UNIVERSITY OF ZAGREB

FACULTY OF SCIENCE

Geology Department

DOCTORAL STUDY IN GEOLOGY

PLAN and CURRICULA

Area of Natural Sciences

Field of Geosciences

Branches of Geology and Mineralogy

Zagreb, May 2006

3.2. The list of compulsory and optional courses with the number of teaching hours required for their fulfillment and the respective ECTS credit points.

Course code	Lecturer	Course	Hours teaching / exercises	ECTS credit points
Basic courses				
5800	Babić, Lj.	Sedimentology and Evolution of Basins related to Convergent Margins	15 + 30	9
5801	Marjanac, T. and visiting professor	Geological Aspects of Karst	15 + 0	4
5802	Bajraktarević, Z.	Biostratigraphy of Paratethys	15 + 0	4
5805	Juračić, M.	Environmental Geology	15 + 0	4
5806	Balen, D.	Mineral Equilibria in Magmatic and Metamorphic Processes	30 + 15	9
5807	Marjanac, T.	Geological Interpretation of Seismic Profiles	15 +15	6
5808	Palinkaš, L.	Isotope Geology	30 + 15	9
5809	Balen, D.	Magmatism, Metamorphism and Geodynamic Processes	30 + 0	8
5810	Tomljenović, B.	Selected Topics on Structural Geology	15 + 0	4
5811	Prohić, E.	Interpretation and Mathematical Methods of Geological Data Analyses	30 + 15	9
5812	Sremac, J. Ćosović, V.	Methods of Investigation in Palaeontology	30 + 15	9
5813	Tibljaš, D. Trojko, R.	X-ray and Thermal Methods of Phase Analysis	15 + 15	6
5814	Tibljaš, D. Bermanec, V.	Spectroscopic Methods of Mineral and Rock Analysis	30 + 15	9
5815	Zupanič, J.	Sedimentary Petrology, Selected Topics	15 + 15	6
5816	Jelaska, S.	Methodology of Scientific Research	15 + 15	6
5817		Seminar I		5
5818		Seminar II		10
5819		Seminar III (public defense of the doctoral thesis)		10
Specific courses				
5900	Alajbeg, A.	Organic Geochemistry	15 + 15	6
5901	Babić, Lj.	Coastal Zone Management: Geoscientific Aspects	15 + 15	6
5902	Ćosović, V. Bajraktarević, Z.	Benthic Foraminifera as a Tool for Paleoenvironmental interpretation of the Paleogene and Neogene Sediments	30 + 15	9
5904	Bermanec, V.	Quantitative Optical Determinations	15 + 15	6
5905	Bermanec, V.	Mineralogy and Geochemistry of Rare Earth Elements	15 + 0	4
5906	Bermanec, V.	Selected Chapters of System of Mineralogy	15 + 15	6
5907	Biondić, B. Kapelj, S.	Hydrogeology and Water Protection in Karst	15 + 15	6
5908	Gušić, I. Cvetko Tešović, B.	Biotas, Paleo-Ecology and Biostratigraphy of Mesozoic Carbonate Platforms	15 + 15	6
5909	Cvetko Tešović, B. Bucković, D.	Carbonate Platforms	15 + 0	4
5910	Marjanac, T. Bucković, D.	Sequence Stratigraphy	30 + 15	9
5911	Juračić, M.	Selected Topics in Marine Geology	30 + 15	9

5912	Juračić, M.	Recent Sedimentation in the Sea	15 + 15	6
5913	Kniewald, G.	Thermodynamics in Mineralogy and Geochemistry	15 + 15	6
5914	Luić, M. Kojić-Prodić, B.	X-ray structure analyses	30 + 15	9
5915	Marjanac, T.	Geological Interpretation of Petrophysical Well Data	15 + 15	6
5916	Palinkaš, L.	Geochemistry of Igneous and Metamorphic Rocks	15 + 15	6
5917	Palinkaš, L.	Mineral Deposits	30 + 15	9
5918	Marjanac, T.	Quaternary Geology	15 + 0	4
5919	Pavelić, D.	Evolution of the Pannonian Basin	15 + 0	4
5920	Tomljenović, B. Herak, M.	Seismotectonics	30 + 15	9
5921	Prohić, E.	Selected Topics on Sediment Geochemistry	15 + 15	6
5922	Prohić, E.	Environmental Geochemistry	30 + 15	9
5923	Sremac, J.	Fossil Communities of the Late Palaeozoic – Palaeoecological and Biostratigraphical insights	15 + 15	6
5924	Ščavničar, S.	Structural Crystallography	15 + 0	4
5925	Ščavničar, S.	Raw Material for Ceramics - Composition of Products	15 + 15	6
5926	Bermanec, V.	Monocrystal Study by Combination of Analytical Methods	15 + 30	7
5927	Tonejc, A.	Electronic Diffraction and Microscopy	15 + 15	6
5928	Palinkaš, L. Horvatinčić, N.	Geochronology	30 + 15	9
5929	Sondi, I.	Physical Chemistry of Pollution Process	15 + 0	4
5930	Sondi, I.	Biomineralization	15 + 0	4
5931	Ćosović, V.	Environmental Micropaleontology	15 + 0	4
5932	Moro, A.	Facies and Macrofossils of the Upper Cretaceous Carbonate Platform	15 + 0	4
5933	Grgasović, T.	Carbonaceous Algae in Sedimentology and Stratigraphy	30+15	9

3.4. Description of each course and/or module:

CURRICULA

Notice: Below mentioned subject contents are standard course contents that are coordinated with the interests i.e. students' research topics as needed.

Order of courses according to the list above.

BASIC COURSES

COURSE: Sedimentology and Evolution of Basins related to Convergent Margins

AUTHOR(S) OF COURSE PROGRAMME:

Prof. dr. sc. Ljubomir Babić, Faculty of Scinece, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+20+10

Lessons, exercises, homeworks, essay, fieldwork, field project

ECTS: 9

COURSE ACHIEVEMENTS:

Students learn how to investigate the combination of various sedimentary features characterizing basins related to convergent margins and how to use them for the interpretation of the basin character and evolution. They also study the different basin types and their dynamics. The importance of making careful observations is emphasized as well as the knowledge of various processes. The theoretical knowledge combined with the first-hand field experience will enable students to better understand theoretical and practical problems. This will be useful when they will be faced with questions on natural resources related to sediments and problems related to modern environments.

COURSE PROGRAMME:

Sedimentary basins and tectonic plates. The relationship between depositional systems and sedimentary basins. Research methods. //Features and evolution of the basins, which precede convergence. //Ocean trenches. Forarc basins. Backarc basins. Sedimentation, dynamics of depositional systems and deformation. Ophiolitic mélange. //Foreland basins. Main features. The character of depositional systems, sedimentary and tectonic evolution, and architecture of the basin fill. The evolution of the foreland platform. //Provenance study as a tool for deciphering tectonic and exhumation history. //Problems of the evolution of the collisional system of the Dinarides. //Controls on the basin filling and stratigraphy. //Specific aspects of the mapping the relevant areas. //Fieldwork on selected localities showing typical features and reflecting typical problems related to the evolution of a collisional basin and orogen.

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

Activity in preparation for lessons, exercises, discussions and fieldwork. Quality of the essays, discussions and fieldwork results. Each kind of the work should achieve a positive grade. The average grade brings 50% of the overall grade.

OBLIGATORY LITERATURE:

Selected sections in books:

Einsele, G., 2000, Sedimentary Basins: Evolution, Facies, and Sediment Budget. 2. Ed. 792 pp. Springer, Berlin.

Miall, A.D., 2000, Principles of Sedimentary Basin Analysis. 3. Ed. 616 pp. Springer, Berlin.

Pickering, K.T., Hiscott, R.N. & Hein, F.J., 1989, Deep Marine Environments: Clastic Sedimentation and Tectonics. 424 pp. Springer, Berlin.

Allen, Ph.A. & Homewood, P., eds., 1986, Foreland Basins. IAS Spec. Publ. 8, 453 pp. Blackwell, Oxford.

Selected works in journals

SUPPLEMENTARY LITERATURE:

Selected works in journals
Selected sections in books for he fieldwork:

Bhattacharrya, A. & Chakraborty, C., 2000, Analysis of Sedimentary Successions. 420 pp. Balkema, Rotterdam.

Collinson, J.D. & Thompson, B.D., 1982, Sedimentary Structures. 2. Ed. Unwin Hyman, London.

Tucker, M.E., ed., 1988, Technics in Sedimentology. 394 pp. Blackwell, Oxford.

Tucker, M.E., 2003, Sedimentry Rocks in the Field. 3. Ed. 234 pp. Wiley, Chichester.

EXAMINATION PROCEDURE: Oral exam. The result brings 50% of the overall grade.

COURSE: Geological aspects of karst

AUTHOR(S) OF COURSE PROGRAMME:

prof. dr. Tihomir Marjanac, Department of Geology, Faculty of Science, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+0+0

(lectures + field excursion)

ECTS: 4

COURSE ACHIEVEMENTS:

The aim of this course is learning on carbonate minerals and their properties; karst relief, both at the surface and underground; and genesis of karst, its evolution and stratigraphy. The aim is also to provide essential knowledge on water dynamics in karst, and ecological as well as geotechnical problems of karst.

COURSE PROGRAMME:

The course will highlight the following topics:

Mineralogy of carbonate minerals

Karstification, karst genesis and speleogenesis

Evolution of karst, stratigraphy of karst

Geomorfology of karst

Hidrology of karst

Hidrogeology of karst

Geochemy of karst

Ecological problems of karst

Geotehnical problems of karst

Sedimentation and sediments in karst

Visiting lecturers will highlight individual topics from the perspective of their expertise.

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

Lecture attendance, field excursion: visit to “classical” karst areas, discussion on processes and forms.

OBLIGATORY LITERATURE:

Ford, D., Williams, P. (1989): Karst Geomorphology and Hydrology, Chapman & Hall, London.
Herak, M. i Stringfield, V.T. (1972): Karst. Important Karst Regions of the Northern Hemisphere. Elsevier Publ. Comp., Amsterdam.
Jakucs, L. (1977): Morphogenetics of karst regions: variants of karst evolution. Akademiai Kiado, Budapest.

SUPPLEMENTARY LITERATURE:

Selected papers from international journals.
EXAMINATION PROCEDURE: Oral exam

COURSE: Biostratigraphy of Paratethys

AUTHOR(S) OF COURSE PROGRAMME

Prof.dr.sc. Zlatan Bajraktarević, Faculty of Science, University of Zagreb, Geological Dep., Geol.-pal. Div**.**

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+0+0

ECTS: 4

COURSE ACHIEVEMENTS: mastering in theoretical (literatuer) and analythical (microscoping) knowledge of the most recent results and capabilities of definition of special nannofossils and microfossils with the purpose of defining of biozones and index fossils needed for the biostratigraphical, paleoecological and paleogeographical interpretation.

COURSE PROGRAMME:

Micropaleontological researches of Neogene sediments of Paratethys from the territory of Croatia and contiguous countries. Significant microfossils and nannofossils for some stratotypes of Neogene. The level of exploration of several microfossil groups with the special reference to cretaceous and siliceous nannofossils, microforaminifera and their application.

STUDENTS' ACTIVITIES AND THEIR EVALUATION: Attending lectures, writing of the topical essays-assignments.

OBLIGATORY LITERATURE:

Bolli, H.M., Saunders J.B. & Perch-Nielsen, K. (1985): Plankton Stratigraphy. Cambridge Earth
Science Series, 1-1032, Cambridge Univ. Press.

Bajraktarević, Z. & Kalac, K. (1998): Regional Geology, Basin Development and Stratigraphical Conceps. - The southwest part of the Pannonian Basin and its borderland. Abh. Senckenberg. naturforsch. Ges. 549, 62-68. In: Cicha, I., Rögl, F., Ctyroka, J. & Rupp, Ch. (Editors) & the members of the "Working group on the Foraminifera of the Central Paratethys" (1998): OLIGOCENE - MIOCENE FORAMINIFERA OF THE CENTRAL PARATETHYS. Verlag Waldamer Kramer. Abh. Senckenberg. naturforsch. Ges. (edit. F. Steininger) 549, 1-325, Frankfurt, a.M.

Bajraktarević, Z. & Pavelić, D. (2003): The Karpatian stage in Croatia. In:
Brzobohaty, R., Cicha, I., Kovač, M. & Roegl, F. (eds): The Karpatian -
an Early Miocene Stage of the Central Paratethys. - Masaryk
University Brno,141-145, Brno.

SUPPLEMENTARY LITERATURE:

Current literature from relevant scientific papers.

EXAMINATION PROCEDURE:

Theoretical oral exam as well as recognition of the most characteristic nanno- and microfossils.

COURSE: Environmental geology

AUTHOR OF COURSE PROGRAMME:

Professor Mladen Juračić, Faculty of Science, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)***:** 15+0+0

ECTS: 4

COURSE ACHIEVEMENTS: Students gain additional knowledge on geological component in environmental protection (geological hazards, groundwater, location and design of landfills).

COURSE PROGRAMME : The role of geology in environmental protection. Basic concepts: environment, environmental protection, contamination/pollution. Interdisciplinarity 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.

STUDENTS' ACTIVITIES AND THEIR EVALUATION: Lectures, seminars and home work

OBLIGATORY LITERATURE :

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

SUPPLEMENTARY LITERATURE:

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

Selected review and original scientific papers

EXAMINATION PROCEDURE: Verbal exam and/or written seminar

COURSE: Mineral equilibria in the magmatic and metamorphic processes

AUTHOR(S) OF COURSE PROGRAMME:

Dr. Dražen Balen, assistant professor, Department of Geology, Faculty of Science, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)* :30 +15+0

ECTS: 9

COURSE ACHIEVEMENTS:

Advanced level of igneous and metamorphic petrology with emphasis on metamorphic and igneous mineral equilibria and analysis of interrelations of geological parameters and processes. Students will achieve knowledge needed for scientific research.

COURSE PROGRAMME:

Homogeneous and heterogeneous phase equilibria. Fundamental relations, activity models for phases of petrologic importance. The Gibbs phase rule, 1-, 2-, 3-, 4-component systems, systems with more than four components. Pelite and metabasite phase relations. Calculation of metamorphic phase equilibria, geothermometry, geobarometry, geooxometry, P-T-t-X-M phase relations. Origin and interpretation of zoned metamorphic and magmatic minerals. Flow of fluids during metamorphism. Metamorphic P-T paths and tectonic evolution.

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

consultations, seminars with individually adopted subjects

OBLIGATORY LITERATURE:

Spear, F.S. (1993): Metamorphic Phase Equilibria and Pressure-Temperature-Time Paths. Mineralogical Society of America, Washington, D.C.

Bucher, K. & Frey, M. (2002): Petrogenesis of Metamorphic Rocks.- Springer, Berlin - Tokyo.

SUPPLEMENTARY LITERATURE:

selection form recent scientific literature

EXAMINATION PROCEDURE:

seminars + written exam + oral exam

COURSE: Geological interpretation of seismic sections

AUTHOR(S) OF COURSE PROGRAMME:

prof. dr.sc. Tihomir Marjanac**,** Department of Geology, Faculty of Science, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+15+0

ECTS: 6

COURSE ACHIEVEMENTS:

The aim of this course is to familiarize students with physical principles of seismic logs, methods of seismic survey, principles of seismic data processing, and geological interpretation of seismic sections with principles of seismostratigraphy and facies analysis.

COURSE PROGRAMME:

Physical principles of seismic survey:
- waves
- acoustic impedance
- wave reflection
- wave refraction
- absorption of acoustic energy

Methods of seismic survey:
- refraction
- reflection

Nature and causes of interference:
- multiples
- noise
- diffraction
- shadow
- structural effects
- velocity effects
- sideswipe
- vertical and horizontal resolution

Processing of sesimic data:
- CDP gather
- migration 2D i 3D
- correlation

Interpretation of seismic sections:
- recognition of disconformities
- recognition of tectonical elements and structures (faults, folds, diapirs)
- recognition of stratigraphic contacts
- recognition of sedimentary bodies (reefs, banks, fans, channels and canyons
- correlation with well logs
- density of coverage

Principles of seismic stratigraphy:
- recognition of seismostratigraphic units

boundaries and surfaces
depositional sequence tracts
analysis and interpretation of seismofacies

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

Attendance of lectures, exercises, interpretation of seismic sections.

