GEOLOGY-GEOPHYSICS DOCTORAL PROGRAMME

Head of Programme: Prof. József Pálfy

FÖL/2/3 Evolution of Ostracods (Emőke Mohr)

6 credits, theoretical, optional, non-repeatable

The course focuses on the Mesozoic phylogeny of ostracods, with particular attention to taxa occurring in Hungary. This is complemented by important genera known from Hungary whose evolutionary history extends back to the Paleozoic.

FÖL/2/9 Taxonomy of Foraminifers (Ágnes Görög)

6 credits, theoretical, optional, non-repeatable

This course introduces the foundations of foraminiferal taxonomy, tracing its development from d'Orbigny's 1826 system to the widely accepted classification of Loeblich & Tappan (1992). Modern taxonomic models of the English and Russian schools are discussed, including Kaminski's taxonomy of agglutinated foraminifera. The main foraminifera families are presented with morphological, evolutionary, and geological characteristics.

FÖL/2/12 Cretaceous Palaeobiostratigraphy, Palaeo-ecology, Palaeoclimatology (Ágnes Görög)

6 credits, theoretical, optional, non-repeatable

Students complete independent assignments describing and evaluating the palaeobiostratigraphic groups of terrestrial and marine Cretaceous environments. The work is based on current literature and consultation as needed.

FÖL/2/15 Methods of Biostratigraphy (Viktor Karádi-Kapiller)

6 credits, theoretical, optional, non-repeatable

- Practical aspects of biostratigraphy: biostratigraphic subdivision and correlation.
- Biostratigraphic significance of various fossil groups.
- Zonation.
- Resolution of biostratigraphic methods.
- "High-definition stratigraphy."
- Integration of biostratigraphic methodologies with other stratigraphic methods.
- Integrated stratigraphy.

FÖL/2/17 Basin Research (László Lenkey)

6 credits, theoretical, optional, non-repeatable

The course provides an overview of basin evolution models, with special emphasis on theories describing the formation and development of the Pannonian Basin. In addition to models for basins formed under various tectonic settings, the course focuses on the subsidence and thermal history of the Pannonian Basin. Conclusions regarding the validity of different theories are drawn by considering the complex geodynamic background and numerous geophysical data (e.g., deep drilling, seismic surveys, thermomechanical modelling). The course also presents hydrocarbon generation mechanisms within the Pannonian Basin.

FÖL/2/22 Recent Geodynamics of the Pannonian Basin, Methodology, Results (László Fodor, László Csontos)

6 credits, theoretical, optional, non-repeatable

The aim of the course is to provide a detailed presentation of the geodynamic processes that influence the evolution of the Pannonian Basin and its surroundings, encompassing two main thematic areas.

First, the methods that enable the investigation of active deformation and related processes are introduced, along with their theoretical background and practical implementation. This is followed by a discussion of the latest findings in active tectonic research and their societal implications. Students complete numerous problem-oriented tasks that deepen their knowledge while also developing their practical skills.

Topics include:

- Fundamentals of the stress field and deformation
- Types of deformation and different tectonic regimes
- Sources of stress within the lithosphere
- Methods for measuring the stress field
- Practical aspects of tectonic stability
- Present-day stress field, rheology, seismicity, and deformation in the crust and lithosphere
- Structure, heat flow, gravity, and geo-electrical characteristics of the Pannonian Basin lithosphere
- Surface processes; rates of horizontal and vertical crustal deformation in the Pannonian–Carpathian region
- Modeling active tectonic processes: methods and results

FÖL/2/23 Digital Terrain Models in Earth Sciences (Balázs Székely)

6 credits, theoretical, optional, non-repeatable

The course focuses on the creation, processing, and interpretation of digital terrain models, exploring their many applications. The main topics include:

- Conceptual approach: the surface to be modeled; the validity limits of digital terrain models; the concept of elevation.
- Vector-based (TIN) and raster-based (grid) digital terrain models and their creation (contour lines, remote sensing). An introduction to the SRTM (Shuttle Radar Topography Mission) and the significance of SRTM elevation models.
- Basic quantities derived from terrain models: e.g., relief, slope angle, elevation distribution.
- Patterns derived from terrain models: river and mountain range orientations, longitudinal profiles of watercourses, anisotropy analysis and detection of tectonic activity, and the effects of glaciation on the landscape.

FÖL/2/28 Propagation of Waves in all form (Orsolya Ferencz)

6 credits, theoretical, optional, non-repeatable

The aim of the course is to provide an introduction to the wave-propagation description of signals with arbitrary shape, transients, and switching phenomena, supplemented with practical application examples.

Topics:

- Interpretation of isotropic and anisotropic media and their physical parameters
- Description of homogeneous and inhomogeneous media
- Main solution methods of Maxwell’s equations
- Wave propagation in plasma
- Description of signals and impulses of arbitrary shape
- Solving Maxwell’s equations for real transients in various plasma models
- Applications in the investigation of geophysical phenomena, including modelling the propagation of whistlers

FÖL/2/29 Study and Filtering of Whistlers (János Lichtenberger)

6 credits, theoretical, optional, non-repeatable

For the detailed analysis of time-varying-frequency signals (e.g., whistlers), it is essential to know the frequency–time amplitude evolution as accurately as possible. Using the matched-filter (MF) technique, the accuracy can be improved by nearly an order of magnitude compared to conventional spectral analysis methods. This accuracy can be further increased by estimating the parameters of the filter output (the MFPE method). During the course, we examine the details of signal generation and propagation through the analysis of ground-based and satellite measurements.

FÖL/2/30 Monitoring of the Upper Athmosphere by ULF and WLF signals (János Lichtenberger)

6 credits, theoretical, optional, non-repeatable

The aim of the course is to introduce students to the electromagnetic methods and measurement techniques used to monitor the physical state of the upper atmosphere.

Topics:

- Monitoring the electron density of the plasmasphere and the continuous determination of the plasmapause position using ELF–VLF signals (whistlers, resonances) and ULF signals (pulsations, field-line resonances), based on both ground-based and in-situ measurements.
- Investigation of particle precipitation induced by wave–particle interactions (Trimpi effect) and transient luminous events associated with lightning, using amplitude and phase perturbations of VLF transmitter signals.

