral exam.

COURSE(s) NEEDED FOR THIS COURSE:

COMPULSORY LITERATURE: Prothero, d. 1998 , Bringing fossils to life. An Introduction to paleobiology. WCB/Mc Graw Hill.

ADDITIONAL READING: http://gpc.edu/-pgore/geology/historical_lab/micro_exercises.php

http://palaeo-eletronica.org/2001_1/past/issue1_01.htm

COURSE TITLE: History of geology		
COURSE TEACHER/TEACHERS: Ivan Gušić, professor		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 4th or 5th		
SEMESTER: 8th-12th, optional		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	Professor
Exercises	-	-
Seminars	1	-
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Students should be acquainted with controversies of ideas that occurred in the history of geological thought and should perceive geology as a unique natural and historical science, dependent on general socio-cultural circumstances in particular periods of its history.		
LEARNING OUTCOMES: Basic knowledge and understanding of the key aspects and concepts in the history of geology. An awareness of the wider spectrum of geology as a scientific discipline. Some understanding of the complexity of development of basic geological ideas. Ability to undertake literature searches, and to use data bases and other sources of information. Recognition of the need for, and engagement in self-managed and life-long learning		
DESCRIPTION OF THE COURSE: The course should demonstrate the chronological development of ideas in geology, their mutual controversies and opposition, resistance of old ideas and their gradual submission to the newer ones. 1. Pre-scientific epoch (antiquity, Middle ages); 2-3. Neptunists – vulcanists – plutonists; 4-5. catastrophists – uniformitarianists; 6. ice ages (glaciations); 7. Age of the Earth; 8-9. geosynclinal theory – plate tectonics (including fixists and mobilists in the Alpine tectonics); 10-11. Constraints of the uniformitarian approach and (12-13) its role in other natural sciences; 14-15. History of geology in Croatia and neighbouring countries.		
STUDENT OBLIGATIONS DURING THE COURSE: Regular attendance of lectures, discussions on particular topics		

METHODS TO EVALUATE STUDENT PERFORMANCE: Regular attendance of lectures
EXAMINATION METHODS:oral exam
COURSE(s) NEEDED FOR THIS COURSE: General geology, General paleontology, Systematic paleontology, Historical geology I, II; Petrology of magmatic and metamorphic rocks, Sedimentology.
COMPULSORY LITERATURE: Hallam, A.: Great geological controversies, Oxford University Press, 1983. Hallam, A: Revolutions in Earth History. Oxford University Press, 1982.
ADDITIONAL READING: Selected articles from domestic and (predominantly) international geological journals.

COURSE TITLE: Paleontological aspects of evolution		
COURSE TEACHER/TEACHERS: Ivan Gušić, professor		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 4th or 5th		
SEMESTER: 8th-12th, optional		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	Professor
Exercises	0	-
Seminars	1	Professor
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Students have to be familiarized with the fact that evolution is a real and permanently present proces sin the nature, occurring at different levels, and that the theory of evolution, like any other scientific theory, should be permanently subject to testing and further developed.		
LEARNING OUTCOMES: Acquiring advanced knowledge and understanding to the study of the evolution from the paleontological aspects. Ability to think creatively to develop new and original approaches and methods of evolution research. Awareness of the limits of current knowledge and paleontological techniques in solving evolutionary problems. Some ability to formulate and solve problems in new and emerging areas of the research on evolution.		
DESCRIPTION OF THE COURSE: 1. History of the evolutionary thought; 2. Cosmic evolution (origin of elements, etc.); 3. Chemical evolution; 4. Origin of life (current hypotheses); 5 Biological evolution (including Red Queen hypothesis, etc.); 6. Origin of eukariotes; 7. Evolution of Metazoa; 8. Speciation (allopatric speciation, island species, etc.); 9. Phyletic gradualism; 10. Punctualism; 11. «Single-step» vs. cumulative selection; 12. Internal selectrion (constraints, etc); 13. Notion and examples of emergence; 14. Creationsts' «objections» to evolution (eye, transitional forms, etc.); 15. Cultural evolution.		
STUDENT OBLIGATIONS DURING THE COURSE: Regular attendance of lectures and seminars during the semester that includes active participation in		

educative process; homeworks (how to solve a problem); seminar works (using the recent scientific literature); continued checking of knowledge through the preliminary exams.
METHODS TO EVALUATE STUDENT PERFORMANCE: Regular attendance of lectures and seminars; regular homework doing, presentation and explication of seminar works; passing of all preliminary exams.
EXAMINATION METHODS: oral exam
COURSE(s) NEEDED FOR THIS COURSE: General paleontology, Systematic paleontology (invertebrates and vertebrates)Historical geology I, II.
COMPULSORY LITERATURE: Skelton, P. (ed.): Evolution – a biological and paleontological approach. Addison-Wesley Publishing Company, 1993. Erben, H.K.: Evolution. Ferdinand Enke Verlag, Stuttgart, 1990. Kalafatić, M.: Osnove biološka evolucije. Sveučilište u Zagrebu, 1998.
ADDITIONAL READING: Dawkins, R.: The blind watchmaker. Penguin, 1991. Dawkins, R.: Climbing Mount Improbable. Penguin, 1997 Selected articles from recent and classical literature (seminars)

COURSE TITLE: Marine Geology		
COURSE TEACHER/TEACHERS: Prof. Mladen Juračić, PMF		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 4		
SEMESTER: 7		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	assistant
Seminars		professor and assistant
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Students gain knowledge about sea bottom and marine environment where most sediments are deposited. Emphasis on physical, chemical and biological processes on sedimentation and diagenesis.		
LEARNING OUTCOMES: Basic knowledge and understanding of the interrelationship of natural sciences (Physics, Chemistry, Biology, Geology) underlying the study of marine environment An awareness of the wider spectrum of geological disciplines Awareness and understanding of the temporal and spatial dimensions in Earth processes Basic ability to describe a solution at an abstract level. Ability to use simple quantitative methods and to apply them to geological problems. Basic awareness of relevant state-of-the-art technologies and their application Ability to learn and study including effective time management and flexibility		
DESCRIPTION OF THE COURSE: <u>Lecturing:</u> History of marine research. Morphology and genesis of oceans. Sources and composition of marine sediments. Lithogenous, hydrogenous and biogenous sediments. Physical oceanography relevant for genesis and sea sediment disposition (wave, current, tide). Sea water and hydrogenous sediments. Coast, sea level processes and effects of sea level change. Climates and sediments. Estuarine and anti-estuarine water exchange currents and their influence to the sea bottom. Organisms and sea bottom. Residence time. Sedimentation rates. Paleocanography. Deep- sea sediments. Mediterranean and Adriatic Sea. Marine geological cartography. Sea-bottom sampling and data acquisition.		

STUDENT OBLIGATIONS DURING THE COURSE: Lectures and practical exercises (optional – field work: sediment sampling, sea bottom profiler)

METHODS TO EVALUATE STUDENT PERFORMANCE:

EXAMINATION METHODS: Preliminary exams during practical exercises, midterm written exam, final oral exam

COURSE(s) NEEDED FOR THIS COURSE: physics, chemistry, mineralogy, general geology

COMPULSORY LITERATURE:

1. Juračić, M.: Geologija mora (http://geol.gfz.hr/Juracic/predavanja/index.html)
2. Selbold E. & Berger W.H.: The Sea Floor. An introduction to Marine geology. Springer Verlag, Berlin, 1996.

ADDITIONAL READING:

Open University Course Team, Butterworth-Heinemann, Oxford, 1997:

- The Ocean Basins: Their Structure and Evolution
- Seawater: Its Composition, Properties and Behaviour
- Waves, Tides and Shallow Water Processes

Ocean Chemistry and Deep Sea Sediments

COURSE TITLE: Glaciology		
COURSE TEACHER/TEACHERS: PhD. Tihomir Marjanac, associate professor, Faculty of Science		
STUDY PROGRAMME: Graduate study of geology		
YEAR OF STUDY: 1. / 2.		
SEMESTER: 2. / 4.		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	3	professor
Exercises	-	-
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Familiarizing with glacial processes on the Earth, dynamics of glacial environments, glacial products, variability of glacigenic sediments and sedimentary bodies, proglacial and periglacial environments, facies and products, learning on stratigraphy of Quaternary deposits in Dinaric Alps.		
LEARNING OUTCOMES: Achievement of specific knowledge on the subject and competences which are necessary for: 1) field study of glacigenic, proglacial and periglacial sediments, 2) thematical mapping, 3) interpretation of geological relationships in the field, 4) recognition of ice-induced deformations, 5) recognition of ice-sculptured topography.		
DESCRIPTION OF THE COURSE: 1) Introduction 2) Snow 3) Avalanches 3) Ice and glaciers 5) Glacial landscapes 6) Glacial and proglacial sediments 7) Glacial depositional bodies 8) Proglacial and periglacial sediments and environments 9) Facies of glacial and periglacial environments		

10) Glaciotectonics

11) Methods of research and dating

12) Quaternary stratigraphy

13) Causes of glaciations

STUDENT OBLIGATIONS DURING THE COURSE:

Regular attendance of lectures, participating in Fieldwork in Glaciology course.

METHODS TO EVALUATE STUDENT PERFORMANCE:

Student work is being evaluated continuously during discussions on individual studied problems and motifs during lectures. Ability to link individual physical processes and their interactions in genesis of sediments, interpretation of climatic conditions after studied sediments are key competences evaluated at the final exam.

EXAMINATION METHODS:

Oral exam.

COURSE(s) NEEDED FOR THIS COURSE:

Physical Geology

COMPULSORY LITERATURE:

Glaciology course DVD provided by the course leader.

Easterbrook, D.J. (1988): Dating Quaternary Sediments. Geol. Soc. Am. Spec. Publ.

Lowe J.J. & Walker M.J. (1997): Reconstructing Quaternary Environments. 2nd ed. Longman, Harlow

Menzies J. (2002): Modern & Past Glacial Environments. 2nd ed. Butterworth Heinemann, Oxford

Stepen, J. & Peter, G. (1991): Quaternary Sediments. John Wiley & Sons, London.

