

Department of Fossil Fuels

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INTRODUCTION

The tradition of the Department of Fossil Fuels and petroleum specialization, with its origins in the applied geology launched by Karol Bohdanowicz goes back as far as the very beginnings of the AGH University of Science and Technology. The modern organizational structure of petroleum studies at the University of Science and Technology was established in 1950 with the Department of Oil and Gas being furnished with the right to award its graduates diplomas in “geology and oil and gas deposits prospecting”. Adam Tokarski was the Head of a Department that was at first a part of the Faculty of Geology and Deposits Prospecting and, after 1992, of the Faculty of Geology, Geophysics and Environmental Protection. It was concerned with educating specialists in petroleum geology as well in recent years with those in geothermic and renewable sources of energy. As a result of successive alterations and reorganizations, it has changed its name several times. During this period its work was supervised by: Stanisław Małoszewski, Roman Ney and Wojciech Górecki. Since 2007, the unit has been functioning as the Department of Fossil Fuels presently headed by Michał Stefaniuk.

RESEARCH AREAS/ RESEARCH GROUP

The research team of the Department concentrates on work within widely understood issues of oil and gas prospecting and the modelling of petroleum systems. Research on a comprehensive and consolidated interpretation of geophysical and geological data has been carried out. In recent years, the range of research has been extended to tasks connected with the application of

electromagnetic methods both in hydrocarbon deposits prospecting and in geothermics. The staff of the Department is also conducting basic and implementation research in water and geothermic energy, surface geochemistry, sedimentology, basins analyses, diagenesis, tectonics and microtectonics as well as imaging using nuclear magnetic resonance. The systematically enlarged scope of research is a result of the regular expansion of the laboratory.

A research team specializing in seismic and micro seismic activity has been doing experimental seismic research along with data processing and interpretation. In the years 1993–2016 they completed a few dozen research projects, the last one on the improvement of seismic research effectiveness in prospecting and recognizing natural gas reservoirs in the Rotliegend structures. As a result – and very important for new gas deposit prospecting – the investigated seismic sections provided new geological data of the Rotliegend basin from depths of 4000–6500 m.

Within a number of research and implementation projects, a comprehensive and integrated interpretation of geophysical and geological data has been acquired. Recently the research has concentrated on the following project “Experimental, comprehensive and multi-variant interpretation of seismic, magnetotelluric, gravimetric and geophysical data as an instrument of structure and deposits research effectiveness” realized within “The Research Applied Programme III”; the project is financed by the National Centre for Research and Development (NCBiR).

The staff of the Department participates in the NCBiR and the Agency of Industry Development. S.A. program: Blue Gas – Polish Shale Gas – supporting the development of technologies connected with shale gas exploitation.

There are three projects currently being conducted in the Department:

- 1) methods of resource assessment and prospecting risk estimation in case of unconventional deposits in Poland such as “shale gas”, “shale oil” and “tight gas” and those of unconventional deposits documentation”;
- 2) application of seismic research into shale gas detection;
- 3) selection of optimal methods of micro seismic monitoring in hydraulic fracturing.

Two successive NCBiR projects within the Blue Gas Program II concern: “Recognition, localization and development into optimum zones of occurrence of unconventional hydrocarbon accumulations of the “shale gas” type in the Flysch Carpathians and technological aspects of exploitation” and “Analysis of geological conditions and recognition of unconventional gas accumulations in the argillaceous formation of the Autochthonous Miocene succession in the Carpathian Foredeep, and technological aspects of development into the accumulations and their exploitation”.

The Department of Fossil Fuels is the leader in geothermal research in Poland. Basic and implementation research including the choice of optimal geothermal heat-generating plants construction zones are being carried out. Geothermal energy resources and technologies of the management of geothermal waters in the Polish Lowlands, the Carpathians and the Carpathian Foredeep are analyzed in the Department. One of the achievements of the Department of Fossil Fuels has been the publication of seven geothermal Atlases covering all sedimentary basins in Poland and summarizing already realized projects.