FÖL/2/35 X-ray Powder Diffraction Analysis (Tibor Németh)

6 credits, practice, optional, non-repeatable

1. Qualitative X-ray powder diffraction (XRD) analysis based on the ICDD–JCPDS database; Hanawalt-type sources of error, manual searching, and computer-based data processing.
2. Indexing of powder diffraction patterns, unit cell refinement, and possibilities for determining the space group.
3. Phase analysis of multicomponent systems, recognition of X-ray–amorphous content and possible approaches for its treatment.
4. Comparison of various powder diffraction techniques (Debye–Scherrer, Guinier focusing method, Bragg–Brentano geometry diffractometers, reflection and transmission techniques, parallel-beam methods).
5. Quantitative phase analysis, internal standard method, RIR method, and phase analysis based on the Rietveld method.
6. Non–room-temperature / non-ambient-pressure measurements: possibilities, equipment, advantages, and limitations.
7. Sample preparation methods.
8. Analytical possibilities for clay minerals.
9. Carbonate sediments; limestones and dolomites.
10. Metastable mineral phases and phase transitions.
11. Structural investigation of minerals by simulating experimental powder diffraction patterns; computer modelling of powder diffraction profiles (stick diagrams vs. realistic profiles).

FÖL/2/36 X-ray Powder Diffraction Phase Analysis I_II (Tibor Németh)

6 credits, theoretical, optional, non-repeatable

I. Theory

1. Generation and physical properties of X-ray radiation, spectral distribution, monochromatization.
2. Interaction of X-rays with solid materials, diffraction by crystal lattices.

3. Fundamentals of X-ray crystallography (symmetry, Bragg equation, squared structure factor formulas), diffraction of single crystals vs. polycrystalline (powder) samples — similarities and differences.
4. Factors influencing the observation, scattering angle, and scattered intensity, XRD reflections.
5. Sources of background scattering, its determination; scattering vs. background.
6. Structure factor theory, factors influencing peak shape and peak shift, reflection conditions.
7. Characteristics of an ideal powder sample, differences between ideal and real powder diffraction profiles and their causes.
8. Experimental errors, their identification and minimization; instrumental profiles.

II. Applications

1. Qualitative phase analysis using the ICDD–JCPDS database.
2. Indexing of powder patterns**,** unit cell determination, possibilities and limitations of deductions.
3. Phase analysis of multicomponent systems**,** recognition and treatment of observed phases.
4. Comparison of various X-ray powder diffraction experimental techniques.
5. Phase quantification**,** internal standard method, RIR method, Rietveld-based phase abundance determination.
6. Non-ambient measurements**:** possibilities, instrumentation, advantages and weaknesses.
7. Sample preparation techniques.
8. Identification of clay **minerals** in mudrocks, sandstones, and limestones.
9. Qualitative analysis of clay minerals and interlayer structures.
10. XRD analysis of carbonate sediments, limestones, and dolomites.
11. Investigation of metastable inorganic phases and phase transitions.
12. Structural analysis of minerals using simulated XRD powder patterns**,** computer modelling of XRD profiles (stick pattern vs. real profile).

FÖL/2/38 Petrographical methdos in the study of archaeological ceramics (György Szakmány)

6 credits, theoretical, optional, non-repeatable

Main Topics:

- Petrographic analysis as a fundamental method for the study of ceramics
- Methodology for the petrographic description of prehistoric and medieval ceramics.
- Possibilities for identifying non-plastic temper/inclusion components.
- Textural examination of ceramics and the conclusions that can be drawn from microstructural features.
- Case studies and examples from Hungary and abroad.
- Petrography as the foundation for subsequent instrumental analytical methods.

FÖL/2/39 Petrographical and Geochemical Methods in Ceramics Research (György Szakmány)

6 credits, theoretical, optional, non-repeatable

Topics:

- Application of instrumental analytical methods used in ceramic research and interpretation of the results
- Petrography
- X-ray powder diffraction
- Chemical analyses
- Scanning electron microscopy
- Electron microprobe mineral chemistry analyses
- Micromineralogy
- Cathodoluminescence
- Magnetic analyses

FÖL/2/40 Provenance Studies in Archaeometry (György Szakmány)
6 credits, theoretical, optional, non-repeatable

- Presentation and application of methods used to determine the provenance of raw materials in various archaeological artefacts.
- Possibilities and methods for identifying raw material sources.
- Specific case studies from the Carpathian Basin and other regions, focusing primarily on ceramics and stone tools.

FÖL/2/41 Provenance of Siliciclastics – Petrographical and Geochemical Methods (György Szakmány)
6 credits, theoretical, optional, non-repeatable

- Application of petrographic, mineral-chemical, micromineralogical and chemical methods to determine and delineate the provenance areas of clastic sedimentary sequences.
- Applicability and limitations of these methods.
- Mineralogical and chemical transformations caused by diagenetic and post-depositional processes.
- Specific case studies.

FÖL/2/42 Geochemistry of Weathering (György Szakmány)
6 credits, theoretical, optional, non-repeatable

- Mineralogical and chemical transformation of rocks under weathering.
- Weathering indices.
- Case studies from archaeometry and the field of siliciclastic rocks.

FÖL/2/44 Introduction to Physical Volcanological Studies (Szabolcs Harangi)
6 credits, theoretical, optional, non-repeatable

- Mechanisms of volcanic eruptions associated with different types of magma
- Specific characteristics of volcanic products and methods of their investigation
- Case studies (project work) from both Hungarian and international locations

FÖL/2/45 Geochemical modelling of igneous processes (Szabolcs Harangi)
6 credits, theoretical, optional, non-repeatable

- Quantitative geochemical modeling of the evolution of magmas with different compositions
- Partial melting models
- Crystallization models
- Modeling of open-system processes
- Case studies (project work) on various magmatic systems

FÖL/2/46 Neogene-Quaternary to Recent Volcanism of the Mediterrranean (Szabolcs Harangi)
6 credits, theoretical, optional, non-repeatable

Interpretation of magmatism and its geodynamic context in the broader Mediterranean region (including the Carpathian–Pannonian area), illustrated through examples from various regions (e.g., the Betic region, Italy, the Aegean region, Anatolia, the Dinarides, and the Carpathian–Pannonian area).

FÖL/2/49 Mineral chemical implications of micromineralogy (Sándor Józsa)
6 credits, theoretical, optional, non-repeatable

Investigation of the major and trace element contents of natural and artificial sediments containing detrital mineral grains, using heavy-mineral analysis to aid in determining their composition and provenance.

FÖL/2/51 Micromineralogy of clastic rocks (Sándor Józsa)

6 credits, theoretical, optional, non-repeatable

Determination of heavy-mineral assemblages in clastic sedimentary rocks containing sand-sized mineral grains using binocular and polarizing microscopy, along with petrological analysis of the possible palaeoenvironment.

FÖL/2/53 Fluids in the Earth (Csaba Szabó)

6 credits, theoretical, optional, non-repeatable

During the course, we examine and interpret fluid and silicate melt inclusions in minerals from crustal and upper mantle rocks, focusing on the information that can be obtained from them. Additional topics include the thermodynamic properties of fluids, the solubility of volatiles in magma, and mantle metasomatism. Completion of mineralogy, petrology, and geochemistry courses at the M.Sc. level is a prerequisite.