OBLIGATORY LITERATURE (*authors, title, publisher, edition, year of publishing*):

Bally A.W. (1987): Atlas of Seismic Stratigraphy. AAPG Studies in Geology 27. vol. 1-2.
Bally A.W. (1983): Seismic expression of structural styles. AAPG Studies in Geology 15. vol. 1-3.
Payton C.E. (1977): Seismic Stratigraphy - applications to hydracarbon exploration. A.A.P.G. Mem. 26, Tulsa.
Vail P.R. (1987): Seismic Stratigraphy Interpretation using Sequence Stratigraphy. Part 1: Seismic stratigraphy interpretation procedure. In: Atlas of Seismic Stratigraphy, 1, (ur.)(Bally A.W.). AAPG Studies in Geology 27, 1-10.
Van Wagoner J.C., Mitchum R.M.Jr., Posamentier H.W. & Vail P.R. (1987): Seismic Stratigraphy Interpretation using Sequence Stratigraphy. Part 2: Key definitions of sequence stratigraphy. In: Atlas of seismic stratigraphy 1 (ur.)(Bally A.W.). AAPG Studies in Geology 27, 11-14.

SUPPLEMENTARY LITERATURE: Case studies in international literature.

EXAMINATION PROCEDURE: Oral exam, based on individually interpreted seismic section

COURSE: Isotope geology

AUTHOR(S) OF COURSE PROGRAMME:

Dr. Ladislav Palinkaš, full professor, Faculty of Science

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 30+15+0

ECTS: 9

COURSE ACHIEVEMENTS:

The aim of this course is introduction of isotope study methods and their use in solving genetic questions of origin of rocks and mineral deposits; introduction of these research methods, and the interpretation of results obtained by nuclear geochronology for age valuation of rocks and minerals.

COURSE PROGRAMME:

1. Roots of isotope geology
2. Internal structure of the atom
3. Decay mechanism and radioactive atoms
4. Mass spectrometry, Rb-Sr, methods of dating, Strontium in two-component mixture, isotope geology of strontium
5. K/Ar method of dating, time scale for geomagnetic polarity reversals
6. Ar-Ar method of dating, incremental heating technique.
7. Re-Os, Lu-Hf, and K-Ca methods of dating
8. U-Th-Pb methods of dating, geochemistry of uranium, concordia diagram.
9. Common lead method, interpretation of anomalous lead
10. Interpretation of multi-stage lead
11. Method of fission tracks, fading of fission tracks, pleochroic haloes.
12. U-disequilibria method of dating.
13. C-14 method of dating.
14. Oxygen, hydrogen ih hydrosphere and lithosphere, carbon, sulphur.

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

Positive average grade from preliminary exams, seminars, practical laboratory exercises and mid-term exams.

OBLIGATORY LITERATURE:

Bowen, R. (1988): Isotopes in the Earth Sciences.- Elsevier App. Science, London.

Faure, G., Mensing, T. M. (2004): Isotopes : Principles and Applications.- John Wiley & Sons, New York, 3rd Edition.

Geyh, M. A., Schleicher, H. (1990): Absolute Age Determination.- Springer-Verlag, Berlin.

SUPPLEMENTARY LITERATURE:

Dickin, A. P. (2005): Radiogenic isotope geology. -Cambridge University Press, 2nd Edition.

Attendorn, H. G., Bowen, R. N.C. (1997): Radioactive and Stable Isotope Geology. -Chapman and Hall, London.

Criss, R. E. (1999): Principles of Stable Isotope Distribution. –Oxford University Press.

EXAMINATION PROCEDURE:

Preliminary exams during practices, written mid-term and written final exam (on request of professor or student final exam can be oral)

COURSE: Magmatism, metamorphism and geodynamic processes

AUTHOR(S) OF COURSE PROGRAMME: Dr. Dražen Balen, assistant professor, Department of Geology, Faculty of Science, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 30+0+0

ECTS: 8

COURSE ACHIEVEMENTS:

Advanced level of igneous and metamorphic petrology with emphasis on metamorphic and igneous rock genesis, geological parameters, geodynamics and processes. Students will achieve knowledge needed for scientific research.

COURSE PROGRAMME:

Magmatism and metamorphism in the orogenic cycle(s). Magma genesis, partial melting, processes in the magma. Igneous rock associations. Metamorphic zone, facies, series. Orogenic cycle, classification and interpretation. Metamorphism of European orogenic belts. Caledonides, Hercynides, Alps and Dinarides.

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

consultations, seminars with individually adopted subjects

OBLIGATORY LITERATURE:

Turcotte, D.L. & Schubert, G. (2002): Geodynamics. Cambridge University press, Cambridge.

Spear, F.S. (1993): Metamorphic Phase Equilibria and Pressure-Temperature-Time Paths. Mineralogical Society of America, Washington, D.C.

Hall, A. (1998): Igneous petrology. Longman, Edinburgh.

SUPPLEMENTARY LITERATURE :

selection form recent scientific literature

Bucher, K. & Frey, M. (2002): Petrogenesis of Metamorphic Rocks.- Springer, Berlin - Tokyo.

Hyndman, D. W. (1985): Petrology of igneous and metamorphic rocks. McGraw-Hill Book Company, New York

EXAMINATION PROCEDURE: seminars + written exam + oral exam

COURSE: Selected Topics in Structural geology

AUTHOR(S) OF COURSE PROGRAMME:

Dr. Bruno Tomljenović, Assistant Prof., University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15 + 0 + 0

ECTS: 4

COURSE ACHIEVEMENTS:

The program of this course is designed to enable students to acquire application skills in structural geology and tectonics in order to be able to understand kinematics and dynamics of deformational processes, which take place at different geodynamic settings of the Earth: at divergent, convergent and transform plate boundaries and within the plate interior. Particularly, it is expected that student will develop analytical and deductive skills in classification, interpretation and description of tectonic structures and deformational styles in different geodynamic settings of the Earth.

COURSE PROGRAMME:

1. Kinematic models of evolution and structural architecture of continental rift zones. Aulacogens.
2. Evolution from continental rift into passive continental margin. Structural architecture of the passsive contintenal margins.
3. Structural characteristics in terranes with extensional tectonics: Geometry of structures and kinematic models of extensional fault systems. Analog models and real examples of kinematic evolution and structural architecture of extensional fault systems. Kinematics of the Pannonian basin fault systems.
4. Structural characteristics in terranes with strike-slip tectonics: Transpression and transtension. Tectonic evolution and architecture of pull-apart basins (Examples from Neogene basins along the SW margin of the Pannonian basin).
5. Transform plate boundaries: Orogin and types of transform faults. Kinematics of active transform faults on continents: San Andreas fault, Dead-sea fault.
6. Structural architecture and deformational processes at convergent plate boundaries: Morphology and geophisical characteristics. Evolution of contintental margin: from subduction to collision.
7. Anatomy of orogenic belts. Collision and "*escape*" tectonics (Example from Neogene tectonic history in the eastern Alps and Pannonian basin).
8. Geometry and kinematics of structures in fold-thrust belts. Analog models of kinematics in fold-thrust belts. Structural evolution of foreland basins (Example: Adriatic basin).
9. Types of fault-related folds: fault-bend, fault-propagation and decollement folding (Key-examples from different orogenic belts and from the Dinarides).
10. Geometry and kinematics of tectonic structures in terranes with salt tectonics: Physical properties of salt, Basic shapes of salt diapirs, Salt tectonics styles seen on reflection seismic profiles, Halokinesis, Ekstensional and compressional salt tectonics.
11. Student seminar presentations: 20 min. per seminar presentation on selected topics in structural geology.čl

STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance, seminars

OBLIGATORY LITERATURE :

1. Moores, E.M. & Twiss, R.J. (1995): Tectonics.- Freeman and Co., pp. 415.

2. Continental Transpressional and Transtensional Tectonics.- Holdsworth, R.E. Strachan, R.A. & Dewey, J.F. (eds.), 1998, Geol. Soc. London, Spec. Pub., No. 135, pp. 360.

3. McClay, K.R. & Price, N.J. (1981): Thrust and Nappe Tectonics.- Blackwell Sci. Int., London.

SUPPLEMENTARY LITERATURE:

Selected articles from journals available online or in library:
1. Journal of Structural Geology (Elsevier)
2. Tectonophysics (Elsevier)

EXAMINATION PROCEDURE: oral exam

COURSE: Interpretation and mathematical methods of geological data analyses

AUTHOR(S) OF COURSE PROGRAMME: Prof. Esad Prohić, Ph.D, Professor, Faculty of Science

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 30+15+0

ECTS: 9

COURSE ACHIEVEMENTS: The aim of the course is to inform students about the basics of geological data interpretation and with some statistical methods which can be applied to data evaluation and interpretation.

COURSE PROGRAMME:

Introduction to statistical analyses of geological data and overview of basic statistics. The basic statistical tests. Funamentals of analyses of variance. Statistical concepts. Theory of errors : types, mathematical and statistical methods of control. Geological map analyses. Contour diagrams. Krigging, trend-analyses. Multivariante analyses: principal component analyses, R Q - analyses, discrimination analyses. Geological processes and its geochemical significance. Variation diagrams.. Normalized Normalizirani multielement diagrams i spider diagrams. Discrimination analysis in geochemistry and petrology and discrimination diagrams. Interpretation of radioisotopes analyses in geochronology and petrogeneses. Interpretation of stable isotopes analytical data.

STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance, seminars

OBLIGATORY LITERATURE :

Davis, J.C. (1986): Statistiscs and data analysis in geology. John Wiley & Sons.

Rollinson, H. (1993): Using geochemical data: evaluation, presentation, interpretation. Longman.

SUPPLEMENTARY LITERATURE:

Swan, A.R.H., Sandilands, M: (1995): Introduction to Geological Data Analysis. Blackwell Science.

Šošić, I. i Serdar, V. (1995): Uvod u statistiku. Školska knjiga.

EXAMINATION PROCEDURE: oral

COURSE: Methods of Investigations in Palaeontology

AUTHOR(S) OF COURSE PROGRAMME:

Dr. Jasenka Sremac, Associate professor and Dr. Vlasta Ćosović, Associate Professor; Faculty of Science, University of Zagreb.

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 30+15+0

ECTS: 9

COURSE ACHIEVEMENTS: Explanation of the "path" from the finding of a fossil, to the interpretation (biostratigraphical, palaeoecological, palaeobiogeographical.

COURSE PROGRAMME :

Laboratory techniques of preparation of macrofossils and microfossils. Principles of modern taxonomy of some cathegories of macrofossils and microfossils, which are important in biostratigraphical interpretation (e.g. foraminifers). Palaeoecological interpretation (biostatistics methods: biodiversity indices, clusters) and principles of functional morphology. Palaeoclimate interpretation (stable isotopes). Palaeobiogeographical interpretation (similarity indices).

STUDENTS' ACTIVITIES AND THEIR EVALUATION: Class attendance, Seminars.

OBLIGATORY LITERATURE:

Bailey, N.T.J. (1995): Statistical methods in biology. Cambridge University Press.
Prothero, D.R. (1998): Bringing Fosils to Life. WCB/McGraw-Hill.
Feldmann, R.M., Chapman, R.E. & Hannibal, J.T. (1989): Paleotechniques. Paleont. Soc. Spec. Publ., 4, Univ. Tennessee, Knoxville.
Tyszka, J., Oliwkiewicz-Miklasinska, M., Gedl, P. & Kaminski, M. (eds), 2005, Methods and applications in micropaleontology. Polska Akademia nauk
Haslett, S.k., 2002, Quaternary Environmental Micropaleontology. Arnold, Oxford University press Inc., London, New York.

SUPPLEMENTARY LITERATURE: Recent scientific papers dealing with palaeontological methods.

EXAMINATION PROCEDURE: Oral exam + seminar results.

COURSE: X-ray and thermal methods of phase analysis

AUTHOR(S) OF COURSE PROGRAMME: Associate professor, DARKO TIBLJAŠ, Faculty of Science; research associate RUDOLF TROJKO, Ruđer Bošković Institute

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+15+0

ECTS: 6

COURSE ACHIEVEMENTS: Obtaining additional information about X-ray and thermal methods of phase analysis required for independent analytical work

COURSE PROGRAMME: Determination of mineral phases by X-ray powder diffraction method: instrumentation, qualitative analysis (databases and search-match methods), quantitative analysis, unit cell parameters calculation and usage, methods of powder pattern fitting techniques. Thermal methods of analysis; thermogravimetry (TG), differential thermal analysis (DTA), differential scanning calorimetry (DSC), simultaneous methods of thermal analyses. High- temperature microscopy.

STUDENTS' ACTIVITIES AND THEIR EVALUATION: In addition to class attendance students have an obligation to elaborate specific topics related to their research work in short essay

OBLIGATORY LITERATURE:

Bish, D.L. & Post, J.E. (eds.) (1989): Modern Powder Diffraction. Reviews in Mineralogy, Vol. 20. Mineralogical Society of America.
Brindley, G.W. & Brown, G. (eds.) (1980): Crystal structures of clay minerals and their X-ray identification. Mineralogical Society.
Duval, C. (1963): Inorganic thermogravimetric analysis. Elsevier Publishing Company.
Mackenzie, R.C. (ed.) (1970): Differential thermal analysis. Vol. 1. Academic Press.
Skoog, D.A. & Leary, J.J. (1992): Principles of instrumental analysis. Harcourt Brace College Publishers.
Wendlandt, W.W. (1974): Thermal methods of analysis. John Wiley & Sons.
Wilson, M.J. (ed.) (1987): A handbook of determinative methods in clay mineralogy. Blackie.

SUPPLEMENTARY LITERATURE: articles from comparatively recent relevant scientific journals

EXAMINATION PROCEDURE: oral

COURSE: Spectroscopic methods of mineral and rock analysis

AUTHOR(S) OF COURSE PROGRAMME: Associate professor, DARKO TIBLJAŠ, Faculty of Science; Full Professor VLADIMIR BERMANEC, Faculty of Science

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 30+15+0

ECTS: 9

COURSE ACHIEVEMENTS: Obtaining additional information about spectroscopic methods of analysis required for independent analytical work

COURSE PROGRAMME: Introduction to spectroscopic methods. Optical spectroscopy. Luminescence. AAS (atomic absorption spectrometry), ICP-AES (inductively coupled plasma-atomic emission spectroscopy). Infrared and Raman spectroscopy: theory of molecular and crystal vibrations, instrumentation, vibrational spectra of minerals, water in crystal structures. XRF (X-ray fluorescence spectrometry): X-ray spectra, sources of X-rays, interaction of X-rays with matter, instrumentation, samples, qualitative and quantitative analyses. Electron microanalysis EMPA: instrumentation, sample preparation, principles of analysis, related techniques. Moessbauer spectroscopy.

STUDENTS' ACTIVITIES AND THEIR EVALUATION: In addition to class attendance students have an obligation to elaborate specific topics related to their research work in short essay

OBLIGATORY LITERATURE:

Bennett, H. & Oliver, G. (1992): XRF analysis of ceramics, minerals and allied materials. John Wiley & Sons.
Farmer, V.C. (ed.)(1974): The infrared spectra of minerals. Mineralogical Society.
Hawthorne, F.C. (ed.)(1988): Spectroscopic methods in mineralogy and geology. Reviews in Mineralogy, Vol. 18. Mineralogical Society of America.
Potts, P.J. (1987): A handbook of silicate rock analysis. Blackie.
Vandecasteele, C. & Block, C.B. (1993): Modern methods for trace element determination. John Wiley & Sons.
Wilson, M.J. (ed.)(1994): Clay mineralogy: Spectroscopic and chemical determinative methods. Chapman & Hall.

SUPPLEMENTARY LITERATURE: articles from scientific journals

EXAMINATION PROCEDURE: oral

COURSE: Sedimentary petrology, selected topics

AUTHORS OF COURSE PROGRAMME:

Dr. sc. Jožica Zupanič, Professor, Faculty of Science, University of Zagreb
Dr. sc. Marijan Kovačić, researcher, Croatian Geological Institute, Zagreb, and honorary Assistant Professor, Faculty of Science, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+15+0

ECTS: 6

COURSE ACHIEVEMENTS:

Students will deepen the understanding complex processes of evolution of sediments. They will gain the knowledge of modern research methods, which provide new insights on tectonic and paleogeographic evolution. Two selected topics, provenance and fresh-water carbonates treat the complexity of processes in natural systems, such as depositional environments influenced by both, intrinsic and extrinsic factors. In the same time, student get the knowledge, which enable them to understand the origin of sedimentary mineral deposits, diagenetic evolution of reservoir rocks, and other economically important features occurring in sediments.