ADDITIONAL READING:

Ehlers, J. & Gibbard, P.L. (2004): Quaternary glaciations – extent and chronology. Development in Quaternary science v. 1 – 5. Elsevier BV

COURSE TITLE: Field work in glaciology		
COURSE TEACHER/TEACHERS: PhD. Tihomir Marjanac, associate professor, Faculty of Science		
STUDY PROGRAMME: Graduate study of geology		
YEAR OF STUDY: 1. / 2.		
SEMESTER: 2. / 4.		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures		
Exercises	3	professor
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Familiarizing with External Dinaride areas which were affected with Pleistocene glaciation, study of glacial landformes, study of glacigenic sediments, study of periglacial and proglacial sediments, study of ice-induced deformations (glaciotectonics).		
LEARNING OUTCOMES: Achievement of specific knowledge on the subject and competences for recognition and study of glacigenic, proglacial and periglacial sediments, competences for the study of sediments in field, lithofacial mapping, and competences for the interpretation of geological features and structures. Recognition of specific deformations induced by ice, recognition of glacial and periglacial landforms. Interpretation of geological history and climate changes.		
DESCRIPTION OF THE COURSE: 1) Glacial landforms on south Velebit Mt. 2) Glacial sediments and sedimentary bodies in Velika Paklenica Canyon: moraines, glaciofluvial sediments, glaciotectonics 3) Glacial sediments on Veliko Rujno: medial moraine, erratic blocks 4) Glacial sediments in Novigrad Sea: moraines, proglacial lacustrine sediments, ice-marginal sediments, paleosols, glaciofluvial sediments, permafrost 5) Glacial sediments in Ravni Kotari: moraines, proglacial lacustrine sediments, glaciotectonics 6) Field research: mapping, logging, sampling of secondary calcite, sampling fossils		
STUDENT OBLIGATIONS DURING THE COURSE:		

Active participation in fieldwork, performing given tasks, possession of personal field equipment and tools.

METHODS TO EVALUATE STUDENT PERFORMANCE:

Discussions on individual studied problems and motifs after each day in the field. Evaluation is based on activity during the course, quality of observations and measurements.

EXAMINATION METHODS:

Grading is equally based on performance in the field and written report.

COURSE(s) NEEDED FOR THIS COURSE:

Physical Geology

COMPULSORY LITERATURE:

Field manual prepared by the course leader.

Stepen, J. & Peter, G. (1991): Quaternary Sediments. John Wiley & Sons, London.

Lowe J.J. & Walker M.J. (1997): Reconstructing Quaternary Environments. 2nd ed. Longman, Harlow

Menzies J. (2002): Modern & Past Glacial Environments. 2nd ed. Butterworth Heinemann, Oxford

ADDITIONAL READING:

Scholary papers in Glaciology.

COURSE TITLE: Methods of remote sensing in geology

COURSE TEACHER/TEACHERS: PhD. Tihomir Marjanac, associate professor, Faculty of Science

STUDY PROGRAMME: Graduate study of geology and Graduate study of environmental geology

YEAR OF STUDY: 1. / 2.

SEMESTER: 2. / 4.

TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	professor
Seminars		

ECTS credits: 5

DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS:

Familiarizing with remote sensing principles, methods, applications and limitations.

LEARNING OUTCOMES:

Achievement of specific knowledge on the subject and mastering skills for recognition and interpretation of lithology, sedimentary bodies, tectonical structures, both in well-exposed and poorly exposed terrains; skills to interpret aerial photographs and produce a photo-geological map. Students achieve competences and knowledge to use various photographic sources for remote sensing-based study; aerial photographs, ortho-photographs, single-channel and multi-channel satellite images.

DESCRIPTION OF THE COURSE:

1) Remote sensing, types, principles, application in Geology.

2) Waves, electromagnetic spectrum, colors, effects of atmosphere.

3) Sensors, properties, resolution.

4) Photographing procedures, aerial phoitographs, satellite imagery, wave lengths, types and properties of images.

5) Aerial photographs, photograms.

6) Properties and types of satellite images.

7) Digital processing of satellite images.

8) Visual interpretation of aerial and satellite images.

9) Application of aerial and satellite images in geology and environment protection.

10) Software for digital processing and analysis of satellite images.

11) Exercises in visual interpretation of aerial photographs,

12) Exercises in digital processing of multispectral satellite images.

13) Exercises in interpretation of stratigraphy and tectonics on selected satellite images.

STUDENT OBLIGATIONS DURING THE COURSE:

Regular attendance of lectures and solving given tasks at exercises.

METHODS TO EVALUATE STUDENT PERFORMANCE:

Monitoring activity during lectures and exercises.

EXAMINATION METHODS:

Oral exam.

COURSE(s) NEEDED FOR THIS COURSE:

Physical Geology, Physics, Geological Mapping

COMPULSORY LITERATURE:

Remote sensing in Geology course DVD provided by the course leader.

Gupta R.P. (2003): Remote Sensing Geology. 2nd ed. Springer

Oluić M. et al. (2002): Snimanje i istraživanje Zemlje iz svemira. Sateliti, Senzori, Primjena. HAZU i GEOSAT

Prost G.L. (2001): Remote Sensing for Geologists: A Guide to Image Interpretation. Taylor & Francis.

Rencz A.N. (1999): Remote Sensing for the Earth Sciences: Manual of Remote Sensing 3.ed. John Wiley & Sons

Donassy, Oluić & Tomašegović (1983): Daljinska istraživanja u geoznanostima. JAZU

ADDITIONAL READING:

Miller V.C. & Miller C.F. (1961): Photogeology. McGraw Hill

COURSE TITLE: Quaternary Geology		
COURSE TEACHER/TEACHERS: assoc. prof. Tihomir Marjanac, Faculty of Science		
STUDY PROGRAMME: Graduate study geology		
YEAR OF STUDY: 4. / 5.		
SEMESTER:		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	3	professor
Exercises	0	
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Acquainting students with Quaternary paleogeography and climate, stratigraphic divisions, research methods, sediment types, and fossil life.		
LEARNING OUTCOMES: Knowledge and understanding of the essential features, processes, materials, history and the development of the Earth and life during the Quaternary geologic period. Knowledge of the common terminology and nomenclature and the use of bibliography in Quaternary geology. Basic ability to apply appropriate technology and use relevant methods in Quaternary geology.		
DESCRIPTION OF THE COURSE: Quaternary stratigraphy. Research methods (field methods: study of outcrops, excavations), laboratory methods. Dating methods (radiometric, paleo(thermo) luminescence, paleomagnetism). Quaternary paleogeography, environments (glacial, proglacial, periglacial, non-glacial: fluvial, lacustrine, marsh, Aeolian, cave) and facies. Glaciation models, causes of glaciations, glaciated areas (continental, marine). Deglaciation models, glacioisostatic rebound, eustacy. Quaternary flora and fauna (continental, marine, cave).		
STUDENT OBLIGATIONS DURING THE COURSE:		
METHODS TO EVALUATE STUDENT PERFORMANCE:		
EXAMINATION METHODS: oral		

COURSE(s) NEEDED FOR THIS COURSE: Physical Geology / General Geology, Historical Geology II

COMPULSORY LITERATURE: Easterbrook, D.J. (1988): Dating Quaternary Sediments. Geol. Soc. Am. Spec. Publ. 227.

Ehlers, J. & Gibbard, P.L. (2004): Quaternary glaciations – extent and chronology. Development in Quaternary science v. 1 – 5. Elsevier BV (ISSN 1571 0866, ISBN 0 444 51462 7)

Lowe J.J. & Walker M.J. (1997): Reconstructing Quaternary Environments. 2nd ed. Longman, Harlow

Menzies J. (2002): Modern & Past Glacial Environments. 2nd. ed. Butterworth Heinemann, Oxford

Nilsson, T. (1983): The Pleistocene. Geology and Life in the Quaternary Ice Age. Ferdinand Enke Verl. Stuttgart

Stepen, J. & Peter, G. (1991): Quaternary Sediments. John Wiley & Sons, London.

Walker, R.G. & James, N.P. (1992): Facies models. Response to sea-level change. Geological association of Canada. St. John's , 1-409, (ISBN 0-919216-49-8)

ADDITIONAL READING: selected papers from literature

COURSE TITLE: Selected chapters form invertebrate paleontology		
COURSE TEACHER/TEACHERS: Doc. Dr. Alan Moro		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 4		
SEMESTER: 1		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	professor
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Introduce students with basic characteristics of invertebrates on example of rudist bivalves and benthic forams, as well as their use in paleontology		
LEARNING OUTCOMES: Advanced knowledge and understanding of carbonate platforms characteristics and facies belts with respect to the fossil assemblage. Advanced understanding of mutual interaction betwen the sea level change and sediments within sequnce stratigraphy as well as associated fossil communities . Advanced understanding of relations between microfossils and macrofossils within shallow water sediments on basis of the paleobathimetry. Some ability to apply knowledge and understanding of shallow water biostratigraphy according to the different fossil remnants from Upper Cretaceous deposits. Ability to explain shallow water paleoenvironments during Upper Cretaceous.		
DESCRIPTION OF THE COURSE: Invertebrates (taxonomy, with accent on rudists, similarities and differences within differet groups, determination fo species), way of living (environments which invertebrates inhabit), relations between different invertebrate fossils within the same environment (different subtidal environments of rudists, environments of benthic forams, relaton between rudists and benthic forams), role of invertebrates for determination of environment and vertical-lateral exchange of facies (invertebrates and paleobathimetry, change of fossil community through time and space, invertebrates as environment indicators) relation sediment-fossil remain (lateral exchange of different limestone types with respect to macro or microfossils), work on individual task.		

STUDENT OBLIGATIONS DURING THE COURSE: During course student will have individual work as task, seminar or homework
METHODS TO EVALUATE STUDENT PERFORMANCE: continous work, presence on exercises
EXAMINATION METHODS: writing and oral exame, notes from exercises
COURSE(s) NEEDED FOR THIS COURSE: Basic paleontology, Systematic paleontology, Micropaleontology 1.
COMPULSORY LITERATURE: Prothero, D. (1998): Bringing fossils to life. An Introduction to paleobiology, WCB/Mc Graw-Hill. Skelton, P.W. (2002):The Cretaceous World. The Open University, Cambridge University Press, 360 pp.
ADDITIONAL READING: www://http: geology.com http://publishing.cambridge,org/resources/0521831121

COURSE TITLE: Geology of Fossil Fuels

COURSE TEACHER/TEACHERS: Associate Professor Bruno Saftić, Faculty of Mining, Geology and Petroleum Engineering

STUDY PROGRAMME: Graduate study of geology

YEAR OF STUDY: 1. / 2.

SEMESTER: 1. / 3.

TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	professor
Seminars		

ECTS credits: 5

DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS:

Introduction to types of fossil fuels. Coal formation and classification. Examples of coal basins in Croatia and worldwide. Formation of oil and gas, conditions for accumulation of hydrocarbons in reservoirs. Petroleum basins in Croatia and worldwide. Theory of basic exploration and mapping procedures in study of fossil fuel resources, and hands-on experience of the same through practical work in small individual mapping projects.

LEARNING OUTCOMES:

Deeper knowledge of a system of geological exploration techniques used to define the subsurface composition and structure of coal-bearing deposits and of hydrocarbon accumulations.

Some ability to solve problems in exploration of the deep subsurface – to analyse and interpret data and draw conclusions integrating knowledge from different disciplines including results of geophysical exploration.

Ability to produce independent work – geological interpretation of E-logs, construction of contour maps, geological cross-sections and correlation schemes including estimates of reserves in a coal basin.

