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Attachment no 3

## **SUMMARY OF PROFESSIONAL ACCOMPLISHMENTS**

presenting the description of scientific achievements and output,  
determined in art. 16, para. 2 of the Law on academic degrees and title  
and degrees and title in the arts of 14 March 2003  
(Journal of Laws 2003.65.595, as amended)

Wrocław, April 2019

**1. FIRST AND LAST NAME**

Justyna Górniak-Zimroz

**2. COURSE OF EDUCATION, HELD DIPLOMAS, SCIENTIFIC DEGREES  
(WITH THE INDICATION OF PLACE AND YEAR OF OBTAINING)**

27.09.2004 obtaining the Ph.D. in technical sciences in the field of *mining and engineering geology*, specialty: *environmental protection*, at the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology, based on the Ph.D. thesis entitled *Integrated management of municipal waste and post-mining excavations* (thesis supervisor: Associated Professor Jerzy Malewski, Ph.D., Eng.).

2000-2004 doctoral studies at the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology in the field of waste and post-mining areas management.

2003-2004 postgraduate studies *Geographic Information Systems* at the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology.

14.07.1998 obtaining the title of Master of Science in Engineering at the specialty: *Water and Soil Protection Systems*, major: *Environmental Protection*, at the Faculty of Environmental Engineering of the Wrocław University of Science and Technology, based on the master's thesis entitled *Concept of a group water supply system for the area of the city of Oleśnica in the perspective period until 2020* (thesis supervisor: Halina Hotłoś, Ph.D., Eng.).

1993-1998 master's degree studies at the Faculty of Environmental Engineering of the Wrocław University of Science and Technology, major: *Environmental Protection*, specialty: *Water and Soil Protection Systems*.

**3. INFORMATION REGARDING PREVIOUS EMPLOYMENT IN SCIENTIFIC UNITS**

2005-2019 job as a scientific and teaching assistant professor at the Department of Geodesy and Geoinformatics at the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology.

2005-2006 job as a scientific and teaching assistant lecturer at the Department of Geodesy and Geoinformatics in the Institute of Mining of the Wrocław University of Science and Technology.

2004-2005 job as a scientific and teaching assistant lecturer at the Department of Mineral Processing and Waste in the Institute of Mining of the Wrocław University of Science and Technology.

**4. INDICATION OF THE ACHIEVEMENT RESULTING FROM ARTICLE 16, PARA. 2 OF THE LAW ON ACADEMIC DEGREES AND TITLE AND DEGREES AND TITLE IN THE ARTS OF 14 MARCH 2003 (JOURNAL OF LAWS 2003.65.595, AS AMENDED)****4.1. TITLE OF SCIENTIFIC ACHIEVEMENT**

As a scientific achievement resulting from art. 16, paragraph 2 of the *Law on academic degrees and title and degrees and title in the arts* of 14 March 2003 (Journal of Laws 2003.65.595, as

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amended) that constitutes the basis for applying for the postdoctoral degree, I indicated the work published in its entirety in the form of monograph entitled:

***GIS in mining – theory and applications***

**4.2. AUTHOR/AUTHORS, TITLE OF PUBLICATION, YEAR OF PUBLICATION, NAME OF THE PUBLISHER**

Author: Górniak-Zimroz Justyna

Title of publication: *GIS in mining – theory and applications*

Year of publication: 2019

Name of the publisher: Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology, ISBN 978-83-951536-7-9

Number of pages: 316

Publishing reviewers: Prof. Edward Osada, Ph.D., Eng.  
University of Lower Silesia, Wrocław  
Maciej Madziarz, Ph.D., Eng.  
Wrocław University of Science and Technology

**4.3. DISCUSSION REGARDING THE PURPOSE OF THE ABOVE-MENTIONED WORK AND ACHIEVED SCIENTIFIC RESULT**

The monograph includes a proposition of the methodology for building GIS for the mining industry. An extensive analysis of the source literature and analysis of the needs resulting from the specificity of the mining industry preceded the original approach presented in the work. This monograph is a result of many years of experience in the scope of building Geographic Information Systems, gained during implementation of research works in a team of specialists from the following fields: geoinformatics, mining, geology and environmental protection, working at the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology, which are described in the subsequent part of this summary of professional accomplishments.

The methodology of building information systems, including Geographic Information Systems, is generally known. The source literature in this area is mainly authorized by specialists in the IT industry or disciplines that use these systems. In both cases, the used language, as well as selected examples are illegible for potential GIS users in mining. On the basis of experience associated with the work in a company engaged in the Geographic Information Systems, as well as designing and building Geographic Information Systems in the Faculty's structures, I concluded that the methodology for building GIS for mining has its specificity, and without knowledge of the mining industry, legal conditions associated with deposit management and specific needs of the end users - building and implementing GIS in the mining industry is extremely difficult and requires an individual approach. Therefore, I formulated the following question in the conducted studies: **How to design and build a Geographic Information System for the raw materials sector?**

I proposed that prior to undertaking such activities, it is necessary to get thoroughly acquainted with the end user of the system, as well as its needs imposed by geological-mining and environmental law conditions, impact of mining activities on the environment and society,

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problems that enforce the building of such system, and to get to know the data needed for its construction, along with the sources of their acquisition, and possibilities of their representation in the GIS, as well as to get acquainted with analytical needs of the user and to propose the methods for data sharing, analytical methods, methods of sharing the results of analyses, along with their reporting.

Many years of work at the Faculty of Geoenineering, Mining and Geology allowed me to learn about the specificity of mining industry, which is an interdisciplinary field that covers connections between many fields, which are schematically presented in figure 4.1. The decision made in one area of mining activity must be consulted with its other areas, and sometimes such decision must be even made together due to the correlations or impacts of many elements included in the mining services industry.

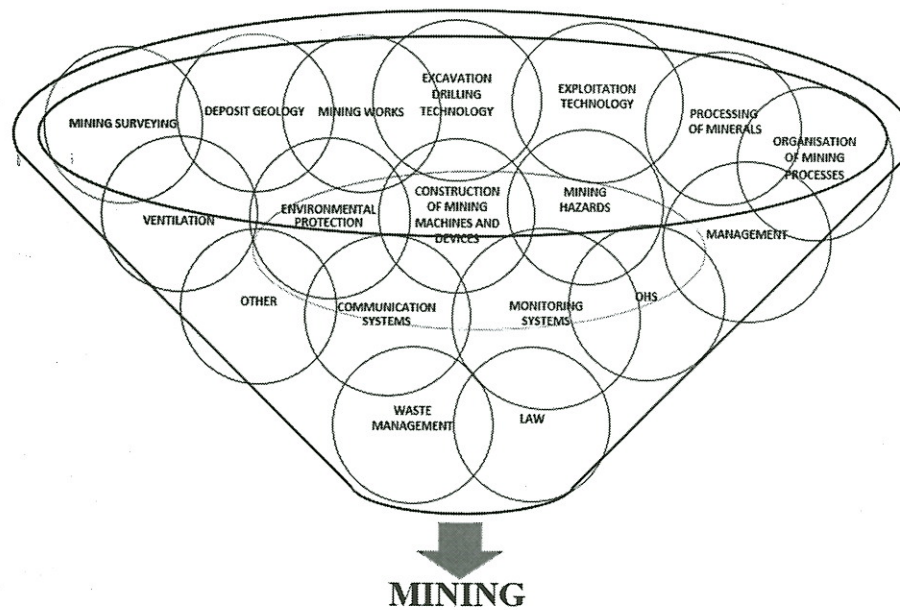


Fig. 4.1 Interdisciplinarity in mining

I defined mining as activities required to extract minerals, including: searching and recognising the deposit, works that prepared and make the deposit available, exploitation, transport, processing of minerals, reclamation and development of post-mining areas. Commencement of the mining works is associated with prior obtaining of a license for exploitation of the mineral and the decision on environmental conditions of the planned undertaking. During and after completion of the mining operation, it is necessary to monitor the impact of mining operations on the environment, including surface deformations and associated mining damage, as well as the pollution of water, soil and air. At every stage of deposit management, mining engineers, geologists, surveyors, environmental protection specialists take care of: acquiring, storing, processing and making available the data that describes parameters of the deposit, exploitation parameters and environmental parameters. Among others, they include: deposit geometry, quality parameters of the mineral, deposit management plan, spoil transport systems, mineral processing systems and data regarding the impact of exploitation on selected elements of the environment. The management of this data, as well as information resulting from its processing, can be facilitated by GIS solutions. In figure 4.2, I presented the life cycle of a deposit from the moment of its searching and recognising to the development, with the indication of application examples for the data processing in the scope of GIS.

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Therefore, it can be summarised that prior to the development of GIS, it is necessary to carry out an extensive analysis that will allow to correctly define the purpose, structure, analytical methods and visualisation of the calculation results in the target system.

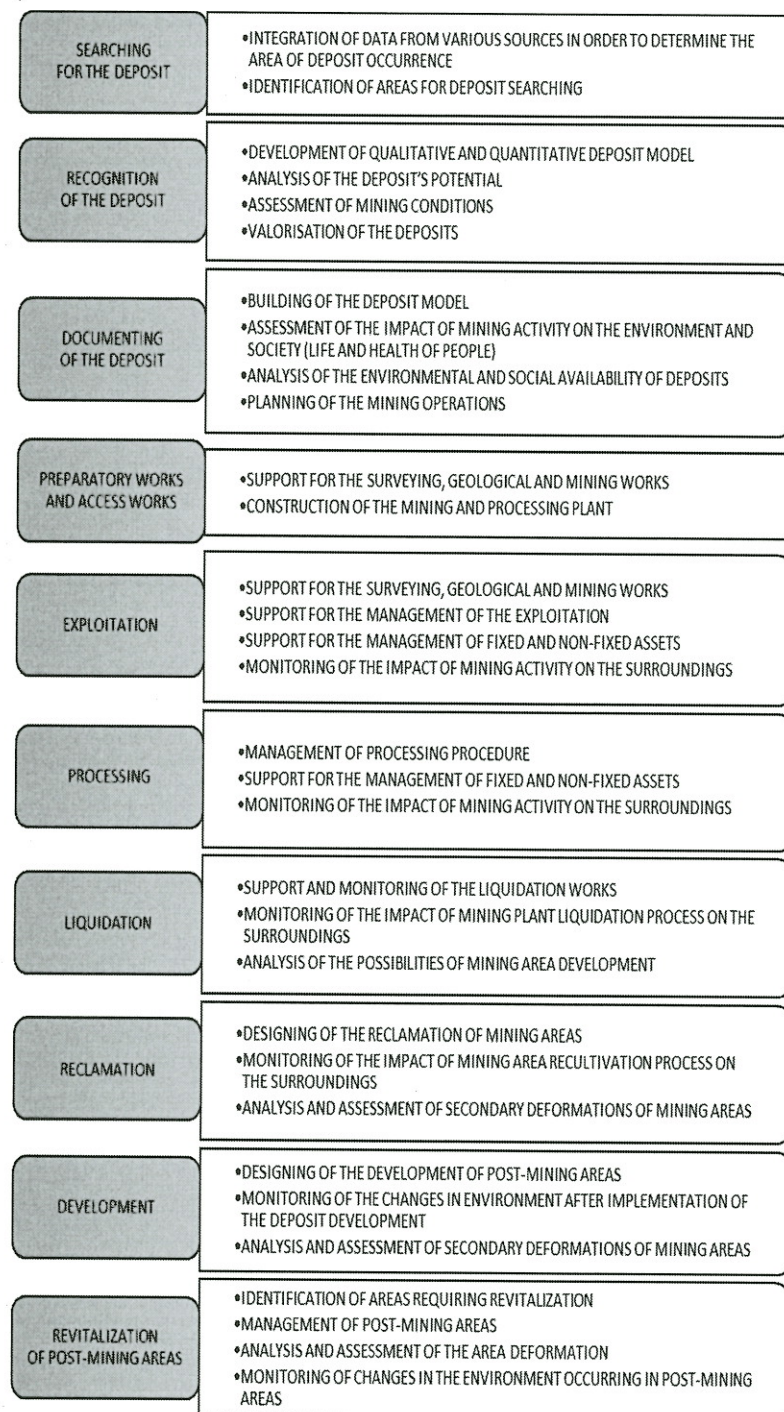


Fig. 4.2 Life cycle of a deposit, along with the proposition of data processing in Geographic Information Systems

In the conducted studies, I have observed a dynamic increase in the number of data, as well as the significance of having reliable information and knowledge obtained from data analysis. Therefore, the database systems based on the techniques of automatic, intelligent and fast data processing are gaining interest and popularity, in order to acquire knowledge about objects described by such data. A special place in the class of database systems is occupied by Geographic Information Systems intended for collecting, verifying, storing, integrating data and performing spatial analyses, along with the collection of statistics and implementation of quantitative calculations,

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during the preparation of reports and presentation of results of the conducted analyses in a clear form. The spatial approach in the analytical systems is noticeable in many sectors of the industry and currently it is also used in mining, in order to support the design surveying, geological and mining works.

