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AUTHOR'S ABSTRACT

presenting the works and scientific achievements,
especially those defined in art. 16(2) of the Act on academic degrees
and scientific titles and on degrees and titles in art
14 March 2003 (OJ L no. 65, item 595, with amendments)

Wrocław, July 2017

1. NAME AND SURNAME

Maciej Madziarz

2. DIPLOMAS AND SCIENTIFIC DEGREES (WITH PLACE AND YEAR OBTAINED)

Master of Science, mining:

- Wrocław University of Technology
- Faculty of Mining
- speciality: **Technology of underground exploitation of deposits**
- obtained on: **2 July 1992**
- thesis titled: *Mechanical loading of explosives on the example of the Polkowice mine*
(thesis supervisor: Henryk Sztuk, PhD, Eng)

PhD IN TECHNICAL SCIENCES:

- Wrocław University of Technology
- Faculty of Mining
- obtained on: 22 September 1998
- dissertation titled: *The influence of the design and technology of performed fabric connections of conveyor belts on their strength* (thesis supervisor Prof. Monika Hardygóra)

3. INFORMATION ON EMPLOYMENT IN SCIENTIFIC INSTITUTIONS

primary workplace:

Wrocław University of Technology, Faculty of Geoengineering, Mining and Geology
ul. Wybrzeże Wyspiańskiego 27, 50-370 Wrocław

employment history:

1.10.1998 - 28.02.2016

and from 1.10.2016 until now, employed as a lecturer

additional workplace

KGHM Cuprum Sp. z o.o Centrum Badawczo-Rozwojowe [*Research and Development Centre*]
ul. Generała Władysława Sikorskiego 2-8, 53-659 Wrocław,

employment history:

from 1.05.2010 until now, employed as a lecturer

4. THE COURSE AND CHARACTERISTICS OF PREVIOUS SCIENTIFIC WORK

After graduating from the Wrocław University of Technology Faculty of Mining with a degree of Master of Science in mining, with speciality in *underground exploitation of deposits* (1992) I started working in the *Polkowice* copper ore mine in Polkowice (presently *Polkowice - Sieroszowice* mine), a division of KGHM Polska Miedź S.A. (*Polish Copper SA*) where I worked until September 1994, acquiring broad practical professional experience. After completion of examinations at the Regional Mining Office in Wrocław I was certified for lower-level mine traffic supervision (overman) and then for medium-level mine traffic supervision (shift foreman). My professional practice in the mine began in the mining preparatory division, after which I worked in the exploration division. Later, in accordance with my predispositions and professional interests, I was employed in the Rock Formation Mechanics Section as a shift foreman, involved in rock formation mechanics. Work in the mining industry, in particular managing teams of people in dangerous conditions and practical familiarization with issues related to underground mining of mineral deposits such as maintaining the stability of mining excavations carried out at extreme depths and the presence of dynamic manifestations of rock formation pressure, provided me with invaluable professional experience which I now apply in my research and teaching work.

Seeking possibilities for further intellectual and professional development, I applied for admission to PhD studies at the Wrocław University of Technology Faculty of Mining. After qualification I pursued doctoral studies (1994-1998), under Prof. PhD, Eng. Monika Hardygóra, in the Department of Machine Systems of the Wrocław University of Technology Institute of Mining. During these studies I dealt with issues of mining transport, especially conveyor and vertical transport. Additionally, I began teaching classes for students of the Wrocław University of Technology Faculty of Mining. In 1998, I defended my doctoral dissertation titled "The influence of the design and technology of performed fabric connections of conveyor belts on their strength", receiving the degree of Doctor in Technical Sciences, awarded by the Council of the Wrocław University of Technology Faculty of Mining.

On 1.10.1998 I was appointed by a resolution of the Council of the Faculty of Mining to the position of lecturer, which I continue to hold at present. I work in the Mining Department of the Wrocław University of Technology Faculty of Geoengineering, Mining and Geology. I conduct scientific research, teaching and popularization work (creating social awareness of the fundamental importance of exploitation of mineral resources for the development of civilization, technology and culture).

Since 2010, I have also been employed at the KGHM Cuprum Sp. z o.o Research and Development Centre in Wrocław, where I applied the results of my many years scientific, research and inventory work to implement the innovative project of examination, conservation and utilization of a complex, of post-mining objects and areas of significant historical value, carried out using interdisciplinary research methods, titled: *Reclamation of areas degraded by mining activities in Mirsk commune, with creation of a tourist and instructional path "In the footsteps of the old ore mines"*.