FÖL/2/54 Fluids in the Earth (Csaba Szabó)

6 credits, practice, optional, non-repeatable

During the course, we examine and interpret fluid and silicate melt inclusions in minerals from crustal and upper mantle rocks, focusing on the information that can be obtained from them. Additional topics include the thermodynamic properties of fluids, the solubility of volatiles in magma, and mantle metasomatism. Completion of mineralogy, petrology, and geochemistry courses at the M.Sc. level is a prerequisite.

FÖL/2/55 Basalts and their phase diagrams (Csaba Szabó)

6 credits, theoretical, optional, non-repeatable

The course includes the systematic interpretation of basalt phase diagrams and their applicability to mantle magmatic processes. The curriculum also covers the quantitative interpretation of fractional and equilibrium crystallization, as well as equilibrium and partial melting. Completion of mineralogy, petrology, and geochemistry courses at the M.Sc. level is a prerequisite.

FÖL/2/56 Subducted lihtospheric plates and the mantle-wedge (Csaba Szabó)

6 credits, theoretical, optional, non-repeatable

The course encompasses the geochemical, lithological, mineralogical, and thermal evolution of the subducted slab and the mantle wedge, as well as their mechanical state, its changes, and the evolutionary history of their fluids. Within the progressive subduction–driven evolution of the slab and mantle wedge, special emphasis is placed on the study of mineral reactions, fluid release and transport, metasomatism, and deformation and melting events that give rise to magmatic and metasomatic processes at convergent plate margins. Completion of mineralogy, petrology, and geochemistry courses at the M.Sc. level is a prerequisite.

FÖL/2/58 Hydrothermal ore-mineralization (Ferenc Molnár)

6 credits, theoretical, optional, non-repeatable

The course covers the types of hydrothermal systems, the characteristics of fluid–rock interactions within these systems, and the thermodynamic modeling of the formation processes of mineral and ore deposits.

FÖL/2/59 Igneous and metamorphic ore-mineralization (Ferenc Molnár)

6 credits, theoretical, optional, non-repeatable

The main topics of the course address the mineralogical and geochemical characteristics of liquid–magmatic segregation processes and the specific properties of melt–fluid systems, with particular emphasis on the formation of ore deposits. In addition, the course provides an overview of the characteristics of skarn ore deposits (intrusion–host rock interaction) as well as the mineralogical, petrological, and geochemical features of metamorphosed and metamorphogenic mineral deposits.

FÖL/2/60 Plate tectonics and ore formation (Ferenc Molnár)
6 credits, theoretical, optional, non-repeatable

The course reviews the characteristics of resource-forming processes associated with different stages of the Wilson cycle and presents examples illustrating the significance of mineral deposit research in reconstructing plate-tectonic processes in various regions. It provides a detailed discussion of the plate-tectonic development model of the Alpine–Carpathian–Dinaric–Balkan region, including the types of mineral deposits associated with each evolutionary phase.

FÖL/2/61 Fluid inclusion studies (Gabriella B. Kiss)
6 credits, theoretical, optional, non-repeatable

The theory and practice of fluid inclusion studies, and their application in solving mineralogical, petrological, and mineral exploration (solid and hydrocarbon) problems.

FÖL/2/68 Sedimentology and micropetrography of travertines (Andrea Mindszenty)
6 credits, theoretical, optional, non-repeatable

- Definitions and history of research.
- Classification of freshwater limestones.
- The cave–spring–travertine continuum.
- Meteoric and thermogenic travertines.
- The role of biological activity in travertine formation.
- Morphology and lithofacies.
- Sequences / parasequences.
- Karst-hydrogeological and paleoclimatic relationships.
- Travertine formations in Hungary.
- Methods of travertine research, with special emphasis on microfacies analysis.
- Travertine as a building and ornamental stone.

FÖL/2/69 Geology of Paleokarst (Andrea Mindszenty)
6 credits, theoretical, optional, non-repeatable

- Definition, significance, and recognition/identification of paleokarst.
- The concept of syngenetic (intraformational) and epigenetic (local or interregional) paleokarst.
- Paleokarst infillings (mechanical/chemical; autochthonous/allochthonous).
- Characteristic dissolution features and karst infillings of the vadose, phreatic, and deep-phreatic zones.
- Fossil/buried/exhumed karst; paleokarst and paleoclimate.
- Continental / coastal / submarine karst.
- Relationship between paleokarst phenomena and sea-level changes.
- The role of paleokarst phenomena in the localization of certain mineral resources.

FÖL/2/70 Palaeopedology (Andrea Mindszenty)
6 credits, theoretical, optional, non-repeatable

- Definitions and historical overview.
- Main criteria for identifying paleosols.
- Classification of paleosols.
- Effects of the major soil-forming factors on soil structure, mineralogical composition, and micromorphology.
- Conditions and consequences of fossilization.
- Detailed comparison of characteristics of modern (recent) and fossil soils.
- Possibilities and limitations of extracting paleoenvironmental information from paleosols.
- The role of paleosols in stratigraphic correlation, raw material deposit localization, and archaeological geology.

- Paleosols as potential environmental hazard sources.

FÖL/2/71 Seismic Sequence Stratigraphy (Orsolya Sztanó)

3 credits, theoretical, optional, non-repeatable

The aim of the PhD course is to provide a deeper understanding of the principles and methods of sequence stratigraphy and to train participating doctoral students in the practical interpretation of systems-tract–level seismic sections from various sedimentary basins around the world.

The outline of the course includes: Sloss (1962) sequences, Vail (1977) sequences, Galloway (1989) sequences, identification of systems tracts based on seismic and well-log data, clastic and carbonate seismic facies, facies and sequence architecture, and the hydrogeological and petroleum geological applications of sequence stratigraphy.