DESCRIPTION OF THE COURSE:

LECTURES (in weeks)

1-2. Coal as an energy source, and as a raw-material in metallurgy and chemical industry. Reserves and yearly production worldwide and in Croatia.

3-4. Organic and inorganic constituents of plant tissue - carbonisation, biochemical and geochemical processes.
5. Classification of coal according to its practical value and carbonisation level.
6. Coal-bearing formations – depositional environments, theories of autochthonous and allochthonous formation of coal beds.
7. Types of hydrocarbons.
8-9. Formation, migration and accumulation of oil and gas – source rocks and reservoir rocks.
10. Water, oil and gas inside the hydrocarbon reservoir.
11-13. Geological operations in petroleum geological exploration.
14-15. Oil and gas reservoirs in Croatia and worldwide.
EXERCISES (in weeks)
1-2. Coal deposits exploration methods - geological, geophysical, drilling; mining exploratory works. Analyses of coal.
3-4. Classification and categorization of coal reserves – methods for reserve estimation.

5-6. Project 1 – Estimation of coal reserves.

7-9. Basic interpretation of wireline logs.
10-11. Wellsite geology, samples and cores from oil wells.

12-15. Project 2 – Petroleum-geological graphic documents (correlation charts and subsurface maps)

STUDENT OBLIGATIONS DURING THE COURSE: Students have to finish two small (individual) projects, and submit the hardcopy. Their results will be graded by oral examination of the project content upon submission.

METHODS TO EVALUATE STUDENT PERFORMANCE: Projects 1 and 2 are obligatory, their average grade accounts for 50% of the total grade for the course.

EXAMINATION METHODS: Final oral examination is obligatory – results make 50% of the total grade for the course.

COURSE(s) NEEDED FOR THIS COURSE: Physical geology, Historical geology I and II

COMPULSORY LITERATURE:

ADDITIONAL READING:

Thomas, L. (2002): Coal Geology. John Wiley & Sons Ltd., Chichester, England, 384 pgs.
Whateley, M.K.G. & Spears, D.A., eds. (1995): European Coal Geology. Geological Soc. of London Spec. Publ. No. 82, 331 pgs.

Doveton, J.H. (1986): Log Analysis of Subsurface Geology. A Wiley-Interscience Publication, New York, 273 pgs.
Hobson, G.D. (1977): Developments in Petroleum Geology. Applied Science Publishers Ltd., London, 335 pgs.

COURSE TITLE: PALAEOBOTANY		
COURSE TEACHER/TEACHERS: PROF.DR. JASENKA SREMAC, PMF		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: IV or V		
SEMESTER:		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	PROFESSOR
Exercises	1	ASSISTANT
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS:		
LEARNING OUTCOMES: Understanding basic plant fossilization processes. Basic knowledge on fossils from different plant groups and their stratigraphic span. Understanding of causes and timing of plant evolution. Ability to recognize plant fossils from hand samples, particularly from Croatian localities.		
DESCRIPTION OF THE COURSE: Getting familiar with essential terms in palaeobotany, main fossil groups and general trends in evolution of plants.		
STUDENT OBLIGATIONS DURING THE COURSE: Regular presence at lectures and exercises, field exercises, independent tasks and essays.		
METHODS TO EVALUATE STUDENT PERFORMANCE: Regular presence at exercises, successfuly done personal tasks, successfuly presented essay.		
EXAMINATION METHODS:Written exam (test).		
COURSE(s) NEEDED FOR THIS COURSE:General palaeontology		
COMPULSORY LITERATURE:Stewart, W.N.: Palaeobotany and the Evolution of Plants. Cambridge Univ. Press, Cambridge, 1990.Sremac,J.: Paleobotanika. Skripta. Prirodoslovno-matematički fakultet, Zagreb, 1997.		
ADDITIONAL READING:Selected papers from scientific and scientific-popular magazines, data from internet pages.		

COURSE TITLE: Applied geophysics		
COURSE TEACHER/TEACHERS		
STUDY PROGRAMME: Graduate study of geology		
YEAR OF STUDY: IV or V		
SEMESTER:		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*teacher or assistant*)
Lectures	2	
Exercises	1	
Seminars		
Laboratory		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Getting of fundamental knowledge from basic geophysical methods.		
LEARNING OUTCOMES:		
DESCRIPTION OF THE COURSE: Seismic exploration – Generation and propagation of seismic waves. Time-distance graph for a layered medium. Instruments and equipment: seismic sources, detectors (geophones), seismographs. Refraction seismic exploration: data acquisition and processing, interpretation methods, complications in refraction interpretation (the blind and hidden layers), applications. Reflection seismic exploration: data acquisition, data processing (the static, the NMO and the residual corrections, the velocity analysis), seismic velocity measuring, interpretation of seismic reflection sections, migration, applications. Well logging.		
STUDENT OBLIGATIONS DURING THE COURSE: Evaluation of lessons in framework of exercises. Regular presence at lectures and exercises, practical exercises		
METHODS TO EVALUATE STUDENT PERFORMANCE: Preliminary exams.		
EXAMINATION METHODS: written, oral		
COURSE(s) NEEDED FOR THIS COURSE: Physics, Geophysics		
COMPULSORY LITERATURE: Griffits, D. H. & King, R. F.: Applied geophysics for geologists and engeneers. Pergamon, Oxford, 1981 Parasnis, D.S.: Principles of Applied Geophysics. Chapman and Hall, New York,		

1986

Šumanovac, F.: Geofizička istraživanja, geoelektrične i seizmičke metode. Rudarsko-geološko-naftni fakultet, Zagreb, 1999.

ADDITIONAL READING: 1. Griffits, D.H. & King, R.F. (1981): Applied Geophysics for Engineers and Geologists. Pergamon Press, Oxford.

2. Sheriff, R.E. (1995): Exploration Seismology. Cambridge Univ. Press, Cambridge.

Optional course list Geology (Mineralogy and Petrology)

<table>
<tr><td colspan="3">COURSE TITLE: Rock Microstructure</td></tr>
<tr><td colspan="3">COURSE TEACHER/TEACHERS: Dr. Dražen Balen, assistant professor, Department of Geology, Faculty of Science, University of Zagreb</td></tr>
<tr><td colspan="3">STUDY PROGRAMME: Graduate study Geology</td></tr>
<tr><td colspan="3">YEAR OF STUDY: 4</td></tr>
<tr><td colspan="3">SEMESTER: 7 (also possible in 6th semester)</td></tr>
<tr><td>TEACHING METHODS</td><td>CONTACT HRS PER WEEK</td><td>DELIVERED BY (professor or assistant)</td></tr>
<tr><td>Lectures</td><td>0</td><td></td></tr>
<tr><td>Exercises</td><td>3</td><td>professor</td></tr>
<tr><td>Seminars</td><td></td><td></td></tr>
<tr><td colspan="3">ECTS credits: 5</td></tr>
<tr><td colspan="3">DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Students achieve basic knowledge needed for mineral, structure and texture identification in common rock types using microscope. Classification of rocks using polarizing microscope.</td></tr>
<tr><td colspan="3">LEARNING OUTCOMES:
Ability to work independently with polarizing microscope.
Ability to recognize unknown minerals independently by using relevant literature.
Knowledge and understanding of the optical properties of minerals in order to indentify them in an unknown sample.
Basic knowledge and understanding of genesis and alteration of minerals, and how they reflect to optical properties of minerals.
Ability to relate optical properties of minerals with their crystallographic and chemical properties on advanced level needed for resolving petrological tasks.
Ability to undertake an investigation by application of appropriate procedures using polarizing microscope.</td></tr>
<tr><td colspan="3">DESCRIPTION OF THE COURSE:
1. Polarizing microscope. Rock forming minerals in igneous, sedimentary and metamorphic rocks.
2. Mineral, structure and texture identification, mineral relations and reactions. Rock classifications, IUGS classification system and recommendations.</td></tr>
</table>

3. Acid plutonic, volcanic and vein rocks. 4. Intermediate plutonic and volcanic rocks. 5. Basic plutonic, volcanic and vein rocks. 6. Ultramafic magmatic rocks. 7. Pyroclastic rocks and volcanic glass. 8. Diagenesis vs. metamorphism. Sedimentary protoliths. 9. Very low grade metamorphism (VLGM). 10. Low grade metamorphism (LG). 11. Medium grade metamorphism (MG). 12. High grade metamorphism (HG). Anatexis. Ultrametamorphism. 13. Metamorphic rocks without preferred orientations (granofels, hornfels, marble, quartzite). 14. Equilibrium mineral assemblages, mineral reactions, graphical presentation, approx. determination of metamorphic conditions. 15. Specific textures and microstructures in sedimentary rocks.
STUDENT OBLIGATIONS DURING THE COURSE: individual reports including thin section descriptions
METHODS TO EVALUATE STUDENT PERFORMANCE: evaluation of individual reports and thin sections description
EXAMINATION METHODS: average grade of all individual reports, oral exam
COURSE(s) NEEDED FOR THIS COURSE: Mineral optics, Petrology of igneous and metamorphic rocks, Petrology of sedimentary rocks
COMPULSORY LITERATURE: Vernon, R.H. (2004): A practical guide to Rock Microstructure.- Cambridge University Press, 594 p.
ADDITIONAL READING: Shelley, D. (1995): Igneous and metamorphic rocks under the microscope: classification, textures, microstructures and mineral preferred orientations.- Chapman & Hall, London.

COURSE TITLE: Microtectonics		
COURSE TEACHER/TEACHERS: Dr. Dražen Balen, assistant professor, Department of Geology, Faculty of Science, University of Zagreb		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 4		
SEMESTER: 8		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	1	professor
Exercises	2	professor
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Students achieve knowledge needed for mineral, structure and texture identification in different rock types using microscope and oriented thin sections. Link between deformation and metamorphism on the small (microscopic) scale. Reconstruction of simple geological events through analysis of deformation and metamorphism. Comparison and evaluation of data collected on different scale (thin section, hand-size specimen, outcrop, regional scale).		
LEARNING OUTCOMES: Appreciation of issues concerning sample selection, accuracy, precision and uncertainty during collection, recording and analysis of data in the field and laboratory. Basic ability to become familiar with new geological methods and technologies. Basic ability to apply appropriate technology and use relevant methods . Basic ability to independently analyze earth materials in the field and laboratory and to describe, process, document and report the results. Ability to conduct appropriate experiments, to analyze and interpret data and draw conclusions. Basic ability to work effectively and communicate in national and international contexts. Ability to evaluate performance as an individual and a team member. Ability to identify individual and collective goals and responsibilities and to perform in a manner appropriate to these roles.		

Ability to evaluate critically professional and research papers.

Ability to plan and appropriate programme of continuing professional development.

