MSc in Geosciences

Course block: Year 1 - Fall

GEOL 501 - Advanced Economic Geology

This course will start with an introduction, classification, distribution, and characteristics of ore deposits, particularly metallic ores. It will also link types of ore deposits with particular plate tectonic settings along with their genesis. Students will get comprehensive mineral-deposit forming (geological) processes all around the world with classical examples. This course will also cover topics on the specific geological setting and geological-geochemical controls on metal systems typical for Kazakhstan and Central Asia and also will deal with the metallogenic provinces of Kazakhstan. Laboratory work involves the understanding of mineral deposits by using various analytical techniques and applied geochemistry in ore geology. Ore minerals, their sequence of formation, and textures will be identified using transmitted and reflected light microscopy, Whole Rock, Trace Elements, Rare Earth Elements, geochemistry, mineral chemistry, isotopes, and fluid inclusions. For the lab, most of the instruments available at SMG and Core facility will be used.

Course learning outcomes
1. Examine the key geological and geochemical processes that control major metal systems and result in the formation of these ore deposits.
2. Describe and classify ore and hydrothermally altered samples using modern petrographic and geochemical tools.
3. Infer ore deposit types, exploration strategies, and ore processing characteristics using classifications of minerals, rocks, and regions in Kazakhstan.
4. Apply geological knowledge and both established and novel methods of geoscientific investigation to find, describe, and interpret ore deposits.

GEOL 502 - Advanced Petroleum Geology

This course includes an introduction to the theory of petroleum formation and occurrence as well as state-of-the-art tools and techniques used in petroleum exploration and reservoir development. Topics include hydrocarbon source rocks (mineralogy, organic carbon content), kerogen (formation, composition, types, and evolution during organic diagenesis and catagenesis), petroleum and gas generation from kerogen, expulsion from source rock and migration to reservoirs, reservoir rocks, petroleum (composition, physical properties, changes upon maturation, biomarkers, maturity indicators), traps and seals, sedimentary basins, petroleum systems, methods of petroleum exploration, introduction to reservoir types with a focus on fluvial and deltaic as well as carbonate settings, introduction to subsurface mapping methods, reserve estimations, and geological controls on recovery methods, production allocation, and enhanced oil recoveries.

Course learning outcomes
1. Competently discuss and evaluate petroleum system elements and processes.
2. Recognize different reservoir types and familiarize with subsurface mapping tools and methods including seismic, logs, cores, fluid properties, and biomarkers.
3. Evaluate exploration and/or development potential and identify geology-related production opportunities and challenges.
4. Through individual and group projects to develop scientific observation skills, scientific communication skills (verbal, presentation, and written), and team skills.

GEOL 503 - Advanced Sedimentology

This course provides a state-of-the-art review of sedimentary systems including those formed in fluvial, lacustrine, deltaic, tidal, shoreline, and deep marine settings. Lectures include discussions, exercises, core and field studies, and consideration of modern and outcrop studies as an aid to subsurface activities. Familiarization with depositional processes, environments, and architecture of depositional elements is

followed by seminars focused on understanding sedimentological control on occurrences of mineral and energy resources hosted in them. This includes accumulation during the deposition as well as post-depositional processes such as fluid movements and mineralization. Particular focus will be given to sediment-hosted resources such as petroleum, uranium, copper, energy minerals, and rare earth elements, as well as sedimentary-hosted geothermal systems and carbon storage strategies in sedimentary basins.

Course learning outcomes
1. Recognize a range of depositional systems in outcrops and subsurface data.
2. Develop skills to identify fairways and play concepts.
3. Familiarize with traditional and advanced tools for describing and characterizing sedimentary deposits and sedimentary-hosted resources.
4. Critically review geological controls on occurrences of resources as well as geological controls on various recovery methods.

GEOL 504 - Advanced Geochemistry

This course provides advanced theoretical knowledge of high-temperature geochemistry required for data interpretation and integration in geosciences. Also, analytical methods including the applications and limitations of each method will be presented along with data analysis. Finally, the course will focus on principles of various isotopic systematics.

Course learning outcomes
1. Describe the principles of geochemistry and analytical methods.
2. Interpret geochemical datasets on a large scale.
3. Analyze and integrate the geochemical data with other geological datasets.
4. Comprehend the fundamentals of isotopic geochemistry in geosciences.