FÖL/2/77 Gravitationally controlled Groundwater Flow Systems (Judit Mádl-Szőnyi)

6 credits, theoretical, optional, non-repeatable

The course begins with an introduction covering definitions, background, methodology, Darcy's law, and the Laplace and diffusion equations. The concept of the "Unit Basin" is then presented, including the fundamental flow pattern and the key parameters that characterize it.
This is followed by an examination of flow systems in complex and heterogeneous basins**,** focusing on how basin geometry and basin geology influence groundwater flow. The course also covers transient pore pressures and transient flow systems, along with the fundamental concepts of "hydraulic continuity."
A major thematic block discusses gravity-driven groundwater flow as a geological agent, including its underlying causes, main processes, and hydrogeological context, as well as its manifestations in various fields: hydrology and hydraulics, geochemistry and mineralogy, soil and rock mechanics, geomorphology, transport processes and accumulation.
Practical applications are demonstrated through case studies characterizing and visualizing regional hydrogeological conditions (Alberta, Australia, Minnesota). Additional applied topics include peatland ecological protection in the Netherlands, environmental management in Japan, and groundwater exploration in Olds.
Examples of recharge–discharge regime effects are presented through studies such as the waterfowl reserve at Lake Kelemenszék and fishpond systems at Kelebia (Hungary); peat mining at Neyveli (India); a municipal wastewater treatment facility in Brooks (Alberta); contamination depth studies in the Netherlands; phosphorus transport into lake water in Alberta; and saline soil reclamation in Alberta.
The course also addresses site selection for radioactive waste repositories, with examples from Sweden (granite), Switzerland (Rhine Valley), Texas (salt), and Canada (granite). Interpretation of fluid-potential anomalies is also covered, illustrated with cases involving reservoir-quality sediment lenses (Alberta), subsurface hydraulic barriers (Alberta), stepwise changes in groundwater chemistry (Alberta), and identification of the causes of subhydrostatic pore pressures (Alberta, Switzerland).
Further applications include hydrocarbon and metallic mineral exploration**,** discussing the hydraulic theory of hydrocarbon migration with examples from the Parentis Basin, the Gulf of Mexico, offshore Qatar, the Junggar Basin, and others; surface geochemical exploration ("the geochemical chimney"); uranium exploration; and ore deposits hosted by sedimentary sequences.

FÖL/2/78 Gravitationally controlled Groundwater Flow Systems (Judit Mádl-Szőnyi)

6 credits, practice, optional, non-repeatable

The course begins with an introduction covering definitions, background, methodology, Darcy's law, and the Laplace and diffusion equations. The concept of the "Unit Basin" is then presented, including the fundamental flow pattern and the key parameters that characterize it.
This is followed by an examination of flow systems in complex and heterogeneous basins**,** focusing on how basin geometry and basin geology influence groundwater flow. The course also covers transient

pore pressures and transient flow systems, along with the fundamental concepts of “hydraulic continuity.”
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Further applications include hydrocarbon and metallic mineral exploration**,** discussing the hydraulic theory of hydrocarbon migration with examples from the Parentis Basin, the Gulf of Mexico, offshore Qatar, the Junggar Basin, and others; surface geochemical exploration (“the geochemical chimney”); uranium exploration; and ore deposits hosted by sedimentary sequences.

FÖL/2/81 Sensitivity and Vulnerability of Karst Systems (Judit Mádl-Szőnyi)
3 credits, theoretical, optional, non-repeatable

- Karst aquifer systems and their hydrogeological behaviour.
- The concepts of sensitivity and vulnerability in hydrogeology.
- Overview of internationally used vulnerability assessment methods.
- Hungarian and international case studies on the vulnerability assessment of karst systems.
- Practical exercise: Applying the European vulnerability assessment approach to a conceptual study area; degradation of karst landscapes.
- Practical exercise**:** Discussion forum.
- Comparison of international vulnerability assessment practice with Hungarian legal regulations.
- To what extent does the Hungarian system stand up to international practice?

FÖL/2/82 Sensitivity and Vulnerability of Karst Systems (Judit Mádl-Szőnyi)
3 credits, practice, optional, non-repeatable

- Karst aquifer systems and their hydrogeological behaviour.
- The concepts of sensitivity and vulnerability in hydrogeology.
- Overview of internationally used vulnerability assessment methods.
- Hungarian and international case studies on the vulnerability assessment of karst systems.
- Practical exercise: Applying the European vulnerability assessment approach to a conceptual study area; degradation of karst landscapes.
- Practical exercise**:** Discussion forum.
- Comparison of international vulnerability assessment practice with Hungarian legal regulations.
- To what extent does the Hungarian system stand up to international practice?

FÖL/2/83 Thermal waters and Geothermics (Judit Mádl-Szőnyi)

6 credits, theoretical, optional, non-repeatable

Introduction: The significance of geothermal energy in the global energy balance, long-term projections
Geothermal Systems I: The geological determinants of geothermal energy.
Natural geothermal systems and their characteristics.
Balneological utilization of thermal waters: presenting the concepts of medicinal waters and mineral waters. The evolution of hot spring exploration, production, and utilization from the mid-1800s to the present day. An overview of Hungary's geothermal potential: karst and porous aquifers, the quality of thermal waters in different types of reservoirs. Environmental issues arising from the utilization of thermal water: disposal of used thermal waters, the questions of sustainable hot spring production. Presentation of the current legal framework.
Geothermal Systems II: Artificially influenced systems: doublet systems; "artificial heat pumps, influenced geothermal systems."Classification of geothermal energy resources and their utilization status worldwide: powergeneration goals, direct heat utilization. Principles of geothermal resource exploration: objectives; exploration of fluid-based reservoirs; geothermal-based research.
Geothermal Resource Assessment I: Objectives, McKelvey diagram, surface heat flow method, volumetric method.
Geothermal Resource Assessment II: Hungarian resources, other new methods, and case studies.
The renewal and sustainable utilization of geothermal resources. Utilization of Geothermal Energy Resources: Power generation, direct heat utilization, waste heat recovery.
Environmental, legal issues.
Economic, social, and environmental considerations.

FÖL/2/85 Siliciclastic Petrography (Sándor Józsa)

6 credits, practice, optional, non-repeatable

Identification and detailed examination of the minerals composing clastic rocks using a polarizing microscope: quartz, feldspars, micas, and accessory components (heavy minerals). The course also covers the study of mineralogical transformations occurring during diagenesis and weathering.

FÖL/2/88 Endemic evolution in long-lasting perennial lakes (Imre Magyar)

6 credits, theoretical, optional, non-repeatable

In lakes whose lifespans can be measured in hundreds of thousands or millions of years, the proportion of endemic organisms is typically very high. Regardless of their size, such lakes have played a role in the evolution of aquatic life comparable to the role of islands in the speciation of terrestrial organisms. In modern long-lived lakes (e.g., Lake Baikal, the Caspian Sea, Lake Tanganyika, Lake Ohrid, Lake Titicaca, Lake Biwa), biological diversity can be studied, whereas fossil long-lived lakes (e.g., Lake Pannon, Lake Steinheim) allow the investigation of the temporal dynamics and history of speciation. Although different organism groups underwent adaptive radiations in different lakes, recurring patterns, similarities, and general principles can be observed in these evolutionary processes.