The digitisation of mining is also more and more often discussed. In this direction, the activities are carried out, e.g. in the EU Framework Program Horizon 2020, which is the largest EU programme in the scope of scientific research and innovations that covers research support programs at the EU level and concerning among others: intelligent production management in underground mining (SIMS), management of mining machines (MaMMa), visualisation of 3-4D models in geological sciences (VISUAL3D), modernisation of existing industrial processes thanks to the implementation of energy and raw materials efficiency principles, along with the use of technological progress and scientific achievements in the area of Industrial Process Control (IPC) (DISIRE), developing the highest quality technical infrastructure through the EIT RawMaterials platform, in order to support the technology and methodology of reactivation of the former mine areas (Re-Activate). Currently, there are also activities implemented under the Real-Time Mining programme, which is also financed by Horizon 2020, concerning the development of a timeframe aimed at reducing the environmental impact and increasing the efficiency of using resources in the European raw material extraction industry, whose key concept is to promote the transition from discontinuous to continuous monitoring of the process and quality management system in highly selective mining operations. The environmental impact that is assumed in the project will be achieved through improving the efficiency of the process and the use of resources. This will increase energy efficiency, as well as facilitate a significant improvement of environmental efficiency of the mining operations through reducing emissions and generated waste. It is believed that deposits, which are currently treated as marginal or difficult to access, can become profitable in such case. As part of this project, it is proposed (among others) to develop an underground map of mining process consisting of a standard chain of underground production processes, from the moment of recognition to the moment of extraction, which cover various data collection, modelling and control processes (<https://www.realtime-mining.eu/>).

I have also observed that the level of awareness concerning geoinformatics is increasing in the mining enterprises, which can help in the running of mining enterprise from the moment of deposit recognition, through gaining access to it and its exploitation, until its recultivation and management. Therefore, the systems based on spatial information in the form of Geographic Information Systems can support the user, e.g. a geologist, clerk or mining entrepreneur, in undertaken activities related to the management of land resources, at every stage of conducted mining activity, among others, in the scope of: supporting decisions made during management activities concerning the entire life cycle of the deposit, moreover providing the possibility to use information from other mine departments for the needs of rational production management in a mining enterprise. The dimension of time and space are two natural backgrounds for the presentation of data analysis results, which can originate from many sources and from foreign systems. In order to integrate technical data, environmental-social data and business data, along with the sharing of analysis results in modern IT tools, the research conducted by me proposed to use Geographic Information Systems with the use spatial analytics.

Currently, many institutions and enterprises associated with mining activities have data in digital form, digital deposit models, and they commonly use digitally implemented maps to plan their production, determine the impact of exploitation on the environment and society, and to visualize hazards caused by mining activity, such as: water hazards (e.g. tanks and watercourses on the surface may cause water accumulation in the excavations or introduction of water into the

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excavations, occurrence of quicksand in the excavation), methane hazards, hazards resulting from rock bursts, coal dust explosion hazards for coal-seams, technical hazards (e.g. hazards resulting from machines and devices that are built-up and operate in a mining plant, electric shock hazards), hazards resulting from working underground (e.g. hazards associated with mining conditions, slope of excavations, limited working space, hazards resulting from the rock mass), hazards resulting from human factors (e.g. caused by improper organisation of the work), hygienic hazards (e.g. hazards resulting from dusts and gas pollutants that are harmful to health, as well as from lighting and noise) and fire hazards (e.g. exothermic and endothermic).

Over the years, I have observed that more and more mining enterprises obtain and store data associated with their activity. For example, sensors are installed within the mines for monitoring and transmitting data from the infrastructure operating within the mine (e.g. belt conveyors, mining machines, technical infrastructure), while satellite systems and drones are used to implement exploitation in the open-cast mines, as well as to monitor quality of water, soil and air, along with the land subsidence. Thanks to the above-mentioned systems, the detailed data concerning mining activities is obtained, which may be useful in the analysis of the deposit's life cycle.

The main purpose of this work is to present the methodology for building the Geographic Information System for the mining industry, along with the examples that illustrate the implemented projects. The proposed methodology reflects the need to systematise knowledge in the scope of Geographic Information Systems, development of analytical and presentation techniques, as well as further popularisation of knowledge. This work is the answer to the above-mentioned need. The work presents:

- "methodology" for building Geographic Information System, which was developed during the research, aimed at the support of decision-making processes in mining (chapter 2);
- selected examples of GIS applications in the mining industry (chapter 3-11);
- defined directions for further research (chapter 12).

This work demonstrated that despite such a varied target specificity of the area, it is possible to generalise the prototyping process of GIS-class decision support system for mining applications, which is presented in figure 4.3. I divided the proposed methodology into five main stages, i.e. the first stage concerns the development of general basis of the system, the second stage concerns the development of methodology for acquiring data for the system, the third stage concerns the development of the concept of system construction, the fourth stage concerns the development of detailed design of the system and the fifth stage concerns the implementation of the system. At each stage of this methodology, I tried to take into account the needs of users, e.g. employees of state institutions responsible for deposit management, employees of companies and design offices engaged in the preparation of documentation regarding the searching, recognition and exploitation of the deposit, as well as the impact assessment of mining activities on the environment and society, as well as employees of mining enterprises working at various stages of the deposit's life cycle, from its searching and recognition, through works that prepare and make it available, exploitation of minerals from the deposit, including: mining, transport, processing of raw material and storage of waste, to recultivation and development of the post-mining area. In this methodology, I also proposed selected capabilities of analytics available in GIS, which after the analysis of needs in the mining industry can be adapted to the needs of end user of the system. Among others, the following are described in the analytical module: tabular analyses, data extraction, cartometric measurement, analysis of distance, analysis of overlapping, 2D and 3D surface analysis, spatial and non-spatial searching for objects that fulfil specific conditions,

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network analyses, exploratory data analyses, statistical analyses and specialized analyses, along with the examples performed on the data associated with mining). I also indicated the sources of obtaining input data for the system, which currently can be acquired from many institutions without incurring any additional costs. However, this data should not be used without analysis and assessment of its quality, coherence and usefulness for the user indicated in this work: employee of the mining services industry.

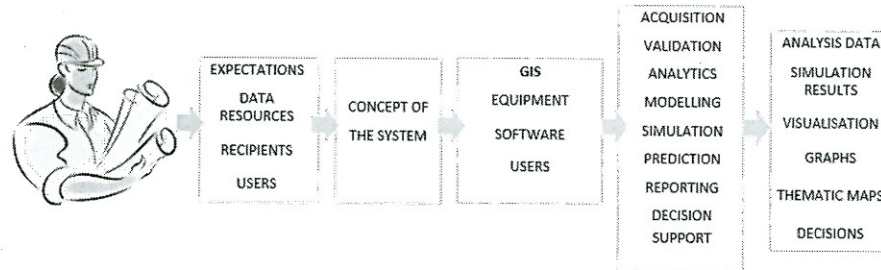


Fig. 4.3 The concept of GIS in mining

Geographic Information System allows to build comprehensive, standardised spatial databases, to implement simple and complex spatial analyses, to visualise, as well as share data and results of their processing, therefore it constitutes more and more widely used platform for the support of decision-making process, by administrative units responsible for the functioning of mining enterprises (e.g.: Higher Mining Office, District Mining Offices, marshal offices, county offices, municipalities), scientific institutions engaged in the research associated with the mining activity (e.g.: Polish Geological Institute, Main Mining Institute, KGHM CUPRUM R&D Centre, Poltegor-Institute Open-cast Mining Institute) and mining companies (e.g.: KGHM Polska Miedź S.A., PGE Górnictwo i Energetyka Konwencjonalna S.A., Power Plants Pątnów-Adamów-Konin S.A. and other smaller mining companies engaged in the exploitation of rock raw materials).

In the subsequent chapters (chapter 3-11), I presented the results of selected research works conducted with my participation at the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology concerning the design and development of modules implementing the functions of decision support systems, with the use of GIS-type software in widely understood mining industry, at various stages of deposit management, among others for: management of resources of the rock raw materials deposits in selected areas of the Lower Silesia Province, analysis of environmental and social availability of deposits of the selected rock raw materials, performed for the deposits prior to commencement of the exploitation of minerals, with the use of multi-criteria analyses, modelling of the granite deposit development status from the commencement of exploitation until its completion, along with a proposal for development of post-mining areas, analysis of seismic phenomena in order to assess threats to the safety of people and machines, planning of the spoil route of rock raw materials and brown coal from a large-scale open-cast pit to the power plant, analysis of post-mining areas as places for placement of waste, as well as for identification and analysis of former areas of mining works that require revitalisation. Multitude of tools and application methods presented in them proves the usefulness and functionality of methods in the scope of Geographic Information Systems, allowing for the collection, effective processing of data, their analysis and presentation of data, along with the presentation of results obtained in the analyses. These examples include the analysis of usefulness of the presented solutions, as well as the possibility of application of the proposed methods in practice by the entities that are engaged in mining.

The monograph can be considered as an introductory material for young scientists and a textbook in the field of GIS applications for students of mining focused on geoinformatics. I hope that it will also be an important reference item for researchers dealing with broadly understood computer-aided (GIS-based) mining activities.

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## 5. DISCUSSION REGARDING OTHER SCIENTIFIC AND RESEARCH ACHIEVEMENTS

### 5.1. BEFORE OBTAINING THE PH.D. DEGREE

In 1998, I graduated from the Wrocław University of Science and Technology, Faculty of Environmental Engineering, majoring in *Environmental Protection*, with the specialty of *Water and Soil Protection Systems*, obtaining the title of master of science in engineering. During my studies, I gained knowledge in the scope of (among others): functioning of mechanisms occurring in the environment understood as entirety of natural elements, including those transformed as a result of human activity, particularly the surface of land, minerals, water, air, fauna and flora, landscape, as well as climate. During my studies, my research interests focused on issues associated with the protection of water and soil. My master's thesis entitled *Concept of a group water supply system for the area of the city of Oleśnica in the perspective period until 2020* was implemented in the Department of Water Supply and Sewage Removal of the Institute of Environmental Engineering of the Wrocław University of Science and Technology. This work included a development of the concept of a group water supply system for the city of Oleśnica and nearby towns, in order to increase the number of users using water with physicochemical composition that is beneficial for human health and life, originating from the underground water intake located northwest of Oleśnica.

After graduating, I started to work professionally in Geological Geotechnical and Construction Company in Wrocław, where I worked as an assistant until 31 December 1998. From 1 September 1999 to 31 January 2002, I worked in SHH System Haus Hemminger Sp. z o.o., with its registered office in Wrocław, where I was a member of the team dealing with the design of geoinformation systems, including Geographic Information Systems.