My scientific activity comprises two basic disciplines:

I. Issues related to historical relics of mining exploitation in the scope of:

- prospecting methodology, identification, recognition and documentation of historical mining posts, including unknown, inaccessible or partly inaccessible historical underground excavations,

- methodology of measures necessary for protection or liquidation of the relics of old mining works due to the risks associated with them,
- methodology of measures necessary for protection, revitalization and preservation of the relics of ancient mining - as a material heritage of the history of industry and technology with significant historical value and monumental character, and as a source of knowledge about the development of mining technology,
- methodology of adaptation of facilities and post-mining sites for the purpose of continued economic exploitation, mainly in industrial tourism and geotourism.

My works concerning the issues of underground mining of mineral deposits are presented in 7.1 of the Author's Abstract.

II. Issues related to technology of underground exploitation of mineral deposits in the scope of:

- casings of underground mining excavations, in particular "in situ" test methodology and anchor casing post tests,
- monitoring of the interaction between anchor casing and rock formations, especially at the occurrence of dynamic manifestations of rock formation pressure,
- use of non-invasive methods to diagnose rock formation surrounded by underground mine excavations, mainly use of the GPR method (georadar)
- development of underground ore deposits mining systems.

My works concerning underground mining of mineral deposits are presented in 7.2 of the Author's Abstract.

5. INDICATION OF ACHIEVEMENTS RESULTING FROM § 16(2) OF THE ACT ON ACADEMIC DEGREES AND SCIENTIFIC TITLES AND ON DEGREES AND TITLES IN ART OF 14 MARCH 2003 (OJ L No. 65, item 595, with amendments)

My most important achievement is, executed in 2010-2013, on my initiative and under my supervision, an author's, **innovative project of examination, conservation and utilization of a complex of post-mining objects and areas of significant historical value, carried out using interdisciplinary research methods, titled: *Reclamation of areas degraded by mining activities in Mirsk commune, with creation of a tourist and instructional path "In the footsteps of the old ore mines"***.

This project combined interdisciplinary research work in various fields and scientific disciplines with efforts to implement the results, including specialized design works and execution of protection, reclamation and adaptation works in objects/buildings and in post-mining areas of significant historical and environmental value.

Elaboration and implementation of the project were the direct consequence of my many years of research devoted to the material heritage of the centuries-long history of mining in Lower Silesia, in particular a cycle of publications devoted to the subject, along with other comprehensive publication and organization activities including the following primary activities:

1. organization of a conference series titled ***Heritage and history of mining and the use of the remains of old mining works***, of which I was the initiator and leading organizer (there were 10 editions of the conference held from 2005 to 2014),
2. publication of a series of monographs by multiple authors titled ***The history of mining - an element of European cultural heritage***, of which I was the initiator and co-editor (5 volumes have been published in this series to date¹).

6. DESCRIPTION OF ACHIEVEMENTS AND RELATED SCIENTIFIC OUTPUT

The project was characterized by its interdisciplinary nature, combining a number of areas and disciplines (in accordance with the *Regulation of the Minister of Science and Higher Education*, dated 8 August 2011, on *areas of knowledge, fields of science and art, and scientific and artistic disciplines*):

I. The area of technical sciences,

- in the field of technical sciences, in the following disciplines:

- *mining and engineering geology*,
- *environmental engineering*.

II. The area of natural sciences,

- in the field of biological sciences, in the following disciplines:

- *environmental protection*,

¹ In 2014 it was transformed into the scientific journal *Hereditas Minariorum*, No. ISSN 2391-9450 (*Mining Heritage*). I am the deputy editor-in-chief to Dr. P.P. Zagożdżon. It is currently the only scientific journal devoted exclusively to issues of the heritage and history of the mining industry in Poland.

- *ecology.*
- in the field of earth sciences, in the following disciplines:
 - *geology and geography.*

III. The area of agricultural, forestry and veterinary sciences

- in the field of agricultural sciences, in the following disciplines:
 - *environmental protection and shaping,*
- in the field of forest sciences, in the following disciplines:
 - *forestry.*

IV. The area of humanistic sciences

- in the field of humanistic sciences, in the following disciplines:
 - *archeology,*
 - *history.*

V. The area of social sciences,

- in the field of legal sciences, the discipline of law:
 - *law.*

The project was of an innovative nature. Its programme assumptions included such values which, apart from its most important scientific effects (the development of knowledge in many areas, disciplines and fields) qualify it as a pro-environment and pro-social project.