COURSE PROGRAMME:

Provenance study. The scope of provenance study. From rock weathering to deposition of detritus. The influence of parent rocks, climate and topography. Processes active on the way from the parent rock to final settling. The influence of diagenesis. Arenites as the main material investigated. Analytical approaches and problems: framework particle composition, heavy mineral associations, varietal studies of heavy minerals (mineral chemistry, fission track method, radiometric dating), and whole rock geochemistry. Mudstones, chemistry and relevant problems. Analysis of the composition of coarse-grained sediments. Interpretation of the source area(s), erosional processes and climate. Interpretation of tectonic evolution, exhumation history and basin evolution. Combining provenance studies and other analytical approaches to geological evolution.
Fresh-water carbonates. Lacustrine, marsh, fluvial and other environments and relevant carbonate sediments. Organic matter. Meteoric diagenesis. Pedogenic processes. Vertical trends, cyclicity. The influence of climate.
Laboratory work. Optical study of arenites. Petrofacies. Determination of heavy minerals. Ribbon method. Whole rock geochemistry. Microscopic study of fresh-water limestone, products of meteoric diagenesis, recognition of pedogenic features.

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

Activity in research in small projects. Special emphasis is put on the active participation in discussions and successful explanation of analytical results.

OBLIGATORY LITERATURE:

Chapters from:
Chamley H. 1989: Clay Sedimentology. Springer, 623 pp, Berlin.
Gautier, D.L. ed. 1986: Roles of Organic Matter in Sediment Diagenesis. SEPM Spec. Publ. 38, Tulsa.
Leeder, M. 1999: Sedimentology and Sedimentary Basins - From Turbulence to Tectonic.

Blackwel Science, 592 pp, Oxford.
Lerman, A. ed. 1978: Lake: Chemistry, Geology, Physics. Springer, 363 pp, Berlin.
Mange, M. & Wright, P. eds., in press. Heavy Minerals in Use. Developments in Sedimentology, Elsevier.
Morton, A.C., Todd, S.P. & Haugton, P.D. eds. 1991: Developments in Sedimentary Provenance Studies. Geological Society, Special Publication 57, 360 pp, London.
Rollinson, R.H. 1992: Using Geochemical Data. Longman, 352 pp, New York.
Tucker, M.E. & Wright, V.E. 1990: Carbonate Sedimentology. Blackwell, 482 pp, Oxford.
Zuffa, G.G. ed. 1985: Provenance of Arenites. NATO-ASI Series 148, 408 pp., D. Reidel, Dordrecht

SUPPLEMENTARY LITERATURE:

Flügel, E. 2004: Microfacies of Carbonate Rocks. Analysis, Interpretation and Application. Springer, 976 pp, Berlin.
Mange, M. & Mauer, F. 1992: Heavy Minerals in Colour. Chapman & Hall, 147 pp, London.
Tišljar, J. 2001: Sedimentologija karbonata i evaporita. Intitut za geološka istraživanja Zagreb. 375 pp, Zagreb.

Selected articles from journals

EXAMINATION PROCEDURE: Oral (+ success in laboratory work and projects).

COURSE: Methodology of Scientific Research

AUTHOR(S) OF COURSE PROGRAMME: Prof. dr. sc. Sibila Jelaska

TEACHING TECHNIQUES *(lectures+practice+seminar)***:** 15+15+0

ECTS: 6

COURSE ACHIEVEMENTS: Students should get familiar with the principles of scientific research, elementary scientific methods, dissemination of scientific information, the design and execution of experiments,organization and arranging of collected data, and reporting the results of research. Also, they should lear how to write a thesis and, a scientific paper, and a review paper, and finally how to present a paper orally and as a poster

COURSE PROGRAMME:

- The choice and statement of a research problem
- Similarity and difference between pure and applied sciences
- Scientific information; INDOK centers, library resources and datebases
- Documentation, dissemination and use of data
- Elementary scientific methods
- The search for causes
- The design of experiments
- Organization and arranging of collected data
- How to write and publish a scietific paper
- The elements of scientific paper
- Format for citations
- The principles and conventions for publishing results of scientific research
- How to deal with editors
- How to present a paper orally and how to prepare a poster

STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance and practical work (Library resources and databases, How to find bibliographic references, Visit to National and university library, Use of online databases, Current Contents and other secondary and signalling resources, How to organize your own bibliography, How to cite the references, Organization of a laboratory dialry, How to design effective tables, How to prepare effective illustrations, The publishing process, How to deal with proofs, A corrected manuscript and proof.readin, How to write a thesis, Organization a poster, How to prepare a paper orally for a conference report)

OBLIGATORY LITERATURE:

Silobrčić V, Kako sastaviti, objaviti i ocijeniti znanstveno djelo, Medicinska naklada, Zagreb, 1994.
Wilson EB, An Introduction to Scientific Research, McGrew Hill Bool Comp. Inc., New York, 1952.
Day RA, How to Write & Publish a Scientific Paper, 3rd Ed. Oryx Press, Phoenix, New York, 1988.
Pavić H., Znanstvene informacije, Školska knjiga, Zagreb, 1980.
Žugaj M., Osnove znanstvenog i stručnog rada, Samobor, 1989.

SUPPLEMENTARY LITERATURE:

EXAMINATION PROCEDURE: written and oral exam

SPECIFIC COURSES

COURSE: Organic geochemistry

AUTHOR(S) OF COURSE PROGRAMME:

PhD Anđa Alajbeg, Assoc. Prof., Faculty of Sci., Univ. Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+15+0

ECTS: 6

COURSE ACHIEVEMENTS: Study of the occurrence of organic matter in the geosphere. The course is related to the organic matter origin and distribution in the geological space and time, as well as to the geochemical approaches in understanding the organic matter precursors, as well as the transformation processes which organic matter undergoes and/ or it influences.

COURSE PROGRAMME:

1. Photosynthesis occurrence; organic carbon cycle.

2. Biomass sedimentation and geological conditions for the organic character preservation along the transformation processes in the deposited biomass.

3. Chemical composition and structure of biomass, especially regarding the lipids, carbohydrates (incl. cellulose), proteins and lignin

4. Transformation processes of the biopolymers into constitutive units, linking by functional groups followed by releasing small molecules, random polycondensation; thermo - catalytic transformation of geopolimers into the low molecular weight organic matter

5. Properties and structure of the high molecular weight organic matter from the geological strata: humin related matter, kerogen, bitumen, asphaltene, coal

6. Properties and structure of the low molecular weight organic matter from the geological strata: alkanes (n-, iso- and cyclo-), aromatics (mono-, di-, tri- and poly-), organic compounds containing N, S and O and their origin

7. Geogenic terpenoids: isoprene as the building unit, mono-, sesqui-, di-, sester- and tri-terpenoids, emphasizing hopanoids and steroids; geological influence of functional groups releasing, isomerization processes and aromatization of MAS to TAS

8. Structure of the geogenic organic matter as the reflection of the live world evolution along the geological past

9. Structure of the geogenic organic matter as the reflection of the deposition environment, of the thermal history and of the lithology along the migration path through geological space

10. Migration, geological fractionation, accumulation and alteration of the low molecular weight organic matter in the geosphere

11. Global distribution of the deposited organic matter and its distribution through geological history

12. Application of the organic geochemistry to the investigation of the ancient and modern environment, spontaneously and/or by men made alteration

13. Application of the organic geochemistry to stratigraphy and to marine geology

14. Application of the organic geochemistry to the petroleum exploration and production

15. Application of the organic geochemistry to the study of the Earth history and of the anthropology

Exercises:

Lab procedures: sample picking, extractions, separations, elemental analyses, AA, C, H, S and O isotopes, pyrolysis, LC, HP LC, HR GC, GC-MS, IR, NMR, UV/VIS

Experimental results evaluation and derivation of the organic geochemistry information

STUDENTS' ACTIVITIES AND THEIR :

Attentive and active attendance to the lectures and exercises

Colloquia exams at the end of each topic

Understanding of the analytical procedures and geochemical data interpretation

OBLIGATORY LITERATURE:

Killops, S. and V. Killops (2004): Introduction to Organic Geochemistry. Blackwell Science, 408 p., Oxford.

SUPPLEMENTARY LITERATURE:

Peters, K.E., C.C. Walters and J. M. Moldowan (2004): The Biomarker Guide, Vol. 1: Biomarkers and Isotopes in Environment and Humen History, 470 p., Cambridge Press.

EXAMINATION PROCEDURE: Success in all the colloquia exams and successful exercises performance, present the exam. Additionally, student can approach the oral examination to show the improvement for some previous lack of knowledge.

COURSE: Coastal Zone Management: geoscientific aspects

AUTHOR(S) OF COURSE PROGRAMME:

Prof. Dr. Sc. Ljubomir Babić, Faculty of Science, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+10+5

Lessons, exercises, homeworks, essay, fieldwork, field project

ECTS: 6

COURSE ACHIEVEMENTS:

Both in the classroom and in the field students gain the knowledge on the variety of the processes and environments of the coastal zone, and constant changes characterizing the coast. They become aware of the vulnerability of the coastal environments, and will be able to act in the matters of preservation of the natural heritage and environmental protection, and cooperate in activities of the Coastal Zone Management.

COURSE PROGRAMME:

Coastal zone as natural and economic resource. //Cliffs and rocky shores: morphology, processes geology. //Linear clastic coasts, open and with barrier islands: environments, processes, sediments. Short term changes. Progradation, retrogradation, sea-level changes. //River mouths. Sediment input mechanisms. Environments, processes, sediments, construction and destruction. //Fan-deltas: processes, morphology, geological setting, evolution. //Coastal dunes. // Carbonate coasts: comparison to clastic shores concerning processes, sediments, morphology and influence of sea-level fluctuation. //Ancient coasts. //Mineral resources in the coastal zone.

Coastal hazards. Hazard, intensity, recurrence, vulnerability, risk. //Erosion, accretion, mass movements, marine flooding. The danger of the development: destruction of natural environments, destruction of landscape, intensification of the erosion, pollution. //Secondary hazards. //Reducing risk. /Recovery. //The influence of sea-level changes and climatic changes. //Investigation and mapping of the coastal zone- purposes and technics. Environmental Impact Assessment.

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

Activity in preparation for lessons, exercises, discussions and fieldwork. Quality of the essays, discussions and fieldwork results. Each kind of the work should achieve a positive grade. The average brings 50% of the overall grade.

OBLIGATORY LITERATURE:

Selected sections in the books:

Reineck, H.-E. & Singh, I.B., 1980, Depositional Sedimentary Environments. 549 pp. Springer, Berlin.

Bird, E., 2000, Coastal Geomorphology: An Introduction. 340 pp. Wiley, Chichester.

Short, A.D., ed., 1999, Handbook of Beach and Shoreface Morphodynamics. 379 pp. Wiley, Chichester.

Bell, F.G., 1999, Geological Hazards. 648 pp. Spon Press, London.

Selected works in journals

SUPPLEMENTARY LITERATURE:

Selected works in journals.
Selected sections in the books:

Bearman, G., ed., 1989, Waves, Tides and Shallow-water Processes. 187 pp. Butterworth Heinemann & The Open University, Oxford.

Chamley, H., 2003, Geosciences, Environment and Man. Developments in Earth and Environmental Sciences 1, 550 pp. Elsevier, Amsterdam.

Fletcher, III, C.H. & Wehmiller, J.F., ed., 1992, Quaternary Coasts of the United States: Marine and Lacustrine Systems, Project #274. Quaternary Coastal Evolution, SEPM Spec. Publ. 48, 420 pp. Tulsa.

Goudie, A., 2005, The Human Impact on the Natural Environment: Past, Present and Future. 6. Ed. 357 pp. Blackwell, Oxford.

Nummedal, D., Pilkey, O.H. & Howard, J.D., eds. 1987, Sea-level Fluctuation and Coastal Evolution. SEPM Spec. Publ. 41, 267 pp. Tulsa.

Nio, S.-D., Shuttenhelm, R.T.E. & Van Weering, Tj.C.E., eds., 1981, Holocene Marine Sedimentation in the North Sea Basin. IAS Sp. Publ. 5, 515 pp. Blackwell, Oxford.

Pye, K., 1994, Sediment Transport and Depositional Processes. 397 pp. Blackwell, Oxford.

Reading, H.G., ed., 1996, Sedimentary Environments: Processes, Facies and Stratigraphy. 3. Ed. 688 pp. Blackwell, Oxford.

Selected sections in books for the fieldwork:

Allen, J.R.L., 1984, Sedimentary Structures, Their Character and Physical Basis. Developments in Sedimentology 30, I+II, 593 + 663 pp. Elsevier, Amsterdam.

Bearman, G., ed., 1989, Waves, Tides and Shallow-water Processes. 187 pp. Butterworth Heinemann & The Open University, Oxford.

Collinson, J.D. & Thompson, B.D., 1982, Sedimentary Structures. 2. Ed. Unwin Hyman, London.

Komar, P.D., 1997, Beach Processes and Sedimentation. 2. Ed. 544 pp. Prentice Hall, Upper Saddle River, New Jersey.

Reineck, H.-E. & Singh, I.B., 1980, Depositional Sedimentary Environments. 549 pp. Springer, Berlin.

Tucker, M.E., 2003, Sedimentary Rocks in the Field. 3. Ed. 234 pp. Wiley, Chichester.

Tucker, M.E., ed., 1988, Technics in Sedimentology. 394 pp. Blackwell, Oxford.

EXAMINATION PROCEDURE: Oral exam; the result brings 50% of the overall grade.

COURSE: Benthic foraminifera as a tool for paleoenvironmental interpretation of the Paleogene and Neogene sediments

AUTHOR(S) OF COURSE PROGRAMME

Professor Zlatan Bajrakatarević

Associated Professor Vlasta Čosović

Faculty of Science, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 30+15+0

ECTS: 9

COURSE

Students will learn how complementary information from the Paleogene and Neogene benthic foramaminifera and geochemical data can be used to define paleoenvironments and document possible changes in shallowmarine to deep basin environments through 65 Ma. Shallow Benthic Zonation will be apply for biotratigraphical interpretation.

COURSE PROGRAMME

Areas addressed include the paleoecology, biogeography and biology of the Paleogene and Neogene benthic foraminifera, as well as their application to biostratigraphy and paleooceanography.

"Smaller" benthic foraminifera from the Paleogene to Neogene, what are they and why do we study them? Methods used in their study (size-fraction, abundances, benthic foraminiferal accumulation rates, diversity, Planktonic/Benthic ratio), their morphological variances, taxonomy and phylogeny. Geochemistry of the deep-sea benthic foraminifera (stable isotopes and trace elements). Factors controlling the distribution of benthic foraminifera (relationship of morphotypes to microhabitats, organic matter and oxygen concentration). Distribution of foraminiferal assemblages along a profile from the supratidal environments down to the abyssal planes.

Larger benthic foraminifera, what are they, the tests architectural characteristics, paleobiogeographic distribution, phylogeny and paleoenvironmental interpretation.

STUDENTS' ACTIVITIES AND THEIR EVALUATION

Class attendances

Practical work with microscopical-slides and thin-sections in order to learn how to identify genera and some characteristic species.

Homework: Analysis of some structural elements within the larger benthic foraminiferal tests and their interpretation in functional morphology terms .Paleooenvironmental interpretation of samples with "smaller" benthic foraminifera.

Seminar: A complete paleoecological interpretation of one sample.

OBLIGATORY LITERATURE

Brasier, M.D., 1985, Microfossils. G. Allen & Unwin Hayman, London.

Hottinger, L. & Drobne, K. (eds), 1998, Paleogene Shallow Benthos of the Tethys. Dela – Opera SAZU, 34/2, Ljubljana.

Haq, B.U. & Boersma, A. (eds), 1998, Introduction to Marine Micropaleontology, Elsevier, New York.

Loeblich, A.R. & Tappan, H., 1987, Foraminiferal genera and Their Classification. Van Nostrand Reinhold, New York.

SUPPLEMENTARY LITERATURE

Selected articles from internationally recognized journals that deal with

Paleogene and Neogene benthic foraminifera.

EXAMINATION PROCEDURE:

Seminars value 30% of total exam, 30% of exam is complete through the microscopical analysis and, 40 % by oral examination.

