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Department of Mineralogy, Petrography and Geochemistry

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INTRODUCTION

Department of Mineralogy, Petrography and Geochemistry is the oldest Earth science department at the AGH University of Science and Technology. It was created in 1919 as one of the first six departments of the Academy of Mining and was initially named as the Department of Mineralogy and Petrography. The Department was organized by Professor Józef Morozewicz (1865–1941) who chaired the Organizing Committee of the Mining Academy. In the early years the Department belonged to the Faculty of Mining, the sole Faculty of the Academy of Mining at that time. In 1951 the Department became a part of the just formed Faculty of Geology and Mineral Exploration which was renamed in 1992 to the Faculty of Geology, Geophysics and Environmental Protection. Since 1929 the Department has possessed its own space in the main building of the University. The Department was chaired by Dr. Stefan Kreutz (1919–1920), Dr. Zygmunt Rozen (1920–1936), Prof. Walery Goetel (1936–1939), Prof. Andrzej Bolewski (1945–1969), Prof. Witold Żabiński (1969–1992), Prof. Andrzej Manecki (1992–2002), Prof. Tadeusz Ratajczak (2002–2011), and Prof. Krzysztof Bahranowski (2011–2012). At present, the Head of the Deparment is Dr. Tomasz Bajda, who has performed this function since 2012. A total of 25 scientists and lecturers as well as 3 persons of technical staff are currently employed in the Department and 21 postgraduate students are working on their PhD theses.

RESEARCH AREAS/ RESEARCH GROUPS

The research activity of the Department focuses on the study of chemistry and mineralogical composition of rocks of igneous, sedimentary and metamorphic origin from Poland as well as different parts of Earth. The research objectives not only involve the phase identification, but also concentrate on the understanding of transformation mechanisms which take place during weathering, chemical and structural changes, and modifications of mineral properties. The ultimate goal is to determine the possibilities of practical use of the obtained results in the field of: mineral resources, technology and environmental protection. The scientific and research activity of the Department deals with the issues of mineralogy, crystal chemistry, geochemistry, petrology and geology of mineral deposits. The research also includes analysis of solid matter of extraterrestrial origin.

The **mineralogical research** conducted in the Department has both a scientific and applied character. The employees work on systematics and nomenclature of minerals. The basic research includes the refinement of silicate and aluminosilicate complex structures and identification of new phases. Apart from aluminosilicates the interest is also focused on other crystalline phases e.g. iron (oxyhydr)oxides, sulfates, sulfosalts as well as rare minerals e.g. phosphates, arsenates and vanadates. The characterization of solid matter goes beyond Earth and is extended to extraterrestrial minerals, in particular matter formed in the protoplanetary disc of the solar system. Research groups of the Department also carry out studies which could be classified as experimental mineralogy e.g. kinetics and mechanisms of minerals crystallization/dissolution and their interaction with living organisms, the role of bacteria in mineral-forming and soil-forming processes. The studies on the mineralization of human organism are undertaken (biomineralogy). The mineralogical topics also include gemology devoted to characterization of precious stones (gems) as well as organic,

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amorphous substances e.g. fossil resins. The applied mineralogy is devoted to crystallochemical research on organo-mineral materials in terms of their use in technologies and environmental protection. The experiments are carried out on synthesis and modification of clay minerals, zeolites and other phases in order to obtain new type of catalysts, adsorbents and nanocomposites.

The **petrological** research conducted in the Department leads to determination of mineral composition, properties and usefulness of genetically and stratigraphically diverse rocks collected from different regions worldwide. The characterization also involves age determination. The examples of realized research include: characterization of geological sediments for the determination of their origin, characterization of mineralization from the economical point of view, studies on metamorphic rocks of the Sudety Mountains, characterization of sedimentary rocks in terms of shale gas exploration. The petrological research is connected also with stone-based products and accompanying sediments discovered in archaeological sites. Apart from the determination of its genesis, the collected material enables paleoclimatic reconstructions.

The **geochemical** research carried out by the Department covers a broad spectrum of issues both in the field of general geochemistry and its applications in the field of geology, mineral engineering and environmental protection. This involves petrological analyses of igneous and metamorphic rocks using major and trace elements as well as dating of geological processes by applying various methods. The geochemistry is also devoted to model and experimental research on CO_2 reactivity and its interaction with rocks in terms of CO_2 sequestration. The conducted research provides information on the transformation mechanisms of minerals in aquatic systems (mineral-rock interaction) also in the presence of bacteria (geomicrobiological research). The studies of geochemical groups involve the analysis of natural precipitates, industrial waste and atmospheric dust. In terms of environmental assessment the chemical/mineralogical composition of soils and selected plants is determined to analyze the toxicity which could be related to industrial activity (e.g. coal mining and the power industry).