The project represented the first comprehensive attempt in Lower Silesia to apply the results of interdisciplinary research in order to identify, document, protect and utilize a large complex of old mining works relics for recreational and educational purposes, located on a large area of over 38 hectares (encompassing terrain in the three villages of Krobica, Gierczyn and Przewcznica) rather than a selected, single post-mining object.

After performance of the necessary scientific and research work, followed by protective and reclamation works based on the science and research conducted, a number of old excavations connected with the most important historical mining and metallurgical fields were adapted for the needs of tourist traffic. They had been subject to intense degradation destruction since the late 1950, when mining exploration ceased and the old excavations became a place for illegal dumping of waste.

The project included two basic areas of activity:

I. interdisciplinary scientific and research work

II. implementation works, including:

- design works,
- execution of protective, reclamation and adaptation works on post-mining areas and objects/buildings.

These implementation works were closely associated with the results of interdisciplinary scientific research work, primarily concerning the planning of protective, reclamation and adaptation works.

It was necessary to solve a number of specific technical, formal and legal issues related to works planned in historical objects/buildings of unclear legal status, under strict environmental regulations².

I took active part in the full scope of interdisciplinary scientific and research works and implementation of the project. I cooperated with representatives of various fields and disciplines. In conducting the implementation of project (as its founder and main author) I was responsible for carrying out specific tasks, both in the area of scientific research and during implementation. I was also responsible for administrative and investment activities - mining, construction and reclamation works.

My role as a mining engineer in possession of vast specialist technical knowledge about mining, and also that of a researcher of the historic development of extraction technologies, allowing me to act as leader of interdisciplinary research and design works (actively participating and conducting them) was crucial in the success of the project.

Project management was a very important and valuable scientific and professional experience for me. It created an opportunity for practical use of the products of my many years of research on the heritage of the mining industry and technology, and for implementation of the concept of comprehensive recognition, documentation, protection and use of the educational and recreational potential in the remains of historical works. The confrontation of theoretical considerations concerning the methodology of dealing with old mining relics and the conditions and specific problems of design and construction of such works in practice highlighted the significant differences between theory and practice.

Ad. I. interdisciplinary scientific and research work included:

1. Analysis of the historical value of post-mining objects (based on available archival materials - including source materials, publications and museum collections) and elaboration of educational materials concerning past mining of tin and cobalt ores in the vicinity of Gierczyn (including the content of informational boards for the tourist-educational path).
2. Archaeological examination of relics from historical mines using advanced search methods for unknown underground excavations and the dendrochronological method of artefact dating.
3. Analysis of basic elements of the environment together with analysis of the expected impact of the planned works.
4. Analysis of the state of transformation and environmental risks, taking into account the types of deposited waste and contamination of soil and water.
5. Analysis of geological and hydrogeological conditions.
6. Analysis of possibilities and existing conditions for adaptation of selected historical excavations for the purposes of an underground tourist route, including:
 - analysis and assessment of the stability of excavations (geomechanical analysis),

² Due to the primary subject of the project, i.e. post-mining objects and areas, where works were essentially completed by 1945, and which, because of the incorporation of Lower Silesia into Poland only at the end of World War II are not, according to the law, liquidated or under liquidation mining facilities; the formal and legal aspects of the task proved to be extremely complex, ambiguous and extremely difficult to formalize.

- analysis of technical possibilities and conditions for ventilation of excavations planned for tourist usage,
 - analysis of the technical possibilities to drain mine water from excavations of the underground tourist route to surface water courses (with particular emphasis on environmental impact).
7. Analysis of formal and legal determinants for performing protective, reclamation and adaptation works in objects/buildings and post-mining areas.

Ad. II. Implementation works included:

1. Elaboration of a comprehensive plan for reclamation of post-mining objects and areas.
2. Elaboration of a multi-branch design for adaptation of selected historical underground excavations for the needs of tourist traffic (including reconstruction, protection and casing, ventilation, drainage, lighting, monitoring and organization of planned tourist traffic).
3. Elaboration of a multi-branch architectural and building design of the surface infrastructure of an underground tourist route.
4. Elaboration of the design of the tourist-instructional path "*In the footsteps of the old ore mines*", including a selection of historical mining objects intended for visiting, setting the route based on results of historical analysis, archaeological and mining studies and environmental analysis (with a particular focus on complex formal, legal and proprietary issues concerning ownership of objects and post-mining areas).
5. Protection, reclamation and adaptation of selected post-mining objects for the needs of tourist traffic.

