

## Department of Hydrogeology and Engineering Geology

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### INTRODUCTION

The Department of Hydrogeology was established, as an independent unit, at the Faculty of Geology and Exploration in 1967. It was headed at the time by Prof. Antoni S. Kleczkowski, and its staff comprised 1 associate professor, 2 assistant professors, 2 senior assistants and 2 technicians. Since that time, despite changing structure of the faculty, the word “hydrogeology” survived to this day in the names created during subsequent reorganizations of the faculty, departments, institutes. Over decades, hydrology was accompanied by engineering geology, geology and mining hydrogeology. This applies both to the formal name of the unit and to the aims of research and teaching conducted here. It should also be mentioned that hydrogeology, as a separate subject, was taught at the Faculty of Geology and Surveying of the AGH much earlier, i.e. since 1946. Those lectures were conducted by Prof.

Roman Krajewski, further long-time head of the department and then an institute containing ‘hydrology’ as part of their names.

In 1969 there was an important reorganization of the Faculty of Geology and Exploration and thus the Institute of Hydrogeology and Engineering Geology was created. Its first head was Roman Krajewski (Fig. 1) and its vice-head was Antoni S. Kleczkowski, who in 1974 became the head of the Institute.

The year 1981 brought an important event for the Kraków hydrogeology and the Faculty of Geology and Exploration – Prof. Antoni S. Kleczkowski (Fig. 2) became the first rector of the AGH chosen in free elections at the AGH University. He held this position for six consecutive years.

Due to enormous amount of new duties, A.S. Kleczkowski ceased to head the Institute of Hydrogeology and Engineering Geology in September 1982, and from October 1<sup>st</sup> 1982 Jerzy Górecki became acting head of the unit.



*Fig. 1. Professor Roman Krajewski*



*Fig. 2. Professor Antoni S. Kleczkowski*

In 1984 Marek Nieć took the position of the head of the Institute and held this position until 1988, when he was replaced by Zdzisław Śmietański. The last head of the unit called Institute of Hydrogeology and Engineering Geology was Stanisław Rybicki.

In 1992 another significant reorganization took place. The faculty name was changed from the Faculty of Geology and Exploration to the Faculty of Geology, Geophysics and Environmental Protection. This was accompanied by the liquidation of institutes. Hence, on October 1<sup>st</sup> 1992 the Department of Hydrogeology, Engineering and Mining Geology was created. The head of the Department became Stanisław Rybicki.

The year 1994 was another year of divisions and creation of new structures at the Faculty of Geology, Geophysics and Environmental Protection. The former Department of Hydrogeology, Engineering and Mining Geology was divided into three new units: Department of Hydrogeology and Water Protection, Department of Engineering Geology and Environmental Geotechnics and Department of Mining Geology. For the first time since 1969 hydrogeology and engineering geology parted ways. The Department of Hydrogeology and Water Protection was subsequently headed by Andrzej Szczepański (1994–1998) and then by Jadwiga Szczepańska (1998–2005). In 2006 the ways of hydrogeology and engineering geology reconnected. The merger of the Department of Hydrogeology and Water Protection and the Department of Engineering Geology and Geotechnics resulted in the formation of the Department of Hydrogeology and Engineering Geology. The newly formed department was headed by Jadwiga Szczepańska-Plewa until 2012.

After her retirement in 2012, the function of the department's head was taken by Henryk Woźniak who held it until 2014. On February 24<sup>th</sup> 2014 Adam Postawa has become the current Head of the Department.

## RESEARCH AREAS/ RESEARCH GROUPS

Synthetic description and strict assignment of research topics carried out at the Department of Hydrogeology and Engineering Geology is not an

easy task. This results from the fact that both the name and personnel structure of the department changed many times over the years. Therefore, it would be more appropriate to describe people related to hydrogeology and engineering geology, who used to work and are currently working at the Faculty of Geology, Geophysics and Environmental Protection of the AGH University, rather than to describe the formal activity of the unit called the Department of Hydrogeology and Engineering Geology. It is those people who are the authors of the concepts that became vital parts of the canon of Polish hydrogeology and their papers are still appreciated and cited.

The first professor working with hydrogeology and permanently associated with AGH was Roman Krajewski. His broad research interests also included hydrogeology, mainly mining hydrogeology, as well as engineering geology. He should also be considered as one of the pioneers of hydrogeological modelling, although understood differently than it is today, in the age of computers. It was him, who together with Zdzisław Śmietański, in the 60s of the 20<sup>th</sup> century studied the possibilities of using Lukyanov's hydrointegrator for the calculation of shaft's freezing wall.

