LAUREA DI PRIMO LIVELLO (DM 270/2004)
IN
SCIENZE E TECNOLOGIE GEOLOGICHE
Geological Sciences and Technologies

Corso di laurea in Scienze e Tecnologie Geologiche Classe L-34

ENGLISH PROGRAM 2008-2009

1° ANNO

Calculus **(12 cfu**
*P*rof. MARINA DI NATALE marina.dinatale@unimib.it
Dipartimento di Matematica e Applicazioni
Via Cozzi, 53 - Ed. U5

Title of the course: Calculus credits: 12
Lecturer: Marina Di Natale
Examination: written and oral exam
Aims:
The basic course in Calculus to enable students to understand and use main tools in: differential calculus and integral calculus in one or more variables, ordinary differential equations, infinite series, linear algebra.
Main topics:
Functions. Elementary functions and graphs. Limits of functions. Continuous functions. Derivatives and differentiation rules. Theorems of differential calculus. Taylor's formula. Local maxima and minima. The Riemann integral. Properties and techniques of integration. The Fundamental theorem of integral calculus. Improper integrals. Ordinary differential equations and Cauchy problem. First-order equations: separable and linear equations. Second-order equations: linear equations with constant coefficients. Infinite series. Power series and Taylor series. Trigonometric series and Fourier series. Functions of several real variables. Partial derivatives. Local maxima and minima. Curves and line integrals. Double integrals. Reduction formulas and change of variables. Linear algebra. Vectors, matrices, determinants. Linear systems.

Fisica (12 cfu)
(*Physics*)
Prof. MIRELLA ENRIOTTI mirella.enriotti@unimib.it
Dipartimento di Fisica "G. Occhialini"
Piazza della Scienza, 2

Title of the course: Physics credits: 12
Lecturer: Mirella Enriotti
Examination: written examination
Aims: The Course is an introduction to the basic models of the classical physics: newtonian mechanics and electromagnetic field.
Main topics: Newtonian mechanics of particles and extended systems.
Oscillations and waves. Statics and elements of the dynamics of fluids.
Electrostatics. Magnetostatics. Faraday's law and RLC circuits.
Displacement current and the Maxwell's equations.The electromagnetic waves and applications.

Chimica generale e inorganica (8 cfu)
(General and Inorganic Chemistry)
Prof. ROBERTO SCOTTI ro*berto.scotti@unimib.it*
Dipartimento di Scienza dei Materiali
Via Cozzi, 53 – 20125 Milano

Examination:
Written and Oral examination

Aims:
Understanding the principles of general chemistry and the properties of the main elements. Learning of the fundamental elements of stoichiometry

Main topics
Matter. Atomic theory. Mole and Avogadro constant. Element and compounds. Nomenclature of elements and compounds. Chemical reactions. The electronic structure of the atom. Ionic and covalent bond. The gases. Thermodynamics. Liquids, solids and intermolecular forces. The solutions. Colligative properties of the solution. Kinetics. Chemical equilibrium. Acids and bases (Arrhenius and Brønsted-Lowry definitions. pH. Acid - base equilibra. Titolations. Indicators). Solubility and solubility products. Complex ions. Lewis acids and bases. Electrochemistry. Chemistry of hydrogen and of s elements. Chemistry of p elements. Chemistry of transition metals.

Learning outcomes
The student will gain the basic knowledge of chemistry and of the properties of the main elements and will be able to solve numerical exercises about mass relations in compounds, mixtures and chemical reactions..

Prerequisites
Basic knowledge of algebra and mathematic

Testi consigliati:
R.H.Petrucci, W.S.Harwood, G.Herring, “Chimica Generale” , Ed. Piccin
W.L.Masterton, C.N.Hurley, “Chimica. Principi e reazioni”, Ed. Piccin
P. Michelin Lausarot, G.Vaglio, “Stechiometria per la Chimica Generale”, Ed. Piccin

Principi di Geologia (8 cfu)
(*Principles of Geology*)
Prof. ANNALISA TUNESI annalisa.tunesi@unimib.it
Prof. ANDREA ZANCHI andrea.zanchi@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: Principles of Geology (**An Introduction to Petrography**) **credits**: **4**
Lecturer: Annalisa TUNESI
Examination:
Written and oral examination

Aims: The first module is focused on the main lithogenetic processes that contribute to the growth of the oceanic and continental crust. We will describe the magma genesis and its crystallization; the weathering of pre-existing rocks and the formation of sedimentary rocks (clastic and carbonatic); the metamorphic process. The identification and classification of the most representative igneous rock-types will perform during practical activities.

Main topics:
Origin and composition of the Solar System and the Earth. Origin of the atmosphere. The Archean. An outline of Mineralogy. Structures of the silicates. Oceanic and continental crust. Modal and chemical classification of igneous rocks. The silicate melts. The Bowen’s series. Volcanoes and plutonic bodies. Mechanical and chemical weathering, erosion and

deposition. Diagenesis of sedimentary rocks. Classification: clastic rocks, carbonate rocks, chemical rocks. The metamorphic process. Identification of the protoliths. Types of metamorphism based on metamorphic conditions. Metapelites and metabasites. Classification of Igneous rocks (practical activities).

Learning outcomes

Understanding geological processes that lead to the growth of continental and oceanic crust through magma generation, formation of sedimentary basins and evolution of metamorphic rocks. Describing textures and mineralogical compositions to classify igneous rocks according to modal proportions of phases.

Prerequisites

Not required

Principles of Geology credits: **4**

Lecturer: Andrea Zanchi

Aims and contents

The second module is focused on geological and structural processes which take to the deformation of rocks, and to the reconnaissance of the main brittle and ductile tectonic structures. This will allow to understand the evolution and the dynamics of the litosphere through the Plate Tectonics theory. The last part of the module concerns the principles of stratigraphy and geological chronology which will be used to understand how geological map have been realized.

The classification of sedimentary and metamorphic rocks will be taught thorough practical activities.

Program details

Brittle and ductile deformation and the main deformational structures. Earthquakes and seismic waves. Rheology and composition of the Earth. Plate tectonics. Paleomagnetism and the structure of the oceanic lithosphere. Evolution and structure of the continents. Collisional belts (Alps and Himalaya). Relative and absolute chronology. Introduction to stratigraphy.

The classification of sedimentary and metamorphic rocks (practical activities).

Learning outcomes

Understanding geological processes in the frame of Plate Tectonics.

Prerequisites

Knowledge of rock classification and of the main petrogenetic processes.

Geografia fisica (8 cfu)
(Physical Geography)
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: PHYSICAL GEOGRAPHY credits: **6**

Examination: written and oral

Aims: to provide a basic understanding of the terrestrial physical environment and the environmental factors that shape the Earth's surface.

Main topics:

introduction to cartography: cartographic projections, reference and coordinate systems. The Earth: geographic distribution of the fundamental subaerial landforms, geomorphic processes and the evolution of the Earth's surface, erosion, transport, and deposition. Introduction to climatology: climatic scales, cosmic and topographic factors, the structure of the atmosphere, rainfall regimes and intensity of precipitation, recent climatic changes and possible causes. Introduction to hydrology: the water cycle, soil hydrology, drainage basins and phreatic aquifers, fluvial regimes. Introduction to glaciology: snowfall and

measurement techniques, trimlines, glaciers, glacier mass balance, glacier classification and dynamics in relation to climate changes. Introduction to oceanography.
Learning outcomes: to acquire a basic understanding of cartography, geomorphology, climatology, hydrology, glaciology, and oceanography.
Prerequisites: none

Introduction to Geological Mapping (2 cfu)
Lecturer: Franco Rodeghiero
Examination: written exercises on topographical and geological maps, personal report on guided field tours.
Aims:
To gain the basic knowledge of the topographical maps; to practise in the geological maps of a region, also with some direct field observations. To be able to draw simple geological sections and to use the basic tools of the geological field survey.
Main topics:
The fundamental principles of the cartography projection. The topographical maps of IGM and the Regional technical Cartography. The scale, the contour lines, the contour interval and the symbols of the topographical maps and the coordinates of a point in the map. Exercises on the altimetric sections and on the catchment basins. Examples of geological maps from the didactic collection. The attitude of the lines and the planes. Geological boundary drawing exercises on a topographical map. Drawing of sections on some simplified geological maps.
Field guided tours are also provided to survey, at the outcropping scale, the lithology and the framework of the different rock beds, their dip and bedding, the tectonical elements and to gain a good knowledge of the attitude of the large rock bodies.

Mineralogia (8 cfu)
(Mineralogy)
Prof. ANNA BRAJKOVIC anna.brajkovic@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: Mineralogy credits: 6 + 2
Lecturer: Anna Brajkovic
Examination: written (exercises of morphological crystallography) + oral
Aims: To teach the students how to recognize minerals by morphological, physical and chemical properties and by means of a microscope (examination of thin sections).
Main topics:
Solid state: crystalline and amorphous solids.*Crystallography:* external form; internal order and symmetry.
X-Ray Crystallography: diffractions effects and the Bragg equation. Laue method. Other single-crystal
methods. Powder method. X-Ray Powder Diffractometer.
Optical Properties of minerals: Nature of light. Index of refraction. Isotropic and Anisotropic crystals. The
polarizing microscope. The uniaxial and biaxial Indicatrix. Optical orientation in biaxial crystals. Absorption and Pleochroism. Crystals between crossed polars. Crystals in convergent polarized light.
Physical properties of minerals. Chemical Analytical Techniques: FAA, XRF, EMPA. IR, UV-Vis, Raman *Spectroscopy. Crystal Chemistry*: bonding forces in crystals, examples of some structure types. Isostructuralism. Solid solutions. Polymorphism. Polytypism. S*ystematic Mineralogy.*

Title of the course: **Methods for mineralogical and petrographical analyses** (2 crediti)
Lecturer: Anna Brajkovic
Examination: oral
Aims:
To teach the student analytical methods for minerals, gemstones and rocks. Description of the principal instruments for these analyses and laboratory-practice.
Main topics:
Analytical methods in mineral science. *Scanning Electron Microscopy (SEM).*
X-Ray Diffraction Techniques (XRD). Introduction. Overview of crystallographic concepts: from symmetry operations to space groups; X-Ray spectra; Diffraction effects and the Bragg equation; Single-crystal X-ray diffraction and structure analysis; X-Ray powder diffraction and mineral identification.
Chemical Analytical Techniques. Flame Atomic Absorption Spectroscopy (FAA). X-Ray Fluorescence Analysis (XRF). Electron Microprobe Analysis (EMPA).
Gemmology - Physical and chemical properties of minerals: determination of specific gravity and of refraction index; IR, UV-Vis, Raman Spectroscopy; Detailed study of diamond.