Due to the high environmental value of the project area, the technical specificities of post-mining objects, and to ensure real environmental protection (both during and after the planned works), preventive measures including continual chiropterologic³ and archaeological⁴ supervision were implemented.

Implementation of an innovative project of examination, conservation and utilization of a complex of post-mining objects and areas of significant historical value, carried out using interdisciplinary research methods, brought many benefits, among which the most important are:

1. Development and implementation of a comprehensive methodology of examination, conservation and modern utilization of mining heritage objects of significant historical value;
2. Implementation of the results of my long-term, systematic scientific and research works concerning old mining sites in Lower Silesia;

³ Concerning habitats of bats.

⁴ Activities related to recognition, documentation and further proceedings with former mining sites localized on the area of a project, especially protective or liquidation works, could not be carried out without cooperation with a professional archaeologist. The use of archaeological research methods (in conjunction with supervision over fieldworks) protected the monumental value of historic remains of old mining works and enabled obtaining much valuable information on the objects (e.g. dating, especially in the absence of background information about the relics). This was of key importance for designing (and subsequent execution) of protection, revitalization and adaptation works, which could lead to a loss (total or partial) of the historic mining heritage of industry and technology covered by the project as a result of excessive interference in its original state.

3. Development of knowledge concerning technical issues of identification, conservation and active protection of mining heritage objects;
4. Development of knowledge concerning technical issues of adaptation of the historical underground excavations to modern economic utilization – primarily in industrial tourism and geotourism;
5. Development of knowledge concerning the history of ore exploration, exploitation and metallurgy;
6. Development of knowledge concerning the impact of the past mining works and ore metallurgy on the natural environment;
7. Development of knowledge concerning the influence of the relics of the old mining works – mostly the remains of underground excavations – on the surroundings, and types and scale of hazards related to not liquidated or improperly liquidated objects of this kind;
8. Development of knowledge concerning the geological structure and hydrogeological conditions in the project area;
9. Detailed identification and active protection of a number of old-times ore mining sites of great historical value from the 16th–19th centuries;
10. Significant progress in the new, emerging research discipline – *mining archeology*.

Along with these tasks, the implementation of the two primary tasks of the project, i.e. the removal of waste from objects and post-mining areas followed by the necessary protective, reclamation and land development works, resulted in a significant improvement of the environment in the areas of old mining works located in Mirsk commune, where intense exploration and exploitation works had been periodically carried out over a period of centuries. In an area encompassing the three villages of Krobica, Gierczyn, Przecznicza (and a small part of Kotlina), we undertook technical and biological reclamation of multiple sites/objects and post-mining areas (in full or in part) in accordance with the *forestry and tourism* purposes set out in the decision of the *Lwówek County Commissioner* no. G.6018a-1/2107/09 of 9 November 2009.

Reclamation was carried out in order to significantly improve the environment and to obtain a new value in a form of tourist route, which also performs an educational role. Environmental balance was restored, which had previously been upset by improperly conducted mining works, improper liquidation of post-mining objects (and the lack of thereof) and subsequent contamination of cavities and pits with waste. As a result of the reclamation, soils degraded during previous mining or processing works were technically and environmentally restored (mainly geotechnically) over an extensive area of 38.86 ha.

The ultimate utilitarian effect of the project, one with significant educational and recreational importance, is the tourism and educational path "*In the footsteps of the old ore mine*". It allows visitors to become acquainted with the history and numerous remains of former mineral extraction sites in one of Poland and Europe's most important historical centres of mining and metallurgy.

The biggest attraction of the proposed path is undoubtedly the underground tourist route of *St. John Mine* in Krobica, leading along excavations preserved in almost their original state dating back to a period from the 16th through 19th centuries.

The project *Reclamation of areas degraded by mining activities in Mirsk commune with the creation of a tourist and educational path "In the footsteps of the old ore mines"* was co-funded by the European Union under *Regional Operational Programme for Lower Silesia Voivodeship for*

years 2007 - 2013, Priority 4 - *Environment and Ecological Safety*, Activity 4.5 - *Reclamation of degraded areas*. The total value of project including additional funding was nearly 3 700 000 PLN, including funding from *Regional Operational Programme for Voivodeship* amounting to 2 594 585 PLN.