COURSE: Quantitative optical determinations

AUTHOR(S) OF COURSE PROGRAMME: Dr. Vladimir Bermanec, full professor, Faculty of Science, Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+15+0

ECTS: 6

COURSE ACHIEVEMENTS:

knowledges and skills in crystallometry using optical methods

COURSE PROGRAMME:

Crystallometry. Crystal habit determination using light. Spindle stage. Refractive indeks and indicatrix dispersion determination. Multi-axes microscopic systems and their application in structural geology and solid solution determinations of some petrogenic minerals (feldspars, chlorites, micas, pyroxenes, amphiboles, olivines, topas, cordierite, beryl).

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

class attendance, completition of exercies

OBLIGATORY LITERATURE:

Bloss, F.D. (1981): The spindle stage. Cambridge University Press.
Fediuk, F. (1961): Fjodorova mikroskopska metoda. Nakladatelstvi ceskoslovenske akademie ved.
Nesse, W.D. (1991): Introduction to optical mineralogy. 2. izd. Oxford University Press.
.

SUPPLEMENTARY LITERATURE :

Sarancina, G.M., Koževnikov, V.N. (1985): Fedorovskij metod (opredelenie mineralov, mikrostrukturnij analiz). Nedra.

EXEMINATIONS PROCEDURE: oral

COURSE: Mineralogy and geochemistry of rare earth elements
AUTHOR(S) OF COURSE PROGRAMME: Dr. Vladimir Bermanec, full professor, Faculty of Science, Zagreb
TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+0+0
ECTS: 4
COURSE ACHIEVEMENTS: knowledge of importance and origin of REE enriched minerals
COURSE PROGRAMME: Geochemical properties, distribution and natural abundance of rare earth elements (REE), mineralogy of REE, REE deposits, cosmochemistry of REE: meteorite study, petrogenetic models using REE, REE in outer mantle, oceanic and continental crust, crustal mobility of REE, hydrochemistry of REE, REE in geochemistry of sediments, economic importance of REE
STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance
OBLIGATORY LITERATURE: Henderson, P.(1984): Rare earth geochemistry. Elsevier, Amsterdam. Jones, A.P., Wall, F. i Williams, C.T. (ur.)(1996): Rare earth minerals: chemistry, origin and ore deposits. Chapman & Hall.
SUPPLEMENTARY LITERATURE: Lipin, B.R., Mc Kay, G.A. (ur.)(1989): Geochemistry and mineralogy of rare earth elements. Reviews in Mineralogy, Vol. 21, Mineralogical Society of America
EXEMINATIONS PROCEDURE: oral

COURSE: Selected chapters of system of mineralogy
AUTHOR(S) OF COURSE PROGRAMME: Dr. Vladimir Bermanec, full professor, Faculty of Science, Zagreb
TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+15+0
ECTS: 6
COURSE ACHIEVEMENTS: knowledge in specific properties of particular mineral groups
COURSE PROGRAMME: Crystal chemistry and structural properties of some mineral groups (feldspars, feldspatoids, zeolites, clay minerals, chlorites, micas, serpentines, amphiboles, cyclosilicates, salts, oxides). Interpretation of formation conditions. Mineral groups of interest will be selected according to the student research interests. The relation among formation conditions will be especially discussed as well as the mechanisms of isomorphic substitutions in various parent rocks.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance and exercise completition
OBLIGATORY LITERATURE: Palache, Ch., Berman, H., Frondel, C. (1951): The system of mineralogy. John Wiley and Sons, Inc., Schroecke, H., Weiner, K.-L. (1981): Mineralogie. Walter de Gruyter.
SUPPLEMENTARY LITERATURE: Nomenlature of important petrogenic minerals
EXEMINATIONS PROCEDURE: oral

COURSE: Hydrogeology and water protection in karst

AUTHOR(S) OF COURSE PROGRAMME:

Ph.D. Božidar Biondić, full professor, Faculty of Geotechnical Engineering, University of Zagreb.

Ph.D. Sanja Kapelj, docent - university lecturer, senior researcher, Faculty of Geotehnical Engineering, University of Zagreb.

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+15+0

ECTS: 6

COURSE ACHIEVEMENTS:

The aim of course is identification of strategic interest of karst water systems as a basis for development and their economic importance. Besides general knowledge about karst hydrogeology, specific knowledge and skills within the course are basis on development of affinity to interdisciplinary work during the choosing of optimal techniques and methods of study for specific purposes and their implementation.

COURSE PROGRAMME:

Introduction to karst hydrogeology (needs, challengers and expectation of karst groundwater resources and protection of their quality); Geologic background of karst hydrogeology (hydrogeological relations - lithology, stratigraphy, structural geology and geomorphology); Typology of karstic aquifers; Geochemistry of karst surface and groundwaters; Methods and techniques of karst hydrogeology studies (hydrogeological mapping, GIS application, natural hydrogeochemical and isotope tracers, dynamic models of water flow in karst - tracing experiments etc.); Groundwater protection in karst (approaches for intrinsic and specific vulnerability assessment, hazard and risk assessment of waters); Regulative about waters in Croatia and EU and criterions for protection of karst groundwaters; Water resources management in karst, inland, coastal and island aquifers; case studies in karst of Dinarides in Croatia.

STUDENTS' ACTIVITIES AND THEIR EVALUATION: Class attendance, seminar and design of project task.

OBLIGATORY LITERATURE:

Biondić, B. et al. Ed. (1995): Hydrogeological aspects of groundwater protection in karstic area. Final report - COST ACTION 65, Bruxelles.

Biondić, B., Biondić, R. & S. Kapelj (2005): The sea water influence on karstic aquifers in Croatia. In: COST Action 621 "Groundwater management of coastal karstic aquifers" Tulipano, L., Fidelibus, D., Panagopoulos, A. eds., EUR 21366, COST Office, Luxembourg, 303-312.

Zwalen, 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, Luxenbourg.

Biondić, B., Biondić, R. & Kapelj, S. (2006): Protection of the karst aquifers in the river Kupa

catchment area and sustainable development. Environmental Geology (on-line).

Kapelj, S., Lambrakis, N., Morell, I. & C. Petalas (2005): Sources of aquifer salinisation. In: COST Action 621"Groundwater management of coastal karstic aquifers" Tulipano, L., Fidelibus, D., Panagopoulos, A. eds., EUR 21366, COST Office, Luxembourg, 154-159.

Kapelj, S., Marković, T., Kapelj, J. & J. Terzić (2002): Application of hydrogeochemistry in studies of hydrogeological systems. Proceedings of workshop „Urban hydrology" - Croatian Hydrologic Society - Croatian Waters, EKO Kaštelanski zaljev- VIK Split, April 25-26, Split, 61-74.

SUPPLEMENTARY LITERATURE:

Biondić, B., Dukarić, F., Kuhta, M., Biondić. R. (1997): Hydrogeological exploaration of the Rječina river spring in the Dinaric karst. Geologica Croatica, 50, 2, 279-288.

Kapelj, J., Kapelj, S. & Singer, D. (2004): Spatial distribution of dolinas and its significance for groundwater protection in karst terrains. Groundwater Flow – Understanding from local to regional scales. Proceedings (CD) XXXIII Congress IAH & 7th Congress ALHSUD, Zacatecas, Mexico.

Tulipano, L. et al. ed. (2005): COST Action 621 "Groundwater management of coastal karstic aquifers" Tulipano, L., Fidelibus, D., Panagopoulos, A. eds., EUR 21366, COST Office, Luxembourg.

EXAMINATION PROCEDURE: Oral and written examination, seminar work and design of project task for particular purpose.

COURSE: Biotas, palaeoecology and biostratigraphy of Mesozoic carbonate platforms

AUTHOR(S) OF COURSE PROGRAMME:
Ivan Gušić, Professor, Department of Geology, Faculty of Science, University of Zagreb
Blanka Cvetko Tešović, Assistant Professor, Department of Geology, Faculty of Science, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+15+0

ECTS: 6

COURSE ACHIEVEMENTS:
Although the carbonate platform biotas are spatially marginal and temporally ephemeral in the Earth history, they are unavoidable in Tethyan biostratigraphy, palaeoecology and palaeobiogeography. The main aim of this course is to applied gathered knowledge for:
1) more detailed stratigraphic division than it is possible with the knowledge gathered in the undergraduate study
2) more completely and versatile stratigraphic correlation of the Outer Dinarides Mesozoic deposits, what is the postulate for successful production (making) of the new Republic of Croatia geological map

COURSE PROGRAMME:
1st teaching topic: Basic concepts and terminology used in biostratigraphy. (2 lessons).
2nd teaching topic: Palaeoecology of Mesozoic biotas (2 lessons).
3rd teaching topic: Palaeobiogeography of Mesozoic biotas (2 lessons).
4th teaching topic: Biotas evolution on the carbonate platforms during the Mesozoic (2 lessons).
5th teaching topic: Biotas on the Adriatic-Dinaridic carbonate platform / Outer Dinarides (3 lessons).
6th teaching topic: Stratigraphic division of the carbonate platforms Mesozoic deposits in the Tethyan realm (2 lessons).
7th teaching topic: Stratigraphic correlation of the Mesozoic deposits of the Adriatic-Dinaridic carbonate platform / Outer Dinarides (2 lessons).

STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance, one seminar that will deal with the most recent achievement from the course topic

OBLIGATORY LITERATURE:
Ginsburg, R.N. & Beaudoin, B. (ur.) (1990): Cretaceous resources, events and rhythms - background and plans for research. Kluwer Academic Publishers.
Gušić, I. & Jelaska, V. (1990): Stratigrafija gornjokrednih naslaga otoka Brača. Djela JAZU 69, Zagreb.
Loucks, R.G. & Sarg, J.F. (1993): Carbonate Sequence Stratigraphy. AAPG Memoir 57, Tulsa
Simo, J.A.T., Scott, R.W. & Masse, J.P. (ur.) (1993): Cretaceous carbonate platforms. AAPG Memoir 56, Tulsa.
Tucker, M.E., Wilson, J.L., Crevello, P.D., Sarg, J.R. & Read, J.F. (ur.)(1990): Carbonate platforms-facies, sequences and evolution. IAS, Spec. Publ. 9.
Articles connected with various biotas on the Adriatic-Dinaric carbonate platform issues.

SUPPLEMENTARY LITERATURE: recent articles from international and domestic journals that deals with course topic

EXAMINATION PROCEDURE: oral exam

COURSE: Carbonate platforms

AUTHOR(S) OF COURSE PROGRAMME:

Dr. Damir Buckovic, Assistant Professor, Department of Geology, Faculty of Science, University of Zagreb

Dr. Blanka Cvetko Tešović, Assistant Professor, Department of Geology, Faculty of Science, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+0+0

ECTS: 4

COURSE ACHIEVEMENTS: Course will introduce students to carbonate facies, field and lab research methods**,** carbonate platform models, carbonate cycles and evolution of carbonate platforms of Tethian realm. By that, actualistic approach to introduce recent platform environments and facies will enable easier understanding of dynamics and evolution of ancient carbonate platforms. Special attention will be given to evolution of the Adriatic-Dinaric carbonate platform.

COURSE PROGRAMME: 1st teaching topic: Basic concepts and terminology using in carbonate sedimentology. Carbonate processes, primary and secondary carbonate constituents and carbonate diagenesis (2 lessons). 2nd teaching topics: Carbonate environments and carbonate facies. Controlling factors that influence on carbonate production (depth, temperature, salinity, light, water energy, biota, etc.) and accommodation (tectonics, climate, eustasy) (2 lessons). 3rd teaching topic: Carbonate cycles (1 lesson). 4th teaching topic: Carbonate platform models; Rimmed carbonate shelf, Carbonate ramp, Epeiric carbonate platform, Isolated carbonate platform, Drowned carbonate platform (3 lessons). 5th teaching topic: Dynamics of Tethian carbonate platforms. Evolution of the Adriatic-Dinaric carbonate platform (geotectonics, geodynamics, terminology) (3 lessons). 6th Modern carbonate platforms and their facies; Bahama platform, Florida shelf, Trucial Coast of the Arabian Gulf (2 lessons). 7th teaching topic: Carbonate platforms through geological past. Evolution of platform biota through the Phanerozoic

STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance*,* one seminar that will deal with the most recent achievement from the course topic

OBLIGATORY LITERATURE:

Tucker, M.E., Wilson, J.L., Crevello, P.D., Sarg, J.R. & Read, J.F. (eds.) (1990): Carbonate platforms. Spec. Publ. 9, IAS, Blackwell, 7-323.
Tucker, M.E. & Wright, P.V. (1990): Carbonate sedimentology. Blackwell, 1-482.
Crevello, P.D., Wilson, J.L., Sarg, J.F. & Read, J.F. (eds.) (1989): Controls on carbonate platform and basin development. Spec publ. 44, Soc. Econ. Paleo. and Min., 3-399.
Wilson, J.L. (1975): Carbonate facies in geologic history. Springer Verlag, 1-471.
Articles connected with various Adriatic-Dinaric carbonate platform issues.

SUPPLEMENTARY LITERATURE: recent articles from international and domestic journals that deals with course topic

EXAMINATION PROCEDURE: oral exam

COURSE: Sequence stratigraphy

AUTHOR(S) OF COURSE PROGRAMME:

Dr. Tihomir Marjanac, Associate Professor, Department of Geology, Faculty of Science, University of Zagreb.

Dr. Damir Bucković, Assistant Professor, Department of Geology, Faculty of Science, University of Zagreb.

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 30+15+0

ECTS: 9

COURSE ACHIEVEMENTS:

Introducing students to concept of subdivision of sedimentary successions into genetic packages, depositional sequences, bounded by unconformities and their correlative conformities, for the purpose of establishing their chronostratigraphic framework essential both to spatial correlation and stratigraphic prediction.

COURSE PROGRAMME:

History of sequence stratigraphy
Principles of sequence stratigraphy
Methods in sequence stratigraphy
- field methods
- geophysical methods
- correlation

Relative sea-level changes
Architectural elements
- sequences
- parasequences
- depositional systems tracts
- shelfal and estuarine sandstones

Boundaries and surfaces in sequence stratigraphy
- sequence boundary (SB)
- regressive surface of marine erosion (RSME)
- flooding surface (FS)
- transgressive surface (TS)
- ravinement surface: tidal, wave (TRAV, WRAV)
- maximum flooding surface (MFS)

Parasequence stacking patterns
Depositional systems tracts
- lowstand systems tract (LST)
- transgressive systems tract (TST)
- highstand systems tract (HST)
- falling stage systems tract (FSST)
- shelf margin systems tract (SMST)

Accommodation space
Graded profile of rivers and shelf
Paleontology in sequence stratigraphy

Controls on carbonate sedimentation
- organic and inorganic carbonate production
- "highstand" shedding
- carbonate platform drowning
- carbonate platform exposure

Carbonate sedimentary environments;
- slopes
- platforms (classification and facies belts on platforms)

Sequence stratigraphic models for
- carbonate ramps
- rimmed shelves
- isolated platforms
- escarpment margins

Cyclicity
Parasequences on carbonate platforms
Influence of relative sea level changes to carbonate diagenesis

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

lectures and exercises, one seminar that will deal with the most recent achievement from the course topic, field excursion: visit to well exposed sections with all architectural elements and bounding surfaces exposed

OBLIGATORY LITERATURE:

Emery, D & Myers, K.J. (eds.) (1996): Sequence Stratigraphy, 297, Blackwell
Marjanac T. (1996): Osnove sekvencijalne stratigrafije marinskih i paraličkih klastita. Priručnik uz tečaj. INA Naftaplin. 1-128.
Miall A.D. (1997): The Geology of Stratigraphic Sequences. Springer Verl. 1-433.
Posamentier H.W., Summerhayes C.P., Haq B.U. & Allen G.P.(1993): Sequence Stratigraphy and Facies Associations. IAS Spec. Publ. 18, Blackwell Sci. Publ., Oxford. 1-644.
Tucker, M. E.: 1993: Carbonate diagenesis and sequence stratigraphy. - In: Wright, V.P. (ed.) Sedimentology Review 1, 51-72, Oxford.
Van Wagoner, J.C., Jones, C.R., Taylor, D.R., Nummedal, D., Janette, D.C. & Riley, G.W.(1991): Sequence Stratigraphy Applications to Shelf Sandstone Reservoirs. Outcrop and Subsurface Examples A.A.P.G. Field Conference.
Van Wagoner J.C., Mitchum R.M., Campion K.M. & Rahmanian V.D. (1990): Siliciclastic Sequence Stratigraphy in Well Logs, Cores, and Outcrops: Concepts for High-Resolution of Time and Facies. A.A.P.G. Methods in Explor. Ser. 7, Tulsa. 1-55.
Walker R.G. & James N.P. (1992): Facies Models: Response to sea-level change. Geol. Assoc. Canada, St John's. 1-409
Wilgus C.K., Hastings B.S., Ross C.A., Posamentier H., Wagoner J.V. & Kendall Ch.G.St.C. (1988): Sea-level changes: An integrated approach. S.E.P.M. Sp. Publ. 42, Tulsa.