Among those the most important are: (1) analysis of Polish hydrogeothermal conditions with considering the energy conversion of thermal waters into electric and thermal ones as well as finding a way of implementation of effective binary technologies including the existing geothermal potential and local infrastructure, and (2) assessment of the possibilities of using geological formations in the construction of Enhanced Geothermal Systems in Poland by mapping some chosen structures as an option for such systems in Poland.

The Department of Fossil Fuels is a leader in the field of surface geochemistry research in Poland.

The research works conducted since 1972 have included oil prospecting, assessment of boreholes tightness, industrial facilities and underground gas reservoirs as well as garbage and waste impact and influence on the environment, the control and monitoring of environmental risks due to the dangerous accumulation of hydrocarbons and carbon dioxides connected with prospecting, exploitation, transport, processing and storage of hydrocarbons and that of garbage and waste, as well as with liquidation of coal mines.

Concerning applications of nuclear magnetic resonance (NMR), two projects financed by NCBiR are currently being conducted in the Department of Fossil Fuels. The first concerns elaboration and preparation for implementation of an innovative method of diffusion measurement by imaging using NMR. The method will be applied to improve the estimation of the petrophysical parameters of reservoir rocks. The second is an interdisciplinary one connected with the development of imaging using NMR in cellular biology.

Within the projects financed by the National Science Centre, basic research is conducted. The following projects are currently being pursued “Pericratonic Silurian shales of the East European Platform – in search for a lost orogenic source” and “Neotectonics of NE termination of the Vienna Basin Fault System”.

FACILITIES

The **3D Computer Modeling Laboratory** was created in response to an increasing demand for the advanced geological 3D computer modelling. The laboratory is equipped with advanced computer stations. Modeling and all kinds of calculation are performed with the use of the world class software, among others such as Petrel*, Techlog*, Geox*, PetroMod*, Eclipse*, COMSOL Multiphysics, @RISK, Cristal Ball and ArcGIS. Part of the software has been made available by the Halliburton and Schlumberger companies. In recent years, as an active cooperation with foreign companies has developed, the collection of licensed software was enlarged with that from such companies as: Geo Tomo Inc. (Houston, USA), Tesserall Inc. (Calgary, Canada) and fFA (London, Great Britain).

Research in the **Laboratory of Gas Chromatography and Geochemical Surface Methods** is carried out from both the prospecting and environmental aspects. The laboratory is equipped with four stationary gas chromatographs (Fisons Instruments, Carlo Erba Instruments and Agilent Technologies), a portable analyzer of volatile organic compounds MicroFid (Phovac Inc.) a flux meter – device recording soil gas emissions (West Systems), waterproof pH-meter CPC-401 and air, nitrogen and hydrogen generators (Fig. 1). The research team has at their disposal a set for sampling of gas from the near-surface layers (patent No. PL 184080, utility pattern: No. PL 58584) and a patented method of measurement of deposit gases emitted out of near-surface soil layers into the air (patent No PL 206259 B1).

The Porosimetry Laboratory has been functioning for many years. Till 2014 the basis of its work was the AuTo Pore II 9220 Mercury porosimeter (Micromeritics Company). Since 2015 the laboratory has been equipped with a new generation Mercury porosimeter: AutoPore 9520 (Fig. 2).

The research results allow for quantitative and qualitative estimation of reservoirs and the physical identification of seal rocks in view of their petrophysical features. The present analytic research is concerned on the characteristics of unconventional reservoir rocks of the shale gas and tight gas types porous structure.

The Optical Microscopy Laboratory is equipped with a universal polarization microscope: AxioImager. A 1m (D1) (Carl Zeiss) with a photometric set (J&M GmbH – MSP 200), a high class digital camera AxioCam MRe and installed AxioVision software (Carl Zeiss). The laboratory conducts and explores two main research directions. The first concerns standard petrographic research and the analysis of diagenetic processes. The second is devoted to comprehensive, qualitative and quantitative source rock analysis.