DESCRIPTION OF THE COURSE:

1. Link between deformation and metamorphism - microscopic scale.
2. Basic approach and methods. Petrographic microscope, U-stage, electron microscope. Computer based image analysis.
3. Sampling, sample orientation, oriented thin section preparation.
4. Geometry and crystallography vs. optical elements. Necessity of 3rd dimension in thin section.
5. Deformation of rock forming minerals, effects in thin sections. Monomineral and polyphase systems.
6. Foliation, lineation, preferred orientation. Mechanism of foliation development, influence and importance of geological factors, practical use of foliation in the event reconstruction.
7. Mineral preferred orientation and shear sense determination.
8. Shear zones, mylonite, mylonitization and metamorphism.
9. Mylonite shear sense indicators.
10. Porphyroblasts and reaction rims. Pretectonic, intertectonic, sintectonic and post-tectonic porphyroblast growth. Inclusions, symplectites. D-t diagrams.
11.-15. Sampling in metamorphic rocks of Medvednica Mt. Oriented cutting and thin sections preparation. Determination of problem, possible approach, problem solving using oriented thin sections. Seminar.

STUDENT OBLIGATIONS DURING THE COURSE: field work, preparation of oriented thin sections, seminar

METHODS TO EVALUATE STUDENT PERFORMANCE: field work, preparation of oriented thin sections, seminar

EXAMINATION METHODS: microscopic work on the oriented thin sections prepared by student

COURSE(s) NEEDED FOR THIS COURSE: Mineral optics, Igneous and metamorphic petrology, Petrology of sedimentary rocks, Rock microstructure

COMPULSORY LITERATURE: Passchier, C.W. & Trouw, R.A.J. (1996): Microtectonics. Springer Verlag, 289 pp.

ADDITIONAL READING: Vernon, R.H. (2004): A practical guide to Rock Microstructure.- Cambridge University Press, 594 p.

COURSE TITLE: MINERALOGY OF SILICATES		
COURSE TEACHER/TEACHERS: Prof.dr.sc. Vladimir Bermanec, PMF		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 4 or 5		
SEMESTER:		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	assistant
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Getting familiar with a wider range of silicate minerals, espiecially rock-forming ones.		
LEARNING OUTCOMES: Basic ability to independently analyze silicate minerals in the field and laboratory and to describe, process, document and report the results.		
DESCRIPTION OF THE COURSE: 1. Crystal-chemical properties of silicates 2. Olivine group 3. Garnet gropu 4. Group of aluminum silicates 5. Calcium silicates 6. Epidote group 7. Beryl group 8. Tourmaline group 9. Inoslicates - pyroxenes 10. Inoslicates - amphiboles 11. Phyllosilicates – mica 12. Phyllosilicates - chlorites 13. Phyllosilicates – group of kaolin - serpentine		

14. Groups of feldspars and scapolites 15. Zeolite group
STUDENT OBLIGATIONS DURING THE COURSE: Attendance at classes, preliminary exams and seminars.
METHODS TO EVALUATE STUDENT PERFORMANCE: Regular attendance at classes, preliminary exams and seminars.
EXAMINATION METHODS: Written and oral exam with the results of the preliminary exams.
COURSE(s) NEEDED FOR THIS COURSE: System of Mineralogy, completed pregraduate study of geology
COMPULSORY LITERATURE: Slovenec, D., Bermanec, V. (2003): Sistematska mineralogija – mineralogija silikata. Denona, Zagreb, 359 str.
ADDITIONAL READING: Wenk, H.-R., Bulakh, A. (2004): Minerals their Constitution and Origin. Cambridge University Press, 646 pp. Hibbard, M.J. (2002): Mineralogy A Geologist's Point of View. McGraw-Hill, 562 pp. Ramdohr, P., Strunz, H. (1967): Klockmanns Lehrbuch der Mineralogie. F. Enke Verlag, Stuttgart.

COURSE TITLE: MINERALOGY OF NON-SILICATES		
COURSE TEACHER/TEACHERS: Prof.dr.sc. Vladimir Bermanec, PMF		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 4 or 5		
SEMESTAR STUDIJA:		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	assistant
Seminars		
ECTS credits: 5		
CILJ KOLEGIJA: Upotpunjavanje znanja o mineralogiji nesilikata težištem na glavne rudne minerale, njihovu genezu i kristalokemijska svojstva.		
LEARNING OUTCOMES: Basic ability to independently analyze non-silicate minerals in the field and laboratory and to describe, process, document and report the results.		
DESCRIPTION OF THE COURSE: 1. Groups of gold and platinum 2. Groups of sphalerite, galena and pyrite 3. Groups of sulphosalts 4. Groups of spinels 5. Oxides of aluminum and iron 6. Oxides of manganese 7. Borates 8. Groups of calcite and dolomite 9. Group of aragonite 10. Grroups of baryte and gypsum 11. Secondary sulphates 12. REE phosphates 13. Group of apatite 14. Pegmatite phosphates		

15. Organic minerals
STUDENT OBLIGATIONS DURING THE COURSE: Attendance at classes, preliminary exams and seminars.
METHODS TO EVALUATE STUDENT PERFORMANCE: Regular attendance at classes, preliminary exams and seminars.
EXAMINATION METHODS: Written and oral exam with the results of the preliminary exams.
COURSE(s) NEEDED FOR THIS COURSE: System of Mineralogy, completed pregraduate study of geology
COMPULSORY LITERATURE: Bermanec, V. (1999): Sistematska mineralogija – mineralogija neilikata. Targa, Zagreb, 264 str.
ADDITIONAL READING: Wenk, H.-R., Bulakh, A. (2004): Minerals their Constitution and Origin. Cambridge University Press, 646 pp. Hibbard, M.J. (2002): Mineralogy A Geologist's Point of View. McGraw-Hill, 562 pp. Ramdohr, P., Strunz, H. (1967): Klockmanns Lehrbuch der Mineralogie. F. Enke Verlag, Stuttgart.

COURSE TITLE: Mineral associations		
COURSE TEACHER/TEACHERS: PhD. Vladimir Bermanec, full professor, Faculty of Science		
STUDY PROGRAMME: Graduate study of geology		
YEAR OF STUDY: 1. / 2.		
SEMESTER: 1. / 3.		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	professor
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Familiarizing with the environments where different mineral associations occur.		
LEARNING OUTCOMES: Ability to conduct appropriate experiments, to analyze and interpret data and draw conclusions about mineral associations and parageneses.		
DESCRIPTION OF THE COURSE: Evolution of minerals. Forming of the Earth – cosmic phase. Meteorites. Differentiation – compositional layers. Magmatic activity. Magmatic environments. Associations of basaltic and acidic eruptives. Pegmatites. Hydrothermal activity. Sediments: chemogenetic, biogenetic. Weathering and diagenesis. Microorganisms. Fossilization.		
STUDENT OBLIGATIONS DURING THE COURSE: Class attendance.		
METHODS TO EVALUATE STUDENT PERFORMANCE:		
EXAMINATION METHODS: Written and oral exam.		
COURSE(s) NEEDED FOR THIS COURSE: Finished Undergraduate study of Geology.		

COMPULSORY LITERATURE:

Bermanec, V. (1999): System of mineralogy – mineralogy of non-silicate minerals. Targa, Zagreb, 264 pp.

Bermanec, V. and Slovenec, D. (2006): System of mineralogy – mineralogy of silicate minerals. Denona, Zagreb, 359 pp.

ADDITIONAL READING:

Textbooks about mineralogy.

COURSE TITLE: GEMMOLOGY		
COURSE TEACHER/TEACHERS: Prof. Goran Kniewald and Prof. Vladimir Bermanec		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 4 or 5		
SEMESTER:		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	professor or assistant
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Upon completion of the course, students should have general and specific competencies requisite for a basic gemmological identification of a gem.		
LEARNING OUTCOMES: Knowledge and understanding of the physical and chemical properties of gem materials. Knowledge of the common terminology and nomenclature of gem materials. Ability to identify the main gem materials.		
DESCRIPTION OF THE COURSE: 1. Fundamental concepts in gemmology 2. Geology of gemstone deposits 3. Crystal optics in gemmology 4. Optical effects on gemstones 5. Colour theory – causes of gemstone colour 6. Gemmological instruments 7. Methods of gemstone testing 8. Common gemstones 9. Rare gemstones 10. Organic gemstones 11. Diamond – grading and imitations 12. Synthetic gemstones 13. Imitiations, composites and gemstone treatments 14. Cutting of gemstones and tzpes of cuts 15. Presentation of student projects		
STUDENT OBLIGATIONS DURING THE COURSE: Regular attendance of course and completion of a written project paper.		
METHODS TO EVALUATE STUDENT PERFORMANCE: Term test and final examination		
EXAMINATION METHODS: Written and oral final exam. The final grade will include marks given for the student's project paper.		
COURSE(s) NEEDED FOR THIS COURSE: Mineralogy, Mineral optics		
COMPULSORY LITERATURE: Read. P. (1999): Gemmology, 2nd edition, Butterworth-Heinemann, London.		

ADDITIONAL READING: Anderson, B.W. (1990): Gem Testing, 10th edition (revised by E.A.Jobbins). Butterworths & Co. London.

Hurlbut, C.S. and Kammerling, R.C. (1991): Gemology. John Wiley and Sons, New York.

COURSE TITLE: Interpretation of geochemical data		
COURSE TEACHER/TEACHERS: prof.dr. Ladislav Palinkaš		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 4.		
SEMESTER: 7.		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	assistent
Seminars		assistent
ECTS credits: 5.		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: The course provides knowledge of geochemical interpretation of data obtained on igneous, metamorphic and sedimentary rocks. By convention, geochemical data are grouped as: major elements, trace elements and stable and radiogenic isotopes. Each of these data enable determination of magma source, way of formation, evolution (partial melting, fractional crystallization, assimilation, etc.) and geotectonic setting. Metamorphic petrology is concerned with precursor rocks, and sedimentary petrology with provenance. The subject deals with different kind of discrimination diagrams in use to solve fore-mentioned problems.		
LEARNING OUTCOMES: The content of the course is linked to the interpretation of magmatic and metamorphic rocks on the basis of geochemical data. The focus of the study is directed to the numerical analysis of major and trace elements, rare earth elements, radiogenic and stabile isotopes. Work in classroom with small group of students enables efficient contact and control of calculation performance. At the same time, field work in the vicinity of Zagreb gives opportunity to collelct samples, to be elaborated by classical and instrumental analyses in the department laboratory. The results are compared with those obtained in previous studies, and contribute to the research performed and mentored by the teacher.		
DESCRIPTION OF THE COURSE: 1. Geochemical data, geological processes and their geochemical significance, analytical techniques in data acquisition, sources of errors.2. Data analysis, correlation, regression, discriminant analysis, 3.Variation diagrams, rock classification, 4. Usage of trace elements, geochemical control of element distributions, REE, spider-diagrams, PGE, Transitional elements-diagrams, bivariant diagrams, modeling of data (vector diagram, partial melting, crystal		

fractionation, AFC processes), 5. Geotectonic discrimination, discrimination in the group of basalts, andesites, and granites, 6.Radiogenic isotopes in geochronology, isochrone methods, errochrones, geochrones, T-CHUR modelna starost, , blocking temperature, crystallization temperature, metamorphic age, mineral age, 7. Radiogenic isotopes in petrogenesis, recognition of isotope reservoir, epsilon notation, isotope correlation diagrams, mantle-crust dynamics, plumbotectonics, geodynamics, 8.Stabel isotopes in genesis of igneous and metamorphic rocks, O,C,S-isotopes.