SUPPLEMENTARY LITERATURE:

Selected articles from international journals

Brookfield M.E. (2004): Principles of Stratigraphy, Blackwell Publ. 1-340.

EXAMINATION PROCEDURE: Oral exam

COURSE: Selected topics in marine geology

AUTHOR OF COURSE PROGRAMME:

Professor Mladen Juračić, Faculty of Science, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 30+15+0

ECTS: 9

COURSE ACHIEVEMENTS: A detailed work on some selected topics in the marine geology. Emphasis on interdisciplinary approach in marine research and especially marine sediments.

COURSE PROGRAMME : Methods in marine research, shelf environments, land ocean interactions (river mouths, coastal processes), diagenetic processes in marine sediments. Sea level changes - causes and consequences. Morphology and genesis of the oceans. Sources and composition of marine sediments. Wave base (determination and importance). Role of organisms in deposition and diagenesis of sediments. Methods in marine geological research and principles of marine geological cartography.

STUDENTS' ACTIVITIES AND THEIR EVALUATION: Lectures, seminars and practical work (field work - optional)

OBLIGATORY LITERATURE :

1. Juračić, M.: Geologija mora (http://geol.gfz.hr/Juracic/predavanja/index.html)
2. Kennett J.: Marine geology. Prentice-Hall International, London, 1982.

SUPPLEMENTARY LITERATURE:

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

Selected review and original scientific papers

EXAMINATION PROCEDURE: Verbal exam and/or written seminar

COURSE: Recent sedimentation in the sea

AUTHOR OF COURSE PROGRAMME:

Professor Mladen Juračić, Faculty of Science, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+15+0

ECTS: 6

COURSE ACHIEVEMENTS: Familiarization of students with formation of sediment in marine environments. Sampling and determination of recent sediments. Recognition of sediment constituents.

COURSE PROGRAMME: Sources and composition of marine sediments. Lithogenous, hydrogenous and biogenous sediments. Importance of physical, chemical and biological processes in origin of sediments. Effects of waves, currents and tides on sediment deposition and distribution. River input and river mouths Estuarine and antiestuarine water circulation and sediments. Life, organisms and sediments. Shelf sediments. Sedimentation rates.

STUDENTS' ACTIVITIES AND THEIR EVALUATION: Lectures, seminars, practical work and home work (field work - optional)

OBLIGATORY LITERATURE :

1. Kennett J.: Marine geology. Prentice-Hall, International, London, 1982.
2. Open University Course Team, Butterworth-Heinemann, Oxford, 1997:
   - Seawater: Its Composition, Properties and Behaviour
   - Waves, Tides and Shallow Water Processes
   - Ocean Chemistry and Deep Sea Sediments

SUPPLEMENTARY LITERATURE:

Reading, H.G..: Sedimentary environments: Processes, Facies and Stratigraphy. Blackwell Science, Oxford, 1996

Selected review and original scientific papers

EXAMINATION PROCEDURE: Verbal exam and/or written seminar

COURSE: Thermodynamics in mineralogy and geochemistry

AUTHOR(S) OF COURSE PROGRAMME: Dr.sc. Goran Kniewald, senior scientist and full professor, Ruđer Bošković Institute, Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 20+10+0

ECTS: 6

COURSE ACHIEVEMENTS: Development of fundamental and special skills in understanding of basic theoretical concepts and reaction mechanisms controlling the attainment of thermodynamic equilibria/disequilibria in natural systems. Implementation of computer codes for the analysis of thermodynamic equilibria and geochemical modelling, and the validation and use of thermodynamic data bases.

COURSE PROGRAMME:

(1) Basic concepts and definitions; (2) Thermodynamic data – measurement and estimation, data-base compilations and validation; (3) First law of thermodynamics, entropy and the second law of thermodynamics; (4) Standard states and equilibrium constants; (5) Homogeneous and heterogeneous systems; (6) Open and closed systems; (7) Solid solutions, aqueous electrolyte solutions; (8) Redox systems; (9) Equilibria in hydrothermal solutions and mineral reaction equilibria; (10) Calculation of activities in gaseous phases, minerals and silicate melts; (11) Geochemical reactions and solid/liquid interfaces, surface complexation on minerals; (12) Speciation and geochemical modelling; (13 and 14) Geochemical computer codes – theoretical considerations, development and applications (GEOCHEM, WATEQ, MINTEQ, HYDRAQL, SOLMINEQ, MINEQL, PHREEQE, EQ 3/6); (15) Presentation of term assignments.

STUDENT'S ACTIVITIES AND THEIR EVALUATION: Active participation in class, preparation and presentation of term assignments (seminar paper). Numerical problems and computer lab.

OBLIGATORY LITERATURE:

1. Anderson, G.M. and Crerar, D.A. (1993) Thermodynamics in Geochemistry – the equilibrium model. Oxford University Press, Oxford.

SUPPLEMENTARY LITERATURE:

1. Bethke, C.M. (1996) Geochemical reaction modeling – concepts and applications. Oxford University Press, Oxford.
2. Zhu, C. and Anderson, G. (2002) Environmental applications of geochemical modelling. Cambridge University Press, Cambridge.

EXAMINATION PROCEDURE: written and oral examination

COURSE: X-ray structure analysis

AUTHOR(S) OF COURSE PROGRAMME

Biserka Kojić-Prodić, Senior Scientist-Emeritus

Marija Luić, Senior Scientist

Rudjer Bošković Institute

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 30+15+0

lectures, seminars, practies on computer graphics for visualisation of symmetry operations and mathematical models

ECTS: 9

COURSE ACHIEVEMENTS:

To gain basic knowledge on X-ray diffraction in identification of minerals and their structures, to develop a space perception.

COURSE PROGRAMME

Crystal and reciprocal lattices; Bragg and Laue law od diffraction; diffraction intensity and factors affecting it; structure factor and the phase problem; Fourier synthesis; refinement of the structure model by least-squares method; calculations of geometric parameters of the molecular structure; interpretation of molecular and crystal structures.

STUDENTS' ACTIVITIES AND THEIR EVALUATION

Class attendance, seminars, practising on computers with computer graphics software to illustrate various complex systems and objects, to write a simple project.

OBLIGATORY LITERATURE

C. Giacovazzo, H. L. Monaco, D. Viterbo, F. Scordari, G. Gilli, G. Zanotti, M. Catti, Fundamentals of Crystallography, International Union of Crystallography, Oxford University Press, 1992.

J.P Glusker, M. Lewis, M. Rossi, Crystal Structure Analysis for Chemists and Biologists, Chemie Verlag, 1994.

SUPPLEMENTARY LITERATURE

EXAMINATION PROCEDURE: oral

COURSE: Geological interpretation of petrophysical well data

AUTHOR(S) OF COURSE PROGRAMME:

prof. dr.sc. Tihomir Marjanac**,** Department of Geology, Faculty of Science, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+15+0

ECTS: 6

COURSE ACHIEVEMENTS:

The aim of this course is familiarizing of students with basic methods of aquisition of the petrophysical data on drilled rocks, tools and their logs, and basics of geological interpretation of data from electric logs. Students will exercise reading the logs, and geological interpretation of petrophysical data.

COURSE PROGRAMME:

History of aquisition of petrophysical data

Description of individual methods; techniques of measurement, tools, investigation depth, resolution, appropriate logs and their contents, differentiation of the bedding planes, depth measurements, influence of formational fluids, and geological interpretation of the log data.

Temperature and geothermical gradient

Well diametre (caliper)

Spontaneous potential of rocks

Electric properties of rocks

Natural radioactivity of rocks

Acoustic impedation of rocks

Bulk density of rocks

Neutron porosity of rocks

Dipmeter

FMS (Formation Micro Scanner)

FMI (Formation Micro Imager)

NMR (Nuclear Magnetic Resonance)

Presentation of electric (wireline) logs

Geological interpretation of electric logs

Interpretation of facies and depositional environments

Analysis of electrosequences

Application in sequence stratigraphy

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

Attendance of lectures, exercises, interpretation of electric logs

OBLIGATORY LITERATURE:

Cant, D.J. (1984): Subsurface Facies Analysis. In: Facies Models, 2. ed. (ed. Walker R.G.): 297-310, Geoscience Canada, Toronto.
Cant, D.J. (1992): Subsurface Facies Analysis. In: Facies Models: Response to sea-level change (eds. Walker R.G. & James N.P.). 27-45, Geol. Assoc. Canada.
Reider, M. (1996): The Geological Interpretation of Well Logs. 2. ed., Whittles Publ., Caithness.

Serra, O. (1987): Sedimentological applications of wireline logs to reservoir studies. In: North Sea Oil and Gas Reservoirs (eds. Kleppe J., Berg E.W., Buller A.T., Hjelmeland O. & Torsaeter O.). 277-299, Graham & Trotman Ltd., London.

SUPPLEMENTARY LITERATURE:

Selected papers in international yournals.

EXAMINATION PROCEDURE: Oral exam, based on individually solved electric log.

COURSE: Geochemistry of igneous and metamorphic rocks

AUTHOR(S) OF COURSE PROGRAMME:

Dr. Ladislav Palinkaš, full professor, Faculty of Science

TEACHING TECHNIQUES: *(lectures+practice+seminar)*: 15+15+0

ECTS: 6

COURSE ACHIEVEMENTS:

The main aim of this course is to familiarise students with the geological and geochemical interpretation of geochemical processes.

COURSE PROGRAMME:

1. Introduction, geochemical data and geological processes, geological control on geochemical data, analytical methods in geochemistry, selecting an appropriate analytical techniques, sources of errors in geochemical data.

2. Analysis of geochem data, correlation, regression, correlation of ratios, interpretation of trends, triangular diagrams, discriminant analysis.

3. Using major element data, rock classification, variation diagrams, phase diagrams.

4. Using trace elements data, REE (rare earth elements), Spider diagrams, PGE (platinum group elements), transition metal plots, bivariate plots, modelling trace elements in igneous rocks.

5. Discrimination between tectonic environments using geochemical data, discrimination basic rocks, granitoids, clastics.

6. Using radiogenic isotopes

7. Using stable isotopes

8. Oxygen in magmatic and hydrothermal processes, ratio water/rock

9. Using carbon and sulphur isotopes.

10. Metamorphic equilibria, concept of metamorphic phaces.

11. Using thermodynamic data in solving problems of magmatic and metamorphic processes.

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

Positive average grade from preliminary exams, seminars, practical laboratory exercises and mid-term exams.

OBLIGATORY LITERATURE:

Krauskopf, K.B. (1979): Introduction to geochemistry. McGraw-Hill Book Company.

Rollinson, H. (1993): Using geochemical data: evaluation, presentation, interpretation. Longman.

Spear, F.S. (1993): Metamorphic Phase Equilibria and Pressure-Temperature-Time Paths.

Mineralogical Society of America, Washington, D.C.

Wilson, M. (1989): Igneous petrogenesis. Unwin Hyman

SUPPLEMENTARY LITERATURE:

Faure, G. (1998): Principles and Applications of Geochemistry (2nd Edition). Prentice Hall.

McSween, H.Y., Richardson, S.M., Uhle, M. (2004): Geochemistry Pathways and Processes (2nd Edition). Columbia University Press.

Deer, W.A., Howie, R.A., Zussman J. (1992): An Introduction to the Rock-Forming Minerals (2nd Edition). Prentice Hall.

Ottonello, G. (1997): Principles of Geochemistry. Columbia University Press.

EXAMINATION PROCEDURE:

Preliminary exams during practices, written mid-term and written final exam (on request of professor or student final exam can be oral)

COURSE: Mineral deposits

AUTHOR(S) OF COURSE PROGRAMME:

Dr. Ladislav Palinkaš, full professor, Faculty of Science

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 30+15+0

ECTS: 9

COURSE ACHIEVEMENTS:

The aim of this course is to make the student familiar with the most common mineral deposits, their formation and geological environment.

COURSE PROGRAMME:

1. Historical introduction, origin of mineral deposit science, Agricola, mining in Dinarides and surrounding areas.

2. Ore-forming fluids, transport of metals, sulphur, geochemical barriers, deposition of ore minerals, alterations, basic principles of geothermometry and geobarometry.

3. Shape of ore bodies, basic principles of ore microscopy, ore textures and structures, parageneses, zoning.

4. Mineral and rock composition of the earth, global tectonic, origin of magma.

5. Deposits associate with ultramafic and mafic rocks, magmatic deposits, sulphide segregations, titanium-magnetite deposits, carbonatites, diamond deposits, komatiites.

6. Plutonic-related deposits, pegmatitic and pneumatolitic deposits, greissen and skarn deposits, cata-, meso-, epi-hydrothermal mineral deposits.

7. Subvolcanic magmatic deposits, porphyry Cu deposits, low and high sulphication, hydrothermal-metasomatic deposits (Trepča), cementation zone, basic principles of fluid inclusions study.

8. Volcanogenic-sedimentary (SEDEX) deposits, Atlantis type, Red sea type (Vareš), Idrija, Kuroko, Beshi, Cyprus type.

9. Pb-Zn mineralization within carbonates (Mississippi valley type, Mežica, Bleiberg)

10. Sedimentary ore deposits, syngenetic and epigenetic (uranium), eary-diagenetic (Sabkha type, Gorski kotar barite deposits), kupferschiefer.

12. Metamorphic and metamorphogenic deposits (Au-conglomerates, Witwatersrand, Fe-quartzites, mesothermal metamorphogic Au-deposits.

11. Wilson cycle and formation of mineral deposits in Dinarides (metallogeny of Dinarides).

12. Global metallogeny, metallogeny of Archean, Proterozoic and Phanerozoic.

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

Positive average grade from preliminary exams, seminars, practical laboratory exercises and mid-term exams.

OBLIGATORY LITERATURE:

Barnes, L. H. (1979): Geochemistry of Hydrothermal Ore Deposits.- Wiley & Sons, New York.

Barnes, L. H. (1997): Geochemistry of Hydrothermal Ore Deposits.- Wiley & Sons, New York, 3rd Edition.

Evans, A. M. (1994): Ore geology and Industrial Minerals.- Blackwell, London.

Guilbert, J. M., Park, C. F. (1986): The Geology of Ore Deposits.- Freeman & Co., New York.

Maynard, B. J. (1983): Geochemistry of Sedimentary Ore Deposits.- Springer, New York.

SUPPLEMENTARY LITERATURE:

Pirajno, F. (2000): Ore deposits and mantle plumes. -Kluwer Academic Publishers.

Blundell, D., Arndt, N., Cobbold, P.R., Heinrich, C. (2006): Geodynamics and Ore Deposit Evolution in Europe. -Elsevier Science.

Misra, K.C. (2000): Understanding Mineral Deposits. -Kluwer Academic Publishers.

Robb, L. J. (2004): Introduction to Ore-Forming Processes. -Blackwell Publishing Limited.

EXAMINATION PROCEDURE: Preliminary exams during practices, written mid-term and written final exam (on request of professor or student final exam can be oral).

COURSE: Quaternary geology

AUTHOR(S) OF COURSE PROGRAMME:

prof. dr. Tihomir Marjanac, Department of Geology, Faculty of Science, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+0+0

lectures + field work

ECTS: 4

COURSE ACHIEVEMENTS:

The goal of this course is to achieve understanding of the Quaternary as a geological stage which whitnessed significant changes in climate, environments, when the relief went throuh the final shaping and significant changes in the evolution of life took place. The goal is also to get knowing the sediments, sedimentary processes and sedimentary bodies which document the geological changes and processes which acted during the Quaternary, with the particular respect to the Central and Southern Europe. During the field work students will familiarize with the sediments on the studied outcrops, sections and excavations. Specifically, the student will learn methods of field research of the Quaternary sediments, techniques of sampling on outcrops and in caves.