The Nuclear Magnetic Resonance Tomography and Spectroscopy Laboratory creates a unique possibility to investigate porous systems using NMR methods to the highest global standards and including the staff's own innovatory solutions at the same time.



Fig. 1. Laboratory of Gas Chromatography and Geochemical Surface Methods (phot. P. Guzy)



Fig. 2. Porosimetry Laboratory (phot. P. Guzy)

Application of the innovatory NMR method allows for increasing registering precision of petrophysical rocks. The laboratory is equipped with the most advanced NMR scanner – Magritek Rock Core Analyzer (RCA) assigned for the investigation of porous systems of all kinds of rocks and furnished with an additional device – Tomography System allowing for complete 2D-3 tomographic experiments. A supplement to RCA scanner is the pressure simulation system (Rick Core Pressure System) allowing for the investigation of rock samples at pressures up to 6000 PSI (41.4 MPa).

The staff of the Department conducts and supervise research into renewable sources of energy in the laboratories of the Center for Sustainable Development and Energy Efficiency in Miękinia.

EDUCATION AND TEACHING OFFERS

The staff of the Department conduct classes connected with petroleum geology and unconventional energy sources in Mining and Geology, Environmental Engineering and Ecological Sources

of Energy. Thanks to modern software used for processing, modeling and interpretation of geological, geophysical and deposits data, excellent teaching conditions for students of modern oil and geology and deposits prospecting, geophysics and geothermic have been ensured. The Department of Fossil Fuels has been always open to bright graduates and, at present, 21 students are following a Ph.D. course.

In the first-cycle degree of Mining and Geology, the staff enlarges the students' knowledge of hydrocarbon resource geology, reservoir geology, structural geology, subsurface mapping and facies analysis. Students may continue their education following 2nd cycle degree of studies within the Petroleum Geology where during recent years new subjects were introduced; among them basin analysis, petroleum geophysics and sequence stratigraphy. Also the total number of practical classes has been enlarged, mainly in the area of the laboratory and project classes.

The first-cycle degree students of Environmental Engineering may choose “the renewable energy sources path “ and then continue their education in the 2nd cycle degree course, being taught ways of

using geothermic, wind, sun, water and biomass energy. Ecological Sources of Energy is an alternative degree course for students who are interested in ecological methods of energy production. This course is realized on first and second cycle degree studies. The Department of Fossil Fuels offers classes in the modern laboratories of the Centre of Sustainable Development and Energy Saving "Miękinia".

It should be noticed that all laboratories of the Department of Fossil Fuels are incorporated into the teaching system and educational activities of the Faculty. They are available and used within the standard programs, laboratory didactic classes, during these preparation or within the activities of Scientific Associations. Two such associations are supervised by the staff of the Department. The "Grzała" Scientific Association of Renewable Sources gathers students fascinated by obtaining energy from unconventional sources. The "Kiwon" Scientific Association unites students willing to broaden their knowledge with regards specialized oil and gas prospecting.

COOPERATION

In the case of extended projects, consortia are appointed. In recent years the partners of the Department have included: Warsaw University of Technology, Geophysical Exploration Co. Ltd, Research and Development Center of Technology for Industry, The Mineral and Energy Economy Research Institute, Polish Academy of Science, Polish Geological Institute- National Research Institute, Polish Oil and Gas Company, PKN Orlen, Lotos Group, Oil and Gas Institute, Gdańsk University of Technology, Geofizyka Toruń, Military University of Technology and the Jagiellonian University.

The staff of the Department also cooperates with several foreign centers: Comenius University, Hungarian Academy of Science, Slovak Academy of Science, Ukrainian Academy of Sciences, Vietnam Academy of Science and Technology, University of Vienna, the Haliburton and Schlumberger companies.