2 ANNO

Paleontologia (8 cfu)
(Paleontology)
Prof. CESARE CORSELLI cesare.corselli@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Examination: written report on field work, fossil recognition and description, oral test.
Aims: to provide the knowledge for the application of fossils to relative dating of rocks and sediments and to the reconstruction of palaeo-environments.
Main topics:
*Theoretical lessons (***6 cfu** *).*
Concept of fossil. Concept of species.
Biostratinomy and diagenesis. Principles of palaeoecology. Biogeography and Palaeo-biogeography. Stratigraphy and biostratigraphy
General concepts. Biostratigraphic units. Biostratigraphic correlations and examples of zonation. Review of the principal systematic groups of marine invertebrates with: a) elements for their recognition, b) evolutionary history and stratigraphic importance, c) environmental significance. Biological evolution.
Laboratory (**1cfu**): recognition of diagnostic characters of the different groups of fossils considered.
Field activity (**1 cfu**). A daily excursion aimed to illustrate didactically significant fossiliferous localities.
Texts:
Allasinaz A.,1999, *Invertebrati fossili.* UTET, Turin.
S. Raffi & Serpagli E.,1993*, Introduzione alla Paleontologia, UTET, Torino.*

Learning outcomes: recognition of the main fossil taxa and knowledge of their stratigraphic distribution and their use for facies reconstruction.

Prerequisites: Exams of General and inorganic Chemistry, Principles of Geology, Mineralogy.

Petrografia (12 cfu)
(Petrography)
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Aims:
Acquire knowledge in Petrography of magmatic and metamorphic rocks and the skills in communicating it
Main topics: Physical and chemical properties of magma. Magmatic differentiation and phase diagrams evidencing crystallization path. Melting process in mantle and genesis of basaltic magma. Melting process in continental crust and genesis of granitic melt. Main features of the magmatic series and relations to the geodynamic setting. Definition, limits and types of metamorphism. Parameters which control metamorphic changes. Principles of metamorphic reactions. Metamorphic grade or facies: petrogenetic grid. Graphical representation of the metamorphic mineralogical assemblages. Metamorphism of different rock compositions: pelitic, mafic and granitoid.

Informatica per le Scienze della Terra (4 cfu)
(Introduction to Computer Science)
Prof. PIETRO BRAIONE *pietro.braione@disco.unimib.it*
Dipartimento di Informatica Sistemistica e Comunicazione, Disco
Viale Sarca, 336, Ed. U14

Title of the course: Introduction to Computer Science **credits**: 4
Lecturer: Braione Pietro
Examination:
Written exam and oral assessment.
Aims:
Providing the basic concepts in computer science and programming: information, binary representation of information, computer architecture, basic concepts in programming.
Main topics:
Computer architecture and binary representation of information (overview);
Programming language hierarchy, compilers and interpreters;
Primitive data types;
Variables, declarations, assignment; Expressions and their evaluation;
Control statements, selection and iteration;
Simple examples of algorithms;
Arrays of primitive types;
Computational complexity (overview);
Defining procedures and procedure calls.
Learning outcomes
By the end of the course the student shall be able to identify the algorithms to solve some simple classes of problems and express them as programs in a suitable programming language.
Prerequisites
none.

Geologia strutturale (4 cfu)
(Structural Geology)
Prof. ALESSANDRO TIBALDI
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Il corso comprende due moduli: **Geologia strutturale** e **Cartografia geologica**

Geologia strutturale:

Aims: Giving the base elements of structural geology.

Main topics: Stress and strain. Fundamental equations and relations in different conditions of pressure, temperature and time. Simple shear and pure shear. The scale of deformations. The principal types of deformations: faults, characteristics, types, classification based on their dip and kinematics, methods and limits of reconstructing fault kinematics, problems and limits for the calculus of fault offset, faults with and without morphological features, possible causes and interactions between endogenous dynamics and exogenous modelling. Possible associations of reverse, transcurrent and normal faults. Folds: nomenclature, scale, amplitude, wavelength, persistence, coherence and interference, styles in relation with rock rheology, origin of stresses, and crustal environment. Foliations and scistosity. Fractures and tectonic joints, types, characteristics, causes and environment of formation.

Suggested texts

Structural Geology of Rocks and Regions, G.H. Davis, John Wiley & Sons, New York, 1998; other texts will be distributed during the course.

Cartografia geologica (4cfu)
(Geological Maps and cross-sections)
Prof. ANDREA BISTACCHI andrea.bistacchi@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Lecturer: Andrea Bistacchi

Examination: practical and oral examination

Aims:To read, understand and implement geological maps. To understand the 3D architecture of geological units and structures recorded in a geological map.

Main topics: The course is composed of concise theory lessons immediately followed by practical exercises. The main topics are: (1) foundations (map scales and topographic bases, reference frames and projections, digital elevation models, different kinds of geological maps, and explanatory notes, structural data, stereoplots, directional statistics, how to define structural elements and homogeneous domains); (2) constructing geological cross-sections (optimal profile orientation, projection of geological boundaries and structural elements, real and apparent thickness and dip); (3) advanced topics (simple 3D models, software for geological mapping and cross-section reconstruction, integrating borehole data).

Learning outcomes: To be able to read and implement geological maps and cross-sections.

Prerequisites: Principles of petrography, stratigraphy, maths and computer science.

Rilevamento Geologico (8 cfu)
(Field Geology and Mapping)
Prof. MARCO MALUSA'
Prof. GIOVANNI VEZZOLI
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: FIELD GEOLOGY AND MAPPING **credits**: 8

Lecturer: MARCO MALUSA' AND GIOVANNI VEZZOLI

Examination: Written examination + oral examination + written report

Aims:

Introduction to field geology and mapping.
Main topics:
a) Sediments and sedimentary rocks. Terrigenous, allochemical and orthochemical components. Extrabasinal and intrabasinal grains. Classification of sedimentary rocks. Conglomerates, sandstones, and shales. Limestones and dolostones. Evaporites. Chert. Phosphorites. Introduction to sedimentary structures.
b) Stratigraphy. Principles. Walther's Law. Unconformities and discontinuities. Stratotype and Type Locality. Lithostratigraphic units, biostratigraphic units, magnetostratigraphic units. Geochronologic and chronostratigraphic units. Tectonostratigraphic units. Unconformity-bounded unit.
c) Field geology techniques. Description and classification of sedimentary, igneous and metamorphic rocks in the field. Quaternary deposits. Compass and basic stereonet techniques. Plotting contacts on base maps. Stratigraphic polarity in deformed successions. Stratimetric problems. Data collection and making standard geological maps. Stratigraphic logs and simple cross-sections from field data. Preparing geologic reports.

Geochimica (8 cfu)
(Geochemistry)
Prof. IGOR VILLA igor.villa@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: GEOCHEMISTRY **credits**: 8
Lecturer: IGOR VILLA
Examination: oral examination
Aims:
Outlines of cosmochemistry. Behaviour and classification of elements; their availability and abundance. Geochemical composition of the whole Earth. Distribution, mobility and behaviour of elements during the main petrogenetic processes (magmatism, metamorphism, surface cycling). Distribution of elements in sedimentary rocks; physical-chemical factors in sedimentation: diagenesis, clays.
Geochemical characterization of the main terrestrial water reservoirs: oceans, surficial and subsurface continental waters. Water-rock interaction. The transport of matter to the oceans: the role of rivers. Lakes and oceans: biomass, nutrients, carbon, nitrogen and phosphorus cycles.
Geochimistry of the atmosphere: present-day composition and evolution of the primordial atmosphere.
Applications of geochemistry to the mitigation of volcanic risk.

Suggested textbooks: A. Longinelli, S. Deganello – Introduzione alla Geochimica – UTET; J.I. Drever –The Geochemistry of Natural Waters – Prentice-Hall.

Campagna geologica I
(Geological mapping I)
PROFF. MARCO MALUSA', EDUARDO GARZANTI E GIOVANNI VEZZOLI
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Geological mapping and application of field geology techniques in structurally simple settings, with exposures mainly consisting of sedimentary rocks, within the Alps-Apennines system and adjacent areas. Activities are carried out in small groups (maximum 10

students each teacher) over an 8 days period in the field. Maps and reports prepared by each student will be evaluated and eventually approved.

3° ANNO

Sedimentologia (8cfu)
(*Sedimentology*)
Prof. EDUARDO GARZANTI eduardo.garzanti@unimib.it
Prof. GIOVANNI VEZZOLI giovanni.vezzoli@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: SEDIMENTOLOGY **credits**: 8
Lecturer: GIOVANNI VEZZOLI and EDUARDO GARZANTI
Examination: Written examination + oral examination + written report.
Aims: Study of transport and sedimentation processes. formation and significance of sedimentary structures. Introduction to facies analysis.
Main topics: Sedimentation: processes and products. Textures and statistical parameters. Sphericity and roundness. Porosity. Cohesive and frictional sediments. Sediment transport: bed load and suspended load. Traction. Settling. Flow regimes. Stokes' law, Impact law and Hjulstrom's diagram. Bedding and bedforms. Sediment gravity flows. Interpretation of sedimentary structures. Current and wave ripples. Structures produced during settling in presence or absence of tractive effects. Tidal structures. Turbiditic currents and turbidites.
Facies analysis. Alluvial, lacustrine, aeolian, and deltaic environments. Coastal and continental shelf environments. Pelagic environments. Deep-sea fans.
Field work: Several daily excursions on the following subbjects: Permian and Triassic Verrucano and Servino Formations. Upper Triassic of Lombardy: a terrigenous/carbonate/evaporite coastal succession. Jurassic pelagic carbonate sequence of the Lombardy Basin. Cretaceous orogenic turbidites of the Lombardian “Flysch”. Terrigenous sediments of the Piedmont Tertiary Basin.
Laboratory: Description of sedimentary rock samples and introduction to the analysis of thin sections.