From 1 October 2000, I started doctoral studies at the Faculty of Mining of the Wrocław University of Science and Technology, where under the supervision of Jerzy Malewski, Ph.D., Eng., who is a professor of the Wrocław University of Science and Technology, I carried out research concerning the issues associated with the inclusion of post-mining areas into the management of municipal waste. As a result of conducted research, a dissertation entitled *Integrated management of municipal waste and post-mining excavations* was created, in which I identified problems that must be solved in the considered sectors of the economy - mining and waste management – and I proposed their systemic solution consisting of building an integrated system for the analysis and support of the management of municipal waste streams, originating from a large number of dispersed sources and post-mining excavations. The difficulty of analysing this issue results from the complex quantitative and qualitative structure of waste, as well as from the difficulty of a detailed description of post-mining objects and from the need to consider the whole issue in the context of legal, social, environmental, technical, economic and spatial conditions. Therefore, the analytical operations on such objects require the use of advanced methods and analysis tools. In the research described in the dissertation, I attempted to build a system focused on the needs of analysis and support of the waste management process, with the use of post-mining areas. For this purpose, I developed methods and tools that allow to rationalise the decision-making process during the selection of post-mining area for the location of the facility associated with waste management, which is run within the framework of generally understood management of environmental resources. In my research, I also developed a model of the waste generation process in dispersed sources on the basis of demographic model, and I implemented a spatial description of the municipal waste stream. Precise identification of the sources of waste generation allowed to study the quantity and quality of generated waste, as well as to visualise the intensity of waste stream, and to study the dynamics of changes occurring in waste, resulting from

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demographic, economic, technological and economic development in the analysed area, while the results obtained during the research allow the analysts or decision-makers to acquire necessary input data for planning the waste management. Based on the detailed analysis of literature data concerning the specification of factors that determine the selection of direction of the reclamation, factors conditioning the use of post-mining areas for the storage of waste, factors taken into account during selection of area for the location of landfill, as well as analysis of Polish and EU law regarding environmental protection, I collected and selected spatial, natural, technical and social factors that describe the condition and economic usability of a post-mining excavation in the waste management, in the form of the so-called "excavation quality". In order to determine "excavation quality", I used symbolic classification methods based on neural networks, in the form of self-organising Kohonen networks. The decision support system, which is proposed in the research, can be useful for solving planning problems associated with the location of new waste management facilities, because it supplies information about the demographic characteristics of analysed area, information on the spatial distribution of waste generation sources, information on the quantity and quality of waste generated in these sources, information on mining areas, natural, communication and other components, as well as creates the basis for forecasting the amount of waste generated in the analysed area, based on the forecasts of demographic changes and changes of factors affecting household waste generation, as well as allows for the performance of advanced optimisation analyses, e.g. finding the best places for the given functions. Also, this system allows the user to get to know the precise features of analysed area by assembling many information layers that store various data regarding the objects that build this area. Depending on the user's needs, it is possible to assemble such layers, whose combination can provide the best image of analysed area, at the time of analysis, or it can allow for the simulation of events that may occur in the future, e.g. forecasting the quantity and quality of waste. The knowledge base built in such system in the form of a graphic and descriptive database significantly improves the searching and acquisition of information facilitating the management of a large number of objects. While building the decision support system in the scope of management of environmental resources, I used GIS technology dedicated to the management of complex objects and phenomena, in which an important role is played by spatial relations existing between particular objects in the analysed space. To sum up, the decision support system in the scope of management of environmental resources, which was developed within the research - including post-mining excavations - is an open system and can be adapted to solving tasks similar to waste management, i.e. requiring organisation of the service points for a large number of geographically dispersed demand sources for various types of services, in the context of social, legal, spatial and environmental conditions.

During my doctoral studies, I obtained a grant from the KBN in the form of a research project no. 5T12A01024 entitled *Integrated management of municipal waste and post-mining excavations* for the years 2003-2005 regarding the development of procedures and tools for supporting the management of post-mining excavations of open-cast mining integrated with the economic environment, in particular municipal management. As part of the project, the *Decision Support System* (DSS) was developed for analysing the effectiveness of management of the post-mining areas of open-cast mines for the storage, processing or neutralising waste in the regional municipal waste management. This system uses Geographic Information System technologies that allow to conduct analyses on the group of associated objects and phenomena, which are spatially referenced and interact with each other for the strictly determined purpose.

In 2003, I participated in the works on creating a Provincial waste management programme for Lower Silesia in the part concerning mining waste management, within the action of the Lower Silesian Geo-environmental Consortium LOGEC consisting of the following research and

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development institutions: Lower Silesian Province Office, Polish Geological Institute - Lower Silesian Branch, University of Wrocław Institute of Geological Sciences, Wrocław University of Science and Technology - Faculty of Mining (currently Faculty of Geoengineering, Mining and Geology), Institute of Open-cast Mining Poltegor-Institute Wrocław, Association of Geologist Graduates of the University of Wrocław, CUPRUM Copper Research and Design Center Sp. with o.o., Poltegor Projekt Sp. with o.o., Geological Enterprise "PROXIMA" S.A., Geophysical Research Company Lower Silesian Geophysical Department and Enterprise Drilling Works "POLWIERT".

Also, I participate in two research projects implemented within scientific and scientific-technical cooperation with Institut für Bergbaukunde III der RWTH Aachen in Germany (KBN-DAAD). In 2003, I took part in the project entitled *Integral concepts of waste management - groundwork for future-oriented, lasting environmentalism*, implemented under the supervision of Jerzy Malewski, Ph.D., Eng. and Professor Christian Niemann-Delius. In the years 2003-2004, I participated in the project entitled: *Possibilities of stabilising the surface of landfills as protection against dusting*, which was led by Professor Jadwiga Więckowska, Ph.D., Eng. and Professor Christian Niemann-Delius. This research focused on the recognition of the existing state of industrial waste management in Germany and Poland, with particular emphasis on the region of Lower Silesia, where Ore Enrichment Plants (ZWR) located in Polkowice, Lubin and Rudna belonging to KGHM Polska Miedź S.A. are the main sources of industrial waste. Also, the research on post-flotation waste originating from ZWR was carried out and new applications were indicated. As part of the projects, I participated in two scientific internships: 2-week internship in 2003 and 1-week internship in 2004 at the Mining Institute III RWTH in Aachen, where I presented the seminar entitled: *Industrial waste management in Poland and in the Region of Lower Silesia*.

On 1 October 2003, I started postgraduate studies in the scope of *Geographic Information Systems* at the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology, which I graduated on 25 September 2004 with the defense of thesis entitled: *Concept of building a support system for decisions made during management of post-mining areas, in the context of municipal waste management*, implemented under the supervision of Józef Woźniak, Ph.D., Eng. I have deepened my knowledge regarding geoinformation systems in the course of these studies.

I was the co-author of the lecture entitled *Geoinformation systems in the management of environmental resources* (Woźniak J., Woźniak P., Zając P., Górniak-Zimroz J.), which was presented at the seminar on 28 November 2003, at the III Session of the Lower Silesian Mining, organized by the Mining Sciences Commission of the Wrocław Branch of the Polish Academy of Sciences and by the Faculty of Mining of the Wrocław University of Science and Technology.

Until September 2004, I wrote 2 independent conference papers and 6 co-authored papers, including: one in the "Górnictwo Odkrywkowe" journal, 4 papers at national conferences and 3 papers at international conferences (AI-METH 2004, MPES 2004, SPILM 2004). During this period, there were also created 3 reports, including 1 in English that summarise the completed research projects.

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## 5.2. AFTER OBTAINING THE PH.D. DEGREE

After obtaining the Ph.D. degree, my scientific and research activity focused on the widely understood environmental protection, waste management in mining and post-mining areas, as well as the impact of mining activity on selected elements of the environment, e.g. areas under legal protection, surface and underground waters, soils, air and society, through the use of methods based on geoinformation systems in the research, which allow for computer aided management of environmental resources with the use of artificial intelligence, decision support systems, modelling and simulation of analysed phenomena.

Main research directions developed in the years 2004-2019:

- identification of sources, quantity and structure of industrial and municipal waste in geographical context on the basis of GIS methods and tools;
- analysis of quality and usability of areas and/or facilities in terms of their use in waste management, with the use of neural networks and taking into account legal, social and technical limitations, as well as environmental safety;
- support for the decision-making process at the stage of planning, organisation and management of undertakings associated with waste management, with the use of GIS technology;
- environmental damage caused by mining plant operations, along with the problem analysis in three aspects: geoengineering, legal and economic aspect;
- recognition and description of the current state of knowledge regarding history and technical state of former mining facilities in Lower Silesia recognized as wealth of material culture, taking into account the field research, assessment of material state and condition of preserved facilities, assessment of their availability and possibilities of legal protection of these facilities, along with the assessment of possibilities of their use for cognitive, teaching and tourist purposes;
- support for the management of continuous transport system exploitation with the use of decision support system methodology, based on the GIS technology;
- analysis of environmental and social conditions of the planned course of spoil transport with the use of long-distance coal conveyors in the GIS environment;
- analysis of environmental and social conditions of the planned course of spoil transport with the use of rock raw materials transport conveyors in the GIS environment;
- collection, processing and integration of data originating from various sources regarding the environmental and social hazards, resulting from open-cast mining activity on a small- and large-area scale;
- monitoring, analysing and forecasting of environmental and social hazards, resulting from open-cast mining activity on a small- and large-area scale;
- analysis and assessment of the impact of planned open-cast mining activity on the environment and society;
- analysis and assessment of environmental and social availability of the initially and precisely recognized deposits of rock raw materials;
- analysis of seismic events;

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- analysis of the impact of light pollution by large-area open-cast pits, belonging to PGE Górnictwo i Energetyka Konwencjonalna S.A., on the environment and health of the people living in close proximity to these open-cast pits;
- identification and analysis of environmental changes resulting from the illegal exploitation of selected deposits of rock raw materials;
- identification and analysis of the waste stream generated by selected mining enterprises;
- identification and analysis of hygienic hazards in the form of gas pollution resulting from the underground exploitation of copper ores;
- analysis of the accident rate in selected copper ore mines;
- availability assessment of the deposits of non-metallic raw materials that are essential in the environmental and social aspect in selected areas;
- identification and analysis of hazardous waste generated in the production cycle of rock raw materials, along with indication of the method of their management in accordance with the Circular Economy principles.

In the years 2004-2005, I participated in the research project no. 5T12A02025 entitled *Environmental damage, compensations and collateral for claims in the mining areas of open-cast mining*, which was led by the Professor of Wrocław University of Science and Technology - Jerzy Malewski, Ph.D., Eng. This project concerned the recognition of claim and compensation processes for environmental damages resulting from mining plant operations, as well as the analysis of legal and economic conditions for the use of environmental insurance in the administrative and economic practice of open-cast mining. The problem put forward in the application was analysed in 3 aspects: geoengineering, legal and economic aspect, because most of the claim and compensation problems occur at the intersection of these three disciplines of knowledge and business practice. As part of the project, the research concerning claim and compensation processes occurring at the operational junction of public administration, mining enterprise and aggrieved parties was carried out. The research was conducted in the mining areas of open-cast mines, mainly brown coal, where these phenomena occur at a higher intensity. The geoengineering practice in the scope of quality of the methods for recognising, marking and forecasting the effects of mining activity was reviewed. Also, the comprehensive study of current environmental protection, administrative, economic, geological, mining, EU and international law was conducted in terms of environmental damage, as well as the rights to pursue claims, and economic systems and methods for assessing the damage were presented, which are significant in the scope of its valuation as damage to the environment and to the personal property of citizens. A review of systemic problems and solutions in the country and around the world, in the scope of environmental insurance as a form of collateral for claims in economic and administrative practice, was carried out. Also, a practical example of the estimation of the amount of collateral at the stage of concession issued for the exploitation of brown coal deposit was also presented, which demonstrated the complexity of analysed issue and its solution that may be a proposition of procedure for possible duplication in similar cases.

In 2005, the cooperation was established with the employees of Wrocław County Office, which resulted in a jointly organised international conference entitled *Municipal waste management in the Wrocław County in the context of solutions implemented in the Haut-Rhin department (France) and the Borken district (Germany)*, which promoted sustainable management of municipal waste in the Wrocław County. Participants of this conference included representatives of the academic community, state administration, as well as institutions and companies engaged in the management of municipal waste. The conference became a place for exchanging experiences and

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ideas regarding the improvement of municipal waste management system in the municipalities of the Wrocław County. I was the initiator of cooperation with the Wrocław County Office and a member of the scientific and organizational committee of the above-mentioned conference.

In the years 2005-2006 I participated in the research project no. 342704 entitled *Functional GIS as an element of support for the management of resources of the Lower Silesia region*, in which information systems based on GIS technology were implemented for selected facilities. These systems can be used in resource management, in order to assess the state of environment, support the planning and location decisions associated with the environmental protection. Effective management of resources and monitoring of the state of natural environment, in accordance with the requirements of sustainable development, requires current and verified spatial and attribute information. Dedicated geoinformation systems allow for keep records of resources and results of the observation of environmental condition, as well as the possibilities of their analysis and interpretation. The research results constituted the basis for preparation of the paper (Open-cast Mining) and their further use in the master's thesis entitled *Numerical sociological and hydrographic map in environmental protection on the example of selected mining area* (Pactwa K. 2006), in regard to which I fulfilled the function of thesis supervisor.

In the years 2006-2007, I participated in the research project no. 342797 entitled *Geoinformation systems in the development models of post-industrial areas*, which concerned the development of a system that supports revitalisation and development of former industrial areas, with particular emphasis on post-mining areas selected from the area of the Lower Silesia Province. Effective development of post-industrial areas, particularly former mining areas is an important research issues, as well as socio-economic issue. For the preparation of development models for such areas, it is necessary to have full and reliable information regarding the state of environment, including surface stability. In the work, Geographic Information Systems are used for the management of spatial and non-spatial data, as well as to build development models, on the example of mining areas of former hard coal mines in Wałbrzych. The system developed as part of the research allows to perform spatial analyses with the use of functions and procedures for geoprocessing of GIS data, as well as supports the performance of works and visualisation of their results for the developed development concepts. Also, it increases the efficiency of tasks associated with assessment of the state and planning of the development of post-mining areas. The obtained result of the works consisted of prepared methodology for building spatial development models based on the use of Geographic Information Systems. After appropriate supplementation, results of the works can be used in processes associated with the economic development of post-industrial areas, e.g. by bodies involved in spatial planning.