Creation of the Department of Hydrogeology resulted in a significant broadening of the scope of hydrogeological studies. Research interests of the department's employees included a wide spectrum of issues. An important line of research conducted at the department included issues related to the regional hydrogeology, particularly those of the depth of groundwater salinity zone, conditions and chemistry of water in Upper Silesia, the Kraków-Wieluń Upland and in the Kraków area. The protagonist and main driving force of these actions was Antoni S. Kleczkowski. He is the author of an important work in the field of regional hydrogeology of the regions neighbouring Poland, with reference to the geological structure and hydrogeological conditions of Poland, entitled *Hydrogeology of areas surrounding Poland*, published in 1979.

The second line of research that has been developed in the department headed by A.S. Kleczkowski, and is continued by his students, Stanisław Witczak and Jadwiga Szczepańska-Plewa and their students, is the groundwater protection. A continuation of research on this subject was an important

project conducted in the period of 1986–1990: “Conservation Strategy for Major Groundwater Basins in Poland”. The result of this project was the *The Map of Critical Protection Areas (CPA) of Major Groundwater Basins (MGWB) in Poland* scaled 1:500 000, developed and published in 1990 under the editorship of A.S. Kleczkowski. Despite the passage of time the map is still an important source of information for hydrogeologists conducting various studies related to the use of groundwater resources and their protection.

Methodological principles of groundwater monitoring and statistical quality control of monitoring studies were and still are within the research interests of the departmental staff. Scientifically important books were also published, such as: *Statistical quality control of data in groundwater monitoring* by Jadwiga Szczepańska and Ewa Kmieciak (1998), or *Methodological aspects of the groundwater chemical composition assessment* (2011).

Thanks to tremendous work of Stanisław Witczak and Andrzej Adamczyk, a two-volume *Catalogue of selected physical and chemical indicators of groundwater pollution and methods of their determination* was published in 1994 and 1995. This book became a basic source of information on substances that may pollute groundwater and methods of their analysis for many people professionally involved with the groundwater protection. The second, revised and extended edition of the catalogue was released in 2013, this time in cooperation S. Witczak with Ewa Kmieciak and Jarosław Kania.

The issues of hydrogeological mapping appeared repeatedly as an objective of scientific activity carried out at the department. The employees of the department participated in a nationwide project related to the development and publishing of the 1:50,000 Hydrogeological Map of Poland (sheets: *Olkusz*, *Ogrodzieniec*, *Kraków*, and *Wola Rzędzińska*).

The issue of groundwater sensitivity to pollution was also among scientific interests of the Department employees. Due to the efforts of the team led by S. Witczak *Groundwater vulnerability to pollution in Poland* scaled 1:500 000 was created and printed in 2011. Robert Duda and Anna Żurek were the co-authors of the concept of the sensitivity map.

An important field of the scientific activity of the Department has been modelling of groundwater flow and transport of substances in water. The collected experience in this field allowed to carry out a number of studies for the industry, related to – among others – liquidation of the mines in the Upper Silesian Coal Basin and the region of Tarnobrzeg, as well as projects funded by the KBN (Scientific Research Committee) and NCBiR (National Research and Development Center) grants. A number of books were also published, that serve as methodological manuals for students and others who wish to undertake studies on this subject. The most important include the script *Modelling of filtration processes* (Ryszard Kulma and Robert Zdechlik, 2009) and a two-volume textbook *Dynamics of groundwater* by Andrzej Haładus and Ryszard Kulma published in years 2012 and 2014.

In the period 1986-2013 the employees of the Department (Andrzej Szczepański, Andrzej Haładus and Jarosław Kania) participated in research conducted at the Department of Energy Resources on the development and release of further *Atlases of water and geothermal energy* in structural regions.

The studies on the issues related to hydrogeology of mineral deposits and mining hydrogeology, such as: prediction of mine water inflow, hydrogeological conditions of mineral deposits and their impact on the use of these deposits, water-related threats in mines, resources of mining water and management thereof, impact of mining in aquatic environment, chemical composition, protection and dynamics of groundwater, as well as the methodology of hydrogeological research, were conducted at the Department under the leadership of Zbigniew Wilk and later Jacek Motyka. Research topics included mainly the Upper Silesian Coal Basin and the Chrzanów-Olkusz region of zinc and lead deposits, the Lublin Coal Basin and the “Wieliczka” salt mine, as well as minor deposits of brown coal in Poland and – to a lesser extent – the Tarnobrzeg region of sulphur deposits and Legnica-Głogów Copper District. It can therefore be concluded that the activity initiated by Roman Krajewski and later continued at the Department contributed to the creation of the Krakow school of mining hydrogeology and hydrogeology of mineral deposits. The crowning achievement of this activity was publishing in

2003–2004 of a three-volume book *Hydrogeology of Polish mineral deposits and water-related problems of mining*.