COURSE PROGRAMME:

Quaternary stratigraphy
Research methods
- Field methods
  - Research on outcrops
  - Excavation techniques
- Laboratory methods

Dating of sediments
- Radiometric dating
- Paleoluminiscence
- Paleomagnetic dating

Quaternary paleogeography
- Environments
  - glacial environments
  - proglacial environments
  - periglacial environments
  - non-glacial environments
    - fluvial, lacustrine, swamp, aeolian, cave environments

Models of glaciation
- Causes of glaciations
  - impacts
  - cosmic causes
  - Milanković cycles
  - Oceanic circulation
- Land glaciation
- Sea glaciation

Ice

Snow-firn-ice
Properties of ice
Speed of ice flow
Models of deglaciation
Glacioisostatic rebound
Eustacy
Quaternary flora and fauna
Terrestrial, marine, cave fauna

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

Lecture attendance, field work: facies mapping, sampling excercises

OBLIGATORY LITERATURE:

Nilsson, T. (1983): The Pleistocene. Geology and Life in the Quaternary Ice Age. Ferdinand Enke Verlag, Stuttgart
Menzies J. (2002): Modern & Past Glacial Environments. 2nd. ed. Butterworth Heinemann, Oxford
Lowe J.J. & Walker M.J. (1997): Reconstructing Quaternary Environments. 2nd ed. Longman, Harlow
Easterbrook, D.J. (1988): Dating Quaternary Sediments. Geol. Soc. Am. Spec. Publ. 227.
Walker, R.G. & James, N.P. (1992): Facies Models. Response to sea level change. Geological Assoc. of Canada, St. John's
Stepen, J. & Peter, G. (1991): Quaternary Sediments. John Wiley & Sons, London.

SUPPLEMENTARY LITERATURE:

Selected papers from relevant international journals

Ehlers, J. & Gibbard, P.L. (2004): Quaternary Glaciations - Extent and Chronology. Developments in Quaternary Science, 2, Elsevier

EXAMINATION PROCEDURE: Oral exam

COURSE: Evolution of the Pannonian Basin

AUTHOR(S) OF COURSE PROGRAMME: Dr. sc. Davor Pavelić, associate professor, Faculty of Mining, Geology and Petroleum Engineering

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+0+0

ECTS: 4

COURSE ACHIEVEMENTS: Understanding of genesis of the Pannonian Basin and external controls on its evolution, students will be capable to distinguish function of depositional environments succession in the meaning of interpretation of the basin evolution as well as to define their stratigraphic position. Students will be able to make interpretation and conclusions about extrabasinal controls, and distinguish syn-rift from post-rift deposits. Their knowledge will be usefull in fundametal geology (stratigraphy, sedimentology, basin analysis, regional geology) as well as in petroleum geology.

COURSE PROGRAMME: Characteristics of Central Paratethys. Chronostratigraphic problems. Continental rift development. Syn-rift and post-rift phase. Synsedimentary tectonics. Compression and basin inversion. Eustatic sea level changes. Characteristics of volcanism. Succesion of depositional environments and external controls. Cyclic deposition and causes.

STUDENTS' ACTIVITIES AND THEIR EVALUATION: Students are obliged to participate on lectures. Students will have to reconstrust sedimentary succesions and make interpretation concerning extrabasinal and intrabasinal controls.

OBLIGATORY LITERATURE:

Horváth, F. (1995): Phases of compression during the evolution of the Pannonian Basin and its bearing on hydrocarbon exploration.- Mar. Petrol. Geol., 12, 837-844.

Lučić, D., Saftić, B., Krizmanić, K., Prelogović, E., Britvić, V., Mesić, I. & Tadej, J. (2001): The Neogene evolution and hydrocarbon potential of the Pannonian Basin in Croatia.- Mar. Petrol. Geol., 18, 133-147.

Pavelić, D. (2001): Tectonostratigraphic model for the North Croatian and North Bosnian sector of the Miocene Pannonian Basin System.- Basin Research, 13, 359-376.

Pavelić, D. (2002): The south-western boundary of Central Paratethys.- Geol. Croatica, 55, 83-92.

Pavelić, D. (2005): Cyclicity in the evolution of the Neogene North Croatian Basin (Pannonian Basin System).- U: Cyclic Development of Sedimentary Basins (Ur. J.M. Mabesoone & V.H. Neumann). Developments in Sedimentology, 57, 273-283, Elsevier.

Prelogović, E., Saftić, B., Kuk, V., Velić, J., Dragaš, M. & Lučić, D. (1998): Tectonic activity in the Croatian part of the Pannonian basin.- Tectonophysics, 297, 283-293.

Rögl, F. (1998): Paleogeographic considerations for Mediterranean and Paratethys seaways (Oligocene to Miocene).- Ann. Naturhist. Mus. Wien, 99A, 279-310, Wien.

Royden, L.H. & Horváth, F. (1988): The Pannonian Basin. A study in Basin Evolution (Ur. L.H. Royden & F. Horváth).- Am. Assoc. Petrol. Geol. Mem., 45, 349 p.

Saftić, B., Velić, J., Sztanó, O., Juhász, G. & Ivković, Ž. (2003): Tertiary subsurface facies,

source rocks and hydrocarbon reservoires in the SW part of the Pannonian Basin (Northern Croatia and South-Western Hungary).- Geol. Croatica, 56, 101-122.

Tomljenović, B. & Csontos, L. (2001): Neogene-Quaternary structures in the border zone between Alps, Dinarides and Pannonian Basin (Hrvatsko zagorje and Karlovac Basins, Croatia).- Int. J. Earth Sci., 90, 560-578.

SUPPLEMENTARY LITERATURE:

Frostick, L.E. & Steel, R.J. (1993): Sedimentation in divergent plate-margin basins.- U: Tectonic Controls and Signatures in Sedimentary Successions (Ur. L.E. Frostick & R.J. Steel), Spec. Publ. Int. Ass. Sediment., 20, 111-128.

Jamičić, D. (1995): The role of sinistral strike-slip faults in the formation of the structural fabric of the Slavonian Mts. (Eastern Croatia).- Geol. Croatica, 48, 155-160.

Kováč, M., Nagymarosy, A., Oszczypko, N., Csontos, L., Slaczka, A., Marunteanu, M., Matenco, L. & Márton, E. (1998): Palinspastic reconstruction of the Carpathian-Pannonian region during the Miocene.- U: Geodynamic development of the Western Carpathians (Ur. M. Rakús). Mineralia Slov. Monograph., 189-217, Bratislava.

Kranjec, V., Hernitz, Z., Reščec, T. & Velić, J. (1976): Neki rezultati dubinskog kartiranja u Dravskoj potolini.- Nafta, 27/3, 123-141.

Leeder, M.R. (1995): Continental rifts and proto-oceanic rift troughs.- U: Tectonics of Sedimentary Sasins (Ur. C.J. Busby & R.V. Ingersoll), 119-148, Blackwell.

Magyar, I., Geary, D.H. & Müller, P. (1999): Palaeogeographic evolution of the Late Miocene Lake Pannon in Central Europe.- Palaeogeography, Palaeoclimatology, Palaeoecology, 147, 151-167.

Márton, E., Pavelić, D., Tomljenović, B., Avanić, R., Pamić, J. & Márton, P. (2002): In the wake of a counterclockwise rotating Adriatic microplate: Neogene paleomagnetic results from northern Croatia.- Int. J. Earth Sci., 91, 514-523.

Nøttvedt, A., Gabrielsen, R.H. & Steel, R.J. (1995): Tectonostratigraphy and sedimentary architecture of rift basins, with reference to the northern North Sea.- Mar. Petrol. Geol., 12, 881-901.

Pamić, J., McKee, E.H., Bullen, T. & Lanphere, M.A. (1995): Tertiary volcanic rocks from Southern Pannonian basin, Croatia.- Int. Geol. Rev., 37, 259-283.

Prelogović, E., Jamičić, D., Aljinović, B., Saftić, B. & Velić, J. (1995) Dinamika nastanka struktura južnog dijela Panonskog bazena.- U: 1. hrvatski geološki kongres, Zbornik radova (Ur. I. Vlahović, I. Velić & M. Šparica), 481-486, Zagreb.

Tari, G., Horváth, F. & Rumpler, J. (1992): Styles of extension in the Pannonian Basin. Tectonophysics, 208, 203-219.

Tari, V. & Pamić, J. (1998): Geodynamic evolution of the northern Dinarides and the southern part of the Pannonian Basin.- Tectonophysics, 297, 269-281.

EXAMINATION PROCEDURE: Oral.

COURSE: Seismotectonics

AUTHOR(S) OF COURSE PROGRAMME:

Dr. Bruno Tomljenović, Assistant Prof., University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering;

Dr. Marijan Herak, Full Professor, University of Zagreb, Faculty of Science

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 30+15+0

ECTS: 9

COURSE ACHIEVEMENTS:

The program of this course is designed to enable students to acquire application skills in seismotectonics in order to be able to understand kinematics and dynamics of tectonic movements, which generate and control spatio-temporal distribution of seismicity at different geodynamic settings of the Earth: at divergent, convergent and transform plate boundaries and within the plate interior. Particularly, it is expected that student will develop analytical and deductive skills in classification, interpretation and description of seismicity and tectonics.

COURSE PROGRAMME:

- Global tectonics i seismotectonically active zones on Earth.
- Earthquakes: magnitue and intensity.
- Seismic waves.
- Earthquake focal mechanism.
- Seismic sources and active fault zones. Determination of seismic sources.
- Neotectonics: Geomorphological indicators of tectonic activity.
- Major characteristics of tectonic activity in terranes with extensional, compressional, transtensional and transpressional tectonics.
- Paleoseismology: methods and data interpretation.
- Geodetic techniques in seismotectonics.
- Evaluation of seismic risk.
- Seismotectonic activity in Mediterranean and in Croatia.
- Presentation of strudents seminars: 20 min. seminar presentation on selected topics in seismotectonics.

Excercises: interpretation of geological, geophysical and seismotectonic data, maps and profiles.

STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance, seminars

OBLIGATORY LITERATURE:

1. Keller, E. A. & Pinter, N. (2002): Active Tectonics – Earthquakes, Uplift and Landscape.- 2nd ed., Prentice Hall, New Jersey, pp. 362.
2. Bolt, B. A. (1999): Earthquakes.- 4th ed., W.H. Freeman and Co., New York, pp. 366.
3. Scheriff, R. E. & Lloyd, P.G. (1995): Exploration Seismology.- 2nd ed., Cambridge Univ. Press, pp. 592.

SUPPLEMENTARY LITERATURE:

Selected articles from journals available online or in library:

1. Journal of Geodynamics (Elsevier)

2. Tectonophysics (Elsevier)

EXAMINATION PROCEDURE: oral exam

COURSE: Selected topics on sedimentary geochemistry

AUTHOR(S) OF COURSE PROGRAMME*:*

Dr. Esad Prohić, Professor, Faculty of Science, Department of Geology

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+15+0

ECTS: 6

COURSE ACHIEVEMENTS: To introduce student to the selected topics on geochemistry of sediments and sedimentary environment. Selection will be provided based upon the student research interest.

COURSE PROGRAMME:

Chemical equilibrium. The basics of physical chemistry of water solutions. Continental chemical weathering. Carbonate system geochemistry. Material input to the oceanic system – reseorvar – river transport. Material modification in the transition zones (estiaries and deltas). Marine organic matter, production and degradation. Vertical and horizontal distribution of biolimited elements. Trace elements in marine water and marine sediments. Statistical analysis and intepretation of geochemical data.

STUDENTS' ACTIVITIES AND THEIR EVALUATION: Obligatory class attendance, homeworks and seminars

OBLIGATORY LITERATURE:

Prohic, E. (1998) : Geokemija, Targa, 554 str, Zagreb
Elderfield, H, ed, (2003) : The oceans and marine geochemistry, in : Holand, H.D. & K. K. Turekian, eds, „Treatise on Geochemistry“, Elsevier, 625.p

SUPPLEMENTARY LITERATURE:

Morse, W.J., Mackenzie, F.T.(1990): Geochemistry of Sedimentary Carbonates. Developments in Sedimentology 48, Elsevier

EXAMINATION PROCEDURE: oral and written seminar

COURSE: Environmental geochemistry
AUTHOR(S) OF COURSE PROGRAMME: Dr. Esad Prohić, Professor, Faculty of Science, Department of Geology
TEACHING TECHNIQUES *(lectures+practice+seminar)*: 30+15+0
ECTS: 9
COURSE ACHIEVEMENTS: To introduce student to some global environmental problems and principles of environmental management.
COURSE PROGRAMME: Sampling procedures for water, soil, stream sediments, vegetation and air samples. Definition and function of trace elements.. Biogeochemical cycles of elements. Origin of anthropogenic elements in the environment. Receiving capacity for elements in natural systems. Interactions at the liquid –solid phase interface. Sequential extraction analyses and its role in environmental protection. Bioavailibility of the elements to the food chain and aquatic life. Trace elements in the environment and human health. Pollution problems in carbonate terrains. The basics of hydrogeochemistry.
STUDENTS' ACTIVITIES AND THEIR EVALUATION: Obligatory class attendance, homeworks and seminars
OBLIGATORY LITERATURE: Prohic, E. (1998) : Geokemija, Targa, 554 str, Zagreb Lollar, B.S.. ed, (2003) : Environmental geochemistry, in : Holand, H.D. & K. K. Turekian, eds, „Treatise on Geochemistry“, Elsevier, 577.p
SUPPLEMENTARY LITERATURE: Botkin, B.D. & Keller, A.D. (1997) : Environmental Science, John Wiley and sons, 649 p
EXAMINATION PROCEDURE: oral and written seminar

COURSE: Fossil Communities of the Late Palaeozoic - Palaeoecological and Biostratigraphical insights

AUTHOR(S) OF COURSE PROGRAMME:

Dr. Jasenka Sremac, Associate professor, Faculty of Science, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 10+15+5

ECTS: 6

COURSE ACHIEVEMENTS: Accomplishing the basic knowledge about the Late Palaeozoic fossils and fossil communities in Croatia (Determination of the most common macrofossils and microfossils. Biostratigraphy of Carboniferous and Permian. Interpretation of palaeoenvironment).

COURSE PROGRAMME:

1. Taxonomy of the most common Carboniferous and Permian fossils (cyanobacteria, calcareous algae, foraminifers, sponges, corals, mollusks, arthropods, bryozoans, brachiopods, echinoderms.
2. Carboniferous in Croatia. The most famous localities and fossils. Biostratigraphical and palaeoecological interpretations.
3. Permian in Croatia. Finding-places and fossils. Biostratigraphical and palaeoecological interpretations.
4. End-Permian mass extinction – possible causes and evidences in rocks.

STUDENTS' ACTIVITIES AND THEIR EVALUATION:

Class attendance. Individual tasks during the exercises. 2 seminars.

OBLIGATORY LITERATURE:

Flügel,E. (2004): Microfacies of Carbonate Rocks. Springer.
Ramovš,A. et al. (1989): Stratigraphic Correlation Forms of the Yugoslav Paleozoic. Rend. Soc. Geol. It., Roma.
Sremac,J. (1991): Zona Neoschwagerina craticulifera u srednjem Velebitu. Geologija, Ljubljana.
Sremac,J. (2005): Equatorial Shelf of the Palaeozoic Supercontinent – Cradle of the Adriatic Carbonate Platform. Geologia Croatica, Zagreb.

SUPPLEMENTARY LITERATURE:

Selected papers on Carboniferous and Permian fossils and fossil communities from local and international magazines, recent data from web-sites.

EXAMINATION PROCEDURE:

Oral exam, combined with success on exercises and seminars.

COURSE: Structural crystallography

AUTHOR(S) OF COURSE PROGRAMME:

professor emeritus, Stjepan Šćavničar, Faculty of Science

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+0+0

ECTS: 4

COURSE ACHIEVEMENTS: acquiring theoretical and practical fundamentals in the field of structural crystallography

COURSE PROGRAMME: Symmetry of crystal structures; possible symmetrical operations and their representation by matrices. Matrices for transformation of unit cell vectors in direct and reciprocal space, transformations of crystal faces indices, axis symbols, and atomic coordinates. Products of symmetrical operations without and with translation component. Application of space group symbols related to change of basic vectors. Deduction of Bravais lattices and space groups. Interpretation of data given in "International Tables of Crystallography", Vol A.

STUDENTS' ACTIVITIES AND THEIR EVALUATION: attendance to consultations and in experimental work that are realized individually with each student

OBLIGATORY LITERATURE:

Boisen, M.B., Gibbs, G.V. (1985): Mathematical Crystallography. Reviews in Mineralogy, Vol. 15. Mineralogical Society of America.
Borchardt-Ott, W. (1995): Crystallography. Springer.
Hahn, T. (1983): International Tables for Crystallography. D. Reidel Publishing Co.
O'Keeffe, M., Hyde, B. G. (1996): Crystal Structures. Mineralogical Society of America.