FÖL/2/91 Salt tectonics (László Csontos)

6 credits, theoretical, optional, non-repeatable

- Mechanical properties of salt.
- Driving forces of salt movement.
- Extensional structures.
- Downbuilding structures.
- Compressional structures.
- Salt tectonic systems.
- Other rocks that mimic salt tectonics.

FÖL/2/92 Petrology of Ophiolites (Sándor Józsa)

6 credits, theoretical, optional, non-repeatable

Presentation of the recognition of ophiolites and ophiolitic sequences, together with their general petrological and geochemical characteristics, occurrence, and geological significance. The formation of the ophiolites of the Dinarides, and the latest results from major- and trace-element geochemical studies as well as petrological investigations.

FÖL/2/93 Key Events of the History of the Biosphere (József Pálfy)

6 credits, theoretical, optional, non-repeatable

The course, in a seminar format, reviews the most significant episodes of evolution known from the fossil record, the key turning points in the history of the biosphere, and the most important biological innovations. With a systems-oriented geoscientific perspective, it examines in case studies the fundamental interactions between the ancient environment and the biosphere. Discussion of the 13 topics listed below is based on the processing of the most influential primary and overview articles in English:

1. The early stages of life on Earth
2. The early history of metazoans and the Ediacara fauna
3. The Cambrian explosion
4. The Ordovician radiation
5. The conquest of the land
6. The end-Permian extinction
7. The Mesozoic marine revolution
8. The end-Triassic extinction
9. The rise of skeleton-bearing microplankton
10. The origin and expansion of gymnosperms
11. The end-Cretaceous extinction
12. Cenozoic events (PETM, spread of C4 plants, Pleistocene megafaunal extinction)
13. The process of human evolution

FÖL/2/99 Laterites – Soils or Sedimentary Rocks (Andrea Mindszenty)

6 credits, theoretical, optional, non-repeatable

1. *Soil versus regolith*
   The problem of the tropical scenario: deep weathering (sometimes >100 m) between the topsoil and the saprolite, and extremely long-lasting pedogenesis.
2. *Phenomenology*
   Macroscopic and microscopic characteristics, chemistry.
   Photographs of hand specimens and thin sections.
   Simple tables presenting the major minerals and chemical components.
   Process-oriented characterization of laterite.
   The role of temperature, precipitation, surface relief, drainage, and parent rock.
   The “lateritic profile”: terminology.
   Topsoil, cuirasse, laterite, lithomarge; relative and absolute accumulation.
   The position of laterites in the landscape.
   Pedogenic versus groundwater laterite.
   Isalterite/alloterite, pisolitic laterite duricrusts.
   Development of lateritic profiles in relation to changing relief.
3. *Lateritization as a time-dependent process*
   Age versus duration of lateritization.
   “Old” laterites are not in equilibrium with their present-day settings.
   Laterites occurring on young geomorphic surfaces.
   The effect of changing environmental conditions.

The “inertia” of a well-developed lateritic profile.
Lateritization and landscape evolution.

4. *Special types of laterite*
5. *Some classical examples*: India (Maharashtra, Orissa, Goa); West Africa (Nigeria).

FÖL/2/101 Introduction to Environmental Geochemistry (Csaba Szabó)

6 credits, theoretical, optional, non-repeatable

During the course, a specific environmental geochemistry topic is developed as a project, with special emphasis on anthropogenic pollution.

FÖL/2/102 Metamorphic Petrology (György Szakmány)

6 credits, theoretical, optional, non-repeatable

During the course, students complete a project focused on the detailed study of a selected metamorphic topic related to the Earth’s crust.

FÖL/2/106 How to write scientific papers? (Balázs Székely, Gábor Timár)

6 credits, theoretical, optional, non-repeatable

The course provides an overview of the process of scientific and science-communication publishing. It reviews the different forms of scientific publications (research articles, review papers, books and book chapters, conference publications), their typical structure and organization, the ways in which they are prepared, and the peer-review process following submission. It presents the content and formatting requirements of citations, the ranking of scientific journals, and the calculation and significance of the impact factor. The course also addresses the preparation of popular-science writings in both print and electronic formats, along with their specific requirements. The overarching aim of the course is to increase students’ “publication confidence” and motivation to publish.

FÖL/2/108 Carbonate-cycles and cyclostratigraphy (János Haas)

6 credits, theoretical, optional, non-repeatable

The aim of the course is to present the sedimentary cycles commonly found in carbonate rocks, to discuss the methods used for their recognition and for determining their duration, and to analyse the causes of cyclic sedimentation. The course covers the principles and methods of cycle stratigraphy, and illustrates the practical significance of carbonate cycles and sequences through case studies.

FÖL/2/109 Modern analytical methods in Geochemistry (Szabolcs Harangi)

6 credits, theoretical, optional, non-repeatable

The course presents the theoretical foundations and practical applications of modern analytical methods used to determine the major and trace elements, as well as the radiogenic isotope ratios, of rocks and their minerals. The methods covered include XRF, ICP-MS, laser ablation ICP-MS, TIMS, electron microprobe analysis, and ion microprobe analysis. In addition to the lectures, students will also have the opportunity to gain hands-on experience with some of these techniques.

FÖL/2/110 Advanced Igneous Petrology (Szabolcs Harangi)

6 credits, theoretical, optional, non-repeatable

This English-language course focuses primarily on the petrological and geochemical characteristics of basaltic magmas, but it also briefly addresses the petrogenesis of other magma types. It introduces the thermodynamic aspects of partial melting and magmatic differentiation, and how these processes manifest in the mineralogical and textural features of rocks. Isotope-geochemical and trace-element geochemical modelling approaches are presented to illustrate the evolution of magmatic systems.

FÖL/2/122 Mantle Convection – Selected Examples (Attila Galsa)

6 credits, theoretical, optional, non-repeatable

The main aim of the seminar is to discuss the up-to-date geophysical and geodynamical problems emerging from the subject of the Earth's mantle convection. During the course the discussion and comparison of the 'canonical' and the most recent professional literature occurs involving PhD students.

FÖL/2/129 Data Analysis in Palaeontology (József Pálfy)

6 credits, practice, optional, non-repeatable

The course provides an overview of quantitative analytical techniques applied to different types of paleontological data (measurements and occurrence data). Advanced methods of exploratory and descriptive statistics are presented, with special emphasis on multivariate techniques. Toolboxes of traditional and geometric morphometrics, quantitative biostratigraphy, paleoecology, paleobiogeography and cladistic phylogenetic analysis are discussed. The PAST (Paleontological Statistics) software will be used for hands-on practices. The analysis and interpretation of own data of doctoral students' projects will be encouraged and supported.