In recent years the issue of water quality started to be treated more broadly in the department, not limiting its approach to groundwater only. The scientific interests of the departmental staff started to include also surface water and water intended for the human consumption. The first in Poland large-scale study on the consumer exposure to the necessity of water intake with high content of metals and metalloids was conducted. This study was carried out in cooperation with NIZP-PZH, University of Silesia, Adam Mickiewicz University of Poznan and Poznan University of Technology, and Kraków University of Technology. The Department of Hydrogeology and Engineering Geology acted as the project coordinator. The experience gained during the implementation of this project and the results of these studies allowed to publishing a monograph in 2011, edited by Adam Postawa and Stanisław Witczak entitled *Metals and related substances in water intended for consumption in Poland*.

Since 2008, under the leadership of Grzegorz Malina, studies on the issues of remediation of contaminated water and soil environment were undertaken at the department. Particular emphasis was put on *in situ* methods and the so-called sustainable remediation, treated as part of the risk management during the reclamation/revitalization actions in degraded areas, as well as on the use of numerical modelling of the dynamics of water and mass transport as a tool to support the selection and design of effective remediation methods. The work in this area was carried out in the period of 2010–2015. Its results are solutions to complex problems of remediation of contaminated soil and water environment, among others in the region of Nowa Dęba and the former Chemical Plant “Zachem” in Bydgoszcz. The textbook *Elimination of threat to the soil and water environment in contaminated areas* by Grzegorz Malina, published in 2007 and reissued in an expanded version in 2011 is the basis for training specialists in the field of environmental engineering and protection, and hydrogeology in the field of remediation of water and soil environment in Poland.

Engineering geology and geotechnics has always been present in the topics of research and teaching

of the department, over the years, in various organizational structures, either as a unit within the current Department of Hydrogeology and Engineering Geology, or as an independent Department of Engineering Geology and Environmental Geotechnics (1994–2004). The first studies were conducted by Roman Krajewski. They were continued by Stanisław Rybicki and later by Henryk Woźniak and their associates. The research activity is dominated by the issues of engineering geology, mainly in the context of opencast, underground and borehole mining, problems related to the analysis of slope stability, geological and engineering analyses of subsoil and bedrock, studies on the natural and anthropogenic geodynamic processes, as well as studies on the physico-mechanical properties of rocks and soils. Studies on modifying the properties of natural and anthropogenically amended rocks and soil, and forecasting engineering-geological conditions of terrain as well as mining and geological conditions of minerals exploitation are also carried out. In recent years, studies aimed to develop a comprehensive system for monitoring of static and dynamic condition of earth flood embankments became an important area of scientific interests of the engineering geology team. They are carried out within the “ISMOP” project.

The most important achievements include original studies on the structure and properties of dump soils (a specific soil medium), published in a number of papers and monographs. Innovative research into kinematics of landslide phenomena of mine working slopes and dump slopes of those mines should also be mentioned. An important achievement was the participation in the implementation and practical mastering of the hole operation technique of sulphur exploitation by underground smelting. Theoretical principles of the underground sulphur smelting process based on the model studies of this process under laboratory conditions were developed within this project.

## FACILITIES

Scientific and service offer of the Department is enhanced by the hydrochemical laboratory (Fig. 3). Since June 14<sup>th</sup> 2009 it has been accredited by the Polish Centre for Accreditation. It conducts analyses of the chemical composition of waters and solids.



*Fig. 3. Hydrochemical laboratory*

The laboratory has implemented a quality system compliant with the PN-EN ISO/IEC 17025 standard, covering the collection of groundwater and surface water samples and their analysis in terms of macro- and microcomponents and field unstable parameters. It is equipped, among others, with a mass spectrometer with inductively coupled plasma (ICP-MS) ELAN 6100, optical emission spectrometer with inductively coupled plasma (ICP-OES) Optima 7300 DV and a microwave digestion system – a device for rapid decomposition

of acid solid samples such as rocks, soils and organic samples. Procedures implemented at the laboratory are based on the existing international standards and its own unique research procedures.