In the years 2006-2008, I participated in the Foresight target project entitled *Scenarios of technological development of the copper ores and associated raw materials mining industry in Poland*, implemented by the Consortium consisting of: KGHM Cuprum Sp. o.o (leading institution), Wrocław University of Science and Technology, Institute of Mineral Resources and Energy Management PAN in Kraków, Main Mining Institute in Katowice, EMAG Electrification and Automation Centre in Katowice, Silesian University of Technology, KGHM Polska Miedź S.A. As part of this project, the research team from the Wrocław University of Science and Technology implemented a research work entitled *Method for analysing the effectiveness of copper production from LGOM deposits*, which was led by Professor Jerzy Malewski, Ph.D., Eng. The work in this task consisted of developing a method for qualitative and quantitative analysis of individual operations and their systems, on the basis of mathematical and digital modelling of technological operations for the given criteria of system efficiency, as well as performance of the analyses of copper production efficiency and costs, on the example of mines from the Legnica-Głogów Copper

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District. The purpose of conducted research was to develop methods and tools for rational management of the deposit, as well as planning and organisation of mining production, assessment of the effectiveness of innovative and investment undertakings in the scope of technology, planning and programming of scientific research in the copper industry. My research purpose was to present the state of waste management in KGHM Polska Miedź S.A. through identification and characterisation of waste generation sources in the entire technological sequence of KGMH PM S.A., with particular emphasis on identification of costs generated during management of created waste. The final result of my research was preparation of the publication, **Górniak-Zimroz J.**, entitled *Sources and environmental costs of waste management in KGHM Polska Miedź S.A.*, published in the Scientific Works of the Mining Institute of the Wrocław University of Science and Technology, no. 36 in 2009.

In 2007, I assisted in the preparation of an expert opinion in the scope of environmental protection by University Professor Jerzy Malewski, Ph.D., Eng., regarding illegal storage of waste by a company running a business activity consisting of storage, disposal, processing, neutralisation, transportation of waste or substances, in the area of allotment gardens POD Oławka at Wilcza street in Wrocław. This opinion consisted of analysing the method of waste storage and the assessment whether the storage of waste is implemented in conditions or in a manner that may threaten the life or health of many people, or cause destruction in the vegetable or animal world in significant sizes, in accordance with art. 183 of the Penal Code. As part of the preparation of this opinion, I participated in: inspection of the submitted place (photographic documentation), consultations with the inspector of the Provincial Inspectorate for Environmental Protection, consultations with the employees of Municipal Water Supply and Sewage Company in Wrocław, as well as the analysis and assessment of the threat to drinking water intakes of the city of Wrocław, and preparation of this expert opinion.

In the years 2007-2008, I participated in implementation of the research project no. 342889 entitled *The use of advanced mobile geoinformation systems for systemic monitoring of the environment of mining areas* concerning the development and verification (during field and laboratory test works) of monitoring methodology of the environmental elements of mining areas using the integrated functions (mobile) of GPS-GIS systems for registration and ongoing updating of information. This methodology constitutes an element of improving the techniques of acquiring and processing geodata, as well as supporting the management of environment, e.g. post-mining areas, in Geographic Information Systems. The applied procedures and technology of acquiring and managing geodata increase the efficiency of tasks associated with the research and assessment of the state and planning of area development. The monitoring methodology based on the functions performed by GPS-GIS systems was of innovative nature during the years of research implementation. Results of the works constituted the basis for publication, auxiliary material for seminars and lectures, as well as source material and training material for institutions responsible for the monitoring of various components of the natural environment.

In the years 2008-2009, I took part in the research implemented as part of an internal grant funded by the Vice-Rector for Scientific Research of the Wrocław University of Science and Technology entitled *Computer Geographic Information Systems for the support of managing information regarding operation of belt conveyor in a brown coal open-cast mine*, the purpose of which was to develop the methodological foundations constituting the basis for building a management system of extensive machine system, on the example of a belt conveyor in the brown coal open-cast mine. Due to the interdisciplinary nature of the works, with the application of IT technologies, database systems, thematic maps, data analysis methods and specialist knowledge in the scope of construction and operation of complex machine systems, a team of

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specialists from the above-mentioned fields (**Górniak-Zimroz J.**, Król R., Zimroz R.) was appointed. Having in mind the perspective of implementation of the projects for KWB Turów regarding the reduction of energy consumption of conveyors, on the basis of modification of the structure of used rollers, as well as implementation of the subsystems for diagnostics of the conveyor drive components, the diagnosis of belts with steel cords and the implementation of rational strategy for replacements of belts, it was justified to develop a management platform for the above-mentioned undertakings. Results of the work were presented at the international conference in the form of a presentation and a paper.

In the years 2009-2014, I participated in the research project entitled *Strategies and technological scenarios of management and use of the deposits of rock raw materials*, co-financed from the European Regional Development Fund under the "Innovative Economy" Operational Programme, Priority 1 - Research and development of modern technologies, Sub-measure 1.3.1 - Development Projects, which was implemented by the Consortium consisting of: Poltegor-Institute Open-cast Mining Institute - Wrocław (Project coordinator), AGH University of Science and Technology in Kraków, Institute of Mineral Resources and Energy Management PAN in Kraków, Polish Geological Institute in Warsaw - Lower Silesian Branch, Wrocław University of Science and Technology, University of Wrocław. The main purpose of this project was to develop innovative development strategies for mining and processing of rock raw materials. It is based on locating centres for the use of raw materials; backlog and prospective resource base; development of innovative technologies for extraction and processing of raw materials. This research constituted basis for the development of technological scenarios of development and comprehensive management of rock raw materials in individual regions of Poland. The project consisted of seven thematically related tasks, the implementation of which resulted in fulfilment of the project's purpose.

The employees of the Wrocław University of Science and Technology participated in the implementation of three tasks: task no. 4 entitled *Innovative technologies of extraction and processing of rock raw materials for the main groups of raw materials*, task no. 5 entitled *Pilot geoinformation system for selected regions of exploitation of the rock raw materials in the Lower Silesia Province* (Wrocław University of Science and Technology was the coordinator of this task) and task no. 7 entitled *Protection of deposits of the rock raw materials – criteria for their rational management and possibilities of implementation*. As part of the project, I implemented task no. 5 and no. 7, and I was the coordinator who organised meetings with the entities performing task no. 5 on behalf of the Wrocław University of Science and Technology (meetings organised once a quarter during the project).

As part of the task no. 5, a pilot geoinformation system was developed in GIS environment for the selected regions of exploitation of the rock raw materials in the Lower Silesia Province, which among others consisted of: procedure for forecasting potential environmental and social conflicts associated with the exploitation and transport of rock raw materials, as well as tools for analysing spatial distribution of rock raw materials, along with their demand. These tools allow the public administration bodies, which are responsible for the management policy of available resources of rock minerals, to manage the deposits of rock raw materials in optimal manner that takes into account the benefits and limitations, in accordance with the principles of sustainable development. The system developed as part of the task no. 5 fulfils complementary role to the existing public databases and portals run by the Polish Geological Institute and by the Institute for Territorial Development in Wrocław. Through the offered functionality that covers, among others: tools for printing thematic maps, searching for data according to the given criteria or locations, identifying facilities on the map, downloading documents, visualising spatial models for the selected deposits, remote editing of spatial and descriptive data, as well as procedures of data geoprocessing, can support the implementation of statutory tasks of the units of county office and

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municipalities of the Wrocław County, Świdnica County and Kłodzko County, for which it was developed. It can also be a source of information for entrepreneurs from the mining industry and other industries. Selected elements of the system in the form of thematic databases were implemented under an agreement concluded between the Wrocław University of Science and Technology and the Wrocław County Office, as an additional module of the spatial information system of the Wrocław County - wroSIP.

As part of the task no. 7, the query of national and EU legal regulations regarding the possibilities of using the developed deposits of rock raw materials from the viewpoint of nature conservation, protection of monuments, protection of forests, as well as protection of therapeutic and health areas, was implemented (among others). On the basis of conducted analysis, the forms of nature protection that can be found in excavations after the exploitation of rock raw materials were described, i.e. nature reserves, landscape parks, protected landscape areas, Natura 2000 sites, monuments of nature, documentary sites, ecological sites, nature and landscape complexes, green areas and afforestation, species protection of plants, animals and fungi. Also, movable and immovable monuments associated with mining activity were described, i.e. technical facilities, such as mines, steel mills, power plants and other industrial plants, technical elements, such as devices, means of transport, machines, tools, and archaeological monuments that may occur in post-mining areas, i.e. remnants of settlements, cemeteries, burial mounds and relics. In the mining or post-mining areas, there can also occur various forms of protective forests, i.e. forests that protect the soil, forests that protect the water resources and forests that protect the environment. Geoparks were also presented, where it is important to present the interaction of inanimate nature with the objects of plant and animal world, as well as to expose the effects of human business activity associated with the rational use of environmental resources, including primarily mineral resources. The idea of geoparks assumes that changes in the natural environment caused by mining activity do not have to have a clearly destructive impact on landscape values and the quality of natural environment, particularly in the case of appropriate performance of reclamation works. Some of the above-mentioned forms of protection were supported by numerous examples. Another research implemented as part of the task no. 7 consisted of the analysis of effects of the spatial development plans for the management of deposits, resulting from legal regulations concerning spatial management. It was concluded from the analysis that the mechanism of shaping spatial planning policy is quite difficult and complex, because it requires the combination of economic, social and ecological issues, while the final effect consists of local spatial development plans that determine where, how and when the given space can be used. Thus, the mining activity must comply with the rules of spatial planning, because it is impossible to start the exploitation of any mineral without assignment of appropriate land use in spatial planning documents. Also, the valorisation of rock mineral deposits for the Łódź Province and Greater Poland Province was carried out, which was implemented on the basis of valorisation principles of undeveloped deposits of rock raw materials, prepared by the employees of the Institute of Mineral Resources and Energy Management PAN in Kraków, as part of the task no. 7 (IGSMiE PAN was the coordinator of task no. 7). Valorisation was performed for four groups of criteria: deposit and raw material criteria determined individually for individual types of deposits (size of resources, quality of minerals), mining criteria (overburden thickness, ratio of overburden thickness to the deposit thickness, water accumulation of the deposit, complexity degree of the deposit structure, possibility of transporting the raw material to the recipients), environmental criteria (access limitations due to nature and landscape protection requirements, usability requirements of underground water, soils and forests), as well as planning criteria (land development). Valorisation of the deposits constituted the basis for the protection of the most valuable among them with supra-local (national and provincial) importance, understood as protection of the area of their occurrence against another method of their development,

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preventing access to them and their exploitation in the future, as well as indication of less valuable deposits, small deposits and those that contain mineral of inferior quality, in relation to which their protection requirements can be considered on a local scale (at the municipality or county level).

The scientific result of this project consisted of the publication of its results by the team of the Wrocław University of Science and Technology in scientific journals (15), in the monograph (1 monograph, 6 chapters in the monograph) and their presentation at the conferences in the form of conference papers, presentations or posters (16), in regard to which I was a co-author.

In 2010, I participated in the implementation of research and development work carried out for O/ZG Polkowice-Sieroszowice KGHM Polska Miedź S.A., entitled *Development of diagnostic management method for machine facilities of the continuous transport system in the O/ZG Polkowice-Sieroszowice mine - stage 3 - Development of strategy guidelines for rational maintenance of machines. Computerisation of belt conveyor management strategy - application of GIS technology*, in which the management rules were developed that constitute strategy guidelines for rational maintenance of conveyor belts in analysed mine. The procedures for determining alarm thresholds were assumed based on the life bathtub curve defined for individual facilities. The characteristics were presented for currently used management systems of machine utilities in the Polish mining industry, and the possibilities of Geographic Information Systems in managing the exploitation of belt conveyors were indicated. Moreover, while taking into account requirements of the users, a structural design was presented and the choice of adopted technology was justified, which was used to develop a *Conveyors Operation Management System* based on the technical condition of used gears and guidelines for the adopted rational strategy of their maintenance. The procedures for obtaining clear information about the necessity of carried out intervention, methods of problem neutralisation that must be adopted in the given situation and precise location of the drive system element that requires such intervention, were defined, prepared and implemented. In the scope of this work, I carried out: status analysis of management system for machine utilities in Polish mining, selection and description of the technological layer in the form of database system, client-server architecture, Geographic Information System and identification of information layers in the scope of information processing in the proposed system for operational management of the drive systems of conveyor belts used in O/ZG Polkowice-Sieroszowice.