Geofisica (8 cfu)
(Geophysics)
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: Geophysics. **credits**: 5
Lecturer:
Examination:
Written and oral exam
Aims:
The student should acquire a knowledge of the geophyisical phenomena that are most relevant for environmental applications, with a specific emphasis on the shallow Earth’s subsurface.
Main topics:
Earth rotation and its variations. Earth shape. Gravitational field of the Earth. Geoid. Tides. Gravimetric surveys. Magnetic field of the Earth and its temporal variations. Solar wind. Elettro-magnetic induction. Geomagnetic surveys. Electric resistivity and conductivity. Fundamentals of geoelettric prospects. Seismic surveys. Equations of the elastic waves

(1D). Thermal properties of rocks. Thermal energy transfer in the soil. Geothermic surveys. Rock radioactivity. Equation of radioactive decay. Radioactive surveys. Seismology. Mechanisms for generation of earthquakes. Problem solving with practical applications in relation to the theoretical part of the course.

Learning outcomes

To quantitatively work on geodynamical projects and to understand the basic relevant literature.

Prerequisites

None (Physics course strongly recommended)

Geologia applicata (8 cfu)
(Basic Engineering Geology)
Prof. GIOVANNI CROSTA giovannibattista.crosta@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: ENGINEERING GEOLOGY credits: **8**

Lecturer: Giovanni CROSTA

Examination: written and oral

Aims:

To provide basic knowledge concerning: engineering geological problems under subaerial and subaqueous conditions; problems linked to engineering structures; the physical mechanical behaviour of soil, rock and rock masses and their characterization; in situ stress state and its changes; seepage; soil and rock stability.

Main topics:

Engineering Geology (8 CFU)

Theory: fields of interest; techniques and methods; engineering geological problems; hazard and risk concepts; geomaterials; principles of stress and deformation analysis; constitutive lawas, time/deformation models; rheological models. Physical properties of soil and rock and their technical classifications. In situ stress in geological media and their changes. Water seepage and its role on in situ stress and soil/rock stability. Consolidation and settlements. Mechanical properties of soils: compressibility, shear strength, in different stress and drainage conditions. Mechanical properties of intact rocks and rock masses: resistance, deformability. Lateral earth pressure: elastic and plastic soil stability; ultimate bearing capacity. Soil and rock behaviour under dynamic conditions.

Lab exercises: physical and mechanical properties of soil and rock; in situ stresses; seepage, flow nets; consolidation and settlement; earth pressure and bearing capacity

Laboratorio di Geotecnica (4 cfu)
(Geotechnics Lab)

Title of the course: GEOTECHNICAL TESTING credits: **4**

Lecturer:

Examination: written and oral

Aims:

To provide a clear understanding of the procedures, interpretation and theoretical principles of geotechnical and geomechanical tests.

Main topics:

Soil mechanics: soil mechanic introduction and classification methods. Working principles and training for using the available apparatus. Execution , elaboration and interpretation of the following tests: granulometric curve, Atterberg limit, permeability, oedometric, direct shear, triaxial compression and compaction tests.

Rock Mechanics: introduction to the Rock Mechanics and classification methods. Execution , elaboration and interpretation of the following tests: Point Load Test,, uniaxial compression and triaxial tests, direct and tensile tests; geometrical and mechanical characterization of discontinuities (JRC,JCS); shear tests on discontinuities.

Georisorse (4 cfu)
(Basics of Ore Geology, Industrial minerals and rocks)
Prof. FRANCO RODEGHIERO franco.rodeghiero@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: Basics of Ore Geology, Industrial Minerals and Rocks **credits**: 4
Lecturer: Franco Rodeghiero
Examination:
oral, with theorical questions, rock sample identification. Personal report on guided field tours.
Aims:
To gain the basic knowledge of the most important ore, industrial minerals and ornamental stones deposits. Practices are directed to identification of the main samples and to approach, through guided visit, a mining site or a processing plant.
Main topics:
Basic concepts about ore geology, raw mineral resources and their industrial uses.
The ore bodies: their shapes, attitudes and host rocks. Outlines of economics and of mining exploitation techniques. The sampling and assaying methods. The ornamental stones: their classification, petrography, physical and mechanical properties. Outlines on main technical tests and manufacturing. The rocks as raw materials for industry and building: binders, aggregates, materials for ceramics and refractories.
Practices on industrial minerals and ornamental stones samples identification. Technical visit to a quarry of industrial minerals or stones and to the International Ornamental Stones Exhibition of Verona.

Laboratorio di Georisorse (4 cfu)
(Methods for mining and quarrying)
Prof. FRANCO RODEGHIERO franco.rodeghiero@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course METHODS FOR MINING AND QUARRYING **credits**: 4
Lecturer: Franco Rodeghiero
Examination:
Oral, with theorical questions, submission and discussion of a personal report on the guided field tours.
Aims:
The rather large number of practical field works are devoted to gain a better knowledge of the attitude of the ore and exploitable rock bodies and to widening the knowledge of the most common and current mining exploitation techniques and of the main processing and production methods.
Main topics:
Basic concepts about the most important mining and quarrying exploitation methods, both in open pit and underground, about the use of the explosive and about the production methods of the ornamental stones.
The several, different in type and binding for examination practical field works will be dealing with the technical visits to exploitation sites, both in open pit and underground, of

geological bodies, which differ as regards their mineralogy, size and setting. A technical visit to a skilled Laboratory for physical and mechanical properties of the ornamental stones is also provided.

Geopedologia (4 cfu)
(*Geopedology*)
Prof. FRANCO PREVITALI franco.previtali@unimib.it
Dipartimento di Scienze dell'Ambiente e del Territorio
Piazza della Scienza, 1

Program:

Soil definitions and functions

Different meanings and definitions of soil. Main environmental and technical functions of soils. The soil as an environmental and productive resource. Historical background of pedology.

Soil description

The soil profile and its horizons. Field morphological description (horizon boundaries, colour, stones, texture, structure, concentrations, cutans, roots, pedofauna, etc.). Genetic horizons and their symbols.

Pedogenesis

Factors of soil formation: climate (moisture and temperature regimes), organisms (vegetation, pedofauna, man), geomorfology and topography, substratum and parental material, aging. Basic soil chemistry. Main pedogenic processes, particularly of the temperate climates. Pedogenic cycles of short (neosols) and long type (paleosols).

Soil classification

Characteristics of the main soil classification systems. Soil Taxonomy (1999) and World Reference Base (2006). Surface and subsurface diagnostic horizons.

Pedogeography

Main pedoclimatic soil types according to the WRB system. Main soil types of Lombardy: genesis, physico-chemical and morphological characters, distribution, uses and pedotechnical properties.

Practice

Field description of soil profiles and the related environments (2 field excursions).
Examples of soil classification according to the WRB system.

Campagna geologica II
(Geological mapping II)
Prof. ANDREA BISTACCHI Prof. ALESSANDRO TIBALDI Prof. ANDREA ZANCHI
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Analogamente al corso "Campagna Geologica I", le attività didattiche relative a questo insegnamento vengono svolte principalmente sul terreno. Il corso è finalizzato all'apprendimento di tecniche di rilevamento geologico più avanzate ed in particolare all'approfondimento di tematiche geologico-strutturali. Nel corso della campagna verrà affrontato il rilevamento di unità di qualsiasi tipo (basamento e/o copertura), caratterizzate da complesse deformazioni, situate in area alpina e/o appenninica. La campagna si sviluppa in un unico periodo di 8 giorni di terreno.
Per lo svolgimento di questa attività, gli studenti saranno divisi in piccoli gruppi (massimo 10 studenti), che lavoreranno sotto la guida di un docente che li seguirà durante il rilevamento.

Ogni studente deve produrre, alla fine della campagna, una relazione corredata da opportuna documentazione cartografica (carte e sezioni geologiche). L'esame consiste nella valutazione degli elaborati prodotti dallo studente e dà luogo ad un giudizio di approvazione.

Laboratorio SIT (4 cfu)
(GIS Lab)
Dott. PAOLO FRATTINI paolo.frattini@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: GIS LAB credits: **4**
Lecturer: Paolo FRATTINI
Examination: written and oral
Aims:
To provide basic knowledge on digital cartography and on the use of GIS systems for the analysis of territorial data.
Main topics
Theory: Introduction to digital cartography; differences with traditional cartography; topographic survey techniques with GPS and photogrammetry; Digital Terrain Model: production techniques and derived themes. Introduction to GIS: territorial data; RASTER and VECTOR formats, conversion techniques, informatization techniques, editing; generation and management of geographic databases; polygonal topologic structures; analysis functions: contiguity, overlay, proximity, selection, generalization.
Digital geological maps.
Lab exercises: data input and georeferencing; use of the main analysis function; use and analysis of DTM. Creation of a digital geological map.

Rilevamento geomorfologico in mare (4 cfu)
(Marine geomorphologic survey)
Prof. CESARE CORSELLI
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Examination: oral test
Aims: Basic knowledge of the marine domain and of the tools for its study.
Main topics:
Principles of Marine Geomorphology. The great morpho-structural units in the marine domain.
Sedimentation in the oceans.
Technologies for observation and sampling at sea.
Positioning and navigation.
Technologies for observations and measures.
Technologies for sampling: sea bottom, water column.
Underwater survey.