9.Sedimentary rocks, geodynamic setting, provenance od detrital component, REE, Sr-isotope stratigraphy.

STUDENT OBLIGATIONS DURING THE COURSE: Obligatory lecture audience and successful lab assignments,

METHODS TO EVALUATE STUDENT PERFORMANCE: colloquies, seminars, mid-term exam are prerequisite for recognition of attendance.

EXAMINATION METHODS: After fulfilling of the course obligation the overall mark is formed by the final exam, written and oral.

COURSE(s) NEEDED FOR THIS COURSE:General mineralogy, Systematic mineralogy, Petrology of igneous and metamorphic rocks, Geochemistry.

COMPULSORY LITERATURE:

3. Rollinson, H.: Using geochemical dana: evaluation, presentation, interpretation. Longman, 1995, str. 348.
4. Ragland, P.C.: Basic analytical petrology. Oxford university press. 1989, str. 370.
5. Winkler, H.G.F.: Petrogenesis of Metamorphic Rocks. Springer-Verlag, 1979, str. 348.

ADDITIONAL READING:

1. Myron G. B.: Igneous and metamorphic petrology. Blackwell, 2003, str. 729.

COURSE TITLE: PHASE AND ELEMENTAL ANALYSIS		
COURSE TEACHER/TEACHERS: professor, ESAD PROHIĆ & associate professor, DARKO TIBLJAŠ, PMF		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: IV or V		
SEMESTER:		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	1	professor
Exercises	2	professor, assistant, research assistant
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Obtaining additional information on methods of elemental and phase analysis reqiured for independant analytical work		
LEARNING OUTCOMES: Knowledge and understanding of the scientific and technical terminology in the domain of analytical chemistry. Ability to understand specific aspects of analytical methods in chemistry (the problem of analytical precision, significant digits, figures of merit). Ability to analyse the results of chemical analysis by statistical means. Capability of performing „classical“ silicate analysis. Knowledge and understanding of factors influencing the measured parameters on X-ray powder pattern and related ability to overcome possible problems.		
DESCRIPTION OF THE COURSE: 1. Qualitative and quantitative parameters of the analytical method choice. 2. Sampling plan design and selection of the best posible methods 3. Preselection of the analytical samples, methods of sample dissolution and destruction 4. Stehiometric calculations in the wet chemistry methods 5.-6. Absorption and emission spectrometric methods, instrumental optical components 7.-8. Mass spectrometry methods, Moessbauer spectroscopy, nuclear activation		

analytical methods

9. Mineral separation methods

10.-13. X-ray powder diffraction (factors influencing diffracted beam intensity, unit cell dimensions calculation from powder patterns, powder pattern fitting techniques)

14. X-ray fluorescence analysis (matrix problem and methods for solving it, sample preparation)

15. Electron microscopy (SEM, EBSD, chemical analyisis, electron diffraction)

STUDENT OBLIGATIONS DURING THE COURSE: attending classes, preliminary exams, homework assignments

METHODS TO EVALUATE STUDENT PERFORMANCE: fulfilled obligations

EXAMINATION METHODS: written exam, final grade includes also results of prelim and homework assignments

COURSE(s) NEEDED FOR THIS COURSE: Principles of elemental and phase analysis

COMPULSORY LITERATURE: Jones, M.P. (1997): Methoden der Mineralogie. Ferdinand Enke Verlag, Stuttgart, 260 pp
Skoog, D.A. & Leary, J.J. (1992): Principles of instrumental analysis. Saunders College Publishing, Fort Worth, 700 pp.
Skoog, D.A., West, D.M. & Holler, F.J. (1999): Osnove analitičke kemije. Školska knjiga, Zagreb, 951 pp.
Whiston, C. (1987): X-ray metods, John Wiley & Sons, New York, 426 pp.

ADDITIONAL READING: Bish, D.L. & Post, J.E. (1989): Modern powder diffraction. Reviews in Mineralogy, 20. Mineralogical Society of America, 384 pp.

Jones, M.P. (1987): Applied mineralogy. Graham & Trotman, London, 259 pp.

COURSE TITLE: Universal stage methods		
COURSE TEACHER/TEACHERS: Nenad Tomašić, Faculty of Science, University of Zagreb		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 4th or 5th		
SEMESTER:		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	1	lecturer
Exercises	2	lecturer
Seminars	0	
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Introduction to the principles of universal stage application in mineral research which should qualify students for their own research.		
LEARNING OUTCOMES: Knowledge and understanding of the advanced application of polarizing microscope equipped with universal stage. Understanding the application of the universal stage microscopy methods in solving geological problems. Ability to relate optical properties of minerals with their crystallographic and chemical properties on advanced level. Ability to undertake an investigation by application of appropriate procedures using polarizing microscope.		
DESCRIPTION OF THE COURSE: 1. Multi-axis microscope (universal stage) 2. Adjustments of universal stage and thin sections 3. Determination of the vibration directions of optical inicatrix 4. Measurement of cleavage and twin composition planes 5. Plotting the results 6. Measurement and solution of twins 7. Determination of plagioclase chemical composition 8. Refractive index corrections		

9-10. Determination of plagioclase using universal stage

11-12. Determination of pyroxene using universal stage

13-14. Determination of amphibole using universal stage

15. Determination of topaz using universal stage

STUDENT OBLIGATIONS DURING THE COURSE: attending classes, preliminary exams

METHODS TO EVALUATE STUDENT PERFORMANCE: fulfilled obligations

EXAMINATION METHODS: written and oral

COURSE(s) NEEDED FOR THIS COURSE: General mineralogy, System of mineralogy, Mineral optics

COMPULSORY LITERATURE:

1. Međimorec, S. (1998): Kristalna optika, interna skripta, Prirodoslovno-matematički fakultet, Zagreb
2. Sarančina, G. M. & Koževnikov, V. N. (1985): Fedrovski metoda (Opredelenie mineralov, mikrostrukturnjii analiz), Nedra, Leningrad, p.

ADDITIONAL READING:

1. Zussman, J. (1977): Physical Methods in Determinative Mineralogy (2nd ed.), Academic Press, London, 720

COURSE TITLE: Geochemistry of sedimentary rocks		
COURSE TEACHER/TEACHERS: Research assisstant, dr. sc. Gordana Medunić, Faculty of Science, Department of geology		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 4 or 5		
SEMESTER:		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	assisstant
Exercises	1	assisstant
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Discussion of chemical changes during all stages of sedimentary rock formation (weathering, transport, deposition, diagenesis and lithification).		
LEARNING OUTCOMES: Knowledge and understanding of basic geochemical processes of interaction amongst sedimentary rocks, water and living / non-living organisms in terrestrial environments. Basic knowledge of the process of chemical weathering of sedimentary rocks (mainly limestone). The ability to discuss the mode of transportation of metals in the surface environment. Ability to predict the disastrous consequences of human activities on the surface environment.		
DESCRIPTION OF THE COURSE: Aquatic solutions: water/ice structure, water's solvent power, quantifying the composition of solutions Aquatic chemistry: chemical equilibrium, the solubility product, ionic strength, activity coefficient, Debye-Hückel equation Chemical composition of continental waters: chemistry of elements with reference to Ca, Mg and Na, ionic potential, weathering patterns Basic chemistry of estuaries; chemical and lithological composition of sedimentary rocks regarding Goldich's weathering series; compositional		

variability of sandstones, shales and carbonate rocks

Chemical weathering: hydrolysis, equilibrium solubilities in the system SiO_2-H_2O, activities of different forms of dissociated silica, behaviour of alluminium and iron during the weathering of silicates, gibbsite solubility

Calcium carbonate solubility: the solubility products of calcite and aragonite, carbonate compensation depth, equilibrium solubilities in the system CO_2-H_2O, Bjerrum's diagram, solubility of the carbonate minerals in a complex system (river, lake, sea), buffering system, *mischungkorrosion*, biomineralization

Weathering agents: carbon diokside, erosion of an average limestone terrain, contribution of plant roots and microbiological degradation of organic matter to the weathering processes

Organic acids: their role in solution processes, significance of chelates for the metal mobility, colloids, floculation

Oxidation-reduction processes: Nernst equation, reduction potential, iron and manganese behaviour regarding electrochemistry, basic concepts of thermodynamics and electrochemistry, different approach of chemists and geochemists in expressing half reactions

Eh-pH diagrams: stability limits of water, stability fields of iron oxides; Eh-pH systems containing carbon diokside: stability of siderite regarding hematite, magnetite and dissolved iron

Diagenesis: definition of processes, kinetic factors, diffusion, Fick's laws, advection, Peclet's number, Darcy's law, kinetics of chemical reactions on the molecular level, general equation of diagenesis

Cementation: growth of oxidized surface layer, distribution of manganese in pelagic sediments, fossilization and growth of concretions

Fate of organic matter during diagenesis: geopolimers, reactions of 'darkening', vitrinite reflection, time temperature index, Van Krevelen's diagram, sulfate reduction, fermentation

Distribution of sedimentary rocks in time and space: assessment of the quantity of sedimentary rocks, distribution of evaporites, Mg/Ca ratio in carbonate rocks, 'dolomite problem', sea-level curve in response to the calcite/dolomite ratio.

STUDENT OBLIGATIONS DURING THE COURSE: Regular attendance of all class lectures, exercises in particular, solving homework problems (calculations, drawing the diagrams, discussing worked examples).

METHODS TO EVALUATE STUDENT PERFORMANCE: Absence from exercises must be less than 20% of the total time-table, and homework results should be presented in written form.

EXAMINATION METHODS: Oral exam.

COURSE(s) NEEDED FOR THIS COURSE: Chemistry I i II, Sedimentary petrology, Geochemistry.

COMPULSORY LITERATURE: Prohić, E. (1998): Geokemija (Geochemistry). Targa, Zagreb, 554 pp. Krauskopf, B. K. (1979): Introduction to geochemistry. McGraw-Hill Book Company, New York, 617 pp.
ADDITIONAL READING: Brownlow, A. H. (1979): Geochemistry. Prentice-Hall, Inc., Englewood Cliffs, New York, 498 pp. Morse, J. W. & Mackenzie, F. T. (1990): Geochemistry of sedimentary carbonates. Elsevier, Amsterdam, 707 pp.