In the years 2010-2012, I participated in the research project entitled *Development of a spatial model for mining excavations of former hard coal mines in Wałbrzych and copper ore mines in Iwiny, along with the geostatistical analysis of the height changes of benchmarks in mining areas*, in the team led by Tadeusz Głowacki, Ph.D., Eng.. This project concerned the development of spatial model analysis method for mining excavations based on geodetic measurements of mining areas and the results of deformation forecasts in mining areas. Archival and current (2010 and 2011) measurements of vertical displacements of the control points were used for the analyses. The excavation model was developed for the following mines: "Thorez" hard coal mine in Wałbrzych, "Konrad" copper ore mine in Iwiny and sodium mine in Canada. These mines have been closed for a long time. A time-varying spatial model of mining excavations was developed, which allows to identify the places with the most unfavourable impact on surface deformations, on the examples of mining areas of the former hard coal mine in Wałbrzych and the copper ore mine in Iwiny. Geographic information systems for engineering structures were used for the analyses of changes on the land surface. After supplementation, the results of these works can be used in processes associated with decision-making. Results of the research constituted an inspiration for the master's theses and were presented as a paper at the international conference (X International Technical Systems Degradation Conference in Liptovsky Mikulas, Slovakia).

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In the years 2013-2014, I participated in the research project entitled *Modelling of contemporary geodynamic movements in the area of central Odra fault zone with the use of analogue and numerical models*, in the team that was led by Piotr Grzempowski, Ph.D., Eng. and which was implemented at the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology. This research concerned the area of Lower Silesia that exhibits vertical and horizontal movements of the land surface, in reference to the geological and tectonic structure of this area. The main part of the research consisted of implementation of the deformation models in the area of central Odra fault zone and identification of the model compliant with the results of geodetic and remote sensing measurements. There are many literature sources that describe contemporary movements with the models based mainly on periodic measurements performed at various intervals. The current development of GNSS satellite and remote sensing techniques allows to carry out measurements in continuous manner and to create kinematic models of land surface displacements. The purpose of conducted research was to develop a system of integration of the deformation model with geodetic and remote sensing measurement systems. The research allowed to integrate deformation models with geodetic and remote sensing measurement systems. The effects of analyses were used to build an integrated system for the monitoring of land surface deformation in the regional scale.

In the years 2014-2015, I was the head of the research project no. S40050 entitled *Methods of data analysis in geoinformation systems dedicated to the mining industry*, which was implemented at the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology, the purpose of which was to develop and test the usability, along with the assessment of effectiveness of the data mining methods in database geoinformation systems used in mining industry. The knowledge hidden in the data collected in the systems of mining industry was analysed during implementation of the research with the use of data mining methods consisting of discovering knowledge in the databases. Modelling, grouping or classification of multidimensional data for large sets, particularly for incomplete, inconsistent data, etc. is a difficult task and it requires advanced tools for validation, initial processing, reduction of dimensionality of the redundant data to the minimum that ensures the preservation of information, etc. Typically, the processing and analysis of such data is carried out with the use of advanced statistical methods and the so-called artificial intelligence. The obtained research results were an inspiration for the implementation of diploma theses by students of the following majors: Mining and Geology, Geodesy and Cartography implemented at the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology in the academic year 2014/2015, which used the knowledge and experience from the implementation of research works, data obtained from the mining industry, algorithms for the processing and analysis of data. The results of research were presented as conference papers concerning the applications and modification of algorithms for the processing, along with data analysis in geoinformation systems concerning the mining industry.

In the years 2015-2016, I participated in the research work no. S50044 entitled *Data mining methods in the modelling of environmental changes caused by mining exploitation*, which was led by Joanna Bac-Bronowicz, Ph.D., Eng. The purpose of this research was to use the methods of data mining for various data, in order to distinguish the boundaries of subareas, characterised by distinctiveness in the scope of environmental data in the geographic information system, and depicting it via demarcation zones that present (among others) imprecision and uncertainty of input data. This research concerned the areas of ongoing, planned or completed mining activity and the development of multi-variant system for the monitoring of surface changes, with the use of multi-resolution layered data models. As part of the implementation of the above-mentioned research purpose, the works were conducted, which were grouped in two main areas. The first

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area concerned the analysis of sources and methods of acquiring selected environmental data of a qualitative and quantitative nature, with particular emphasis on satellite sources of the Copernicus-Sentinel program. Also, the analysis of existing works regarding the use of satellite imagery to monitor and assess the state of land cover, and to build land surface models, was carried out, e.g. to monitor deformations caused by the exploitation of mineral deposits, in regard to the environment. The second area of research concerned the development of principles for the acquisition, harmonisation, processing, visualisation and interpretation of topographic data, in accordance with EU legal provisions and national legal provisions. In this scope, the analysis of possibilities for harmonisation of BDOT10k and BDOT500 conceptual models in the context of data exchange was carried out. Also, the analysis of application possibilities of the Topographic Facilities Database (BDOT10k and BDOT500) for cartographic developments in open-cast mining was conducted, which resulted in a thesis, which was written under my supervision. The obtained research results constituted a contribution to a more complete understanding of processes occurring at the contact point between nature and the material activities of current civilisation. The research results allowed to develop R&D application algorithms. The research results were presented in scientific journals, at the conferences as presentations or conference papers, and in the diploma theses, which I co-authored (presentations along with the conference papers at the following conferences: SGEM 2016, WMESS 2016 (2 conferences indexed on Web of Sciences), GIS in SCIENCE 2016) and a paper in the journal called "Roczniki Geomatyki".

In the years 2016-2017, I was a researcher of the research work no. 0401/0174/16 entitled *Data mining methods in the modelling of environmental changes*, which was led by Joanna Bac-Bronowicz, Ph.D., Eng. The purpose of this research was implemented with the use of various methods of acquiring, analysing, interpreting, practical application and disseminating geoinformation with scientific and technical methods used in geomatics. The research includes an analysis of sources and methods of obtaining selected qualitative and quantitative data, their reliability and methods of processing and building relations between the features. The accuracy of the data was assessed on the information layers of the models and also the efficiency of adopted method of processing was evaluated for some data. The boundaries of subareas were constructed in the geographic information system (GIS) and illustrated with the use of screen visualisations, as well as the maps of developed models. The resulting papers and monographic presentations present the applications of geomatics in open-cast mining and underground mining. Mining applications of geomatics are presented on such examples as the assessment of: availability of resources and deposit of crushed stone from the environmental and social perspective, as well as the analysis of post-mining excavations as a place for locating municipal waste. As part of this research, the methodology was developed for identification of environmental and social changes in the vicinity of KWB Turów in the historical context, as well as the study of conceptual model of the Geographic Information System for spatial analysis of seismic events. The works were performed concerning selected methods and sensors for satellite remote sensing in the monitoring of mining areas. Also, the topography of selected areas was implemented, starting from the development of imaging applications originating from the unmanned aerial vehicle to the construction of a numerical model of land cover, as well as the construction of metric 3D models based on UAV's images, both for urban areas (application of geomatics in the city inventory, with particular emphasis on monuments) and areas outside the cities with distinctive morphometric characteristics. For this purpose, the methods for supplying the base of regular spatial reference fields with information obtained from the physical and geographic units of the micro-region level were developed, and the development of patterns for this level of units was commenced, in order to use micro-regions in further studies as reference units for studying the distribution of various environmental factors. The example phenomenon important for the environmental models

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consisted of the distribution of atmospheric precipitation, while assuming the concurrency of sub-regional boundaries with the course of zones separating physical and geographical units, with the use of neural networks for implementation of the affiliation analyses. Also, a method for analysis of the possibility to make space-time changes in the surface and type of forests dependable on the climate change, was implemented. The conducted research includes an attempt to use the dynamic development of solutions dedicated to spatial data analysis and the democratisation of information, known more widely as the open data formula. The use of localisation data originating from the Internet of Things (IoT) as the latest tool for map makers, was also addressed. The research results were presented at national and international conferences, as well as in the scientific journals (e.g. the Conference of Ph.D. Students and Young Scientists, WMESS 2017, MPES 2017, which resulted in publications indexed on the Web of Sciences and in the journal from the JCR database (*International Journal of Mining Reclamation and Environment* 2018) and in the "Roczniki Geomatyki".

In the years 2017-2018, I was a research of the research work no. 0401/0123/17 entitled *Research on natural and anthropogenic changes in the environment with the use of geographic information technology*, which was aimed at improving the methods of acquiring, exploring, processing, integrating, analysing and visualising of various types of geodata, on the basis of which it is possible to detect, observe and interpret natural and anthropogenic changes in the environment. The analyses concerned facilities and areas subject to the impact of human activity, primarily the exploitation of mineral resources and the determination of areas with changes caused by the human activity and climate change. The research was based on the results of classical geodetic measurements, radar imagery and remote sensing images, with the use of integrated analysis of this data (remote sensing, satellite GNSS, seismic, environmental, geological, topographic and other). Geodata processing algorithms were developed, along with their testing on the selected research facilities. On this basis, the uncertainty analysis of quantitative and qualitative data was performed and the effectiveness of applied measurement methods was assessed. The results were also used to determine and correlate changes in the area of research facilities, along with the conditions and potential factors of these changes.

In 2018, I participated in the implementation of the research work entitled *Inventory of the amount of deposited exploitation waste generated during mining and processing of rock raw materials in the Lower Silesia Province in the years 2010-2016 in active mining plants*, in the team led by Jan Blachowski, Ph.D., Eng. This work was commissioned by the Marshal Office of the Lower Silesia Province as part of the CircE project - European Regions Toward Circular Economy, co-financed under the European Regional Development Fund of the Interreg Europe Programme. The task of the regional stakeholder group in the CircE project consists of (among others) creation of an action plan for Lower Silesia, leading to the action plan for circular economy, which was arranged with the representatives of European regions, along with the determination of strengths of the Lower Silesia Province in the analysed areas of circular economy. This project is implemented by the Lombardy Region, the Lower Silesia Province, the Catalonia Region, the Gelderland Region, the Association of Cities and Municipalities of Slovenia, the London Board for Waste and Recycling, Sofia City and Creation Development EcoEnterprises of the Hautse-de-France in the years 2014-2020. As part of the research carried out by the employees of the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology, an inventory of deposited mining and processing waste was carried out, along with the spatial representation of their location in mining plants in Lower Silesia. Additionally, as part of the study, the quantitative and qualitative analysis of this waste was performed. Conducted quantitative analysis allowed to obtain reliable information concerning the amount of rock mining post-excavation waste in individual counties. The qualitative analysis recognized the nature and type

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composition of deposited waste, which allowed to identify 6 enterprises from the studied area or enterprises that run business activity in this area, whose waste due to quantity, nature and type composition could be used in the next 3 years for industrial production purposes, while assuming the use of world-known and/or new technologies. Moreover, the possible applications of waste after its processing were determined. In order to construct and develop a database of analysed objects (conceptual and physical model), QGIS software was used. The *desk research* technique was used for the quantitative and qualitative analysis of the waste. The method of hierarchical analysis of the decision problem (AHP) was used as the method supporting the qualitative analysis. The cartodiagram method was used to develop the cartographic materials. The waste qualitative analysis was conducted in two aspects: economic and environmental. As part of the environmental analysis, two analysis criteria were adopted: waste category (hazardous or inert) and location in protected natural areas and Main Underground Water Reservoirs. The following economic criteria were adopted: raw materials that are essential for the economy, occurrence of waste > 10 000 thousand Mg, occurrence in waste of clay raw materials (application e.g. in the agriculture or food industry), occurrence in potassium waste in the form of dusts and fine granite fractions, occurrence in the waste of raw materials that are a source of magnesium (e.g. serpentinite, basalt, syenite). As a result of the use of environmental and economic criteria, 20 Mining Waste Disposal Facilities were selected for the study, which were subjected to AHP multicriteria analysis, in order to identify enterprises whose post-mining waste could be used in the next 3 years for the purposes of industrial production. As a result of the multicriteria analysis with the use of analytic hierarchy process (AHP), the significance of economic and environmental criteria was determined in the assessment of waste usability for potential economic application. The most important criteria included: location of waste in protected areas (27.3%), occurrence of raw materials that are essential for the national economy (20.6%) and occurrence of clay raw materials in waste (12.2%), whereas the smallest criterion consisted of hazardous or neutral waste category. Also, the analysis of research concerning the development of technology for the use of mining waste, including technologies covered by patent protection and good practices from the country and from the Lower Silesia Province, was conducted, which may be the basis for the development of technologies adapted to the specific nature of waste deposited in selected mining plants. However, in order to enable the possible use of waste located in the Mining Waste Disposal Facilities, it is necessary to perform detailed and specialised tests of their suitability. Verification of the review of research concerning the use of waste generated during the extraction and processing of rock raw materials demonstrated that the studies are carried out to a limited extent and mostly in the basic phase, therefore there is a need to expand the perspectives of research works in regard to the possibilities of using extractive and processing waste. The scientific effect of conducted research was the publication of papers in three scientific journals that are included in the *JCR database (Minerals, Sustainability and Applied Sciences)*, which I co-authored.