Texts: they will be indicated from the teacher at the beginning of the course.
Learning outcomes: ability to read bathymetric-morphological maps and basic knowledge of the main techniques which are used for the geomorphologic analysis of the marine domain.
Prerequisites: Exams of Physic and of Introduction to ocean geography

Introduzione alla geografia degli oceani (4 cfu)
(Introduction to ocean geography)
Prof. CESARE CORSELLI
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Examination: oral test
Aims: to provide the basic knowledge of the oceanic domain
Main topics:
Principles of marine ecology and paleoecology.
Introduction to the marine environment: physiographic and bathymetric classification; water masses classification.
Ecological factors: abiotic climatic factors; abiotic edaphic factors; biotic factors.
Organic matter in the marine environment: primary productivity, bio-geochemical fluxes, role of the sedimentary processes and effects of the bioturbation.
Learning outcomes: basic knowledge of the functioning of the different components in the marine systems.
Prerequisites: exam of Palaeontology
Texts: they will be indicated from the teacher at the beginning of the course.

Geologia del Quaternario (4 cfu)
(Geology of the Quaternary)

Title of the course: QUATERNARY GEOLOGY credits: 4
Lecturer:
Examination: oral
Aims:
to provide an in-depth understanding of the Quaternary, including the effects induced on the contemporary physical environment.
Main topics:
stratigraphy of the Quaternary. Paleoclimatology: the astronomic theory of past climate changes, sea level oscillations, climatic characteristics of the last glacial-interglacial transition and the corresponding climatostratigraphic subdivision. Lacustrine environments and deposits: lake, marsh, peat and relevant deposits. Sampling and probing techniques for lacustrine and marshy deposits. Glacial environments and deposits: classification and representation of glacial deposits, thermal classification of glaciers, ice flux, erosion, transport of subglacial deposits, deglaciation of a glacierized valley and glaciofluvial deposition. Paraglacial deposits. Periglacial and eolic environments: permafrost, periglacial landforms and deposits, loess. Colluvial deposits, soils and paleosols, the radiocarbon dating method.
Learning outcomes: to be able to interpret a formerly glaciated landscape.
Prerequisites: math: calculus, physics, principles of geology, sedimentology

LAUREA MAGISTRALE
IN
SCIENZE E TECNOLOGIE GEOLOGICHE
Geological Sciences and Technologies

Corso di laurea Magistrale in Scienze e Tecnologie Geologiche Classe LM-74

Geological Sciences and Technologies

ENGLISH PROGRAM 2008/2009

1° ANNO

Geologia dei bacini sedimentari (8 cfu)
(Geology of Sedimentary Basins)
Proff. EDUARDO GARZANTI E MARCO MALUSA'
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the cours: GEOLOGY OF SEDIMENTARY BASINS **credits**:8
Lecturer: EDUARDO GARZANTI
Examination: Written examination + oral examination + written report
Aims: Understanding largescale geological processes, the evolution of sewdimentary basins, and the formation of associated economic resources

Main topics:
Subsidence mechanisms. Classification of sedimentary basins. Principles of seismic and sequence stratigraphy. Divergent plate margins and associated sedimentary basins: active and passive rifts; the Red Sea - Gulf of Aden system; passive continental margins; intracratonic basins. Convergent plate margins and associated basins: arc-trench systems; subduction complexes; forearc, intra-arc, and back-arc basins. Obduction orogens. Collision orogens; foreland and retroarc basins; piggy-back basins; examples from the Himalayas, the Alps, and the Apennines. Transform plate margins and associated basins: strike-slip systems and pull-apart basins; examples from California and the Dead Sea.
Laboratory: Laboratory work will be dedicated to the geological interpretation of seismic reflection lines across different types of sedimentary basins, including passive and active continental margins.

Geodinamica e geologia strutturale 8 cfu
(*Geodynamics and structural geology*)
PROF. ANDREA ZANCHI
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Aims:
To introduce students to Plate Tectonics using a structural approach based on the analysis of tectonic structures occurring in different geodynamic environments. The main emphasis will be on active margins and orogenic belts. General principles and theoretical models will be discussed as well as several real examples chosen in the Alpino-Himalayan belts and in the Mediterranean region. The construction of complex geological cross sections will be the subject of practical activities.
Main topics:
Rocks rheology: elastic deformation, brittle and viscous behaviour and associated tectonic structures; lithosphere and astenosphere. Plate motions; continental break-up and ocean spreading; ocenic ridge and transform faults, subduction zones and accretionary wedges,

forearc and backarc basins; obduction and continental collision, intracontinental transform faults; continental indentation and post-orogenic extension.
The construction of complex geological sections related to different deformational environments will be carried out during practical activities through advanced geometrical techniques, including retrodeformation. A three-days field excursion in the Alps will be held at the end of the course

Learning outcomes

Capacity of describing and understanding the geodynamic environment, through the analysis of tectonic structures. Ability in constructing complex cross sections using advanced geometrical techniques and specific software.

Prerequisites

Fundamentals of structural geology and of tectonic structure. Fundamentals of Plate Tectonics and of Petrology. Use of specific software in a windows environment

Idrogeologia generale e Idrogeologia applicata (12 cfu)
(*Hidrogeology and applied hydrogeology)*
Proff. GIOVANNI CROSTA e Dott. PAOLO FRATTINI
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: HYDROGEOLOGY AND APPLIED HYDROGEOLOGY credits: 12
Lecturer: Giovanni CROSTA
Examination: oral
Aims:
To provide advanced knowledge and modelling techniques for: the identification and characterization of aquifers, the laws that govern groundwater flow, the contaminant migration and solute transport; the hydrogeological investigations.
Main topics:
Hydrogeology (8 CFU)
Theory: Hydrologic cycle and water circulation in different geological systems. Hydrogeological balance: rainfall, temperature, real and potential evapotraspiration. Fluid flow in saturated and unsaturated soil, porous rocks or jointed rocks. Reconstruction and interpretation of piezometric surfaces. Classification and analysis of springs. Well design and installation. Monitoring and interpretation of well hydraulic testing and pumping tests. Well sampling. Applying site characterization to model development. Solute transport and contaminant migration in saturated and unsaturated soils. Multi-fluid processes.
Lab exercises: Flow net construction, simple solution of water flow in porous media, interpretation of well tests.

Applied Hydrogeology (4 CFU)
Theory: Interaction between soil matrix and solutes. Transformation, attenuation and decay processes of solutes. Biodegradation: theory, in situ extimation, and modelling. Organic and inorganic compound in subsurface water. Treatments at contaminated sistes. Risk analysis for soil and water contamination. Reference legislation: regional, national and european laws for surficial and subsurface water.
Lab exercises: design of a reclamation scheme for different contaminated sites.

Prospezioni geofisiche (8 cfu)
(*Geophysical Prospecting*)

Title of the course: Geophysical prospecting **credits**: **8**

Lecturer: Roberto de Franco
Examination: Home exercises, oral examination. The oral examination is subjected to the execution and presentation of the home exercises.
Aims:
Providing the basic knowledge and tools for the interpretation of seismic refraction data and geo-electrical data.
Main topics:
Introduction to geophysical data inversion. Basics of the geophysical prospecting techniques and their physical basic principles. Introduction tothe geophysical signal. Introduction to seismic processing. Propagation of seismic waves. General information on seismic method. Seismic refraction method. Seismic reflection method. Trasmission Seismic tomography. Theory of geo-electrical methods. Vertical Electrical surveys, horizontal electrical surveys, electrical resistivity tomography. Inversion and interpretation of geo-electrical data. Basics in gravimetric, geomagnetic and electromagnetic and radar methods. Acquisition protocols and acquisition logistic for seismic refraction technique and geo-electrical technique.
Learning outcomes
Ability in the acquisition and interpretation of the seismic refraction and geo-electrical data.
Prerequisites
Basics of mechanics and electromagnetism.

Metodi di indagine geologico-tecnica (8 cfu)
(Engineering geological survey)
Dott. AGLIARDI FEDERICO *federico.agliardi@unimib.it*
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Examination: oral
Aims:
To provide an advanced knowledge on the collection, representation and analysis of geological and geomechanical field data for the characterization of soil and rock masses and their physical and mechanics parameters.
Main topics:
Theory: Planning and management of an engineering geological field survey Technical standards of field investigation of soils and rocks. Sampling principles: techniques, errors, analysis, corrections.
Engineering geological survey: characterization of soil, rock and rock mass. Engineering geological classification (soil: AASHTO, USCS; rock mass: SRS, RMR, SMR, Q-system, GSI).
Borehole survey: sampling methods and reconstruction of a lithostratigraphic profile; borehole logging; drilling techniques; penetrometric tests; electric Soundings; seismic profiles.
Basic and advanced principles, and use of stereographical projections. Finding the orientation data for discontinuity sets, rotation of poles and planes, inclined emispherical projections.
Lab exercises: techniques for engineering geological classification; stereographical projections.
Field activity: field description of soil and rock mass; borehole survey.