GEOL 505 - Advanced Geophysics

This course provides theoretical foundations that are required for the understanding and critical interpretation of modern geophysical concepts and in-depth knowledge of basic mathematical methods like multidimensional analysis, optimization, and approximation theory as well as physical modeling. Additionally, the module teaches fundamentals of statistical methods which are essential for processing observational data. The course further teaches broad basic algorithms from numerical mathematics that are used to evaluate and simulate physical models on computers.

Course learning outcomes
1. Describe the physical fundamentals of the geophysical methods.
2. Examine the mathematical and statistical concepts of Advanced Geophysics.
3. Implement standard geophysical models on computer systems, compare and evaluate different implementations.
4. Explain advanced theoretical basics of system theory and understand the interaction between space/time and frequency domain.

Course block: Year 1 - Spring

GEOL 506 - Advanced Petrology
This course provides all the information about igneous and metamorphic rocks including their important geochemical and isotopic systematics. The igneous part will start with the classifications and textures of igneous rocks and structures of bodies. It will cover the origin, generation, and emplacement of magmas, their types, and possible variations in the chemistries of rocks in different tectonic boundaries. The course will also cover the characteristics of mineral- and petro-chemistry of rocks in different tectonic settings and origins. The metamorphic part covers metamorphic phase equilibria and thermodynamics, types of metamorphism. It will explore more detail of metamorphic mineral assemblages in different metamorphic grades and facies with changes in their chemistry. Finally, students will be introduced to constraining the

conditions of metamorphism using modern tools. Students will be taught to interpret igneous and metamorphic rocks with minerals present in them and their textures using various tools including a microscope. Using the chemical data students will practice interpreting the paleo-tectonic environment emplacement of igneous rocks. They will also learn how to construct P-T diagrams of the metamorphic condition using pseudosections. The weekly round-table discussions in this unit will cover and explore critical problems and hot topics of igneous and metamorphic petrology and petrogenesis.

Course learning outcomes
1. Interpret the significance of mineralogy and texture of magmatic and metamorphic rocks.
2. Explicate the key processes involved in the evolution and emplacement of igneous rock using the field, microscopic, and chemical evidence.
3. Interpret the major magmatic rock associations, and their characteristics and link them to specific tectonic settings.
4. Elucidate the geochemical data to understand igneous and metamorphic processes.
5. Infer the mode of formation (cooling history; protolith; P–T conditions; deformation) of igneous and metamorphic rocks.

GEOL 507 - Exploration Geosciences

This course offers an in-depth exploration of the geological, geochemical, and geophysical techniques that are crucial for understanding the Earth's lithosphere and its mineral and energy resources. The course is structured into modules that address exploration methods frequently applied in minerals and energy exploration. It encompasses subsurface exploration methods (drilling and geophysical techniques: gravity, magnetic, electrical, electromagnetic, and seismic surveys) and surface exploration methods (geological and geochemical techniques: rock, regolith, hydrologic sampling, and analytical approaches). Theoretical foundations, data collection, analysis, and geologically constrained interpretation are explored. The course includes two one-day field trips where students gather geological and geochemical samples, and geophysical data over an exploration target in mineral and fossil fuel deposits. These data will be subsequently processed, analyzed, and interpreted in practical sessions.

Course learning outcomes
1. Examine scientific principles underlying mineral, energy, and natural resource formation, distribution, and extraction.
2. Identify and interpret generic characteristics of economic mineral and energy resources, including anomalies in geological, geophysical, and geochemical data.
3. Differentiate and apply various surface and subsurface exploration techniques for analyzing surface and subsurface properties and locating resource anomalies effectively.
4. Apply and select appropriate surface and subsurface exploration techniques for sampling media and sampling strategies.

GEOL 508 - Advanced Structural Geology and Microtectonics

This course provides the student with an advanced level understanding of structural geology, stress and strain, brittle and ductile rock deformation mechanisms, and geometries at micro-, meso- and macro-scale and trains 3D thinking to help solve more complex tectonic problems.

Course learning outcomes
1. Critically interpret the various natural rock deformation mechanisms and geometries at an advanced level.
2. Analyse complex deformation structures using data in profile, map, and stereographic projections.
3. Develop improved 3D imagination skills.

GEOL 509 - Advanced Field Geology

Application of geological field methods to produce a geological map, cross-sections, a report, and an oral presentation describing the local geological structure and history in a structurally or sedimentologically

complex area in sedimentary, metamorphic, or magmatic rocks.