It is worth to underline the research which involves mineralogical, geochemical and petrological analysis of metamorphic complexes of Spitsbergen. Each year a polar expedition to this region is organized by the Department employees in cooperation with other Polish and foreign partners. The expeditions also involve PhD and MSc students of the Department.

In the past ten years the employees of the Department have completed over 40 projects of scientific and/or applied character which were financed by different Polish institutions: Ministry of Science and Higher Education, National Science Centre, National Centre for Research and Development and National Fund for Environmental Protection and Water Management.

FACILITIES

The Department possesses analytical laboratories, where mineralogical, petrographical, as well as chemical and geochemical research is carried out. These include laboratories of: light (optical) microscopy, gemology, experimental mineralogy, analytical geochemistry and geomicrobiology. Moreover, the Department cooperates closely with the up-to-date-equipped Laboratory of Phase, Structural, Textural and Geochemical Analyses of the Faculty, which is chaired by the former Head of the Department, Prof. Krzysztof Bahranowski. A part of the Department's equipment, including scanning electron microscope and atomic absorption spectrometer was also handed over to the Laboratory.

Laboratory of optical microscopy is equipped with universal microscope Olympus BX-51 and stereoscopic microscope Olympus SZX-9. The documentation of the research is facilitated by digital camera Olympus DP-12 and dye-sublimation A3+ printer Olympus Camedia P-400. Professional software enables a deep analysis of the recorded images. The scope of the research performed here includes microscopic observations in both transmitted and reflected light as well as macrophotography using stereoscopic microscope or bellows. Identification of minerals, classification of rocks and quantitative measurements are carried out. A wide range of samples are investigated – minerals, rocks, ores, soils, meteorites, atmospheric dust, slags, waste materials etc.

Laboratory of gemology is equipped with, among others, immersion microscope SYN GSZ/2T-SYNTEST G ImmersionScope, refractometer, polariscope, spectroscope, UV lamp, electric tester, Duotester, TLZ/3 THERMOLYZER, hardness microtester, carat balance and proportionscope. The immersion microscope allows the identification of inclusions in mineral phases. The evaluation of the gem resistance to mechanical and thermal treatment is performed. The equipment also allows to distinguishing between natural and synthetic gems, analogs and imitations, etc. The refractometer is applied to the determination of the gem index of refraction, birefringence and optical character. Pleochroism as well as the amount and direction of optical axes are determined using polariscope. The collection of absorption spectra allows the identification of natural gems and their analogues and the evaluation of chromophores. The determination of the luminescence and phosphorescence (both their intensity and color) are carried out using ultraviolet lamp. Diamonds and their synthetic analogs (e.g. zirconia and moissanite) can be distinguished by using the electrotester. Other gem features: heat conductivity, reflectivity, hardness and the proportions of the sections are determined using duotester, hardness microtester and proportionscope, respectively.

In the **laboratory of experimental mineralogy** various mineralogical and geochemical studies are carried out. They include the research on kinetics and mechanism of mineral dissolution, synthesis of minerals and composites, modifications of minerals and mineral raw materials, determination of sorption properties, thermodynamic studies etc.

Laboratory of analytical geochemistry is intended for both teaching and research. This is the main lab, where the courses related to general chemistry and analytical (geo)chemistry take place. The research carried out here includes preparation as well as chemical analyses of environmental samples, i.e. rocks, minerals, wastes, soils, plants and water. Besides standard chemical facilities, the laboratory is equipped with UV-Vis and infrared spectrometers.

Laboratory of geomicrobiology is used for researching microbial processes in natural systems. The effect of microorganisms on the environment and the influence of chemistry on the microbial life are also investigated here. The microbe-mineral interactions in soils, aquifers and caves under terrestrial and extraterrestrial conditions are of particular interest. The laboratory is currently equipped with culturing facilities for aerobic microbes. The facilities include: level 2 biosafety hood (ThermoFisher Scientific), incubator (ThermoFisher Scientific), autoclave, gyratory shakers and vortex shaker.

EDUCATION AND TEACHING OFFERS

In the first-cycle of studies at the Faculty of Geology, Geophysics and Environmental Protection the Department gives courses which provide fundamental knowledge necessary to continue the studies devoted to Earth Sciences. These are mainly: Chemistry, Mineralogy, Petrography, Geochemistry and Methods of Mineral and Rock Analysis.