Functioning of the stationary laboratory is supported by a mobile laboratory for sampling and water quality testing. It is equipped with a van-type vehicle with permanent specialized laboratory equipment enabling field measurements (Fig. 4) as well as sampling and transportation of water samples (Fig. 5).



*Fig. 4. Hydrogeologists at work (Robert Zdechlik and Stanisław Witczak)*



*Fig. 5. Mobile hydrochemical laboratory*



*Fig. 6. Mobile geotechnical laboratory*

The Department has also laboratory and field equipment allowing to performing soil and rock analyses (Fig. 6). Equipment of the geotechnical laboratory comprises, among others, Proctor apparatus, edometers, consolidometers, Casagrande apparatus, Wasiliew apparatus, sieve and aerometry analysis kits, direct shear AB and triaxial AT

apparatus, and sets of tooling for the determination of shear and tear strength of rocks. Mobile geotechnical laboratory (Fig. 7) is equipped with a set of handheld dry drilling of geotechnical holes, CPTU probe (Fig. 8), dynamic probe light (DPL), PSO probe, rebound hammers, pocket shear vanes and piston penetrometers.



*Fig. 7. Engineering geologists with a CPTU probe*



*Fig. 8. Geotechnical laboratory*

## **EDUCATION AND TEACHING OFFERS**

The department employees conduct classes for the first degree students in the fields of Mining and Geology, Environmental Protection, Geophysics, Ecological Energy Resources and Environmental

Engineering. The department also teaches students of the second degree in specializations of Hydrogeology and Engineering Geology, and Engineering Geology and Geotechnics (Mining and Geology Major), as well as Applied Hydrogeology and Geotechnics (Environmental Engineering Major) and Protection of Water and Soil Environment (Environmental Protection Major).

## COOPERATION

Experience gained in cooperation with other academic communities and centers in Poland during the implementation of CPBPP 04.10.09, has been used during another large research task, entitled: "Regional monitoring of groundwater quality in the upper Vistula basin". This project, unique at the national scale, was financed by the European PHARE fund. The coordinator of the entire project was Stanisław Witczak and the AGH UST team (at that time the Institute of Hydrogeology and Engineering Geology) cooperated with teams of the University of Silesia and the Polish Geological Institute, Holy Cross Branch. In 1992–1994 a pioneering, systematic study of the chemical composition of groundwater was conducted and methodological principles of water quality monitoring were developed. Research on issues concerning the problems of quality control in the sampling procedure and analytical process in water monitoring based on control samples (QA/QC) was also carried out. Scientific cooperation with other research centres in the country and abroad has always been an important part of the department activities. This cooperation resulted in important scientific reports and publications. Particular emphasis should be put on the participation of the department employees in international research and educational projects implemented under successive EU framework programs.

In 2000–2003 the "BASELINE" project was carried out under the Fifth Framework Programme of the European Union. A natural continuation was the participation in another project, already under the Sixth Framework Programme of the European Union. The project was carried out in the period of 2004–2005 and was called "BRIDGE". The department team was led by Stanisław Witczak.

In 2009–2014 the team of the department employees, along with the colleagues from the Faculty of Physics and Applied Informatics participated in the international project "GENESIS". This project was carried out under the Seventh Framework Programme of the European Union. Similarly to the previous projects, the AGH team was led by Stanisław Witczak, while after his formal retirement the leadership duties of the AGH team carrying out the "GENESIS" project were taken over by Adam Postawa.

In 2010–2015 Grzegorz Malina was the head of teams carrying out the "HOMBRE" and "ADVOCATE" research projects, under the Seventh EU FP.

A series of *Best Practice Guides* developed by the international teams of researchers and practitioners and issued by the International Water Association publishing house was prepared with the participation of Adam Postawa, Stanisław Witczak and Ewa Kmiecik. These publications are the aftermath of the participation of the department employees in the international project "COST Action637", carried out under the European cooperation in the field of science and technology in years 2007–2010.

In 2014 the team of the department employees, again with the colleagues from the Faculty of Physics and Applied Informatics started a new international project named "Soils2Sea – Reducing nutrient loadings from agricultural soils to the Baltic Sea via groundwater and streams". Scientists from five European countries are involved in this project (Poland, Denmark, Germany, Russia and Sweden). The project proposes to exploit the fact that the retention of nutrients in groundwater and surface water systems presents a significant spatial variation, depending on the local hydrogeological and riverine regimes to achieve the goals for nutrient load reduction set out in the Baltic Sea Action Plan.