Course learning outcomes
1. Apply geological field methods in mineral exploration.
2. Construct a geological map, cross-section, and report in a geologically complex area.
3. Develop written and oral communication skills.

Course block: Year 2 - Fall

GEOL 601 - Advanced Tectonics and Geodynamics

This course provides an advanced level understanding of large-scale scale deformation processes that shaped the Earth, including plate tectonics (e.g. evolution of subduction zones, spreading ridges) and other deformation processes at the scale of the entire crust and mantle such as the dynamics of mantle plumes, hotspots and the effect of large-scale meteorite impacts. An overview will be presented of the tectonic evolution of the main types of continental margins (active margins, passive margins), volcanic arcs, fore- and back-arc basins, the evolution of entire mountain ranges, large continental sedimentary basins, and at a somewhat smaller scale: salt tectonics, intrusion tectonics, thrust tectonics.

Course learning outcomes
1. Apply plate tectonic theory and principles in interpretation.
2. Describe the large-scale structure of the Earth and its evolution in time.
3. Analyze the structure of mountain ranges and basins and discuss possible mechanisms of their formation.

GEOL 690 - Thesis Research

This course aims to train the students to identify relevant research problems, perform a continuous literature review on a research problem, and develop and implement an original methodology to investigate possible solutions to this problem. The thesis topic will be proposed by the student in consultation with the thesis supervisor before the commencement of the second year. Students will have to defend the findings and present the outcome of the thesis research. The committee will evaluate the research approaches and monitor student progress as well as the thesis research and oral defense.

Course learning outcomes
1. Identify the advanced level of a research problem in geology and investigate issues and benefits.
2. Develop appropriate research skills to carry out and conclude a research project.
3. Practice and manage a research project to its successful completion and achieve its objectives.
4. Defend research results in the form of a conference-style verbal presentation to the thesis committee.
5. Present the research findings in the form of a thesis and conference-style paper.

Course block: Year 2 - Spring

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Course block: Year 2 - Fall

Elective Courses of Year 2 - Fall. Please take one elective course (6 ECTS) from the provided list of the courses

GEOL 602 - Advanced GIS

GIS course for MSc in Geosciences introduces advanced practical applications of geospatial, remote sensing, and geodetic surveying methods applied for geosciences with a focus on the onshore and marine petroleum and gas & mineral and mining industry. This course promotes advanced geospatial data collection, quality assurance, manipulation, storage, digital cartographic mapping, data analytics, and interpretation methods for geosciences with a focus on the onshore and marine petroleum and gas & mining industry. Principles of geodetic measurement and UAV technologies are also key components of this course. Publicly accessible and commercial geospatial software packages are intensively utilized in the scope of this course.

Course learning outcomes
1. Collection and quality assurance of geospatial and geodetic data applied for geosciences.
2. Geodetic and UAV observations applied for Advanced geosciences.
3. Advanced digital cartographic products and geo visualizations for geosciences.

GEOL 605 - Geology of Central Asia and Metallogenesis

This course is designed to discuss the geology and the tectonic processes involved in the formation of the Central Asian Orogenic Belt (CAOB) with a focus on the Western part that includes Kazakhstan. The first part of the course includes an introduction to the formation of major orogens of the world with examples- Himalayan, Alpine, Andean, Appalachian, and Grenville. This will be followed by a general discussion on tectonic processes involved in the formation of the orogens and a comparison between each of them. The third part of the course includes a description of the Central Asian Orogenic Belt-tectonic processes, timing, and classification. Various tectonic models proposed for the formation of the CAOB will also be considered. Part four comprises the details on Kazakhstan orocline- tectonic processes and age. The fifth segment of this course will be about the various metallogenic provinces of central Asia- the Uraltides Belt, the Kazakh Steppe Belt, the Kazakh Uplands Belt, the North Tienshan Belt, the South Tienshan Belt, and the Pamir Belt. This segment also includes a description of the discussion about the types of ores, ore grade, and genetic processes. The final segment of this course will discuss strategic mineral resources of Kazakhstan- Li, Co, and REE-bearing mineral and metal resources and also their future prospects.

Course learning outcomes
1. Comprehend the tectonic process related to various orogenic belts of the world.
2. Describe the geology of central Asia including chronology and the crustal evolutionary processes.
3. Visit major metallogenic provinces of Central Asia to observe the geological setting and for sample collection.
4. Determine the composition of various ores to assess the ore grade or type and be able to explain economic mineral deposits.