Geomorfologia applicata e stabilità dei versanti (8 cfu)
(Applied geomorphologyc and slope stability)
Prof. GIOVANNI CROSTA e Dott. FEDERICO AGLIARDI

Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: APPLIED GEOMORPHOLOGY AND SLOPE STABILITY credits: **8**
Lecturer: Giovanni B. CROSTA
Examination: oral
Aims:
To reach a general understanding of slope processes, data collection and site investigation, slope hydrology and slope stability both in soil and rock materials.
Main topics:
The slope system and its relationships with the hydrologic network. Review of fundamentals of alteration and weathering. Soil erosion: controlling factors, description and simple methods for quantification. Slope hydrological cycle: subsurficial and deep water cycle, infiltration, and change in the degree of saturation. Runoff computation, hydrograms and base flow.
Recognition and investigation of slope instabilities. Investigations by in situ and remote techniques. Groundwater in hillslope processes: monitoring and modelling for slope stability analysis. General review of soil and rock properties. Slope stability analysis in soil and rock materials. Limit equilibrium and numerical methods. Role of vegetation. Long runout processes. Monitoring techniques and use of data for warning systems.
Lab exercises: use of softwares for slope stability analyses

Valutazione dei rischi geologici (4 cfu)
(Assessment of geological risks)
Dott. FRATTINI PAOLO *paolo.frattini@unimib.it*
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: ASSESSMENT OF GEOLOGICAL RISKS credits: **4**
Lecturer: Paolo FRATTINI
Examination: oral
Aims:
To give a general view of criteria and strategies for the analysis and the assessment of the different geological risks, both natural and Man induced.
Main topics:
Natural (geological) hazards: ground movements (landslides, subsidence); snow avalanches; soil and coasts erosions; flooding; seismic activity; volcanic activity; tsunami.
Man induced hazards: ground movements (slope failures, earth dumping; surface and subsurface excavations; accelerated subsidence); contamination.
Definition of risk parameters: intensity, hazard, elements at risk, vulnerability, value of the elements at risk, specific risk, total risk. Acceptable risk.
Criteria and strategies for risk assessment: empirical, statistical and mathematical models.
Criteria and strategies for risk mitigation: prevision, prevention, land planning, reconstruction and rehabilitation.
General criteria and techniques for monitoring.

Statistica (4cfu)
(Statistical Methods)
Prof. GIANMARIO TESSITORE
Dipartimento di Scienze Ambientali
Piazza della Scienza, 1

Title of the course: Statisitics **credits**: 4

Lecturer: Gianmario Tessitore
Examination: written
Aims: Give the fundamental tools of statistical data analysis and of hypothesis testing
Main topics*:* Descriptive statistics. Notes on probability theory . Basics ideas of Statistical estimation theory: confidence intervals, testing Statistical hypotheses.. Notes on linear regression.
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Testi consigliati: verranno indicati dal docente all'inizio del corso.

Applicazioni di Geobiologia (12 cfu)
(*Geobiology*)
Prof. CESARE CORSELLI – Prof. DANIELA BASSO
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Il corso si articola in tre moduli:
***First module* - Paleoecology and geobiobiology (cfu)** Prof. CESARE CORSELLI
cesare.corselli@unimib.it
Examination: oral test
Aims: Deep knowledge aimed to characterize the biocoenosis and the biotopes in the Mediterranean sea and the oceans.
Main topics:
Biotopes and marine associations: application to geobiology. Biotope: definition and characterization. Biocoenosis: definition and characterization. The Mediterranean benthic bionomy as a template for other seas. Community: definition and characterization. Major marine benthic communities. Comparison between community and biocoenosis. Criteria for cursory identification. Application to the fossil record with selected case histories. Statistical methods in geobiology: univariate, bivariate and multivariate analyses.
Learning outcomes: Ability to plan proper analysis of the present and past marine environments.
Prerequisites: Exams of Introduction to the geography of the oceans and Palaeontology or Zoology.

Second module - Paleoecologia dei sistemi bentonici (4 cfu)
(Benthic paleoecology)
Prof. DANIELA BASSO daniela.basso@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

The benthos in historical geology. Biogenic calcification and processes of bio-mineralization. Evolution of reef builders along the Phanerozoic. Living builders, biological associations, ecological factors of control and distribution. Diagnostic criteria, ecological significance and distribution of the major benthic associations and related sediments. Applied marine Paleoecology: principles, aims and methods

Third module: Plankton paleoecology (4cfu)
Lecturer: Prof. Daniela Basso
Examination: practical test and oral examination

Aims: knowledge of the taxonomy and ecological characterization of the main phytoplankton taxa, for their application in micropalaeontology and paleoceanography
Main topics:

Marine plankton. Elements of taxonomy for the recognition of the main phytoplanktonic and zooplanktonic groups (calcareous nannofossils, diatoms, silicoflagellates, dinoflagellates, plankton foraminifera, radiolarians), ecological characterization and applications in paleoceanography.
Biostratigraphy: bases and examples from Italian stratigraphic sections.
Ecobiostratigraphy: concepts and examples.

Learning outcomes: Ability in the recognition of biozones and in the use of planktonic remains for paleoceanographic reconstructions.

Prerequisites: Exams of Introduction to the geography of the oceans and Palaeontology or Zoology.
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Suggested text-book: documents will be provided by the teacher.

Geomorfologia marina (8cfu)
(Marine geomorphology
Prof. CESARE CORSELLI cesare.corselli@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course Marine geomorphology credits: 8
Lecturer: Prof. Cesare Corselli
Examination: oral test
Aims: delving into the main issues concerning the marine geomorphology of the coastal and deep water systems.
Main topics:
Marine geomorphology of the coastal system (4 cfu): Land-sea interaction, integrated coastal zone management, detailed analysis and peculiar features of beaches, harbours, land accesses of pipelines, marine protected areas, laying of pipelines and cables. Advanced study of the state of the Italian and Mediterranean coasts.
Marine geomorphology of the deep systems (4 cfu): Continental margins: geosphere, biosphere and hydrosphere interactions. Sedimentary processes along the continental margins. Morphological expression of: mud-volcanoes, pockmarks, hydrothermal vents and cold seeps, cold water coral reefs, carbonate mounds and seamounts.

Learning outcomes: Ability to recognize the main geomorphological aspects related to different processes acting on the shelf, the slope and the abyssal plains.

Prerequisites: Exams of Introduction to Ocean Geography and Geology of sedimentary basins.

Laboratorio di Geomorfologia Marina (8 cfu)
(Marine geology lab)

Title of the course: Laboratory of marine geomorphology credits: 8
Lecturer: Prof. Cesare Corselli
Examination: written and oral examination

Aims: Ability to use proper tools for the acquisition and processing of electromagnetic, acoustic and seismic data.
Main topics:

Data acquisition on board an oceanographic vessel (**4cfu**).
Processing and analysis of electromagnetic and acoustic data acquired within coastal environments and their interpretation. (aerial photos, satellite images, bathymetric data, side scan sonar and sub-bottom profiles). Processing and analysis of water column profiles and their interpretation.

Seafloor mapping of the main benthic biocoenosis and their morphological characterization.
Production of thematic maps and territorial information systems in marine environments. (**4cfu**).

Learning outcomes: Ability to carry out marine surveys and to process the acquired data.

Prerequisites: Exam of Marine Geomorphology
Text-books: they will be suggested by the teacher during the course.

Ecologia dei sistemi acquatici (8 cfu)
(Ecology of aquatic systems)

Il corso consiste di due moduli:
Idrobiologia e Pescicoltura (4 cfu)
(Hydrobiology)
Part 1: Freshwater ecology: This introductory course aims at providing the students with the basic knowledge of the structure and the functioning of freshwater ecosystems. The abiotic (physical and chemical)characteristics of lakes and rivers, as well as the qualitative and quantitative composition of the different biological communities are reviewed. Major attention is paid to the materials budget of the inland waters and on the interactions between the living and non-living components. The practical training includes qualitative and quantitative microscopial analysis of the major biological communities living in freshwater ecosystems (phyto- and zooplankton, periphyton, macrobenthos). Marine ecology This course aims at describing and illustrating the fundamental concepts and general processes governing marine ecosystems. In the theoretical course, the interactions between the abiotic factors and the structure and function of marine ecosystems are reviewed in detail. The practicals on the other hand are focussing on the systematics and auto- and synecology of the different groups of marine organisms. The practical exercises are supported by field excursions and case studies. The integration of the theoretical and practical aspects of marine ecology give the student an in-depth, experience-oriented knowledge of this scientific field.

• **Part 1**: Freshwater ecology
• Distribution, age and genesis of inland waters
• Structure and physical properties of water
• Physical relationships in natural water bodies
• Radiation climate
• Heat balance of water bodies
• Water movement and exchange in natural waters
• Chemical properties of water
• Dissolved gases and solids
• Organic solutes in natural waters
• Associations of living organisms in inland waters
• Lakes, ponds, bogs

• Flowing waters
• Materials budget of inland waters
• Production
• Consumption
• Destruction and the role of bacteria
• Materials transport and energy flux in aquatic ecosystems
• General characteristics of the marine environment
• Zonations in the marine environment
• Physical factors
• Chemical factors
• Systematics of marine organisms
• Ecology of pelagic communities
• Ecology of benthic communities
• Synecology of the benthos
• Productivity of marine systems
• Explotation of marine systems - fisheries and aquaculture

Analisi e gestione delle biocenosi acquatiche (4cfu)
(Analysis and management of aquatic biocoenoses)

A study of the interrelationships among animals, plants, and physical and chemical aspects of the marine environment with an emphasis on management of aquatic biocenosis.
Arguably, the most significant issue we are now facing is environmental degradation. The intensive utilization of our natural resources in a non-sustainable manner has contributed to environmental deterioration at a global scale. Because coastal and marine habitats are affected directly or indirectly by many of these human activities, this course has a strong environmental science and policy component that will underscore most of our discussions, assignments, and exams. Unlike a traditional marine ecology course, our focus will include the impact of anthropogenic activities on coastal and oceanic systems. This course will also explore potential strategies that allow humans to use marine resources in a sustainable manner. We will initially focus on selected marine systems (e.g., coastal areas, coral reefs, deep sea, etc.) in order to explore various natural factors that affect marine biodiversity. We will then consider the role of human disturbances and their effects of these systems. Finally, we will briefly discuss various case studies as examples of the successful management strategies being implemented. One of our goals is to familiarize you with some of the scientific concepts studied by marine ecology as a discipline. In addition, and as important, is our goal to help you develop vital skills such as effective oral and written communication, critical thinking, and problem solving. We will emphasize graphical representations and quantitative skills.

Tettonica attiva e vulcanotettonica (8 cfu)
(Active tectonics and volcanotectonics)
Prof. ALESSANDRO TIBALDI alessandro.tibaldi@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: Active tectonics and volcanotectonics **credits**: 8
Lecturer: Prof. Alessandro Tibaldi
Examination: oral
Aims: Explaining methods of geological-structural analysis for the recognition of recent and active tectonic deformations, and for the analysis of the structures in volcanic areas.