COURSE TITLE: Field techniques *MP*		
COURSE TEACHER/TEACHERS: Dr. Dražen Balen, assistant professor, Department of Geology, Faculty of Science, University of Zagreb		
STUDY PROGRAMME: Graduate study Geology		
YEAR OF STUDY: 4		
SEMESTER: 8		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	0	
Exercises	3	professor
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Aim of course is to train students in the individual geological field techniques encouraging individual (but tutored) field work and mapping. During the course, students typically spend longer period in the field working on a variety of group and individual projects. Student applies previously achieved knowledge how to describe rocks, measure sections, and record geologic field data. After this initial introductory period, students conduct a series of specific tests including laboratory work. This course is introduction in master thesis.		
LEARNING OUTCOMES:		
DESCRIPTION OF THE COURSE: Individual (but also tutored) field work. Field work is focused on igneous and metamorphic complexes in the Croatia (Medvednica, Moslavačka Gora, Slavonian Mts., Inner Dinarides) or in favorable circumstances to Alps and Carpathians. Field technique course ended with producing of geological map and column. Written report includes field and laboratory data.		
STUDENT OBLIGATIONS DURING THE COURSE: The course represents one of the finishing steps in the master degree education cycle. Since it includes large quantity of individual work (especially in the field) one of the basic prerequisite is psychophysical ability of student together with knowledge learned in basic courses. Sub steps in the course should be discussed with supervising professor before final report submitting.		
METHODS TO EVALUATE STUDENT PERFORMANCE: course proposal		

EXAMINATION METHODS: final report
COURSE(s) NEEDED FOR THIS COURSE: depending on field and professor
COMPULSORY LITERATURE: depending on selected professor
ADDITIONAL READING: depending on selected professor

Optional course list Environmental geology

COURSE TITLE: ENVIRONMENTAL MINERALOGY		
COURSE TEACHER/TEACHERS: Prof. Vladimir Bermanec and Prof. Goran Kniewald		
STUDY PROGRAMME: Graduate study Environmental geology		
YEAR OF STUDY: 4th or 5th year		
SEMESTER:		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Upon taking the course, students will acquire general and specific competencies aimed at a sound understanding of basic concepts and applications of environmental mineralogy.		
LEARNING OUTCOMES: Awareness and understanding of the temporal and spatial dimensions in Earth processes Understanding the need of a rational use of earth resources. Knowledge and understanding of the complex nature of interactions within the geosphere . Awareness of the applications and responsibilities of Geology and its role in society including its environmental aspects.		
DESCRIPTION OF THE COURSE: 1. The nature and scope of environmental mineralogy 2. Research methods in environmental mineralogy 3. Minerals and soil developments 4. Mineralogy of marine sediments 5. The influence of microbes on minerals 6. Aerosols in the atmosphere 7. Mineralogy of mine wastes 8. Suitability of minerals for environmental remediation purposes 9. Mineralogy in nuclear waste management 10. Mineralogy and cultural heritage 11. Mineralogy and human health 12. Presentation of student's project papers.		
STUDENT OBLIGATIONS DURING THE COURSE: Regular attendance of classes, active participation in colloquia and seminaries		
METHODS TO EVALUATE STUDENT PERFORMANCE: Successful completion of assigned coursework and tasks		
EXAMINATION METHODS: Term papers and written and oral final exam		

COURSE(s) NEEDED FOR THIS COURSE: Mineralogy, Quantitative and isotope geology
COMPULSORY LITERATURE: Vaughan, D.J. and Wogelius, R.A. (2000): Environmental Mineralogy. EMU Notes in Mineralogy, Eötvös University Press, Budapest, 434 p.
ADDITIONAL READING:

COURSE TITLE: INSTRUMENTAL METODS IN ENVIRONMENTAL ANALYSIS		
COURSE TEACHER/TEACHERS: Prof. Goran Kniewald and Prof. Vladimir Bermanec		
STUDY PROGRAMME: Graduate study Environmental geology		
YEAR OF STUDY: 4th or 5th year		
SEMESTER:		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Upon taking the course, students will acquire general and specific competencies aimed at a sound understanding of basic concepts and applications of instrumental methods of environmental chemical analysis.		
LEARNING OUTCOMES: Knowledge of the common terminology and nomenclature of instrumental analytical methods. Ability to create necessary analytical methods.		
DESCRIPTION OF THE COURSE: 1. The role and importance of environmental chemical analysis 2. Sampling procedures and classical methods of environmental analysis 3. Spectrophotometric methods 4. Electrochemicl methods of analysis 5. Mass spectrometry 6. Methods for solid sample analysis 7. Gas chromatography 8. Analysis of water samples 9. Analysis of gaseous samples 10. Direct spectrophotometric analysis of gaseous air pollutants 11. Analysis of sulfur dioxide 12. Analysis of carbon monoxide 13. Analysis of nitrogen oxides 14. Analysis of hydrocarbons 15. Analysis of particulate matter.		
STUDENT OBLIGATIONS DURING THE COURSE: Regular attendance of classes, active participation in colloquia and seminaries		
METHODS TO EVALUATE STUDENT PERFORMANCE: Successful completion of assigned coursework and tasks		
EXAMINATION METHODS: Term papers and written and oral final exam		
COURSE(s) NEEDED FOR THIS COURSE: Chemistry I and II, preferably Analytical Chemistry I and II, Fundamentals of element and phase analysis, all courses from semesters 3 and 4.		

COMPULSORY LITERATURE: Manahan, S.E. (1994): Environmental Chemistry, 6th edition, Lewis Publishers, Boca Raton.
ADDITIONAL READING:

COURSE TITLE: HYDROGEOCHEMISTRY AND GROUNDWATER PROTECTION

COURSE TEACHER/TEACHERS: Sanja Kapelj, PhD, senior researcher, Institute of Geology, Zagreb

STUDY PROGRAMME: Graduate study Environmental geology

YEAR OF STUDY: 4th year

SEMESTER: 7th semester

TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	professor
Seminars		

ECTS credits: 5

DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS:

The course includes basic principles of hydrogeochemical characteristics of groundwaters and groundwater protection. Attention is focused on theoretic background and its practical application in governing and managing of groundwater protection.

LEARNING OUTCOMES:

1. Awareness of the applications and responsibilities of Geology and its role in society including its environmental aspects.

2. Ability to integrate field and laboratory evidence with theory following the sequence from observation to recognition, synthesis and modelling

3. Ability to conduct appropriate experiments, to analyze and interpret data and draw conclusions.

4. Basic ability to prepare, process, interpret and present data, using appropriate qualitative and quantitative techniques and packages

DESCRIPTION OF THE COURSE:

1-3. Basic principles of hydrogeochemistry: formation of natural water composition, precipitation, surface and groundwater; physical and chemical properties, isotope composition; thermodynamic equilibrium in water solutions; dissolution of gases, liquids and solids in water, fractionation, diffusion and osmosis, vapour pressure, dissolution of electrolytes, chemical kinetics and equilibrium (water dissociation and pH, equilibrium in acid and base solutions, buffer solution, hydrolysis of salts);

carbonate equilibrium (dissolution and precipitation, water hardness, open and closed system of carbonate dissolution, dissolution of dolomites); stability of primary silicates and weathering products (weathering kinetics, mass balance, precipitation and dissolution); redox reactions (redox equilibrium, stability of dissolved ionic species, gases and minerals – Eh-pH diagrams –oxidation of pyrite, oxidation and reduction of ionic species of nitrogen, sulphur, iron); basic chemistry of colloids, ionic exchange, adsorption; chemical composition of natural waters (gases, main ions, biogenic substances, microelements, organic matter); 4. Natural radioactive and stable isotopes in soils, surface and ground waters – isotopes of carbon, hydrogen, oxygen, sulphur, nitrogen (^{14}C, ^{3}H, ^{18}O, D, ^{13}C, ^{34}S, ^{15}N), origin, geochemistry, application in water and soil studies; 5. Water-soil-rock interaction: reactions in unsaturated and saturated zone of aquifer (dissolution of gases, silicates and carbonates, oxidation of sulphides, cationic and anionic exchange, organic reactions); influence of salinization of different origin; geochemical types of water); 6. Fundamentals of geochemical modeling of processes in natural waters -speciation models, mass balance models, reaction-path models; 7. Groundwater protection – natural and anthropogenic sources of groundwater contamination, types of contamination sources, types of contaminations and its behavior in the underground. Aspects of alluvial and karst aquifer protection – different approach; 8. Geochemical aspects of groundwater protections, simulation of contaminant behavior by geochemical modeling; 9. Basic principles of contaminant transport modeling, analytical and numerical models and its application; 10-11. Groundwater protection and management: monitoring of water quantity and quality, vulnerability mapping (intrinsic and specific), mapping and classification of hazards, risk assessment, GIS application in groundwater protection; 12. Overview of legislative on environmental protection, waste disposal and emission of contaminants in the environment, protection of quantity and quality of groundwaters; 13.-14. Criterions of groundwater protection – case study analysis, determination of sanitary protection zones, study of influence on environment for different purposes.

STUDENT OBLIGATIONS DURING THE COURSE: Regular attendance of lectures and seminars during the semester that includes active participation in educative process; homeworks (how to solve a problem); seminar works (using the recent scientific literature); continued checking of knowledge through the preliminary exams.

METHODS TO EVALUATE STUDENT PERFORMANCE: Regular attendance of lectures and seminars; regular homework doing, presentation and explication of seminar works; passing of all preliminary exams.

EXAMINATION METHODS: Final exam in writing form, oral examination depends on teacher evaluation or depends on student require.

COURSE(s) NEEDED FOR THIS COURSE: Chemistry, Geochemistry, Hydrogeology

COMPULSORY LITERATURE:

Appelo, C.A.J. & D. Postma (1994): Geochemistry, groundwater and pollution. Balkema, Rotterdam.

Levačić, E. (1997): Osnove geokemije voda. Sveučilište u Zagrebu, Geotehnički fakultet Varaždin, 232 str.

Mayer, D. (1993): Kvaliteta i zaštita podzemnih voda. Hrvatsko društvo za zaštitu voda i mora. 146 p., Zagreb.
Parkhurst, D.L. (1995): PHREEQC- computer program for speciation, reaction-path, advective-transport and inverse geochemical calculations. Water-Resources Investigations Report 95-4227, USGS, Lakewood, Colorado.
Plummer, L.N., Prestemon, E.C. & D.L. Parkhurst (1994): An interactive code (NETPATH) for modelling net geochemical reactions along flow path, Version 2.0. USGS Water-Resources Investigation Report 94-4169, Reston, Virginia.
Chapters in:
Biondić, B, Bakalowitz, M, Zwalen, F., Almeida, O., Hoetzl, H. (1995): Hydrogeological aspects of groundwater protection in karstic area. EU COST ACTION 65, Project, EU, Bruxelles
Fritz.P. & Fontes, J.C. eds. (1980): Handbook of Environmental Isotope Geochemistry. Elsevier, Amsterdam.
IAEA (1983): Guidebook on Nuclear Techniques in Hydrology, Techical report series No. 91, International Atomic Energy Agency, Vienna.
Soliman, M.M., La Moreaux, P.E., Memon,B.A., Assaad, F.A., La Moreaux, J.W.(1998): Environmental Hydrogeology, Lewis Publishers, 386 str.
Vrba J. & Zaporozec, A. (ed)(1994): Guidebook on Mapping Groundwater Vulnerability. Vol. 16/1994, IAH, Verlag Hinz Heise, Hannover.
Zwahlen, F. (ed.)(2004): Vulnerability and risk mapping for the protection of carbonate (karst) aquifers. Final report – COST Action 620. European Commision - Office for Official Publications of the European Communities, Luxembourg.