After completion of the above-described research work, the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology signed a Letter of Intent with the Marshal Office of the Lower Silesia Province regarding mutual cooperation in the scope of implementation of the CircE project - European Regions Toward Circular Economy, co-financed under the Interreg Europe Programme, in order to achieve the objectives and results assumed in the project. As part of the project, it was planned to perform the following activities (among others): regional meetings of stakeholders in I phase of the project (at least once every six months) organised by the Marshal Office of the Lower Silesian Province, which will be aimed at participation in the process of knowledge exchange (learning cycle), as well as the discussion concerning existing or planned solutions in the scope of circular economy in Lower Silesia,

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international meetings dedicated to the Stakeholders organised by Project Partners, as well as conferences organised in Lower Silesia during I phase of the project.

In 2018, I participated in the research work entitled *Impact of the conveyor belt movement on climate hazard during the transport of air to mining regions in deeper areas of the deposit*, implemented on the basis of agreement no. KGHM-KP-U-0479-2018-U/0180/507/2018 for KGHM Polska Miedź S.A. Oddział Zakłady Górnicze Polkowice-Sieroszowice, whose purpose was to develop an expert assessment of the impact of the conveyor belt movement in mining excavations on climate hazard during the transport of air to mining regions in deeper areas of the deposit, in terms of fulfilling the requirements of §445 of the Regulation of the Minister of Energy of 9 June 2017 *on detailed requirements concerning the routing of movement in underground mining facilities* (Journal of Laws 2017.118, as amended). The study presents the results concerning research in the area of climate hazards during the transport of air to mining areas in deeper areas of the deposit, taking into account the operation of conveyor belt built in the excavation. Thermovision methods were used to identify the heat sources associated with operation of the drive system elements, as well as with the conveyor belt route. On the basis of conducted research, the recommendations were proposed concerning the possibility of improving the microclimate in the excavation with the conveyor belt.

I participated in seminars, scientific conferences and popular science events as a speaker, author or co-author of the presentations, promoting the gained knowledge and experience associated with the use of geoinformation systems in the mining industry. The most important of them include:

- International Symposium on Mine Planning and Equipment Selection, delivering a presentation at the international conference, **Górniak-Zimroz J.**, Malewski J. entitled *Decision support system for management of municipal waste and mining voids*, The 13th International Symposium on Mine Planning and Equipment Selection, 2004;
- GIS-day, Górniak-Zimroz J. *Municipal waste management in the GIS environment - spatial information systems as a tool for the support of municipal waste management on the example of Milicz County*, delivering a lecture, 28 September 2004;
- GIS-day, *Spatial Information Systems - perfect tool for the support of management and public services*, running geoinformation workshops, 28 September 2004;
- Seminar in the Polish Geological Institute in the Lower Silesian Branch in Wrocław, presentation of the paper entitled *Methodology of building a decision support system in the scope of management of post-mining areas for the purposes of municipal waste management on the example of Milicz County*, November 2004;
- SPILM 2004, SUSTAINABLE POST-MINING LAND MANAGEMENT, delivering a presentation at the international conference, **Górniak-Zimroz J.**, Malewski J., Woźniak J., entitled *The methodology of development of decision support system for management of municipal waste and mining voids*, Kraków, 2004;
- AI-METH 2004, Symposium on Methods of Artificial Intelligence, delivering a presentation at the international conference, **Górniak-Zimroz J.**, Malewski J. entitled *Application of the Kohonen neural network for classification of mining voids*, Gliwice, 2004;
- Seminar at the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology, Malewski J., **Górniak-Zimroz J.** entitled *An integrated method of*

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- management of municipal waste and mining voids*, delivered for the delegation from Angola, September 2004;
- VIII Days of Mining Surveying and Protection of Mining Areas, Problems of mining exploitation under developed areas, delivering a presentation at the conference, **Górniak-Zimroz J.**, Kaźmierczak U. *Development of post-mining areas of Lower Silesia on the example of educational path – On the trail of extinct volcanoes*, Ustroń, 15-17 June 2005;
  - Mining workshops from the series entitled *Natural hazards in mining*, delivering a presentation at the conference, **Górniak-Zimroz J.**, Kaźmierczak U., Malewski J. *Ecological aspects of the exploitation of mineral resources on the example of the Bystrzyca river basin environment*, Kazimierz Dolny on the Vistula, 20-22 June 2005;
  - Conference entitled *Municipal waste management in the Wroclaw County in the context of solutions implemented in the Haut-Rhin department (France) and the Borken district (Germany)*, presentation at the international conference, **Górniak J.**, Malewski J. entitled *Logistic aspects of waste management*, Wrocław, 3 June 2005;
  - X Lower Silesian Science Festival 2007, Kaźmierczak U., **Górniak-Zimroz J.**, *Exploitation and what is next? - restoring natural and usable values to post-mining areas*, delivering a lecture, 17-25 September 2007;
  - IV Conference entitled *Heritage and history of mining, and the use of remains of old mining works*, delivering a presentation, **Górniak-Zimroz J.**, Maluga R., entitled *Inventory and assessment of the possibilities of using old mining works in the Miedzianka region*, Złotniki Lubańskie, 23-25 April 2008;
  - International Mining Forum 2009, as part of the Underground Exploitation School 2009, co-author of the presentation at the international conference, **Górniak-Zimroz J.**, Zimroz R., Król R., Jurdziak L., entitled *Decision making system based on GIS technology for supporting machinery maintenance*, Kraków, 18-21 February 2009;
  - 3<sup>rd</sup> International Congress Design and Modelling of Mechanical Systems CMSM'2009, co-author of the presentation at the international conference, **Górniak-Zimroz J.**, Zimroz R., Król R., Jurdziak L., entitled *The application of GISs to support belt conveyor maintenance management*, Hammamet, Tunisia, 16-18 March 2009;
  - X Mineral Aggregates Conference Raw Materials-Market-Technologies-Quality, co-author of two presentations: Blachowski J., **Górniak-Zimroz J.**, Pactwa K., Specylak-Skrzypecka J., Ślusarczyk G., entitled *Analysis of tools and information resources in the scope of documenting deposits of rock raw materials in the Lower Silesia Province*, Blachowski J., **Górniak-Zimroz J.**, Pactwa K., entitled *Analysis of selected geoinformation systems that provide data on rock raw materials*, Szklarska Poręba, 14-16 April 2010;
  - XX Underground Exploitation School 2011, co-author of the presentation at the conference, King R., Zimroz R., **Górniak-Zimroz J.**, Hardygóra M., Gładysiewicz L., Bartelmus W., entitled *Management system for the operation of belt conveyors DIAG MANAGER for KGHM O/ZG Polkowice-Sieroszowice*, Kraków, 21-25 February 2011;
  - VII INTERNATIONAL CONGRESS of Brown Coal Mining, co-author of the presentation at the international conference, Biernat S., Hardygóra M., **Górniak-Zimroz J.**, Król R., Zimroz R., *Proposition of building an IT decision support system in the area of integrated technical data concerning the operation processes of continuous transport systems*, Bełchatów, 11-13 April 2011;



- X International Technical Systems Degradation Conference, co-author of the poster at the international conference, Zimroz R., Bartelmus W., **Górniak-Zimroz J.**, entitled *Application of information system and data mining for maintenance of large scale spatial transportation system*, Liptovský Mikuláš, Slovakia, 27-30 April 2011;
- XI Mineral Aggregates Conference Raw Materials-Market-Technologies-Quality, co-author, Blachowski J., **Górniak-Zimroz J.**, Jurdziak L., Kawalec W., Pactwa K., Specylak-Skrzypecka J., Ślusarczyk G., entitled *Structure of the geoinformation system of rock raw materials deposits - assumptions*, Szklarska Poręba, 27-29 April 2011;
- XII Seminar from the series entitled "Methodology of documenting and recognising deposits and geological service of mines" on the subject of: Documenting and protecting mineral deposits, and the problems of environmental protection, co-author of the presentation, Blachowski J., **Górniak-Zimroz J.**, Jurdziak L., Kawalec W., Pactwa K., entitled *Acquisition of input data from the geological documentation for building a geoinformation system of the rock raw materials deposits*, Międzyzdroje, 8-10 June 2011;
- 22<sup>nd</sup> World Mining Congress & Expo, co-author of the presentation at the international conference, Zimroz R., Król R., Hardygóra M., **Górniak-Zimroz J.**, Bartelmus W., Gładysiewicz L. Biernat S., entitled *A Maintenance Strategy for drive units used in belt conveyors network*, Istanbul, Turkey, 11-16 September 2011;
- Conference called *Sustainable production and consumption of mineral resources in Europe - integration of social aspects and rational consumption of resources*, which was organized by the Institute of Mineral Resources and Energy Management PAN, EUROMINES-European Association of Extractive Industry, Metal Ores and Useable Minerals in Brussels, and the Employers Association Polish Copper in Lubin, as part of the Polish presidency of the EU Council, delivering a lecture, Blachowski J., **Górniak-Zimroz J.**, Pactwa K., Jurdziak L., Kawalec W., entitled *Geoinformation system of rock raw materials deposits for management of the sustainable use of regional raw materials base*, Wrocław 20-22 October 2011;
- XXI Conference *Current issues and prospects of mineral resources management*, co-author of 3 presentations: Blachowski J., Duczmal M., **Górniak-Zimroz J.**, Nowacka A., entitled *Selected data processing procedures in the geoinformation system of rock raw materials deposits*; Kawalec W., **Górniak-Zimroz J.**, Jurdziak L., Pactwa K., Blachowski J., entitled *Application of virtual reality in the geoinformation system*; **Górniak-Zimroz J.**, Pactwa K., Blachowski J., Jurdziak L., Kawalec W., Specylak-Skrzypecka J., Ślusarczyk G., entitled *Pilot geoinformation system for the management of resources, along with the testing of exploitation of the rock raw materials in selected region*, Krynica, November 16-18, 2011;
- XI International Technical Systems Degradation Conference, co-author of the presentation at the international conference, Stefaniak P., Zimroz R., Bartelmus W., **Górniak-Zimroz J.**, entitled *Application of self organizing maps for gearbox diagnostic data analysis*, Liptovský Mikuláš, Slovakia, 11-14 April 2012;
- CMMNO 2012 Conference, Condition Monitoring of Machinery in Non-Stationary Operations, co-author of the presentation at the international conference, Stefaniak P., Zimroz R., King R., **Górniak-Zimroz J.**, Bartelmus W., Hardygóra M., entitled *Some remarks on using condition monitoring for spatially distributed mechanical system belt conveyor network in underground mine - a case study*, Hannamet, Tunisia, 26-28 March 2012;
- Conference organized by Poltegor-Institute Open-cast Mining Institute as part of the project entitled *Strategies and technological scenarios of management and use of the deposits of rock raw materials*, co-author of the presentation, Blachowski J., **Górniak-Zimroz J.**, Jurdziak