Main topics: I modulus - Active tectonics: geology of earthquakes; geologically active and seismogenetic structures; geological-structural and morphostructural analyses for recognizing active faults and folds; measure of the offset along active faults; dislocation rate; relationships between surface rupture length, magnitude, dislocation; influence of the topography on the dislocations; measures of stress orientation; palaeoseismologic techniques; evaluation of geological hazard; examples of study.
II modulus - Volcanotectonics: deformations of volcanic areas; calderas; lateral collapses; tectonic stress and volcano morphometry; rheology of lava flows and pyroclastic deposits and correlated structures; volcanism in areas of transcurrent, normal, and reverse faulting; subvolcanic bodies; contribution for the evaluation of the geological hazard; examples of study.

Suggested texts

Texts will be indicated at the course beginning.

Geologia del vulcanico (8 cfu)
(Volcano Geology)
Prof. GIANLUCA GROPPELLI
Istituto per la Dinamica dei Processi Ambientali - CNR

Aims:
To give a theoretical and practical grounding in a geological and structural study of a volcanic areas.

Main topics:
Background about volcanoes with some indications of volcanology.
Geological mapping and geology of volcanic areas at different scales. During the course, different field survey methodologies are discussed, and geological maps with different representation approaches are shown.
Study of the structures characterizing volcanic areas: structures linked to the volcanic dynamics, magma intrusion, and regional tectonics. Relationship between the evolution of a volcanic area and the changes in regional stress. Lateral collapses are examined using analogue and numerical modelling. Role of active structures in volcanic instability.
Geological maps as tools for the hazard assessment in volcanic areas.
4 days compulsory field trip.

Geologia Stratigrafica e Regionale (8 cfu)
(Advanced Stratigraphy and Regional Geology)
Dott. MARCO MALUSA' e Prof. EDUARDO GARZANTI
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: ADVANCED STRATIGRAPHY AND REGIONAL GEOLOGY
credits:8
Lecturer: MARCO MALUSA' ed EDUARDO GARZANTI
Examination: Written + oral examination + written report
Aims: Integrated analysis of orogenic belts and associated sedimentary basins, geology of Italy, Alps and Apennines.
Main topics:
First part (Advanced stratigraphy): Sequence stratigraphy. Geohistory diagrams and basin analysis. Stratigraphic and geodynamic evolution of the Southern Alps. *Field work*: Daily excursions on the following themes: Early Permian tectono-magmatic event; Mid-Triassic tectono-magmatic cycle; Rifting and spreading of Alpine Tethys. ***Second part (Regional Geology):*** Geology and geodynamic evolution of the Alpine orogen. Main

paleogeographic domains and their classical stratigraphic successions. Metamorphic zoneography. History of Alpine geology, from pioneers to the advent of global tectonics. Modern tectonic interpretations as constrained by deep geophysical and surficial stratigraphic evidence. Exhumation of the Alpine belt and the sedimentary record of foreland basins. Evolution of the Alps-Apennines system in the framework of Mediterranean geology. *Field work*: Field excursion of several days on the Alps-Apennines system.

Testi di riferimento:

Guide Geologiche Regionali, B.E.M.A. Editrice, Volume 1: Alpi e Prealpi Lombarde (Cita M.B., Gelati R. & Gregnanin A., 1991); Volume 2 : Alpi Liguri (Vanossi M., 1991); Volume 6: Appennino ligure-emiliano (Zanzucchi G., ed., 1994).

Miall A.D., 1997, The geology of stratigraphic sequences, Springer Verlag.

Wilgus et al., 1988. Sea-level changes: an integrated approach. S.E.P.M. Spec. Publ. 42.

Articoli di riferimento (Geologia Stratigrafica) :

Bosellini A., Winterer E.L., 1981, Subsidence and sedimentation on Jurassic passive continental margin, Southern Alps, Italy, *Am. Ass. Petrol. Geol. Bulletin,* v. 65, p. 394-421.

Bosellini A.,1984, Progradation geometries of carbonate platforms: examples from the Triassic of the Dolomites, northern Italy, Sedimentology, v. 31, p. 1-24.

Gaetani M., Gnaccolini M., Jadoul F. & Garzanti E., 1998, Multiorder sequence stratigraphy in the Triassic System of the Western Southern Alps. In : Mesozoic and Cenozoic sequence stratigraphy of European Basins, S.E.P.M. Spec. Publ. 60, p. 701-717, Tulsa.

Muttoni G, Erba E, Kent DV, Bachtadse V., 2005, Mesozoic Alpine facies deposition as a result of past latitudinal plate motion, Nature, v. 434, p. 59-63.

Muttoni, G., Kent D.V., Garzanti, E., Brack, P., Abrahamsen, N., and Gaetani M., 2003, The mid-Permian revolution from Pangea 'B' to Pangea 'A', Earth Planet. Sci. Lett., v. 215, p. 379-394.

Articoli di riferimento (Geologia Regionale) :

Dal Piaz G.B, Dal Piaz G.V., 1981, Sviluppo delle concezioni faldistiche nell'interpretazione tettonica delle Alpi. In: Cento anni di geologia italiana, Società Geologica Italiana, p. 41-70.

Dal Piaz G.V., Gosso G., 1981, Le moderne interpretazioni tettoniche delle Alpi. In: Cento anni di geologia italiana, Società Geologica Italiana, p. 95-112.

Scrocca D., Doglioni C., Innocenti F., 2003, Vincoli per una interpretazione della geodinamica italiana: una revisione. Mem. Descr. Carta Geol. d'It., LXII, p. 15-46.

Bernabini M., Nicolich R., Polino R., 2003, Le linee sismiche CROP-ECORS attraverso le Alpi Occidentali. Mem. Descr. Carta Geol. d'It., LXII, p. 89-96.

Montrasio A. , Nicolich R. , Sciesa E. , 2003, Il profilo CROP Alpi Centrali. Mem. Descr. Carta Geol. d'It., LXII, p. 96-106.

Laboratorio di Geologia Strutturale (4 cfu)
(Structural Geology Lab)
Prof. ANDREA BISTACCHI andrea.bistacchi@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: **Structural Geology Lab** credits: 4
Lecturer: Andrea Bistacchi
Examination: presentation of a report
Aims: To carry out practical exercises regarding structural data collection in the field and in labs and the integrated analysis of structural data.

Main topics: The following activities will be carried out in two different modules, regarding different case studies, simulating all the phases of an up-to-date structural geology project. (1) Definition of geological, structural and tectonic setting; (2) support data acquisition and database design; (3) field survey: geological mapping, collection of structural data and oriented samples, detailed surveys, etc.; (4) database implementation and data output; (5) microstructural analysis; (6) other lab analyses; (7) data analysis with stereoplots, orientation statistics, cross-sections, deformation phases characterization; (8) discussion and conclusion

Chimica Fisica (4 cfu)
(Physical Chemistry)
Prof. GIORGIO MORO giorgio.moro@unimib.it
Dipartimento di Scienze Biologiche e Biotecnologie
Piazza della Scienza, 3

To provide the student the basic instruments of thermodynamics and kinetics for the understanding and modelling of chemical systems and processes
Thermodynamics. ***Energy and I law.*** Heat measure as a state variable. Enthalpy. Thermal capacity. ***Entropy, II and III law***. Spontaneous processes. Entropy and spontaneity. Examples of spontaneous processes. ***Free energy and equilibrium***. Gibbs free energy. ΔG and spontaneity. Chemical potential. Equilibrium constant; variation of standard free energy; temperature dependence of ΔG and K. Chemical equilibria in biological systems.
Kinetics and reaction mechanism of discontinuous reactions. Kinetic equations. Experimental determination of reaction order. Elementary steps and reaction mechanism. Temperature dependence of velocity constant. Enzymatic catalysis and inhibition processe

2° ANNO

Georisorse minerarie e lapidei - (8 cfu)
(*Earth resources: industrial minerals and rocks)*
Prof. RODEGHIERO FRANCO *franco.rodeghiero@unimib.it*
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: Earth resources: industrial minerals and rocks
Lecturer: Franco Rodeghiero
Examination:
Oral, with theorical questions, interpretation of thematical maps, rock sample identification. Personal report on guided field tours.
Aims:
To widen the knowledge of different types of ore deposits and of the ornamental stones. Practical field works to acquire a more in-depth approach of selected ore deposits and of exploitable rock bodies.
Main topics:
The ore geology: the nature, the mineralogy and the morphology of the principal types of ore deposits. A review of the main processes and geological environments concerning the major theories of ore genesis.
Textures and structures of ore and gangue minerals. Types of wall rock alteration.
Practices on mining and metallogenic maps reading.
Outline of the main Italian ornamental stones.

Practical field works, with geological and technical observations, through some visits to mining works at the surface and underground.

Introduzione alla Meccanica del continuo (4 cfu)
(Introduction to continuum mechanics)

Il corso intende fornire le conoscenze di base della meccanica dei continui necessarie per un'adeguata modellazione dei geomateriali (mezzi bifase e trifase). Come tale è da ritenersi propedeutico al corso di Laboratorio di Modellistica.
Il corso si articolerà nei seguenti punti:
1) Introduzione: i geomateriali come più continui sovrapposti (solido, liquido e gassoso)
2) Definizioni delle grandezze tensoriali relative ad un mezzo continuo: il tetraedro di Cauchy
3) Cenni all'algebra tensoriale.
4) Continuo solido: equazioni indefinite: i) equilibrio, ii) congruenza, iii) legame costitutivo; analisi dei modelli costitutivi per geomateriali.
5) Continuo fluido (e gassoso): equazioni indefinite: i) legge di Darcy, ii) equazione di continuità, (leggi dei gas).
6) I geomateriali come mezzo poroso saturo: interazione tra scheletro solido (continuo solido) e fluido interstiziale (continuo liquido): le equazioni del problema geotecnico in quiete, in regime stazionario ed in regime transitorio.
7) I geomateriali come mezzo poroso non saturo: interazione dei 3 continui sovrapposti (Formulazione di Biot)
8) Problemi accoppiati: effetto della temperatura e delle reazioni chimiche; formulazione di modelli termo-idro-chemo-meccanici; equazioni di trasporto di contaminante reattivo in un mezzo poroso
9) Formulazione di un problema al contorno: dominio, condizioni al contorno e condizioni iniziali; cenni a soluzioni analitiche di problemi semplici
10) Intergrazioni approssimata di un problema al contorno mediante il metodo degli elementi finiti e delle differenze finite
11) Cenni alla formulazione dinamica del problema geotecnico (terremoti e liquefazione).