ADDITIONAL READING:

Chapters in:
Boulding, R.J. (1995): Practical Handbook of Soil, Vadose Zone and Groundwater Contamination - Assessment, Prevention, and Remediation. Lewis Publishers, 948 p.
Coplen, T.B. (1993): Uses of Environmental Isotopes. In: Regional Ground-Water Quality, Edited by Alley, W.M., Van Nostrand Reinhold, New York, 223-254.
IAEA (1981): Stable Isotope Hydrology. Tehnical Report Series No. 210, Vienna.

COURSE TITLE: Geological aspects of waste disposals		
COURSE TEACHER/TEACHERS: prof.dr. Ladislav Palinkaš		
STUDY PROGRAMME: Graduate study Environmental Geology		
YEAR OF STUDY: 5.		
SEMESTER: 9.		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	assistent
Seminars		assistent
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Mining, industry, energy production, nuclear power station, traffic, oil and gas pipe-lines and change in living habits of urban and rural population produce enormous quantity of all kind of wastes, some of them even toxic and hazardous. Needs for construction of safe waste disposal sites requires proper knowledge of geological characteristics of the terrain provided for that purpose. It includes regime of underground water, retention capacity of artificial and natural membranes and sills, geochemical and geo-mechanical features of landfill rocks, evaluation of possible mineral resources and other qualities of the ground which is planned as the waste disposal. The course deals with modern technical solution of waste disposal construction of solid, liquid, gaseous, hazardous and nuclear wastes and geological prerequisite for their safe, long-term usage and final conservation.		
LEARNING OUTCOMES: To gain basic knowledge from the Law on Waste; To gain knowledge of main types of wastes; To gain knowledge of basic classification of hazardeous wastes; To become acquainted with selection criteria for landfill sites; To obtain basic knowledge of some special wastes; case study : Electric and Electronic wastes.		
DESCRIPTION OF THE COURSE: 1. Definition of the waste, kind of wastes (solid, liquid, gaseous, hazardous, radioactive, communal, etc.), 2.Waste producer (industry, energetic plants, mining, communal infrastructure, agriculture). System of waste disposals (unsorted, sorted), incineration, communal landfills, nuclear waste disposals (low, medium, high activity		

wastes), 3. Incineration plant, , emission of pollutents and toxicants, dioxin, energy production, incineration products (ashes, smoke filtrates), 4. Communal solid waste disposals:, technical characteristics, geomembranes, leachate chemistry, biogas, balling, composting, geological characteristics of an ideal waste disposal, monitoring, transport of waste, remediation and conservation, case studies, 5. Industrial and hazardous waste disposal, sources, (industry, medicine, oil industry, metallurgy, pharmaceuticals), waste disposal preparation (air filtration, extraction, chemical oxidation, membrane processes, adsorption on active carbon, liquefaction), biological treatment, stabilization and thermal methods, 6. Radioactive waste disposals (industry, medicine, scientific activity, nuclear energy production, nuclear weapons, nature of radioactivity, ionizing radiation, measuring of radioactivity (dose and sievert), biological effects, natural sources of radioactivity, radon problem, artificial sources of radioactivity, level of exposure to radioactivity, 7. Solid waste disposal sites, selection of site, geological criteria, protection of underground water, leachates collection, geomechanical stability, remediation of soil, monitoring, GIS, case studies, 8. Radiotoxicity, legislation, nuclear waste disposal, site selection, surface and underground disposals, low-medium and high activity wastes, deep geological waste disposals, case studies (Croatia, NPS "Krško", possible accidents).

STUDENT OBLIGATIONS DURING THE COURSE: Obligatory lecture audience and successful lab assignments,

METHODS TO EVALUATE STUDENT PERFORMANCE: colloquies, seminars, mid-term exam are prerequisite for recognition of attendance.

EXAMINATION METHODS: After fulfilling of course obligation the overall mark is formed by final exam, written, and oral.

COURSE(s) NEEDED FOR THIS COURSE:General mineralogy, Systematic mineralogy, Petrology of igneous and metamorphic rocks, Geochemistry, Quantitative and isotope geochemistry.

COMPULSORY LITERATURE:

LaGrega, D.M., Buckingham, P.I., Evans, C. J.: Hazardous Wast Managment, McGraw-Hill, 1994, str. 1145.

Murarka, I.P.: Solid waste disposal na re-use, Vol. I., Vol. II., CRC Press, 1987., str. 347.

Simončić, V.: Svjetska iskustva u zbrinjavanju otpada, ZGO, «Ognjen Prica», 1991., str. 472.

ADDITIONAL READING:

1. Chemley, H.: Geosciences, environment and man, Elsevier, 2003., str.525.
2. Jahić, M.: Deponije i zaštita voda, Sarajevo, 1980., str. 143.

COURSE TITLE: Geochemical methods of environmental investigation		
COURSE TEACHER/TEACHERS: prof.dr. Ladislav Palinkaš		
STUDY PROGRAMME: Graduate study Environmental geology		
YEAR OF STUDY: 4.		
SEMESTER: 7,		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	assistent
Seminars		assistent
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS. The course deals with investigation of supergene distribution of metals (trace elements) of natural and anthropogenic origin in atmosphere, hydrosphere, and pedosphere. It explains processes of anomaly formation (mobilization, transport, fixation, geochemical barrier). Methods and techniques: sampling, sample protection, instrumental methods of analyses, planning of sampling, basics of statistical data treatment.		
LEARNING OUTCOMES: Knowledge and understanding of geochemical principles by which it is possible to solve environmental geochemical problems. Ability to plan, conduct and report environmental geochemical investigations. Ability to carry out field and laboratory work in a safe manner.		
DESCRIPTION OF THE COURSE: 1.Geochemical environment, dispersion, mobility, reactivity, 2.Principles of trace metal analyses (sampling, digestion, separation, analytical techniques: AAS, ICP-MS, XRF, GC, LC, polarography, etc., reliability, precision, accuracy), 3. Ore deposits and rocks as sources of natural pollution, 4. Soil origin, chemical weathering of rocks and ores, soil classification, 5. Composition of natural waters, Eh-pH measuring techniques, complexes, solubility of minerals, cation-anions exchange processes on clays and organics (colloids), 6.Geochemical investigation of soil, 7.Anomalies in natural waters, 8.Anomalies in stream sediments, lake and sea sediments, 9. Geochemical exploration of drainage systems, 10.Vegetation, volatiles (particles in atmosphere), 11. Statistical treatment of data, 12. Mapping and interpretation, 13. Geochemical exploration of mineral deposits, 14.Geochemical search for anthropogenic polluter, case studies.		

STUDENT OBLIGATIONS DURING THE COURSE: Obligatory lecture audience and successful lab assignments,

METHODS TO EVALUATE STUDENT PERFORMANCE: colloquies, seminars, mid-term exam are prerequisite for recognition of attendance.

EXAMINATION METHODS: After fulfilling of course obligation the overall mark is formed by final exam, written, and oral.

COURSE(s) NEEDED FOR THIS COURSE:General mineralogy, Systematic mineralogy, Petrology of igneous and metamorphic rocks, Geochemistry, Quantitative and isotope geochemistry.

COMPULSORY LITERATURE:

1. Rose, A.W., Hawkes, H.E., Webb, J.S.: Geochemistry in mineral exploration, Academic press, 2nd ed. 1979., pp. 657.
2. Dean, J.R.: Methods for environmental trace analysis, Wiley, 2003., pp. 253.

ADDITIONAL READING:

1. Watts, S. & Halliwell, L. :Essential Environmental Science, Methods and Techniques, Routledge, London and Newyork, 1996., str. 512.
2. Chamley, H.: Geosciences, environment and man, Elsevier, 2003, pp. 527.
3. Aswathanarayana, U.: Geoenvironment, an introduction, Balkema, 1995, pp. 270

COURSE TITLE: ENVIRONMENTAL GEOCHEMISTRY		
COURSE TEACHER/TEACHERS: professor, ESAD PROHIĆ, Faculty of Science		
STUDY PROGRAMME: Graduate study Environmental geology		
YEAR OF STUDY: IV		
SEMESTER: 8		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	professor, assistant, research assistant
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Obtaining basic knowledge about environmental geochemistry, biogeochemical cycles of elements and global changes at the Earth. The course deals with principles of behaviour and movement of pollutants in the environment.		
LEARNING OUTCOMES: To gain basic knowledge of the environmental issues; To become acquainted with the most important global environmental issues: acid rain problem; Global warming and climatic change; „ozone hole“ problem; To gain basic knowledge of poolution problems in carbonate terrains..		
COURSE DESCRIPTION: 1. Glossary, introductory remarks, definition and basic concept of environmental geochemistry 2 -3. Environment in crisis; analysis of dynamic environmental system, equilibrium, geochemical system, feedback mechanism 4. Biogeochemical system of carbon 5. Greenhouse efect, greenhouse gases, efects, causes, consequences 6. Biogeochemical cycles of ozone and halogenides 7. Ozon layer depletion, ozone hole , causes, consequences. 8. Biogeochemical cycles of sulphur and nitrogen 9. Acid rains, pH of rainwater, causes and consequences of acid rains 10-11 . Chemical time bomb, definition, explantionof cincept, prediction of CTB,		

examples 12 - 13. Trace elemets and health, concept of geomedicine. examples 14 - 15. Problems of trace element analysis in environemtal sciences.
STUDENT OBLIGATIONS DURING THE COURSE: attending classes, preliminary exams, homework assignments
METHODS TO EVALUATE STUDENT PERFORMANCE: fulfilled obligations
EXAMINATION METHODS: written exam, final grade includes also results of prelim and homework assignments
COURSE(s) NEEDED FOR THIS COURSE: Chemistry 1 i 2, Geochemistry
COMPULSORY LITERATURE: Prohić, E.. (1998): Geokemija, Targa, 554 str. Berner, E.K. & Berner, R.A.. (1996): Global environment : Water, Air, and Geochemical Cycles, Prentice Hall, INC, USA
ADDITIONAL READING: Schlensinger, H.W. (1997): Biogeochemistry – An Analysis of Global Change, Academic Press, USA, 587 str..