SUPPLEMENTARY LITERATURE:

articles in relevant professional and scientific journals

EXAMINATION PROCEDURE: written and oral

COURSE: Raw materials for different ceramics - composition of products
AUTHOR(S) OF COURSE PROGRAMME: professor emeritus, Stjepan Šćavničar, Faculty of Science
TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+15+0
ECTS: 6
COURSE ACHIEVEMENTS: acquiring theoretical and practical fundamentals for the field covered by the subject
COURSE PROGRAMME: Clays, composition and genesis; properties of the system clay-water (colloids, ion-exchange, deflocculation and flocculation, adsorption, intercalation compounds, viscosity, plasticity, thermal decomposition). Raw materials for different types of cement (portland, highly aluminous, pouzzollanic, oxichloride). Raw materials for refractories: Al_2O_3, earth alkali's oxides, sillimanite, andalusite, kyanite, steatite, magnesite, dolomite, spinel, rutile, zirkone, chromite. High-temperature ceramics: processing and properties; application in mechanical engineering, electro-technique (superconductors, dielectrics, piezoelectrics, semiconductors, ferritic magnets, IR and radar windows).
STUDENTS' ACTIVITIES AND THEIR EVALUATION: attendance to consultations and in experimental work that are realized individually with each student
OBLIGATORY LITERATURE: Kostorz, G. (ed.)(1989): High-tech ceramics. Academic Press. Worrall, W.E. (1986): Clays and ceramics raw materials. Elsevier.
SUPPLEMENTARY LITERATURE: articles in relevant professional and scientific journals
EXAMINATION PROCEDURE: written and oral

COURSE: Monocrystal study by combination of analytical methods

AUTHOR(S) OF COURSE PROGRAMME: Dr. Vladimir Bermanec, Professor, Faculty of Science, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+30+0

ECTS: 7

COURSE ACHIEVEMENTS: Students should get familiar with the important methods of monocrystal investigation, which are significant for determination of optical, morphological and structural properties of minerals.

COURSE PROGRAMME:

The methods from the following three topics will be taught: 1. Investigation of optical properties of minerals using universal and uniaxial stage (spindle stage), 2. Investigation of crystal morphology by reflective goniometer, 3. Determination of unit cell and space group from diffractograms (Weissenberg and Buerger camera). During all measurements the same crystal mounted to a goniometer head will be used, providing the input of all crystallographic, optical and morphological properties into the single stereographic projection. This approach helps in complex problem solutions like those occurring during investigation of very small crystals, twins, intergrown crystals or zonal crystals.

STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance, single crystal measurements, exercies

OBLIGATORY LITERATURE:

Bloss, F.D. (1981): The spindle stage. Cambridge University Press.
Buerger, M.J. (1964): The precession method in x-ray crystallography. John Wiley and Sons, Inc.

Nesse, W.D. (1991): Introduction to optical mineralogy. 2. izd. Oxford University Press

SUPPLEMENTARY LITERATURE:

EXAMINATION PROCEDURE: oral examinationa

COURSE: Electron diffraction and microscopy

AUTHOR(S) OF COURSE PROGRAMME*:*

Prof. dr. sc. Anđelka Tonejc, professor of physics, Faculty of Science, University of Zagreb, Department of Physics

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+15+0

ECTS: *(lectures+practice+seminar)*: 6

COURSE ACHIEVEMENTS:

The course gives an overwiev of the modern methods of the electron microscopy used in order to examine and determine the fine structure of materials. The course would be wellcome to the students that will work in an electron microscopy laboratory.

COURSE PROGRAMME**:** Fundamentals of electron microscopy.
Application of electron microscopy and electron diffraction in materials science, chemistry and geology.
The modern methods of examination of materials in an electron microscope:
Scanning electron microscope (SEM), SEM for enviromental examination (ESEM), of materials by energy dispersive X-ray analyses (X-ray mapping), Transmission electron microscopy and selected area electron diffraction (TEM and SAED), High resolution electron microscopy (HRTEM), Convergent beam electron diffraction (CBED).
The interpretation of the TEM images and diffraction of the polycrystalline, monocrystalline and amorphous samples.
The diffraction contrast . The defects characterisation in the material. Characterisation of stacking faults, tweens and antiphase boundaries using bright and dark field images.
The phase contrast. The high resolution imaging. Observation of different type of defects in high resolution mode (HRTEM) and Z- contrast imaging with the resolution beyond 0.1 nm.
The crystallographic image processing of high resolution images in order to determine the lattice deformation, dislocations, the lattice parameter , stacking faults, grain and phase boundaries. The structural resolution from 0.2 to 0.1 nm.
CBED is used for space group determination, the lattice parameter of examined crystal, thickness of the crystall examined in EM.
The latest discoveries in electron microscopy will be given: observation of oxigen positions and bonds in cuprite; atomic –scale imaging of individual dopant atoms and clusters in silicon.

The structure factor determination from HRTEM images and electron diffraction (ED). The application of Rietveld method to the images of nanocrystalline materials. The grain size, microstrain and unit cell parameters of nanocrystalline samples. The comparison of ED, X-ray and neutron diffraction .
Exercises: Practical work in EM laboratory; the evaluation of TEM, HRTEM and ED images. The practical presentation of the methods working in the JEOL 200 kV EM. The HRTEM image processing analyses of some images and ED.

STUDENTS' ACTIVITIES AND THEIR EVALUATION : Course attendance is controlled. The students receive the topics for written seminars and oral presentation. The results of the seminars will be included into the final note. The students will be given

practical work in EM laboratory: the preparation of the samples for EM observation and practical review of the methods of high resolution microscopy will be given.

OBLIGATORY LITERATURE:

D.B. Williams and C.B. Carter (1996), Transmission Electron Microscopy, A Textbook for Materials Science, Plenum Press, New York.

SUPPLEMENTARY LITERATURE:

1. Buseck, P.R. (ur.)(1992): Minerals and reactions at the atomic scale: Transmission electron microscopy. Reviews in Mineralogy, Vol. 27. Mineralogical Society of America

2. Goldstein, J.J., Newbury, D.E., Echlin, P., Joy, D.C., Fiori, C., Lihshin, E. (1984): Electron Microscopy and X-ray Microanalysis, Plenum Press, NewYork/London.
3. Reimer, L. (1997), 4th ed.: Transmission Electron Microscopy. Physics of image formation and Microanalysis,Springer-Verlag,Berlin.
4. Spence, Y.C.H. (2003) 3rd ed.: Experimental High-Resolution Electron Microscopy, Claredon Press,Oxford.
5. Thomas, G.T. (2000): Electron Microscopy and Structure of Materials, University of California Press, Berkley.

6. Electron Crystallography: Novel Approaches for Structure Determination of Nanosized Materials, eds. T.E. Weirich, J. Labar and X.D. Zou, Nato ASI Series C, Mathematics, Physics, and Chemistry , Vol 211. Springer, Dordrecht, (2004), Netherlands.

EXAMINATION PROCEDURE: Oral presentation of seminars in power-point presentation

COURSE: Geochronology

AUTHOR(S) OF COURSE PROGRAMME: Nada Horvatinčić,DSc., senior scientist, Ruđer Bošković Institute, Zagreb**,** Ladislav Palinkaš, DSC., Professor, Faculty of Science, Mineralogical Department

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 30+15+0

ECTS: 9

COURSE:
Application of stable and radioactive isotopes in oceanography and related disciplines (hydrogeology, climatology, geochemistry of sediment, karst geology, geochronology).The ocean water as a part of hydrogeochemical system is in permanent interaction with atmosphere, hydrosphere, lithosphere and biosphere. Isotopic geochemical methods are the important tools in studying of these processes, e.g. determination of residence time of some elements in sea water (^{226}Ra, ^{210}Pb), paleotemperature, evaporation (□^{18}O, □^{13}C, □□H), isotope variations in geological time ((□^{34}S, □^{18}O, ^{87}Sr/ ^{86}Sr) , sedimentation rate (^{210}Pb, ^{230}Th/^{234}U, ^{14}C) dating of groundwater (^{3}H, ^{14}C), process of contamination in atmosphere-water-sediment interaction, etc

COURSE PROGRAMME:

- Introduction- Isotopes in the nature (stable and radioactive), application in geology/hydrology. Radioactive decay, nuclear technique, measurement, mass spectrometry.
- ^{14}C dating: Principe of method, measurement techniques, dating method, application in archaeology, hydrology, palaeoclimatology, ecology, geology.
- ^{10}Be: in atmosphere, soil profile, ocean, geological system
^{36}Cl, ^{129}J, ^{26}Al
- Uranium disequilibrium: ^{230}Th/^{234}U, method princip, measurement technique, application in geochronology, palaeoclimatology; ^{234}U disequilibrium, ^{234}U/^{238}U geochronometry;
- ^{210}Pb dating, chronology of ice, lake and marine sediments.
- Rb-Sr dating method, K/Ar and Ar/Ar dating method; U-Th-Pb dating method;
- Oxygen and hydrogen in hydrosphere and atmosphere – isotopes O and H in water, water vapor, stratigraphy of snow and ice, isotopic composition of ocean, paleotemperature, geothermal waters, ^{3}H in hydrogeology.
- Carbon – fractionation of carbon isotopes in the environment (atmosphere, water, biosphere, marine and terrestrial sediments)
- Sulphur – biogenic fractionation, S-isotopes in recent sediments, fosil fuel, marine sulphate etc.
- Application of radioactive and stable isotopes in Dinaric karst investigation (lake and marine sediments, speleothems, surface and groundwater)

STUDENTS' ACTIVITIES AND THEIR EVALUATION

Seminars, practice examines, final examine

OBLIGATORY LITERATURE :

Faure, G. (1989): Principles of isotope geology. Smith-Wyllie, str.463.
Dickin, A.P. (2002): Radiogenic isotope geology. Cambridge university press, str.490.

SUPPLEMENTARY LITERATURE (*authors, title, publisher, edition, year of publishing*):

Prasada Rao (1996): Moder carbonates (tropical, temporate, polar). Univ.Tasmania, str.206.

Pearson, F.J. (1991): Applied isotope hydrogeology. Elsevier, str. 439.

Pezdić, J. (1999): Izotopi in geokemijski procesi. Littera picta, Ljubljana, str. 269.

Heaman, L. i Ludden, N.J. (1991): Short course handbook on application of radiogenic isotope systems to problems in geology. Min.ass.Canada, str. 498.

Fritz, P. I Fontes, J.Ch. (1980): Handbook of environmental isotope geochemistry. Elsevier, vol.1, str 545, vol.2, str.557.

Ivanovich, M. I Harmon, R.S. (1992): Uranium series disequilibrium: Applications to environmental problems. Clarendon Precc, Oxford, str.571.

EXAMINATION PROCEDURE: Practice examine, final examine

COURSE: Physical Chemistry of Pollution Processes

AUTHOR(S) OF COURSE PROGRAMME

Dr. sc. Ivan Sondi, Research Associate

Center for Marine and Environmental Research "Rudjer Bošković" Institute, Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+0+0

ECTS: 4

COURSE ACHIEVEMENTS

Introduction to physico-chemical processes at the solid/liquid (surfaces of mineral particles – aquatic system) interfaces. Understanding their role in binding, transport, and deposition of contaminants and pollutants in natural aquatic environments.

COURSE PROGRAMME

Mechanical and chemical disintegration of rocks and minerals. Genesis of small particles and their active interfaces. Classification and the methods of characterization of micro- and nanosize particles in natural aquatic media. Suspended materials and sediments. Basic properties, structural and interfacial physico-chemical characteristics of clay minerals, carbonates, oxides, and oxyhydrates. Surface charge and the electrochemical double layer. Electrokinetics and the zeta-potential. Colloidal stability and the processes of aggregation of micro- and nanosize particles in natural aquatic environments. Basic physico-chemical processes of interaction of solid surfaces with organic and inorganic compounds. Surface complexes at the solid/liquid interface. Contaminants and pollutants in natural waters. Micro- and nanosize particles in processes of binding, transport, and deposition of pollutants in nature. Sediments as depositories of pollutants.

STUDENTS' ACTIVITIES AND THEIR EVALUATION

Lectures or consultations + writing seminar, depending on the number of students.

OBLIGATORY LITERATURE

Stum, W., 1992. Chemistry of the solid-water interface. John Wiley. New York. 428 p.

Buffle, J., van Leeuwen, H.P., 1992. Environmental particles. Lewis Publishers. 554 p.

SUPPLEMENTARY LITERATURE

Hunter, R. J., 2001. Foundations of colloid science. Oxford University Press. 806 p.

Sondi, I., 2002. Electrokinetic of clay particles. In: Interfacial Electrokinetics and Electrophoresis, (ur. Delgado, A. V.). Marcel Dekker, Inc., New York, Chapter 27, p 773-797.

Sondi, I., Pravdić, V. (2002): Electrokinetic of clay mineral surfaces. In: Encyclopedia of Surface and Colloid Science, (ur. Hubard, A. T.). Marcel Dekker, Inc., New York, p 1887-1893.

EXAMINATION PROCEDURE:

Verbal exam or written seminar (depending on the number of students).

COURSE: Biomineralization

AUTHOR(S) OF COURSE PROGRAMME

Dr. sc. Ivan Sondi, Senior Research Associate

Center for Marine and Environmental Research "Rudjer Bošković" Institute, Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+0+0

ECTS: 4

COURSE ACHIEVEMENTS

Introduction to basics of biological mineralization, its importance for the geosphere, for the global geochemical cycle, and for the characterization of the state of the environment. Introduction to biomimetically inspired preparation of inorganic materials.

COURSE PROGRAMME

Introduction to biomineralization. Links between biota and the nonliving geosphere. Biominerals – the inorganic structure of biota. Biomineralization processes and the marine biogeochemical cycles. Basic processes of formation and the morphogenesis of organic-mineral architecture of biominerals. Structure and dynamics of organic and inorganic interfaces and the role of organic macromolecules in the genesis of biominerals. The characteristics of supramolecular structures and of self organizing inorganic structures. Understanding of relations between structure and function of biominerals. Biominerals as indicators of the state of the environment. Biomineralization of nanoparticles, and nano-composite biomaterials in marine environments. Biomimetically inspired synthesis of inorganic materials.

STUDENTS' ACTIVITIES AND THEIR EVALUATION

Lectures or consultations + writing seminar, depending on the number of students.

OBLIGATORY LITERATURE

Simkiss, K., Wilbur, K.M. (1989): Biomineralization. Cell biology and mineral deposition. Academic Press, 337 p.

Lowenstam, H.A., Weiner, S. (1989): On biomineralization. Oxford University Press. 336 p.

Mann S. (2001): Biomineralization. Principles and concepts in bioinorganic materials chemistry. Oxford Press, 216 p.

SUPPLEMENTARY LITERATURE

Baeuerlein, E. (ed) (2002): Biomineralization. From Biology to biotechnology and medical applications. Wiley, 316 p.

Muller, W.E.G. (ed) (2003): Silicon biomineralization: Biology, biochemistry, molecular biology and biotechnology. Springer Verlag, 340 p.

Sondi, I., Salopek-Sondi, B. (2005): The influence of the primary structures of urease enzyme on the formation of $CaCO_3$ polymorphs: A comparison of plant (*Canavlia ensiformis*) and bacterial (*Bacillus pasteurii*) ureases. *Langmuir* 21, 8876-8882.

EXAMINATION PROCEDURE:

Verbal exam or written seminar (depending on the number of students).

COURSE: Environmental micropaleontology

AUTHOR(S) OF COURSE PROGRAMME

Associated professor Vlasta Čosović, Faculty of Science, University of Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+0+0

ECTS: 4

COURSE ACHIEVEMENTS: Students will get an overview of how to use different kinds of microfossils in environmental studies and of their unique potential to document changes in marine and fresh water environments through time.

COURSE PROGRAMME

Environmental Micropalaeontology deals with the use of microfossils to interpret environmental changes, whether naturally or human induced. Examples from marine and paralic systems are presented, focusing on how the different microfossil groups provide information about different aspects of the environment. The fact that this information is highly complementary broadens our understanding of environmental changes in aquatic environments (e.g., pollution, eutrophication, climatic change). (1) Basic considerations about Foraminifers; morphologies, growth patterns and reproduction, anomalies in test morphologies, sampling techniques and biological role in ecosystem. (2) Foraminifers as indicators of natural and anthropogenic induced changes. (3) Distribution of foraminifers in the Northern Adriatic Sea (lagoons, estuaries, coastal region and offshore), anthropogenic (industrialization in last 150 years) and natural changes (diatoms and dinoflagelattes bloom) in environments. (4) Ostracods: morphologies, growth patterns, aberrations in carapace morphologies, sampling and biological impact on ecosystem. (5) Changes in composition of ostracod assemblages in brackish, lagoonal and coastal environments due to human (heavy metal contamination, industrialization, sewage pollution and agriculture processing) induced changes, and to marine regime changes in estuaries and lagoons (physiographic and weather conditions).