FÖL/2/134 Carbonate Sedimentology and Facies Analysis (János Haas)

6 credits, theoretical, optional, non-repeatable

FÖL/2/135 Clay Minerals in Geology (Tibor Németh)

6 credits, theoretical, optional, non-repeatable

Clay minerals are characteristic minerals of the Earth's outer crust and the surface environment. Due to their small grain size, sorption capacity, and swelling behavior, they fundamentally control the physical and chemical properties of geological formations, and as a result their environmental significance is considerable. According to the syllabus outlined below, students will become familiar with the structure, properties, and formation of clay minerals in sedimentary, hydrothermal, and metamorphic processes as well as in soils, their geological applications and environmental importance. In addition, they will acquire routine clay mineralogical analytical methods, potentially applied to samples related to their own research. The course may be particularly useful for doctoral students working in environmental geology, soils, hydrothermal systems, petroleum geology, hydrogeology, or archaeometry.

- Structure and properties of clay minerals.
- Weathering and soil-forming processes. Formation of secondary clay minerals.
- Clay minerals in hydrothermal systems.
- Clay minerals in sedimentary basins. Diagenesis and low-grade metamorphism. Illite and chlorite "crystallinity" methods.
- Swelling and sorption capacity of clay minerals; their hydrogeological and environmental roles.
- Clay mineralogical analytical methods. Identification and characterization of clay minerals.

FÖL/2/136 Raman-spectroscopy in Earth Sciences (Márta Berkesi)

6 credits, theoretical, optional, non-repeatable

Raman spectroscopy is a non-destructive analytical method known for its wider application in the earth sciences. Mineral identification, stress / strain tests, liquids, gases, archaeometric finds, gemstones can be quickly analyzed by the method, even with 2D or 3D maps, at different temperatures if needed. This course aims to present all the possibilities in the application of Raman spectroscopy in earth science research. The main significance of this lies in the fact that the doctoral students completing the course become familiar with the wide-ranging application of an instrument that is available at the university with excellent parameters, so it can even be used in their research.

Schematic structure of the course:

1. *Theoretical basics of Raman spectroscopy, detailed built-up of the instrument, accessories*

Raman effect, Types of lasers, significance of confocal Raman spectroscope, types of optical gratings, filters, lenses, detectors, 2D and 3D mapping, accessories: optical fiber, removable stage, portable Raman

2. *Getting to know, interpreting Raman spectra, using them in research*
   Raman activity, selection rules, molecular vibrations, Raman spectrum: factors influencing intensity and Raman shift value, and the mineralogical, compositional, and other information that can be extracted from it. Significance of FWHM. Main steps of spectrum evaluation, deconvolution.
3. *Combination of Raman and other methods* (stage, HDAC, FTIR, micro-XRF) and their research potential
4. *Raman application 1:* Mineral identification and geochemistry
   Fingeprint mineral identification, Raman active-inactive minerals, polymorphs, crystal inclusions, stress / strain tests
5. *Raman Application 2:* Investigation of Fluid and Melt Inclusions
   Raman spectrum of fluid (volatile) molecules, density-pressure estimation, monitoring of melting processes on Raman spectrum, 2D and 3D mapping, determination of fluid composition
6. *Raman Application 3: Archaeometry*
   Non-destructive examination of protected objects, paintings and archaeometric devices
7. *Raman Application 4:* Geobiology and Biomineralization
   Raman investigation and mapping of mollusks, corals, fossil bones, Raman spectra of organic matter
8. *New trends in Raman spectroscopy*
   Mars expedition, extreme high spectral resolution spectroscopy

FÖL/2/140 Structural elements of Hungary – Analysis and History (László Fodor)

6 credits, theoretical, optional, non-repeatable

The aim of the course is to familiarize students with the structural elements that deform the crust of Hungary. As a first step, the geometry and kinematic characteristics of these elements are introduced, using methods that facilitate their identification and understanding. This is followed by a presentation of the relationships between structural elements and the formation of contemporaneous sedimentary basins, thereby establishing links to stratigraphic knowledge. The course then discusses the system of structural elements and their temporal evolutionary history, including the Alpine–Carpathian–Pannonian system as a natural geological framework.In addition to attending the lectures, students are expected to learn how to critically read the scientific literature, which they demonstrate through short practical presentations.

FÖL/2/145 Dolomitization (János Haas)

6 credits, theoretical, optional, non-repeatable

FÖL/2/146 Introduction to Seismic Geomorphology (Orsolya Sztanó)

6 credits, theoretical, optional, non-repeatable

The practical course will demonstrate the basics of paleogeographic and paleoenvironmental interpretation of 3D seismic volumes and related attribute maps. The method explores the ancient surface of the earth, its relief and the distribution of different sedimentary bodies. By interpreting successive slices, evolution of the paleoenvironments over time can be followed. This requires basic knowledge of some seismic interpretation software, as well as knowledge of geology or sedimentology. Through a few case studies, the student will become familiar with the background of each frequently used attribute map, what geological uses they may have, and what is the relationship

between the mapped feature and the various rock bodies and/or their fluid content. Independent interpretation tasks help to gain some practice.

FÖL/2/147 Nuclear Analytical Methods and their Application to Earth Sciences and Archaeometry-I. (Katalin Gméling)

6 credits, theoretical, optional, non-repeatable

1. Basic physical concepts. Nuclear chemistry**:** elementary particles and interactions. Structure of the atomic nucleus. Nuclear reactions, fusion, fission. Radioactive decay, decay series. Cosmochemistry: origin of the elements. Periodic table, isotope chart, short- and long-half-life isotopes.
2. Alpha-, beta-, and gamma radiation, X-ray radiation**.** Natural radioactivity, stable isotopes. Radiation physics and dosimetry. Radiation biology and health physics. Radiation protection, mitigation of nuclear accidents.
3. Fundamentals of neutron activation analysis**.** Neutron activation; gamma-photon interactions: photoelectric effect, Compton scattering, pair production. HPGe detectors. Gamma spectroscopy: energy calibration, efficiency, energy resolution, nonlinearity, dead time. Digital and analog measurement systems. Gamma spectrum evaluation: peak area, uncertainty, B-peak integration, annihilation peak, Ge-triangles, peak identification, coincidence measurements. Low-background chamber. PGAA (Prompt Gamma Activation Analysis).
4. Artificial radiation: nuclear explosions, fuel cycle, isotope enrichment, nuclear reactors, reprocessing, nuclear accidents, medical applications. Reactor accidents: Chernobyl, Fukushima. Neutron sources: neutron generators, reactors.
5. NAA standardization**:** absolute, relative, k-factor, k_o-factor methods. Neutron flux parameters. Sample preparation and post-irradiation handling. Monitors. Procedures for short- and long-term irradiations. Spectrum fitting and evaluation. Data handling. Calculation of decay-derived intensities, uncertainty calculation. QA/QC.
6. Similarities and differences between NAA and PGAA, advantages of their combined application. PGAA measurement procedure: sample preparation, measurement, fitting of PGAA spectra, evaluation of results. Reporting and interpretation of results, deviation from the mean, z-score, zeta-score. Importance of NAA and PGAA in the analysis of geological and environmental samples. Significance of rare earth elements (REE). NAA as a primary method. Investigation of standard reference materials (SRMs). Presentation of BKR and BNC.
7. Presentation of application possibilities in geology, archaeometry, and environmental science, illustrated by analytical results and research projects.