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- L., Kawalec W., Pactwa K., entitled *Effective support for the regional mineral resources management – experiences from the building of regional geoinformation systems for the deposits of rock raw materials*, Wrocław, 27-28 November 2013;
- VVaPOL 2014 Conference - Conference on Research, Production and Use of Steel Ropes, Conveyors and Hoisting Machines, delivering a presentation at the international conference, **Górnjak-Zimroz J.**, entitled *Spatial planning using GIS technology for optimal multi-criteria location of belt conveyor route*, Podbanske, Slovakia, 23-26 September 2014;
  - XVII Lower Silesian Science Festival 2014, Pactwa K., **Górnjak-Zimroz J.**, *The path to information*, delivering a lecture, 3 October 2014;
  - Academy of Cartography and Geoinformatics 2015, delivering a presentation at the conference, Bac-Bronowicz J., **Górnjak-Zimroz J.**, Pactwa K., entitled *The use of topographic facilitates database as a source of data in open-cast mining*, Wrocław, 13-15 May 2015;
  - WMESS 2015, The World Multidisciplinary, Earth Sciences Symposium, delivering a presentation at the international conference, **Górnjak-Zimroz J.**, Pactwa K., entitled *The use of spatial data in granite deposit life cycle assessment*, Prague, Czech Republic, 7-11 September 2015;
  - WMESS 2015, The World Multidisciplinary, Earth Sciences Symposium, co-author of a presentation at the international conference, Pactwa K., Blachowski J., **Górnjak-Zimroz J.**, entitled *GIS as a support tool in regional management of rock mineral resources – experiences from SW Poland*, Prague, Czech Republic, 7-11 September 2015;
  - III Polish Mining Congress, MINING AND ENVIRONMENT conference, co-author of a presentation at the conference, **Górnjak-Zimroz J.**, Kawalec W., entitled *The concept of carbon delivery via long-range conveyors, taking into account the environmental conditions*, Wrocław, 14-16 September 2015;
  - XVIII Lower Silesian Science Festival 2015, Pactwa K., **Górnjak-Zimroz J.**, *GIS – useful(less) system*, delivering a lecture, 18-23 September 2015;
  - Practical workshops entitled *Selection of optimal location for the planned investment* in the scope of Geographic Information Systems, organised for students of the Nicolaus Copernicus' School Complex no. 3 in Wałbrzych, run by **Górnjak-Zimroz J.** and Milczarek W., which promoted knowledge regarding Geographic Information Systems, Wrocław, 30 September 2015;
  - *Environment of Information 2015* Conference, co-author of a presentation at the conference, Blachowski J., **Górnjak-Zimroz J.**, Pactwa K., Jurdziak L., Kawalec W., *Application of GIS tools for the management of rock raw materials on the example of selected county in the Lower Silesia Province - case study for the Wroclaw County*, Copernicus Science Centre, Warsaw, 7-8 October 2015;
  - V National GIS in Science Conference, co-author of a presentation at the conference, Blachowski J., **Górnjak-Zimroz J.**, Pactwa K., *The use of geographic information systems in mining*, Warsaw, 8-10 June 2016;
  - 16th International Multidisciplinary Scientific GeoConference, SGEM 2016, co-author of a presentation at the international conference, **Górnjak-Zimroz J.**, Pactwa K., entitled *Influence of opencast mining activity on the environment and on man - an analysis with the use of geographic information systems*, Albena, Bulgaria, 30 June – 6 July 2016;

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- WMESS 2016, The World Multidisciplinary, Earth Sciences Symposium, co-author of a presentation at the international conference, Pactwa K., **Górniak-Zimroz J.**, entitled *Identification of social and environmental conflicts resulting from open-cast mining*, Prague, Czech Republic, 5-9 September 2016;
- Practical workshops in the scope of Geographic Information Systems, organised for students of the Secondary School Complex in Bystrzyca Kłodzka, run by **Górniak-Zimroz J.** and Milczarek W., which promoted knowledge regarding GIS, Wrocław, 30 September 2015;
- XXVI Conference of the Polish Society of Spatial Information entitled *Geoinformation aspects of space management*, co-author of the presentation, Bac-Bronowicz J., **Górniak-Zimroz J.**, Pactwa K., entitled *The use of state geospatial registers in the GIS environment for identifying environmental and social conflicts caused by the open-cast mining of raw material resources*, Warsaw, Polish National Library, 8-9 November 2016;
- GIS-day, *Taking a walk around the Wrocław University of Science and Technology Campus in the Geographic Information System*, running of geoinformation workshops, November 2016;
- XVII Conference of Ph.D. Students and Young Scientists, presentation of a poster at the conference, **Górniak-Zimroz J.**, entitled *Analysis of post-mining excavations as locations for the placement of municipal waste*, Szklarska Poręba, 23-26 May 2017;
- XVII Conference of Ph.D. Students and Young Scientists, co-author of a presentation at the conference, Cieślik T., **Górniak-Zimroz J.**, entitled *Methodology for identification of environmental and social changes in the KWB Turów area in the historical context*, Szklarska Poręba, 23-26 May 2017;
- 17th International Multidisciplinary Scientific GeoConference, SGEM 2017, co-author of a presentation at the international conference, Blachowski J., **Górniak-Zimroz J.**, Milczarek W., Pactwa K., entitled *Applications of geomatics in underground mining*, Albena, Bulgaria, 29 June - 5 July 2017;
- Mine Planning & Equipment Selection MPES 2017, co-author of a presentation at the international conference, **Górniak-Zimroz J.**, Pactwa K., entitled *Methodology for assessment of the accessibility of dimension and crushed stone deposits from the environmental and social perspective*, Lulea, Sweden, 29-31 August 2017;
- WMESS 2017, The World Multidisciplinary, Earth Sciences Symposium, co-author of a presentation at the international conference, **Górniak-Zimroz J.**, Blachowski J., Milczarek W., Pactwa K., entitled *Applications of geomatics in surface mining*, Prague, Czech Republic, 11-15 September 2017;
- XXIII Jacek Rejman's Autumnal School of Geodesy, delivering a poster at the conference, **Górniak-Zimroz J.**, Wyłomańska A., Stefaniak P., Michalak A., entitled *Development of a conceptual model of the Geographic Information System for spatial analysis of seismic events*, "Former Mine" Science and Art Centre in Wałbrzych, 21-22 September 2017;
- First International Conference, Mines of the Future, presentation of a poster at the international conference, **Górniak-Zimroz J.**, Pactwa K., entitled *Dimension and crushed stones extraction as a source of social and environmental conflicts in Poland*, 23-24 May 2018;
- First International Conference, Mines of the Future, presentation of a poster at the international conference, Blachowski J., **Górniak-Zimroz J.**, Kaźmierczak U., entitled *Quantitative and qualitative research of waste resulting from mining of rock raw materials in Lower Silesia*, 23-24 May 2018;

- WMESS 2018, The World Multidisciplinary, Earth Sciences Symposium, presentation of a poster at the international conference, **Górniak-Zimroz J.**, Wyłomańska A., Stefaniak P, Michalak A., entitled *Development of a gis system prototype for spatiotemporal analysis of seismic events*, Prague, Czech Republic, 3-7 September 2018;
- WMESS 2018, The World Multidisciplinary, Earth Sciences Symposium, presentation of a poster at the international conference, **Górniak-Zimroz J.**, Lisiewicz M., entitled *Tourist attractiveness analysis of relicts of the former construction and mining works within Lower Silesia*, Prague, Czech Republic, 3-7 September 2018.

I reviewed papers for the journals that popularise the results of research concerning the mining industry (among others: *Cuprum Czasopismo Naukowo-Techniczne Górnictwa Rud*, *Górnictwo i Geologia Prace Naukowe Instytutu Górnictwa Politechniki Wrocławskiej*, *Górnictwo Odkrywkowe*, *Wiadomości Górnicze*) and at the conferences of Ph.D. students, which were organised by the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology. Also, I was a reviewer of the monograph by Górecki A. and Gnat D., entitled *Environmental assessment of the spatial planning process in the Bolesławiec Municipality in the Wieruszów County*, which was published by the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology in 2018.

My scientific achievements in the years 2004-2019 (after obtaining the Ph.D. degree) cover publications listed in table 1, which are described in detail in the annex *List of habilitation achievements* (attachment No. 4) that also demonstrates the value of my scientific achievement expressed in the bibliometric index Impact Factor (IF) indicator and the points of scientific journals of the Ministry of Science and Higher Education (MNiSW).

Table 1

List of scientific and research achievements after obtaining the Ph.D. degree (as of April 2019)

No.	Indicator	Indicator value	Points achievements	IF
1	Authorship or co-authorship of scientific publications in the journals contained in the <i>Journal Citation Reports (JCR)</i> database	5	115	8,692
2	Authorship or co-authorship of monographs, scientific publications in the international or national journals:			
	- books, monographs and chapters of collective works	13	104	
	- monograph editing	1	0	
	- scientific publications in the journals that do not have an <i>Impact Factor (IF)</i>	29	149	
	- publications in materials from international conferences included in the recognized database of international publications (among others Wos, Scopus, ProQuest, EBSCOHost, CrossRef)	10	150	
	- publications in materials from the conferences not included in the publication databases	8	0	
	- delivered unpublished conference papers	2	0	
<b>IN TOTAL:</b>		<b>67</b>	<b>518</b>	<b>8,692</b>

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3	Number of cited publications: – according to Web of Science – according to Scopus – according to Google Scholar	27 (15) 14 136		
4	Hirsch index of published publications: – according to Web of Science – according to Scopus – according to Google Scholar	3 3 6		
5	Authorship or co-authorship of collective studies, documentation of research works and expert opinions	20		
6	Leading international or national research projects or participation in such projects	16		
7	Awards for scientific activity	1		

As of 01.04.2019, the value of my total IF ratio amounts to **8.692**. In collected **518 MNiSW points** in my account. I have compiled the list of my citations on the basis of three selected databases, i.e. Web of Science, Scopus and Google Scholar, which are summarised in table 1, along with the Hirsch index.

I participated in two scientific research consortia:

- Consortium consisting of: KGHM Cuprum Sp. o.o (leading institution), Wrocław University of Science and Technology, Institute of Mineral Resources and Energy Management PAN in Kraków, Main Mining Institute in Katowice, EMAG Electrification and Automation Centre in Katowice, Silesian University of Technology, KGHM Polska Miedź S.A., which was established for implementation of the Foresight targeted project entitled *Scenarios of technological development of copper ore mining industry and associated raw materials in Poland* in the years 2006-2008;
- Consortium consisting of: Poltegor-Institute Open-cast Mining Institute - Wrocław (Project coordinator), AGH University of Science and Technology in Kraków, Institute of Mineral Resources and Energy Management PAN in Kraków, Polish Geological Institute in Warsaw - Lower Silesian Branch, Wrocław University of Science and Technology, University of Wrocław, which was established for implementation of the project entitled *Strategies and technological scenarios of management and use of the deposits of rock raw materials*, co-financed from the European Regional Development Fund under the "Innovative Economy" Operational Programme, Priority 1 - Research and development of modern technologies, Sub-measure 1.3.1 - Development Projects, which was implemented in the years 2009-2014.

Also, I participated in the popularisation of mining activities among the youngest in kindergarten no. 33 "Staromjejskie" and no. 18 "Wiolinek" in Wrocław.

I passed on and I still try to pass on my knowledge and experience gained during the conducted research in the didactic classes for students of the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology, both full-time and part-time studies, engineering and master program for the following majors: Mining and Geology; Geodesy and Cartography, within the following courses:

- *Waste management*, lecture and seminar, major: *Mining and Geology*, specialty: *Management of Earth Resources and Environmental Protection*, full-time master studies, full-

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- time master studies and part-time master studies, academic year: 2004/2005 and 2005/2006;
- *Geographic Information Systems II*, laboratory, major: *Mining and Geology*, specialty: *Management of Earth Resources and Environmental Protection*, full-time master studies, academic year: 2004/2005 and 2005/2006;
  - *Geographic Information Systems I*, laboratory, major: *Mining and Geology*, specialty: *Management of Earth Resources and Environmental Protection*, full-time master studies, academic year: 2005/2006 and 2008/2009;
  - *Application of Geographic Information Systems in the management of environmental resources*, selectable course, laboratory, major: *Mining and Geology*, full-time master studies, specialty: *Management of Earth Resources and Environmental Protection*, academic year: 2005/2006;
  - *Damage and compensations in mining areas*, lecture and seminar, major: *Mining and Geology*, specialty: *Management of Earth Resources and Environmental Protection*, full-time master studies, academic year: 2005/2006;
  - *Information systems in environmental protection*, lecture and laboratory, major: *Mining and Geology*, full-time master studies, specialty: *Geoinformatics and Geoengineering*, academic year: 2006/2007, 2007/2008, 2008/2009 and 2009/2010;
  - *Basics of Geographic Information Systems*, laboratory, major: *Mining and Geology*, full-time master studies, academic year: 2006/2007, 2008/2009 and 2009/2010;
  - *Environmental protection management systems*, lecture and laboratory, major: *Mining and Geology*, full-time master studies, academic year: 2007/2008, 2008/2009, 2009/2010 and 2010/2011;
  - *Modelling of production processes*, laboratory, major: *Mining and Geology*, full-time master studies, academic year: 2007/2008;
  - *Spatial analysis systems*, laboratory, major: *Mining and Geology*, full-time master studies, academic year: 2008/2009;
  - *Environmental management*, lecture and seminar, major: *Mining and Geology*, full-time master studies and part-time master studies, academic year: 2009/2010, 2010/2011, 2011/2012, 2012/2013, 2013/2014, 2015/2016, 2017/2018;
  - *Spatial economy*, laboratory, major: *Mining and Geology*, full-time master studies, academic year: 2009/2010;
  - *Spatial economy with the use of GIS environment*, laboratory, selectable course run jointly with architect Jadwiga Brzuchowska, Ph.D., Eng. from the Faculty of Architecture of the Wrocław University of Science and Technology, major: *Mining and Geology*, specialty: *Geoinformatics*, full-time master studies, academic year: 2009/2010 and 2010/2011;
  - *Mining surveying*, laboratory, major: *Mining and Geology*, full-time engineer studies and part-time engineer studies, academic year: 2010/2011, 2011/2012, 2013/2014, 2014/2015, 2015/2016;
  - *Computer science*, laboratory, major: *Geodesy and Cartography*, full-time engineer studies, academic year: 2011/2012 and 2015/2016;
  - *Reclamation*, project and seminar, major: *Mining and Geology*, full-time engineer studies, academic year: 2011/2012;