Exercise: Collecting material (techniques, laboratory treatments). Systematic of the most common foraminiferal and ostracod species from the Adriatic sea (eventually Mediterranean Sea). Biodiversity indexes, calculation and interpretation. Monitoring of changes in composition of foraminiferal and ostracod assemblages, finding the causes and interpretation of the consequences.

Seminars: A complete ecological interpretation of the selected sample.

STUDENTS' ACTIVITIES AND THEIR EVALUATION: Class attendance

Exercise: analysis and interpretation of samples collected for the particular settings in the Northern part of the Adriatic sea (Plomin bay, Mirna river estuarine, Lago di Garda). Seminars on particular case studies related to changes in composition of foraminiferal or ostracod assemblages from the Adriatic Sea or Mediterranean Sea.

Written tests related to each topic, homework includes writing the essay on the Case study.

OBLIGATORY LITERATURE :

Tyszka, J., Oliwkiewicz-Miklasinska, M., Gedl, P. & Kaminski, M. (eds), 2005, Methods and applications in micropaleontology. Polska Akademia nauk
Haslett, S.k., 2002, Quaternary Environmental Micropaleontology. Arnold, oxford University press Inc., London, New York.
Martin, R. (ed), 2000, Environmentl Micropaleontology, the application of Microfossils to Environmental geology, Kluwer Acad. Publ.
Scott, B.D., Medioli, F.S. & Schafer, C.T., 2001, Monitoring in coastal environment using Foraminifera and Thecamoebian Indicators. Cambridge Univ. Press.
Sen Gupta, B.K. (ed), 1998, Modern Foraminifera. Kluwer Acad. Publ.

SUPPLEMENTARY LITERATURE:

Haslett, S.K., 2003, Coastal Systems. Routledge, London.
Samir, A.M., 2000, The response of benthic foraminifera and ostracods to various pollution sources. Journal of Foraminiferal Research, 30: 83-98.
Barnes, R.S.K. & Hughes, R.N., 1999, An Introduction to Marine Ecology. Blackwell Science.

EXAMINATION PROCEDURE: Homeworks make 30% of exam and final oral exam 70%.

COURSE: Facies and macrofossils of the Upper Cretaceous carbonate platforms

AUTHOR(S) OF COURSE PROGRAMME:

Doc. Dr. Alan Moro

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 15+0+0

ECTS: 4

COURSE ACHIEVEMENTS: Aim of the course is to give students knowledge about rudists as most common macrofossils of carbonate platforms, their environmental and paleontological characteristics, relations to associated fossil communities, as well as their relations to the facies changes and end of Upper Cretaceous deposition.

COURSE PROGRAMME: Introduction to rudists (what they are and their appearance), rudists and their relations with other micro- and macrofossils of carbonate platforms (benthic forams, pelagic particles, other bivalves, cephalopods), rudists and different types of carbonate platforms (rudist versus shallow carbonates, foundered platform and rudists), rudists within sequence stratigraphy framework (basic of sequence stratigraphy for carbonates, how shallow water carbonates react on sea-level changes), Adriatic carbonate platform development during Upper Cretaceous-changes of facies characteristics from shallow subtidal to the foundered platform environment (relation between ACP, rudists and sea level change, their responses of mutual reaction).

STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance, active participation during programme, seminars, personal tasks.

OBLIGATORY LITERATURE :

Cestari, R. & Sartorio, D. (1995) - Rudists and Facies of the Periadriatic Domain. Agip S.p.A., S. Donato Milanese, 208 pp.Milano.
Coe, A.L.; Bosence, D.W.J.; Church, K.D.; Flint, S.S.; Howell, J.A.; Wilson, R.C.L. (2003) - The Sedimentary Record of Sea-Level Change. Cambridge University Press, 288 pp, Cambridge.
Skelton, P.W.; Spicer, R.A.; Kelley, S.P. & Gilmour, I. (2003) - The Cretaceous World. Cambridge University Press, 360 pp, Cambridge.
Tucker M. E. (1993) - Carbonate diagenesis and sequence stratigraphy. in Wright, V.P. (Ed.) Sedimentology review, v. 1, pp. 51-72, Oxford.
Tucker M. E. & Wright V.P. (1990) - Carbonate sedimentology. 482 pp., Blackwell Scientific publications, Oxford.

SUPPLEMENTARY LITERATURE :

Gili E., Skelton W.P., Vinces E. & Obrador A. (1995a) - Corals to rudists-an environmentally induced assemblage succession. Palaeogeogr., Palaeoclimatol., Palaeoecol., v. 119, pp. 127-136, Amsterdam.
Gili E., Masse J-P. & Skelton P.W. (1995b) - Rudists as gregarious sediment-dwellers, not reef-builders, on Cretaceous carbonate platforms. Palaeogeogr., Palaeoclimatol., Palaeoecol., v. 118, pp. 245-267, Amsterdam.
James N.P. (1984) - Shallowing upward sequences in carbonates. In: Walker, R.G. (ed.)

Facies models, pp. 213-228, Geological Association Canada, Toronto.
Kauffman E.G. & Sohl N.F. (1974) - Structure and evolution of Antillean Cretaceous rudist frameworks. Verh. naturf. Ges. Basel, v. 84, pp. 399-467, Basel.
Moro, A., Skelton, P.W. & Ćosović, V. (2002): Palaeoenvironmental setting of rudist in the Upper Cretaceous (Turonian-Maastrichtian) Adriatic carbonate platform (Croatia), based on sequence stratigraphy. Cretaceous Research, 23/4, 489-508.
Moro, A. & Ćosović, V. (2002): Rudists and Larger Benthic Foraminiferes as relative indicators of subtidal depth-an example from Istrian (Upper Cretaceous and Eocene) part of Adriatic Carbonate Platform. Memorie della Societa Geologica Italiana, 57, 203-208.
Polšak A. (1965) - Geologija južne Istre s osobitim obzirom na biostratigrafiju krednih naslaga (Géologie de l'Istrie méridionale spécialement par rapport a la biostratigraphie des couches crétacées). Geološki Vjesnik, v. 18, pp. 415-509, Zagreb.
Polšak A. (1967) - Kredna makrofauna južne Istre (Macrofaune crétacée de l'Istrie méridionale, Yugoslavie). Palaeontologia jugoslavica, v. 8, pp. 1-219, 85 tab., Zagreb.

EXAMINATION PROCEDURE: Oral exam and fulfillment of all practice tasks**.**

COURSE: Calcareous algae in sedimentology and stratigraphy

AUTHOR(S) OF COURSE PROGRAMME:

Dr.sc. Tonći Grgasović, Scientific associate, Croatian Geogical Survey, Zagreb

TEACHING TECHNIQUES *(lectures+practice+seminar)*: 30+15+0

Lectures, practice, and field trip (1 day).

ECTS: 9

COURSE ACHIEVEMENTS:

Course is designated to students interested in carbonate deposits, their sedimentology, stratigraphy and micropaleontology. During this course students will achieve modern knowledge on living and fossil calcareous algae, their systematics, structure and calcification processes, as well as their use in sedimentological, paleoecological and biostratigraphical investigations. Students will become familiar with the most important groups of calcareous algae, and their recognition in field and in thin sections.

COURSE PROGRAMME:

1) SYSTEMATICS OF ALGAE:
   older and modern classifications
   morphological vs. genetic classification – pro and contra
   domenes and kingdoms of the living world
   nanobes, archaea, bacteria, cyanobacteria, algae and plants
   calcareous algae
   bentic and pelagic algae
   research methods
2) ALGAE IN SEDIMENTOLOGY:
   photosynthesis and production of $CaCO_3$
   calcareous skeleton in different algal groups
   production of calcareous sediment
   origin of calcareous mud
   bacteria, calcification and dolomitization
   "algal limestone"
   Praecambrian stromatolite empire, Paleozoic algal reefs, Mizzia limestone, Diplopora limestone, "Hauptdolomit" – cyanobacterial heaven, Clypeina limestone, "Istrian yellow" limestone, "Litavac" limestone, tufa
3) CYANOBACTERIA
   systematics
   porostromata – spongiostromata
   environment – are all cyanobacteria intertidal?
   deep water stromatolites
   cyanobacterial mats, origin of stromatolite lamination
   biofilms
   porostromata – spongiostromata
   microbial sediments
   endolithic and epilythic cyanobacteria – micritization and overgrowth

4) RED ALGAE - CORALLINACEAE
structure – nets, holes and perforations
systematics – no-name species in the sea of names
ecology and sedimentology – are all Lithothamnion limestones the same?
5) GREEN ALGAE – HALIMEDACEAE AND GYMNOCODIACEAE
structure
systematics – green or red?
recognition
ecology and sedimentology – whit mud and green curtain
6) GREEN ALGAE – DASYCLADALES
structure – living and fossil taxa
systematics
recognition
ecology and sedimentology – lagoons and reefs, storms and swamps
7) PALAEOZOIC AND TRIASSIC ALGAE
the most important taxa
biostratigraphy
8) JURASSIC ALGAE
the most important taxa
biostratigraphy
9) CRETACEOUS AND PALEOGENE ALGAE
the most important taxa
biostratigraphy
10) FIELD TRIP
1 day: Mt. Medvednica and Mt. Žumberak (Triassic, Jurassic, Paleocene, Miocene)

STUDENTS' ACTIVITIES AND THEIR EVALUATION: class attendance, exercise attendance, practical lessons (thin-section analysis), field-trip (field recognition of fossil taxa).

OBLIGATORY LITERATURE:

BERGER, S. & KAEVER, M.J. (1992): Dasycladales: an illustrated monograph of a fascinating algal order. Thieme, 247 pp.
DE CASTRO, P. (1997): An approach to thin-section study of fossil Dasycladales. Quaderni dell' Accademia Pontaniana, Napoli, 22, 261 pp.
RIDING, R. (ed.) (1991): Calcareous algae and stromatolites. Springer Verlag, 571 pp.
RIDING, R. & AWRAMIK, S. (eds.) (2000): Microbial sediments. Springer Verlag, 332 pp.

SUPPLEMENTARY LITERATURE:

BASSOULLET, J.-P., BERNIER, P., CONRAD, M.A., DELOFFRE, R. & JAFFREZO, M. (1978): Les Algues Dasycladales du Jurassique et du Crétacé. Geobios, Lyon, Mémoire special 2, 330 pp.
BASSOULLET, J.-P., BERNIER, P., DELOFFRE, R., GÉNOT, P., PONCET, J. & ROUX, A. (1983): Les Algues Udoteacées du Paléozoïque au Cénozoïque. Bulletin des Centres Recherches Exploration-Production Elf-Aquitaine, Pau, 7/2, 449-621.
CHUVASHOV, B.I., SHUYSKY, V.P. & IVANOVA, R.M. (1993): Stratigraphical and facies complexes of the Paleozoic calcareous algae of the Urals.-*In:* BARATTOLO, F., DE CASTRO, P. & PARENTE, M. (eds.): Studies on fossil benthic algae. Bollettino della Società Paleontologica Italiana, Special Volume 1, 93-119.
DELOFFRE, R. & GÉNOT, P. (1982): Les Algues Dasycladales du Cénozoique. - Bulletin des Centres Recherches Exploration-Production Elf-Aquitaine, Pau, Mém. 4, 205 str.

DELOFFRE, R. & GRANIER, B. (1992): Inventaire critique de Algues Dasycladales fossiles. I partie - Les Algues Dasycladales du Tertiare.- Revue de Paléobiologie, 11/2, 331-356.
FLÜGEL, E. & FLÜGEL-KAHLER, E. (1980): Algen aus den Kalken der Trogkofel-Schichten der Karnischen Alpen. Carinthia II, Sonderheft 36, 113-182.
GRANIER, B. & DELOFFRE, R. (1993): Inventaire critique de Algues Dasycladales fossiles. II partie - Les Algues Dasycladales du Jurassique et du Crétacé. Revue de Paléobiologie, 12/1, 19-65.
GRANIER, B. & GRGASOVIĆ, T. (2000): Les Algues Dasycladales du Permien et du Trias. Nouvelle tentative d'inventaire bibliographique, géographique et stratigraphique (Permian and Triassic Algae. Bibliographic, geographic, and stratigraphic reappraisal). Geologia Croatica, 53/1, 1-197.
MAMET, B., ROUX, A. & NASSICHUK, W.W. (1987): Algues carbonifères et permiennes de l'Arctique canadien.- Geological Survey of Canada, Bulletin, 342, 143 str.
ROUX, A. (1991): Révision des Gymnocodiaceae (Algues rouges, Permien-Crétacé). Taxonomie, Biostratigraphie, Paléobiogéographie. 2e Partie: Inventaire taxonomique critique des espèces de Gymnocodiacées du Permien et du Trias. -Rev. Micropaléont., 34/2, 136-173.
ROUX, A. & DELOFFRE, R. (1990): Révision des Gymnocodiaceae (Algues rouges, Permien-Crétacé). Taxonomie, Biostratigraphie, Paléobiogéographie. 1re partie: Généralités sur la familie. -Rev. Micropaléont., 32/2, 123-137.

Publications of Croatian authors (Geološki vjesnik, Geologia Croatica): Sokač, Herak, Kochanski-Devidé, Gušić, Milanović, Grgasović.

WEB LINKS:

Algae:
Atlas de Microorganismos. Microalgas: http://personal.telefonica.terra.es/web/ayma/atlas_m.htm
Bacterial Paleontology: http://macroevolution.narod.ru/rozbak.htm
Cyanosite: http://www-cyanosite.bio.purdue.edu/
Fossil Coralline Algae: http://www.paleoweb.net/algae/
International Fossil Algae Association: http://www.ku.edu/~ifaa/home.html
Introduction to Coralline Algae: http://www.botany.uwc.ac.za/clines/
Life in Extreme Environments: http://www.astrobiology.com/extreme.html
Microbial Mats: http://nai.arc.nasa.gov/students/this_month/
Microbial Mats Page:
http://www.uta.edu/paleomap/homepage/Schieberweb/microbial_mat_page.htm
Nanobes: http://www.microscopy-uk.org.uk/index.html?http://www.microscopy-uk.org.uk/nanobes/nanoimages.html
Stromatolites: http://hoopermuseum.earthsci.carleton.ca//stromatolites/CONTENTS.htm
The Earliest Life: http://www.uni-muenster.de/GeoPalaeontologie/Palaeo/Palbot/seite1.html
Tonći Grgasović – Triassic Dasycladales from Croatia:
http://www.ku.edu/~ifaa/jpg/Grgasovic/page_01.htm
Welcome to the World of Microbes: http://user.uni-frankfurt.de/~schauder/

Links:
Algae Links: http://www.nmnh.si.edu/botany/projects/algae/Alg-Link.htm
History of Life links: http://www.wooster.edu/geology/HOL.html
Links for Paleobotanists: http://www.uni-wuerzburg.de/mineralogie/palbot1.html
The World of Algae – links: http://www.botany.uwc.ac.za/algae/index.htm

GeoScienceWorld search engine: http://www.geoscienceworld.org/

Online text-books on biology and paleontology:
Botany - Michigan State University: http://taggart.glg.msu.edu/bot335/335syl.htm
Online Biology Book: http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookTOC.html
Palaeos: The Trace of Life on Earth: http://www.palaeos.com/Default.htm
The Life System Syllabus: http://www.ldeo.columbia.edu/edu/dees/ees/life/schedule.html
University of California, Berkeley, The History of Life: http://www.ucmp.berkeley.edu/

Other:
International Comminssion on Stratigraphy: http://www.stratigraphy.org/
International Code of Botanical Nomenclature: http://www.bgbm.fu-berlin.de/iapt/nomenclature/code/SaintLouis/0000St.Luistitle.htm
Guide to the International Code of Botanical Nomenclature: http://fp.bio.utk.edu/mycology/Nomenclature/nom-index.htm
Virtual Fossil Museum: http://www.fossilmuseum.net/

EXAMINATION PROCEDURE: oral and practical exam (microscope, magnifying lens).