In the second-cycle of studies the Department teaches in the field of 3 different specializations: (i) Applied Mineralogy and Gemology, (ii) Minerals Engineering, and (iii) Environmental Assessment.

A student of the Applied Mineralogy and Gemology specialization is offered to acquire both general knowledge and practical skills related to Earth sciences, modern analytical techniques and technology as well as prospecting and management of mineral resources. It is attained thanks to a wide spectrum of basic and advanced courses, including mineralogy, geochemistry, petrology, solid state chemistry, crystallography and crystal chemistry, geochronology, gemology and many others. A student is taught how minerals and mineral raw materials are utilized and processed. The problems related to effective and sustainable management of environmental resources and management of wastes and accompanying minerals are also brought up. Moreover, the biochemical, medical, archaeological and cultural heritage-related applications of mineralogical sciences are presented. The examples of deep processing, mining and interpreting of analytical data are presented as well. Therefore, a graduate is thoroughly prepared to take up a job not only related to traditional

Earth Sciences but also to material science and engineering, environmental engineering, gemology and jewelry, archeology, monument conservation and even to medicine and forensic science.

Minerals engineering specialization prepares the graduate to start professional work or research in the field of characterization and application of highly processed mineral-based materials, mineral derivatives as well as micro- and nanocomposites. The knowledge gained during various classes makes the graduate ready to work in different fields of technology i.e.: in particular in the mineral, ceramic and chemical industry as well as foundry. The experience also allows the graduate to undertake work connected with environmental protection. After several classes the graduate has the ability to work in laboratories which deal with mineral-based materials and organic derivatives of the minerals. The graduate demonstrates the knowledge regarding application and interpretation of the results obtained using modern analytical techniques dedicated to solid and liquid phase analysis. The knowledge enables the graduate to synthesize and manufacture modern mineral materials.

A graduate of the Environmental Assessment specialization has a broad knowledge in the scope of atmosphere, water and soil geochemistry, and in particular the knowledge regarding their monitoring and protection. During various courses both natural biogeochemical cycles and pollutants behavior in the environment are discussed and analyzed. The students are familiarized with the basics of mining, industrial and municipal wastes and waste management as well as the protection of mineral deposits. They also possess the knowledge on land use planning, environmental management and legally binding acts related to these issues. These features make the graduate of this specialisation a very good candidate for work in any government offices and departments related to environmental protection. The graduate may also apply for the job in laboratories which deal with environmental and industrial issues.

All the specializations offer courses with a large portion of laboratory classes. This allows the students to practice sampling, preparation and analysis involving a wide spectrum of traditional and modern techniques. These include e.g. optical microscopy, electron microscopy and microanalysis, X-ray diffractometry and X-ray fluorescence, UV-vis spectroscopy, atomic absorption spectroscopy, infrared absorption spectroscopy, Raman spectroscopy and various gemological techniques.

COOPERATION

Decades of scientific achievements, the gained research experience, professional staff as well as the appropriate equipment makes the Department ready to carry out the following research projects, consultancy projects and services:

- detailed qualitative and quantitative analysis of mineral composition and chemistry of mineral substances and synthetic crystalline and amorphous phases,
- comprehensive analysis of rocks and artificial solids of multiphase composition e.g. slag and ash, ceramic products, soils, as well as substances of extraterrestrial origin,
- evaluation of chemistry and mineral composition of mineral waste and possibilities of its utilization,
- determination of selected physical and chemical properties of minerals, rocks, and other solids which determine the possibilities of their use in e.g. ceramic industry and environmental protection,
- modification of selected physical and/or chemical properties of minerals, rocks and other solid substances,
- the synthesis of selected minerals and their characterization using mineralogical methods and determination of their thermodynamic properties,
- detection and quantitative determination of harmful substances in the natural environment and indication of conditions for their neutralization,
- application and use of chemical and mineralogical analysis in other disciplines involving archeology, art history, medicine and forensics,
- the research on physical and chemical properties of natural and modified mineral-based sorbents e.g.: carbonates, iron minerals, clay minerals and zeolites.

The Department cooperates with industry: PGE Polish Mining and Conventional Power Generation, Bełchatów Coal Mine, KGHM Polska Miedź S.A. Capital Group, Czatkowice Limestone Mine,

PPUH "Dolomit" Dolomite Ząbkowice Mine, Eurovia Polska and Pedmo S.A. The collaboration involves joint research projects relevant for the development of the Polish economy, implementation of projects, documentation of mineral deposits, introduction of innovative technological solutions as well as the organization of student training for the completion of MSc and PhD theses.