- *Environmental protection*, lecture and laboratory, major: *Geodesy and Cartography*, full-time engineer studies, academic year: 2013/2014, 2014/2015, 2015/2016, 2016/2017, 2017/2018, 2018/2019;
- *Geographic Information Systems I*, laboratory, major: *Geodesy and Cartography*, full-time engineer studies, academic year: 2013/2014, 2014/2015, 2015/2016, 2016/2017, 2017/2018;
- *Numerical map technologies*, laboratory, major: *Geodesy and Cartography*, full-time engineer studies, academic year: 2013/2014;
- *Cartography I*, laboratory, major: *Geodesy and Cartography*, full-time engineer studies, academic year: 2014/2015, 2015/2016, 2016/2017 and 2017/2018;
- *Cartographic digital models*, laboratory, major: *Geodesy and Cartography*, full-time master studies, academic year: 2017/2018 and 2018/2019.

Also, I run classes at the postgraduate studies *Mineral Processing - Minerals Engineering* in Lubin-Polkowice in the academic year 2005/2006 and 2009/2010, course: *Mineral waste management*, as well as for students of the *European Geotechnical and Environmental Course*, subject: *Computer Aided Geological Modelling & Land Reclamation* in the academic year 2007/2008, 2008/2009, 2009/2010, 2010/2011 and 2011-2012 (classes run in English together with Witold Kawalec, Ph.D. eng.).

I organized seminars and field practices for students concerning the management of environmental resources in the institutions engaged in the activities associated with environmental protection:

- Field classes for students of the 4th and 5th year of the specialty: *Management of Earth Resources and Environmental Protection* from the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology in Jaroszów, which is located in the Strzegom municipality in the Świdnica County in the Lower Silesia Province. These classes covered, among others, getting acquainted with the operation of the Rusko-Jaroszów mine, which includes the area of depleted "Halina" deposit, as well as exploited and partially reclaimed "Stanisław" deposit. The area of the first deposit was reclaimed and developed into the municipal waste landfill entitled "Ecological Utilisation Centre". While in the area of the former "Stanisław" deposit, the ashes from the power plant "Elektrociepłownia Wrocław" are stored (as part of the reclamation). Field classes took place in the academic year 2004/2005 and 2005/2006;
- Field classes for students of the 4th and 5th year of the specialty: *Management of Earth Resources and Environmental Protection* from the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology in the Turów Brown Coal Mine in Bogatynia, where the students got acquainted with practical aspects of recultivation and management of external and internal spoil tip, which was run within the Mine. These classes took place in the academic year 2005/2006;
- Seminar concerning the scope and results of research carried out as part of the National Environmental Monitoring, run by the employees of the Provincial Inspectorate for Environmental Protection in Wrocław, organised for students of the 3rd year of the specialty: *Geodesy and Cartography* of the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology in the academic year 2013/2014, 2014/2015, 2015/2016.

*J. Górniak-Zimroz*

My research finds recognition among students, who are eager to choose the subjects of diploma thesis proposed by me, which promote sustainable management of environmental resources with the use of geoinformation systems. In the years 2004-2019, I was the thesis supervisor for 64 diploma theses, including: 37 engineer's theses, 25 master's theses and 2 works on postgraduate studies *Geographic Information Systems*, organised in the Centre for Continuing Education of the Wrocław University of Science and Technology. Below I presented those theses that are the most related to the subject of my research:

- Pluta G., 2005, *Evaluation of mining excavations in terms of their use in waste management*, engineer's thesis;
- Pactwa K., 2006, *Numerical zoological and hydrographic map in environmental protection on the example of a selected mining area*, master's thesis;
- Łupina U., 2006, *Determination of the impact of the planned operation on environmental elements on the example of a selected documented deposit*, master's thesis;
- Maługa R., 2006, *Inventory and assessment of the possibility of using relics of former mining works in the Miedzianka area*, engineer's thesis;
- Dec G., 2009, *Environmental conditions for the construction of the Rogóżno-Adamów long-range coal conveyor belt*, master's thesis;
- Walska W., 2009, *Environmental conditions for the construction of the Piaski-Adamów long-range coal conveyor belt*, master's thesis;
- Juszcak K., 2010, *Environmental conditions for the construction of the Złoczew-Belchatów long-range coal conveyor belt*, master's thesis;
- Węgier M., 2010, *Development of a system supporting the management of conveyor belt operations for a given area in the GIS environment in Polkowice-Sieroszowice*, master's thesis;
- Gruszka K., 2011, *Transport infrastructure for rock raw materials in the powiat of Wrocław with the use of GIS tools*, master's thesis;
- Kozyra A., 2011, *Development of a resource management system for a selected powiat - powiat of Wrocław*, master's thesis;
- Matczak J., 2011, *Analysis of transport of rock raw materials in the Kłodzko powiat with the use of GIS tools*, master's thesis;
- Słoniński T., 2011, *Development of a spatial model of the Stupiec-Dębówka gabbro deposit with the use of GIS tools*, master's thesis;
- Korona B., 2012, *Construction of a database of mining areas for deposits of rock raw materials in the Świdnica powiat in the GIS environment*, engineer's thesis;
- Szczęsny D., 2012, *Development of a spatial model of a rock raw material deposit using GIS tools*, engineer's thesis;
- Seweryn M., 2015, *Location of self-propelled mining machines in the selected KGHM area using GIS tools*, engineer's thesis;
- Wyżkiewicz K., 2015, *Analysis of transport infrastructure for rock raw materials in a selected province with the use of GIS tools*, engineer's thesis;
- Pacyniak M., 2015, *Modeling of seismic phenomena in the excavation with the use of geoinformatic tools*, master's thesis;

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- Kułaga M., 2015, *Construction of a system supporting the decision making process of belt haulage - based on diagnostic data from the transmission*, master's thesis;
- Kozub K., 2015, *The GIS system for monitoring and forecasting the technical condition of conveying conveyor belts*, master's thesis;
- Cyza M., 2015, *GIS system in crisis management for self-propelled mining machines*, engineer's thesis;
- Leń I., 2016, *Using the Topographic Data Database as a data source for the development of mining maps*, engineer's thesis;
- Sitarek P., 2016, *GIS system to support the management of the conveyor network in the selected opencast mine*, engineer's thesis;
- Sewina S., 2016, *Analysis of post-mining excavations as potential landfills for municipal waste - analysis for a selected powiat*, master's thesis;
- Cieślík T., 2017, *Identification of environmental and social changes in the vicinity of KWB Turów on the historical background*, engineer's thesis;
- Dymacz A., 2017, *Determination of potential locations of underground repositories of hazardous and radioactive waste in the Lower Silesian Voivodship*, engineer's thesis;
- Lisiewicz M., 2018, *Analysis of the availability of the Lower Silesia tourist base (relics of old mining and construction works)*, master's thesis;
- Dymacz A., 2018, *Analysis of the influence of light pollution on the environment on the example of the Turów brown coal mine*, master's thesis;
- Kik E., 2018, *Analysis of the influence of light pollution on the environment on the example of the Bełchatów brown coal mine*, master's thesis;
- Mielczarek K., 2018, *Analysis of the influence of light pollution on the environment on the example of the Konin brown coal mine*, master's thesis;
- Królik P., 2019, *Development of a relational database of accidents in selected copper ore mines*, engineer's thesis.

In the years 2004-2019, I implemented organisational activity for the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology, for the University and for the Lower Silesia Province as:

- member of the scientific and organisational committee of the international conference entitled *Municipal waste management in the Wrocław County in the context of solutions implemented in the Haut-Rhin department (France) and the Borken district (Germany)*, Wrocław, 3 June 2005;
- member of the organisational committee of the *XIX Jacek Rejman's Autumnal School of Geodesy*, Polanica-Zdrój, 22-24 September 2005;
- member of the Disciplinary Appeals Commission for students at the Wrocław University of Science and Technology, 2010-2013;
- member of the organisational committee of the *Academy of Cartography and Geoinformatics* entitled *Digital topographic maps - theory and workshops*, Wrocław, 13-15 May 2015;

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- member of the organisational committee of the *Academy of Cartography and Geoinformatics* entitled *Editing of digital thematic maps - science and practice*, Wrocław, 28-29 March 2017;
- member of the organisational committee of the *IX National Geoinformation Symposium* entitled *Thematic maps of the natural environment*, Wrocław, 28-29 March 2017;
- member of the organisational committee of the *XXIII Jacek Rejman's Autumnal School of Geodesy*, the "Former Mine" Science and Art Centre in Wałbrzych, 21-22 September 2017,
- member of the Council of the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology, from November 2016 until now;
- member of the editorial committee of conference materials from *XXIII Autumnal School of Geodesy*, published in the publishing series E3S Web of Conferences ISSN 2267-1242, vol. 55.

I belong to the Association of Mining Engineers and Technicians and to the Association of Graduates of the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology.

For my scientific, research and teaching activity, I received the following distinctions and mining grades:

- 3<sup>rd</sup> Degree Mining Director awarded by the Minister competent for economy matters in 2011;
- 1<sup>st</sup> Degree Mining Director awarded by the Minister competent for economy matters in 2015;
- Honorary Badge for Merit for the Environmental Protection and Water Management awarded by the Minister of the Environment in 2017;
- Rector's Award of the Wrocław University of Science and Technology in recognition of a distinctive contribution to the university's activity in 2017;
- Silver Honorary Badge for Merit for the Lower Silesia Province in 2018;
- Honorary Badge "Merit for RP Mining" No. 75/2018/2, which is a distinction awarded by the Minister competent for the management of mineral deposits in 2018.

In my opinion, my greatest achievements in scientific, research and teaching work implemented at the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology in the years 2004-2019 include:

- participation in research projects (16);
- participation in national and international seminars and conferences as a speaker propagating the results concerning the conducted research (44);
- publication of research results in JCR journals (5), other journals (47), in monographs (2), in chapters of collective works (11) and in reports documenting the results of research results (20);
- publication of research results in the monograph entitled *GIS systems in mining - theory and applications*, in which the methodology for building GIS systems for mining has been proposed. Moreover, set of analytical procedures and techniques for visualization of the results are proposed and discussed. It is believed that the described methodology may be a contribution to the further development of the discipline *Mining and Geological Engineering* thanks to the use of computer aided mining operations;

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- cooperation with other R&D units established as part of the Consortium and beyond (Poltegor-Institute Open-cast Mining Institute, AGH University of Science and Technology in Kraków, Institute of Mineral Resources and Energy Management PAN in Kraków, Polish Geological Institute in Warsaw - Lower Silesian Branch, University of Wrocław);
- cooperation with the local government administration in the region (Marshal Office of the Lower Silesia Province, Wrocław County Office, Kłodzko County Office, Świdnica County Office, District Mining Office in Wrocław);
- implementation of the elements of the *Deposit Resources Management System* for the Wrocław County into the spatial information system of the Wrocław County - wroSIP, conducted as part of the project entitled *Strategies and technological scenarios of management and use of the deposits of rock raw materials*;
- cooperation with the industry (KGHM Polska Miedź S.A., KWB Turów, KWB Bełchatów, SHH Sp. z o.o.);
- running didactic classes of full-time and part-time engineer studies and master studies for the faculties of *Mining and Geology* (14) and *Geodesy and Cartography* (6);
- implementation of diploma theses in the scope of engineer (37), master (25) and postgraduate studies (2 theses).

J. Górniak-Zimroz