FÖL/2/148 Nuclear Analytical Methods and their Application to Earth Sciences and Archaeometry-II. (Katalin Gméling)

6 credits, practice, optional, non-repeatable

1. Centre for Energy Research (CER), Hungarian Academy of Sciences (HAS): reactor visit.
2. Neutron imaging**:** radiography and tomography, elemental mapping. NIPS/NORMA, RAD.
3. Measurement of natural radioactivity (DÖME), investigation of environmental samples. Radioecology.
4. PGAA practical session: sample preparation, measurement, spectrum fitting and evaluation, interpretation of results.
5. NAA practical session: sample preparation, measurement, spectrum fitting and evaluation, interpretation of results.
6. Handheld XRF and Raman spectroscopy. Applications (large-scale facilities); advantages, applicability, fields of investigation, built-in software, suppliers, reliability.
7. Mössbauer measurements: advantages, applicability, fields of investigation, software, data evaluation.

8. Presentation of students' PhD research**,** potential links to the analytical and investigative methods introduced during the course. Mapping of measurement opportunities, professional internship possibilities.

FÖL/2/149 Fluid-Rock Interaction (Gabriella B. Kiss)

6 credits, theoretical, optional, non-repeatable

1. Introduction: basic processes
2. Hydrothermal fluid circulation systems developed on mid-oceanic ridges. Part 1. Characteristics of the fluid, the alteration and the geochemical changes.
3. Hydrothermal fluid circulation systems developed on mid-oceanic ridges. Part 2. Characteristics of the ore forming processes. Effects of the low temperature alterations on the submarine rock series.
4. Hydrothermal processes connected to rifting related basaltic volcanism: characteristics of the fluid, the alteration, the geochemical changes as well as the ore forming processes.
5. Characteristics of epigenetic fluid-rock interaction processes, related to basic magmatic rock series.
6. Characteristics of fluid-rock interaction processes, related to submarine sedimentary rock series.
7. Outline of the research methods.
8. "New" possibility to evaluate the geochemical data of altered rocks: mass transfer calculation, theory.
9. "New" possibility to evaluate the geochemical data of altered rocks: mass transfer calculation, practice.
10. Case study I.: volcanogenic massive sulphide deposits.
11. Case study II.: rifting related fluid-rock interaction processes in magmatic and sedimentary rocks.
12. Case study III.: Epigenetic fluid-rock interaction processes in magmatic and sedimentary rocks.
13. Case study IV.: Examples presented by the participants of the course.

FÖL/2/150 Applied Geology Seminars (József Pálfy)

6 credits, theoretical, optional, repeatable

The course provides a framework for holding any short course or lecture series within the broadly interpreted subject area of applied Earth sciences, and for doctoral students presents an opportunity to acquire relevant knowledge, where foreign experts visiting our university in the given semester give lectures on new research methods and results in their field of expertise. The lectures are held in English.

FÖL/2/157 Advanced geochronology (Réka Haranginé Lukács)

6 credits, theoretical, optional, non-repeatable

The aim of the course is to provide a comprehensive, practice-oriented introduction to modern isotopic dating methods, with a particular focus on zircon-based geochronology. We cover in detail the theoretical foundations and practical application of U–Pb geochronology, as well as the evaluation of LA-ICP-MS measurements using the IOLITE software environment. The course also presents the principles and thermal sensitivity of (U–Th)/He dating, and compares the results and applications of SIMS, TIMS and LA-ICP-MS zircon geochronology through selected case studies. A key theme of the course is the interpretation of zircon crystallization ages in the context of magmatic petrochronology, along with the critical assessment of analytical uncertainties and data quality.

FÖL/2/158 Transmission electron microscopy practice (Viktória Kovácsné Kis)

6 credits, practice, optional, non-repeatable

During the course, the student will become familiar with the development of transmission electron microscopy (TEM), the operating principle and structure of the instrument. He will acquire detailed knowledge about the preparation of samples necessary for TEM examination, the requirements for the samples, and the artifacts potentially formed during the examination. He will become familiar with the basics of electron diffraction, amplitude and phase contrast imaging, and at a basic level with the simulation methods necessary for the interpretation of the latter. He will also become familiar with the specifics of TEM energy dispersive spectroscopy. Within the framework of the course, he will have the opportunity to apply the above examination methods in practice.

FÖL/2/164 Raw materials of Prehistoric polished stone tools in th eCarpathian basin (György Szakmány)

6 credits, theoretical, optional, non-repeatable

- Occurrence of polished stone tools in the Carpathian Basin, with special emphasis on the stone tool assemblages from Hungary that have been processed to date.
- The raw material types, petrographic, and geochemical characteristics of polished stone tools found in Hungary and its immediate surroundings. Spatial delimitation of raw material occurrences and the characteristics of their geological settings. The frequency of stone tools made from individual raw material types within assemblages recovered from Hungary and its immediate environs.
- Common raw material types: contact metabasite varieties; regional greenschist–amphibolite varieties; blueschist; hornfels; high-pressure meta-ophiolitic varieties (Na-pyroxenite, eclogite); nephrite; basic–ultrabasic magmatic rocks, metamamatic rocks and their differentiates (Plio–Pleistocene basalt–basanite–alkaline basalt); Mecsek-type alkaline basic magmatic rocks and their differentiates; subvolcanic/dyke basites and their very low- to low-grade metamorphic varieties; intermediate to acidic volcanic rocks, metavolcanics, and their subvolcanic and dyke varieties, including their pyroclastic and volcanoclastic counterparts; serpentinite and other meta-ultrabasic varieties; Tertiary intermediate to acidic volcanic rocks; Triassic (Eastern Bükk) intermediate to acidic volcanic rocks; “white stone.”
- Other, rarely occurring raw materials: lithological types of minor occurrence.