GEOL 603 - Advanced Hydrogeology

This subject covers a range of hydrogeological disciplines, including physical and chemical hydrogeology, as well as groundwater management and assessment. By the end of the course, students will have acquired

essential skills for critical thinking, rigorous and independent analysis, and problem-solving in novel contexts. This course seeks to provide students with specialized knowledge and skills relevant to advanced research in the field at a post-graduate level. Furthermore, it aims to furnish students with discipline-specific expertise that prepares them for roles as professional geologists within industries or government entities.

Course learning outcomes
1. Determine the distribution, movement, and quality of groundwater using conventional and emerging approaches/technologies.
2. Assess the groundwater movement, storage, recharge, and discharge, in the context of resource management, by applying appropriate tests.
3. Evaluate the impact of chemical and biogeochemical elements on the development of groundwater characteristics.
4. Utilize the insights gained from the course to tackle significant challenges in the minerals and/or water resources sector, through addressing issues regarding mine tailings dams and the mitigation of contaminant plumes.

GEOL 604 - Engineering Geology and Geotechnics

The aim of the course is to introduce the fundamentals and application of engineering geology and geotechnics for geologists to evaluate mining and construction projects such as mine design, buildings, tunnels, highways, and land-based waste disposal facilities. The course has three modules including rock engineering, soil mechanics, and engineering geology. Rock engineering includes physical and mechanical properties of rocks, common intact rock tests, rock mass classification, and characterization, and also covers example projects such as tunnels, drilling, and pillars. The soil mechanics module contains physical and index properties of soils, common soil tests, and classification of soil and also covers example projects such as slope stability and foundation. The last module is engineering geology involves geotechnical site investigation, drilling, sampling in a field, and engineering mapping. The course is graded based on assignments, exams, project reports, and presentations.

Course learning outcomes
1. Analyze fundamental knowledge of soil and rock for the purposes of mining and construction application.
2. Apply the principles of engineering geology and geotechnics to solve problems in geology.
3. Define a problem related to geotechnics and develop and implement an appropriate research method, and approaches to solve it.
4. Evaluate and manage the economic, legal, social, ethical, environmental, and technical aspects of application projects and defend the results.
5. Effectively communicate in the team to solve engineering-related problems as a geologist by conducting teamwork as well as individual efforts.

MINE 503 - Applied Geostatistics

This course familiarize the students with the process of geological block modeling that is applicable for further analysis of mining activities (e.g. mine planning). It covers the traditional and modern algorithms for mineral resource estimation and reporting based on JORC code associated with discussion of the advantages and disadvantages in each. Beside of that, the most widespread applied Geostatistical tools such as variogram, kriging, simulation and change of support will be thoroughly discussed.

Course learning outcomes
1. Describe the data structures and integrated technologies required for practical 3D application of geostatistics.
2. Evaluate the current methodology for resource estimation and choose the optimum one according to the type and complexity of a deposit.
3. Analyze the block model and preparation for calculation of recoveries function (tonnage, mean grade above cut-off and metal quantity).
4. Apply simulation methods in resource estimation and probabilistic modeling of recovery functions.

5. Critically evaluate and manage uncertainty in resource estimation.

PETE 504 - Advanced Formation Evaluation

Review of conventional and contemporary well logging and core analysis methods and technologies. Log and core data interpretation techniques for lithology and hydrocarbon identification and calculation of reservoir parameters, including computerized processing and interpretation. Utilization of well-log and core data in evaluating well performance before, during, and after production of hydrocarbons. Sensitivity of hydrocarbon in place determination to formation evaluation parameters. Regular, special (SCAL), and integrated core-log analysis of formation resistivity, saturation, porosity, and lithology. Lithology and stratigraphy estimations from spectral gamma ray logging, fluid and permeability characterization from nuclear magnetic resonance (NMR), and thin bed, stratigraphic, and structural (e.g. fracture) analysis from formation micro-imaging (FMI).

Course learning outcomes
1. Improve reservoir characterization using SCAL and integrated core-log data.
2. Perform formation evaluation with methods such as spectral gamma ray logs, NMR, and FMI.
3. Characterize carbonate, sandstone and shale reservoirs with information derived from various logs.
4. Integrate the log, core and other well data to produce a consistent interpretation of a given reservoir.