COURSE TITLE: ENVIRONMENTAL LAW		
COURSE TEACHER/TEACHERS: professor, ESAD PROHIĆ; Faculty of Science		
STUDY PROGRAMME: : Graduate study Environmental geology		
STUDY YEAR: IV. ili V.		
SEMESTER:		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	professor, assistant, research assistant
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Getting the students acquainted with legal framework and legal concept of environment with the getting knowledge of the environmental policy in Croatia and abroad.		
LEARNING OUTCOMES: To become acquainted with definitions and basic terms ; To obtain knowledge about types pf environmetal protection; To be acquainted with main theories in environmental protection; To gain basic knowlledge about primary and secondary principles; To become acquainted with basics of international environmental law; UN conferenceon Earth To become familiar with most important conventions.		

COURSE DESCRIPTION:
1. Definition of environment, introductory and basic questions of the environmental law, philosophy of the environment.
2. Environmental law as a concept and its position in the legal system
3. Sources of the environmental law in the Croatian legal system
4. Environmental policy and strategy
5.-6. Protection of the special parts (national parks natural parks, etc) in the Croatian legal system
7. Implementation and surveillance of the environmental protection
8. Concept and definition of the sustainable development;
9. Permanent sustainable development and ecological modernization.
10.International legal concept of the environmental protection and preservation of the environment. Development of international environmental law.
11-12. The most important international legal acts dealing with environmental protection.
13. Environmental law in the European community
14. Environment from the legal tax standpoint
15. Instruments of implementation and control of the environmental protection.

STUDENT OBLIGATIONS DURING THE COURSE: attending classes, preliminary exams, homework assignments

METHODS TO EVALUATE STUDENT PERFORMANCE: fulfilled obligations

EXAMINATION METHODS: written exam, final grade includes also results of prelim and homework assignments

COURSE(s) NEEDED FOR THIS COURSE: Environmental geochemistry

COMPULSORY LITERATURE:
Lončarić-Horvat, O., Cvitanović, L., Gliha, I., Josipović, T., Medvedović, D., Omejec, J., & Seršić, M. (2003) : Pravo okoliša, Organizator, 348 str. Zagreb
Carter, N. (2004) : Strategije zaštite okoliša, Barbat, 383 str, Zagreb

COURSE TITLE: CLAY MINERALOGY		
COURSE TEACHER/TEACHERS: Associate professor, DARKO TIBLJAŠ, Faculty of Science		
STUDY PROGRAMME: Graduate study Environmental geology		
YEAR OF STUDY: IV or V		
SEMESTER:		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	1	professor
Exercises	2	professor and assistant
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Acquiring knowledge on clay minerals classification, genesis, properties and methods for their investigation		
LEARNING OUTCOMES: Knowledge and understanding of basic crystallochemical characteristics of clay minerals, and their genesis. Knowledge and understanding of most common procedures and methods of clay minerals analysis. Capability for separation of clay fraction. Capability for performing qualitative phase analysis on the basis of recorded X-ray powder patterns by using apropriate software and literature data. Capabilitiy for logical thinking and for preparing written investigation report.		
DESCRIPTION OF THE COURSE: 1. definition of clays and clay minerals, division of clay minerals, properties of clays 2.-4. structures, chemistry and occurrences of different clay minerals groups (kaolinite, serpentinite, micas, vermiculite, smectite, chlorite, interstratified clays) 5.-6. methods of sample preparation: rock disaggregation, chemical treatment, fraction separation, sample preparation 7.-8. methods for clay minerals analysis: X-ray powder diffraction method (qualitative and quantitative analysis) 9.- 11. methods for clay minerals analysis: thermal methods, infra-red spectroscopy, electron microscopy		

12.-14. clay minerals genesis, clay minerals transformations during digenesis and low-grade metamorphosis, Kübler and Árkai indices 15. usage of clays
STUDENT OBLIGATIONS DURING THE COURSE: attending classes, preliminary exams, homework assignments
METHODS TO EVALUATE STUDENT PERFORMANCE: fulfilled obligations
EXAMINATION METHODS: written and oral exam, final grade includes also results of prelim and homework assignments
COURSE(s) NEEDED FOR THIS COURSE: System of mineralogy, Principles of elemental and phase analysis
COMPULSORY LITERATURE: Moore, D.M. & Reynolds, R.C. (1997): X-ray diffraction and the identification and analysis of clay minerals, Oxford University Press, Oxford, 378 pp. Brindley, G.W. & Brown, G. (1980): Crystal structures of clay minerals and their X-ray identification. Mineralogical Society, London, 495 pp.
ADDITIONAL READING: Clay sedimentology, Springer Verlag, Berlin, 623 pp. Wilson M.J. (1994): Clay mineralogy: spectroscopic and chemical determinative methods. Chapman & Hall, London, 367 pp.

COURSE TITLE: ORGANIC GEOCHEMISTRY OF POLLUTANTS		
COURSE TEACHER/TEACHERS: dr. Marijan Ahel, Ruđer Bošković Institute		
STUDY PROGRAMME: Graduate study Environmental geology		
YEAR OF STUDY: III		
SEMESTER: 5		
TEACHING METHODS	CONTACT HRS PER WEEK	DELIVERED BY (*professor or assistant*)
Lectures	2	professor
Exercises	1	assistant
Seminars		
ECTS credits: 5		
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES – KNOWLEDGE AND SKILLS: Study of major types of anthropogenic pollutants, methods for their determination and the most important processes, which govern their behaviour and fate in the environment		
LEARNING OUTCOMES: Understanding the basics of chemical contamination, especially organic pollutants. Understanding the role of biogeochemical processes in transport, distribution and transformation of pollutants in environment. Knowledge of critical paths for exposure to organic pollutants in environment to assess chemical contamination. Knowledge of consequences of athropogenic influence on environment. Knowledge of basics in analytical determination of pollutants in environment. Knowledge of fundamentals of biogeochemical processes and their role in environment. Understanding of processes involved in pollutants transfer in environment – diffusion and advection processes. Knowledge of physico-chemical processes involved in distribution of pollutans in environment, especially geoaccumulation and bioaccumulation. Knowledge of basic transformation processes – chemical, photochemical and biological transformation of pollutants. Knowledge of procedures in assessment of pollutants behavior in environment and assessment of environmental risks.		

DESCRIPTION OF THE COURSE:

1. Introduction to environmental organic chemistry – definition and relationship to other disciplines of science;
2. Basic structures and nomenclature in organic chemistry; anthropogenic vs. natural compounds; definition, classification and major types of pollutants;
3. A brief introduction to analytical chemistry of organic pollutants;
4. Thermodynamics and molecular interactions;
5. Main geochemical processes, which determine behaviour and distribution of organic pollutants in the environment and their relationship in real systems;
6. Transport and transfer of pollutants – diffusion and advection;
7. Distribution of organic pollutants between aquatic systems and atmosphere;
8. Distribution of organic pollutants in aquatic systems – solubility and partition coefficients;
9. Distribution of organic pollutants in aquatic organisms – bioaccumulation and biomagnification;
10. Exchange of pollutants between solid-phase and water – sorption and geoaccumulation;
11. Chemical transformations of pollutants;
12. Photochemical transformation of pollutants;
13. Biological transformations of pollutants;
14. Modelling in organic geochemistry of pollutants;
15. Geochemical processes and environmental risk assessment;

STUDENT OBLIGATIONS DURING THE COURSE: lectures, seminars, homework

METHODS TO EVALUATE STUDENT PERFORMANCE: regular fulfilment of obligations

EXAMINATION METHODS: oral exame, colloqia

COURSE(s) NEEDED FOR THIS COURSE: Chemistry I and II

COMPULSORY LITERATURE:

Schwarzenbach, R.P.; Gschwend; P.M.; Imboden, D.M. (2003): Environmental organic chemistry, John Wiley & Sons, Inc., New Jersey, USA, 1313 pp.

ADDITIONAL READING:

1. Baird, C; Cann, M. (2005) Environmental chemistry. W.H. Freeman and Company, New York, 652 pp.

3.3 Structure of the study program

Study program is organized by scheme 3+2 (with exception of Educational study) presented on the graphical sketch and on the items 3.1 and 3.2. At present the basic principle of the study program is “year by year”. The general intention of the study program is, however, permanent improvement of the study efficiency, approaching system “semester by semester” through permanent control of acquirements of knowledge by colloquies, tests, seminars, mid-term exams, and final exams, according to specificity of a particular course and choice of the teacher (item 3.2). Optional courses are to be selected by suggestions of the student adviser or mentor.

3.4 List of courses acceptable from other study programs.

Students are free to choose courses from other study programs of Faculty of Sciences, as well as from related faculties, by assistance of student advisors, and constrained by legislation of the University and Faculty of sciences.

3.5 List of courses performable in English language.

English can be a teaching language instead of Croatian in case of particular interest of auditorium (more than 50 % of auditorium).

3.6 ECTS transfer criteria

ECTS credits achieved at other faculties, will be evaluated at the rate proposed by the particular study program but not against limitations prescribed by legislation of University or Faculty of Sciences. The Education Council of Faculty of Science restricts enrolment of 3 ECTS credits, from other faculties of the University, which accomplish the total of 60 ECTS credits, but in line with the course time-table of the study program.

3.7 The completion of the study

In the case of a student decision not to continue into a higher level of educational process

(graduate study) completion of the undergraduate study will terminate with a defence of a justifiable written assignment.

3.8 The students may get involve again into the educational process at the stage whereupon the study process was interrupted, except in the case of the lost student’s rights, forced by the University legislation.

4. Qualities of the study performance

4.1. Location of the study program performance

The study program will be executed in the building facilities of the Mineralogy and Petrology institute and Geology-Palaeontology institute of the Faculty of Sciences, Faculty of Philosophy and Faculty of Mining-Geology-Petroleum Engineering. A part of the teaching will be performed in field in the frame of field courses.

4.2 Study rooms and laboratory equipment

Geological department of the Faculty of Sciences consists of two institutes (Mineralogy and Petrology institute and Geology-palaeontology institute).

Mineralogy and Petrology institute incorporates:

Three teaching rooms, surface area of the institute are 495 m^2.
Geology and Palaeontology institute incorporates:
Two teaching rooms, surface area of the institute are 470 m^2.
In recent time a new study space at the Horvatovac locality is available and relocation of the institute is going on. A new space facilities offer at disposal four teaching rooms and a common space what significantly improves performance of the study program.
The teaching rooms of the Geological department are equipped with presentation facilities (multimedia projectors, overhead projectors, slide projectors, video and TV receivers). One of the rooms is provided for microscopy with tens of polarizing microscopes, and tens of stereo-lenses.
The department posses two preparatory labs (with equipment for sample preparation, sieving, sawing, grinding, polishing, centrifuge, sedigraph), chemical and XRD spectrometer (powder diffractometer and XRF spectrometer), electron-microscopy lab (with SEM), provided for research, teaching and diploma works. Fossil, mineral and rock collections for study purposes are available as well. Library with 13500 entrances is at disposal. Use of 14 computers in the teaching process is routine.
With regrets one must admit that teaching space available in the Geology department does not satisfy the present needs, a great deal of the microscopy facilities is out of time.