Laboratorio di modellistica applicata (8 cfu)
(Numerical Modelling Lab)
Prof. GIOVANNI B. CROSTA, Dott. FEDERICO AGLIARDI e PAOLO FRATTINI
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: Numerical modelling lab credits: 5
Lecturer: Giovanni B. Crosta
Examination: written and oral
Aims:
Familiarize students with fundamental techniques and tools applied to modelling geological and engineering geological problems, groundwater flow and soil-rock mechanics problems.
Main topics:
General review of geological and engineering geological problems, physics and mechanics applied to geology, and fundamentals of numerical models. Use of general purpose computational tools (e.g. Excel, Matlab), and advanced modelling tools for groundwater and soil-rock mechanics problems. Examples for groundwater flow and solute transport,

slope stability in continuous and discontinuous media, superficial and underground excavations. Comparison of analytical and numerical models.

Geocronologia e archeometria (8 cfu)
(Geochronology and Archeometry)
Prof. IGOR VILLA *igor.villa@unimb.it*
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

The course will deal with the main dating methods relevant for geological and archeological research.
Isotopic geochronology: radioactive decay. The age equation. Rb-Sr, Sm-Nd, U-Pb, K-Ar and 39Ar-40Ar methods. Statistical and systematic errors. Isotope geochemistry of Sr, Nd, Pb. Applications of isotopic geochemistry to studies on provenance of sediments and archeological objects.
Quaternary geochronology: radiocarbon, uranium series disequilibrium, fission tracks, thermoluminescence, dendrochronology. Other non-isotopic direct and indirect dating methods.
Stable isotope fractionation: deuterium, carbon, oxygen, heavy elements.

Suggested textbooks: G. Faure – Principles of Isotope Geology – Wiley; M. Walker – Quaternary Dating Methods - Wiley.

Laboratorio di Geobiologia (4 cfu)
(Geobiology lab)
Prof. DANIELA BASSO daniela.basso@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Sampling strategies and techniques, laboratory techniques and analyses for the study of marine and transitional biocoenoses, dead and fossil assemblages. The effects of biostratinomy on shelled macrobenthos. Multivariate statistical analysis in paleoecology. Examples of applied marine paleoecology. Microfacies analysis.
Suggested text-book: documents will be provided by the teacher.

Petrologia (8 cfu)
(Petrology)
Prof. ANNALISA TUNESI annalisa.tunesi@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Aims: *(2 lines)*
The petrogenesys of igneous, metamorphic or sedimentary rocks of some regions of the Alps. This study involves a combination of mineralogical, chemical and field data.

Main topics: *(8 lines)*
Chemical dynamics of melts and crystals: viscosity. Kinetics paths and fabric of magmatic rocks. Magma ascent and emplacement: field relations of intrusions.
The trace elements, isotopes as petrogenetic and geodinamic indicators.
The metamorphic reactions: dehydration and decarbonization reactions. Metamorphism of ultramafic rocks, dolomites and limestones. Phase diagrams. The phase rule.
Geothermobarometry. P-T-t paths and reaction hystory. Petrophysics: deformation of rocks. Stress

and strain. Continuous and discontinuos deformation. Planar and linear textures.Crenulation and fracture cleavage. Microstructure.

Il corso si articola in una serie di lezioni teoriche in aula per complessive 48 ore (gli argomenti sono sotto elencati). A conclusione del corso, verrà effettuata una escursione di tre giorni sui basamenti cristallini delle Alpi occidentali.
Il corso approfondisce le tematiche affrontate nel corso di Petrografia. Particolare attenzione viene rivolta allo studio microstrutturale e del comportamento reologico di rocce magmatiche e metamorfiche.
Magmatismo. Fusione parziale nel mantello superiore. Fusione parziale nella crosta continentale. Segregazione e risalita dei magmi. Classificazione delle rocce magmatiche attraverso lo studio dei diagrammi di variazione chimica. Cristallizzazione: rapporti tra nucleazione e crescita. Caratteristiche geochimiche ed isotopiche delle rocce magmatiche come indicatori petrogenetici.
Metamorfismo. Questa parte di corso prosegue lo studio delle rocce metamorfiche al fine di fornire allo studente una base solida per la comprensione delle associazioni di minerali e tessiture delle rocce metamorfiche. Fattori di controllo e meccanismi del metamorfismo. Le reazioni metamorfiche: reazioni di deidratazione e di decarbonatazione. Metamorfismo di rocce ultramafiche. Metamorfismo di rocce carbonatiche. Rappresentazione grafica: costruzione di diagrammi di fase per sistemi multicomponenti. Uso dei geotermobarometri. Traiettorie P-T-t per la comprensione dell'evoluzione geodinamica di una catena.

Testi consigliati
K. Bucher & M. Frey, 1994: *Petrogenesis of Metamorphic Rocks*. Springer- Verlag. Berlin.
Myron G. Best & Erich H Christiansen, 2001. *Igneous Petrology*. Blackwell Science, Inc., USA
Wilson M., 1989. *Igneous petrogenesis. A global tectonic approach*. Chapman & Hall, London.
Hall A., 1991. *Igneous Petrology*. Longman Scientific & Technical, John Wiley & Sons, New York.
Nicholas A., 1986. *Principles of rock deformation*. Reidel Publishing Company Dordrecht.
Yardley B.W.D., 1989. *An Introduction to Metamorphic Petrology*. Longman Earth Science Series.
Approfondimenti e letture
Hess, Paul C. *Origins of Igneous Rocks*. Harvard University Press
Philpotts, Anthony R., 1990. *Petrography of Igneous & Metamorphic Rocks*. Prentice Hall.
Faure, G., 2001. *Origin of Igneous Rocks. The Isotopic Evidence*. Springer-Verlag Heidelberg.

Paleoclimatologia (4 cfu)
(Paleoclimatology)
Prof. CESARE CORSELLI cesare.corselli@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

The climate system: the components of the system, annual, interannual and decadal climate variability, teleconnections.
Mechanisms that control global scale climatic variations: astronomical, geological and geographic factors, human impact.
The impact of climate change on marine and terrestrial ecosystems.
Chronology: dating methods in paleoclimatic studies.

Paleoclimatic proxies in the marine, terrestrial and glacial environment: applications and case studies. Climate evolution in the geological past: greenhouse and icehouse states, climate fluctuations in the Pleistocene and Holocene, some case studies. Man and climate: effects and interactions, from prehistoric cultures to the present-day.

Testi consigliati: verranno indicati dal docente all'inizio del corso.

Sedimentologia applicata (4 cfu)
(Applied Sedimentology)
Dott. GIOVANNI VEZZOLI giovanni.vezzoli@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: APPLIED SEDIMENTOLOGY credits: 4
Lecturer: GIOVANNI VEZZOLI
Examination: ORAL EXAMINATIONS
Aims: (2 lines)
FACIES ANALYSIS. DEPOSITIONAL SYSTEMS. EROSION RATES. SEDIMENT LOAD. SEDIMENTARY BUDGET. CATASTROPHIC EVENT. COASTAL EROSION.

Main topics: (8 lines)
Facies analysis. Meandering river, and braided river. Delta. Coastal environment. Continental shelf and deep sea. Turbidity current and sediments. Dynamic of the sedimentary succession. Sea level change: Cause and effect. Depositional systems. Dynamic fluvial processes. Stream corridor restoration. Erosion rate and sediment load. Suspended load and bedload. Sediment yield. Sedimentary budget. Dynamic coastal processes, coastal erosion. Coastal management.

Field: Field Excursion to the Bocca di Magra Basin and Arno Delta, (Italy). Field Excursion to the Po Delta, (Italy). Field Excursion to the Venice lagoon, (Italy). Field Excursion to the Nile Delta, (Egypt). This exscursion consists of four days of field-based activities focused on fluvial and coastal erosion. Sedimentation and subsidence. Environmental problems.

Learning outcomes
To learn the various methods to quantify river sediment load; to quantify erosion rate and sediment budget in river catchments; to quantify coastal erosion.

Prerequisites
Sedimentology. Sedimentary processes and structures.

Laboratorio di Sedimentologia (4 cfu)
(Methods in Sedimentary Geology)
Prof. GIOVANNI VEZZOLI giovanni.vezzoli@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: METHODS IN SEDIMENTARY GEOLOGY **credits**: 4
Lecturer: Prof. GIOVANNI VEZZOLI
Examination: ORAL
Aims:
Introduction to most commoly used laboratory methods in sedimentology, stratigraphy and sedimentary petrology.

Main topics:
Methods in Sedimentary Geology. Description of sediments and sedimentary rocks in the field. Measurement of stratigraphic sections. Sampling criteria. Treatment of loose and consolidated samples in the laboratory. Quartering and separation techniques. Grain size analysis. Determination of the carbonate fraction. Presentation of results and interpretation. Major components of clastic sediments and sedimentary rocks. Intrabasinal and extrabasinal grains. Carbonate sediments and carbonate rocks: textures, textural and compositional classifications, microfacies, environmental diagnosis. Terrigenous sediments and terrigenous rocks: textures, compositional classification, provenance diagnosis. Heavy minerals as natural tracers of sedimentary transport. Introduction to diagenetic transformation of carbonates, sandstones, and clays.