FÖL/2/169 Vertebrate paleobiology (Attila Ősi)

6 credits, theoretical, optional, non-repeatable

The course focuses on paleobiological studies of Mesozoic vertebrates, especially that of sauropsid reptiles. Functional morphological questions related to dental function, jaw mechanism, or muscle reconstruction in fossil animals are discussed, but also the processes of movements in vertebrates adapted to different habitats will be also detailed. Besides discussing these questions, the different state-of-the-art analytical and reconstruction methods used in vertebrate paleobiology are also in focus to connect them to current PhD projects.

FÖL/2/170 Seminar of the shape of the Earth (Gábor Timár)

6 credits, theoretical, optional, non-repeatable

The course reviews scientific research on the shape of the Earth (from Archimedes and Eratosthenes to Gauss), with separate discussions on the physical concepts of the Earth as a sphere, an ellipsoid of resolution, and a geoid, and the determination of its geometric parameters. It also touches on the foundations of cosmic geodesy through the concepts of Helmert, Vening Meinesz, and Heiskanen. The teaching method is a seminar discussion based on articles selected from a collection of 25 articles. The course is available in English only.

FÖL/2/174 Karst bauxites (Andrea Mindszenty)

6 credits, theoretical, optional, non-repeatable

1. Ferrallitic soils (humid tropical wethering products) in general.
- The tropical scenario
  - deep weathering (sometimes > 100 m) between top-soil and saprolite
  - extremely long-lasting pedogenesis
  - *in situ* vs. transported/redeposited weathering products in the tropics
- Zone of pedogenesis = the zone of interaction between atmosphere biosphere and lithosphere

2. Transportation and resedimentation of ferrallitic soils
3. Fossilization of ferrallitic soil-type materials - the effects of burial and diagenesis
4. Phenomenology

- Macroscopic and microscopic features, chemistry of ferrallitic soils
  - hand-specimens and thin sections
  - simple tables showing major minerals and chem. components
  - process oriented characterization of the characteristics of ferrallitic soils
  - precursor materials, eventual provenance-indicator
- The role of temperature, rainfall, surface relief, drainage, parent rock

5. The lithofacies concept of karst bauxites

- The imporint of vadose/semivadose and phreatic depositional environments and their changes during burial and diagenesis

6. Lithological, minerlaogical and geochemical features documenting soil erosion, transport, deposition of allochthonous weathering products; accumulation and geochemical evolution of ferrallitic soil materials over a karstic terrain; the terra-rosssa analogue)
7. Bauxites, paleorelief and tectonics
8. Some classical examples

- Lateritic weathering crusts within the Tethyan realm
- Tethyan Karst Bauxites

9. Karst bauxite deposits of Hungary

FÖL/2/175 Cosmochemistry (Stephen J Mojzsis)

6 credits, theoretical, optional, non-repeatable

This course explains the origin, history and transformation of matter in the solar system including the biologically important elements. We survey the various forms in which this matter occurs as primitive bodies (meteorites, comets), planets and stars and then focus on the history of that matter. Explains basic concepts of nucleosynthesis (the origin of elements) and devotes this knowledge to the chemistry and mineralogy of the planets and meteorites. Since I teach this material under the auspices of Earth Sciences, the majority of this course is therefore devoted to traditional geological topics. For astronomy students, it should be a useful introduction to concepts of geology. For geology students, it will be a new application of their knowledge towards astrophysical phenomena. For other advanced students of the physical sciences and engineering, it provides a springboard to a whole new field.

FÖL/2/178 Challenges in hydrogeology in the 21st century – problems and solutions (Szilvia Szkolnikovics-Simon)

6 credits, theoretical, optional, non-repeatable

The main natural resource of the XXI century is water. The water supply of human and groundwater dependent ecosystems is impacted by several problems and factors. The increasing water demand and usage of the growing population, the climate change, and the disproportional distribution of the water resources on earth result in significant problems related to the quantity and quality of our water supplies. In the framework of the course we discuss the status (quantity and quality) and availability of groundwater resources, the connected possible research methods, and innovative solutions (i. e. managed aquifer recharge), which help in the sustainable water management and groundwater dependent ecosystem protection.

FÖL/2/180 Dynamics of the plasmasphere (Balázs Heilig)

6 credits, theoretical, optional, non-repeatable

- Basic concepts of plasma physics, with special emphasis on magnetized plasmas
- The formation of the ionosphere and its dynamical processes
- The formation and dynamical processes of the plasmasphere, with particular attention to the processes of the quiet plasmasphere, the changes in global convection during magnetic storms, and its connection to substorm dynamics
- The role and significance of magnetosphere–ionosphere coupling
- In-situ measurements in the magnetosphere and ionosphere, and remote-sensing techniques from the ground, with special emphasis on the FLR method

FÖL/2/181 Practical applications of muography in geophysics (Gergő Hamar)

6 credits, theoretical, optional, non-repeatable

Muography is a new scientific field at the interface of geophysics and particle physics, in which particle-physics detectors are used to map the internal density of geological objects and, through this, their structure. The method is currently an active area of research and can be applied in mining, speleology, geological structural studies, volcanology, geotechnics, and in the scanning of industrial facilities. The aim of the course is to provide a deeper understanding of the physical principles underlying muography, to present the operating principles of the modern detectors used, to compare the technologies, and to explain their applicability. The course also covers methods for processing measurement data and reconstructing density distributions. We examine major applications in detail and how muography fits into the broader system of geophysical measurements.

FÖL/2/182 Magmatic petrochronology: decphering magmatic processes using geochemistry of phenocrystals and accessory minerals (Réka Lukács Haranginé)

6 credits, theoretical, optional, non-repeatable

The source rock of magma, its nature, and the conditions of its evolution can be traced through the study of numerous igneous minerals. Among these, particular emphasis is placed on accessory minerals (e.g., zircon) that can simultaneously provide geochronological and geochemical information. Furthermore, for most minerals, it is possible to determine the timing of diffusion-controlled chemical relaxation of certain elements, which can be linked to processes occurring within magma reservoirs.
During the course, students will become familiar with the minerals that can provide such geochronological and/or geochemical information, the methods used to study them, illustrative examples through case studies, as well as the limitations of these methods and their interpretations.

FÖL/2/183 Inversion and Tomography (László Balázs)

6 credits, theoretical, optional, non-repeatable

Inversion is the basic method for the model-based evaluation of a measurement data system, that properly manages potential sources of error. Although many variants are used in practice, they all have in common that they start from some variational problem. This course deals partly with the theory of inversion and partly with practical applications, from model building to the associated numerical methods.
Special attention is given to the statistical properties of the estimated parameters, related information quantities and information geometry. We also deal with the properties of inversions with constrains or a priori information, or with linearization issues that are often necessary in practical applications.
Because of their importance, part of the course is devoted to tomography as a special inversion problem. For tomography, the focus is on regularization and the resulting bias. The course will be completed with numerical methods related to tomography.