Petrografia del Sedimentario (4 cfu)
(Sedimentary Petrology)
Prof. EDUARDO GARZANTI eduardo.garzanti@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: SEDIMENTARY PETROLOGY credits: 4
Lecturer: Prof. EDUARDO GARZANTI
Examination: ORAL
Aims: To understand and the characteristics of source area from measurement of compositional and textural properties of sediment..
Main topics:
Description of sediments and sedimentary rocks: provenance, chemical weathering, hydraulic sortings, diagenesis. Bulk petrography and provenance models. Heavy minerals. Geochemistry of the clastic sediments. Geochronology of the detrital minerals. Fission track analysis. Tectonic and sedimentation.
Factors controlling exhumation in several geodynamic settings. Erosion and sediment budget. Compositional data and linear mixing model. Triangular plot, confidence and predictive region. Similarity analysis in provenance diagnosis.

Modellazione Geologica 3D (4 cfu)
(3D Geomodelling)
Prof. ANDREA BISTACCHI andrea.bistacchi@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: 3D Geomodelling credits: 4
Lecturer: Andrea Bistacchi
Examination: practical and oral examination
Aims: To carry out a thorough review of 3D geomodelling techniques with advanced software.
Main topics: The course includes a review of theory tightly integrated with practical exercises. Principal topics are: (1) fundamentals of geomodelling, topology, discrete models, grids, geostatistics and interpolation; (2) 3D data sources: surface geology, borehole, and geophysics data; (3) software: problems and functionalities; (4) modelling a simple layer-cake stratigraphy; (5) fault networks; (6) cylindrical folds; (7) complex geo-bodies; (8) representation, modelling and simulation of properties of geological objects; (9) fracture network modelling; (10) retrodeformation; (11) using 3D geomodels as input data for further modelling steps: mechanical models, flow simulators in hydrocarbon geology, hydrogeological models, etc.

Reologia delle rocce e analisi microstrutturale (4 cfu)
(Rocks rheology and microstructural analysis)

Lezioni frontali (3cfu)
Introduzione – Proprietà fisiche delle rocce e reologia sperimentale presentate come punto di contatto tra le diverse discipline come la Petrologia, la Geofisica, la Geologia strutturale, etc. L'origine della Petrofisica, i suoi recenti sviluppi, i suoi campi di applicazione.
Introduzione al concetto di modelli matematici per il calcolo delle proprietà fisiche – Teoria dei mezzi effettivi. Modelli a elementi paralleli. Modelli di particelle solide a geometrie semplici. Modelli basati sulle condizioni di interazione di due o più componenti. Metodi self-consistent.
Relazioni tra caratteri petrografici e caratteri tecnici delle rocce – Quali parametri caratterizzano le seguenti proprietà, come misurarli, come calcolarli, quali elementi componenti la roccia influenzano le seguenti proprietà fisiche: densità; spazio dei pori: porosità, permeabilità, superficie interna; proprietà termiche; proprietà magnetiche; proprietà elastiche: cristalli singolo, rocce policristalline.
Reologia sperimentale – Mappe di meccanismi di deformazione. Applicazione dei risultati di laboratorio per predire deformazioni in natura attraverso i "profili di resistenza".
Meccanismi di deformazione e leggi di flusso che li descrivono – Deformazione cataclastica. Plasticità intracristallina. Diffusione allo stato solido.
Laboratorio (1 cfu)
Determinazione di densità e porosità in laboratorio
Determinazione delle velocità ultrasoniche in laboratorio – Analisi delle diverse tecniche di laboratorio, dei loro limiti di applicabilità. Preparazione dei campioni, test di velocità a pressione variabile. Esempi di applicazione dei risultati di laboratorio
Calcolo delle velocità sismiche in aggregati polimineralici – Determinazione della orientazione cristallografica preferenziale dei componenti di un aggregato policristallino secondo vari metodi analitici: microscopio ottico, goniometro a raggi X, SEM. Traduzione della funzione di orientazione preferenziale alla matrice delle costanti elastiche dell'aggregato e da qui il calcolo di velocità anisotropia di velocità e direzioni di polarizzazione delle onde elastiche.

Geomorfologia avanzata (4 cfu)
(Advanced Geomorphology)
Title of the course: ADVANCED GEOMORPHOLOGY credits: 4
Lecturer:
Examination: written and oral
Aims:
general understanding of the evolution of mountain drainage basins through the study of colluvial and fluvial processes.
Main topics:
temporal and spatial scales in geomorphology. Introduction to the topographic zonation of mountain drainage basins. Colluvial and fluvial processes, geomorphic process domains and corresponding topographic signatures. Interaction between colluvial and fluvial processes: the concept of geomorphic coupling. Sediment budgets. Mountain streams: hydrology, channel morphology, and hydraulic geometry. Techniques of topographic surveying, sediment sampling, and measurement of sediment transport in mountain stream channels. Relict glacial macroforms. The impact of landscape history on drainage basin spatial organization: glaciated vs. unglaciated environments.
***Testi consigliati*:** verranno indicati dal docente all'inizio del corso.

Applicazioni GIS avanzate (4cfu)
(Advanced GIS analysis)
Prof. PAOLO FRATTINI paolo.frattini@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: ADVANCED GIS APPLICATIONS credits 4
Lecturer: Paolo FRATTINI
Examination: written and oral
Aims:
To develop an advance knowledge on the analysis and the modelling of geographic data for different fields: geomorphology, engineering geology, marine geology, structural geology.
Main topics:
Theory: Advanced vector analysis for the construction of geodatabases and the analysis of network data. Advanced raster analysis: DTM generation using raster and TIN structures, hydrological functions for land modelling, spatial filters. Mathematical analysis of raster images: 2D Fast Fourier Transform, Waveletes. Geostatisical analysis (Kriging) and its application to problems in engineering geology, hydrogeology and marine geology.
Lab exercises: practical utilization of different softwares for the application of the techniques introduced in the theory. Exercises are a fundamental part of the course and will be directly held PC with the analysis of geological problems.

Trattamento e consolidamento di terre e rocce (4 cfu)
(Treatment and Improvement of Soils and Rocks)
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: TREATMENT AND IMPROVEMENT OF SOILS AND ROCKS credits: **4**
Lecturer:
Examination: oral
Aims:
To give a general view of the different methods for treating and consolidating soil and rock masses, through application examples.
Main topics:
Engineering geological and environmental situations that may require treatment and consolidation works: foundations of engineering structures; natural slopes; earthworks; subsurface and subsurface excavations; waste landfills; large infrastructures; historical sites and monuments.
Geosynthetic materials and products: types; properties; applications.
Treatment and consolidation methods: earth filling; surface and subsurface drainage; treatment, with and without adding of other materials; reinforcement.
Techniques of bioengineering: aims; materials; types of structures; applications.
Examples of applications.

Mineralogia applicata (4 cfu)
(Applied mineralogy)
PROF. ANNA BRAJKOVIC anna.brajkovic@unimib.it
Dipartimento di Scienze Geologiche e Geotecnologie
Piazza della Scienza, 4

Title of the course: Applied Mineralogy credits 4
Lecturer: Anna Brajkovic

Examination: oral
Aims:
To teach the students modern diffractometric and microscopical technique. Application of these techniques to the industrial, environmental and cultural fields.
Main topics
Physical properties of crystals. Interaction of X-rays with materials. Single crystal and powder experimental diffraction techniques. Bragg-Brentano diffractometer: qualitative and quantitative analytical methods. Rietveld method in the quantitative analysis. Application diffractometric techniques in the industrial field.
SEM and TEM. Diffracted and transmitted electrons, X-rays irradiation. SAED electronic diffraction. Bright field (BF), dark field (DF) and high resolution (HR) TEM images. Interpretation of HR images. Application of the modern microscopical techniques to the industrial, environmental and cultural fields. Structure, composition and genesys of the **clay-minerals** and of the **zeolites**. Properties and applications of the clays (ceramics, bricks,..) and of zeolites (purification of natural gases, industrial, civil and zootechnical refluxes).
Gemmology – IR, UV-Vis, Raman Spectroscopy; detailed study of diamond.

Geofisica ambientale (4 cfu)
(Environmental Geophysics)

The course objective it to introduce and discuss the non invasive techniques that can be successfully used to help characterize the subsurface for environmental applications.
Main topics: *(8 lines)*

The module presents the theoretical background and the applications of non invasive techniques aimed at the characterization of the shallow subsurface, with specific attention for objectives of hydrogeological interest, and environmental in a wider sense. The considered techniques are the ground penetratine radar (GPR), the electrical resistivity tomography (ERT) and the induced polarization (IP). Several application cases are presented particularly for borehole and cross-borehole methodologies, and their integration with modelling of flow and transport in porous media.

Testi consigliati: verranno indicati dal docente all'inizio del corso.

Laboratorio di Geofisica applicata (4 cfu)
(Applied geophysics lab)

Il corso intende illustrare le applicazioni della geofisica applicata superficiale, concentrandosi sulla pianificazione delle indagini geofisiche, sull'acquisizione di dati sismici, elettrici ed elettromagnetici e sull'elaborazione ed interpretazione di rilievi. In particolare verranno rivisti brevemente, in chiave applicativa, i principi dei metodi sismici a rifrazione e per onde superficiali, della tomografia elettrica di resistivita' e del radar, con particolare enfasi sulle strategie di acquisizione e sui metodi di valutazione della qualita' dei dati. Verranno inoltre presentate le caratteristiche degli strumenti ed i principi di pianificazione delle indagini geofisiche superficiali. La parte sperimentale prevede esercitazioni di laboratorio ed esercitazioni in situ.
Le esercitazioni pratiche in laboratorio verteranno sulla valutazione di fattibilita' e sulla pianificazione delle indagini, sulla verifica degli strumenti, e sull'elaborazione ed

interpretazione dei rilievi. Durante le esercitazioni in situ verranno acquisiti dati sismici, elettrici ed elettromagnetici.