A detailed description of the project *Reclamation of areas degraded by mining activities in Mirsk commune with the creation of a tourist and educational path "In the footsteps of the old ore mines"* and related scientific achievements are included in Appendix 3a to this application for post-doctoral diploma proceedings, titled: *Synthetic characteristics of a completed, original project achievement*.

7. OTHER SCIENTIFIC ACHIEVEMENTS

7.1. Scientific research concerning historic mining exploitation relics

The purpose of my many years of work and research on historical relics of mining exploitation is to elaborate an appropriate methodology for dealing with the legacy of industry and technology associated with the extraction of mineral resources, to develop knowledge about the evolution of mining technology based on interdisciplinary studies of former mining sites, and to make use the products of this work by undertaking comprehensive measures to protect mining heritage and make use of it in contemporary activity.

The subject of my studies are the numerous relicts of prospecting and extraction activities preserved in our country, particularly in Lower Silesia, which contains a rich and outstanding industrial and technological heritage unique to Poland and Europe.

This area of my research can be defined as *applied mining archaeology*, including primarily the technical aspects of dealing with the heritage of the mining industry and technology. The term *mining archaeology* (German: *Bergbauarchäologie*) was used for the first time in the 2nd half of the 19th century by the mining engineer (not archaeologist or historian) Theodor Haupt. In the works of this mining specialist, who in the course of his long professional practice in Tuscany and Sardinia often dealt with traces of former mining activity, he emphasized the role and importance of such objects in learning the history and culture of our civilization.

In order to achieve these objectives I undertook research work on the heritage of the mining industry and technology (independently and on my own initiative) at the Wrocław University of Technology Institute of Mining, which I continue to the present day (currently at the Faculty of Geoengineering, Mining and Geology). I have achieved implementation of the results of my work by the elaboration and implementation of an innovative, comprehensive project concerning one of the historical mining sites in Lower Silesia.

Lower Silesia may be viewed as one of the most interesting, yet still insufficiently recognized, historical regions with a rich heritage of historical mining and metallurgical works in Poland and Europe⁵. Research on the mining heritage of Lower Silesia was joined relatively early by archaeologists; however, their interests were focussed primarily on studies of medieval gold mining. Much less recognized are the remains of historical extraction of other non-ferrous metal ores in Lower Silesia (silver and lead, copper, tin, cobalt, manganese, etc.). The catalogue of historical mining sites prepared by Dr. T. Stolarczyk (a specialist archaeologist with whom I closely cooperate) comprises 146 archaeological sites of extraction of non-ferrous metal ores in Lower

⁵ Historians dealing with the issues of mining treat Lower Silesia as a special mining district of Central Europe. Its formation was mainly influenced by existing gold deposits - both as secondary and primary deposits - and numerous, easily accessible polymetallic deposits, which clearly distinguished the described region from mining districts in the area of Upper Silesia and distant German, Czech or Hungarian centres. The prospecting and exploration works conducted in Lower Silesia over many centuries left numerous, easily located transformations of the land surface and significant areas of old mining works. These are primarily relicts of old works (surface and underground), spoil banks, metallurgical slags or waste left after enrichment of ores, remains of hydraulic engineering devices - intrinsically connected with former mining techniques - and even the preserved fragments of surface infrastructure of mines. Their state of preservation largely depends on the location. The least disturbed and easy to recognize are objects located some distance from buildings, roads and other contemporary infrastructure. The sites of former ore mining in the Sudety mountains and at their foothills were usually located on steep slopes of hills, in relatively inaccessible places and after the completion of exploration and exploitation their residues were not liquidated and reclaimed. It is the reason for the threats resulting from post-mining facilities, but at the same time it facilitates scientific and inventory research in places of historical exploitation. After appropriate protective and adaptation activities the remains of former works can be successfully used today, primarily as attractive tourist objects.

Silesia, dating back to the XIII-XVII centuries⁶. These are primarily gold mining sites (approx. 50% of their total number). Other groups are sites related to the extraction of copper ore (32 sites), silver and lead ores (31 sites). Another 9 sites are relics of the extraction of tin and cobalt.

Methods of dealing with the heritage of the mining industry and its technology comprise searches (source and field) of the remains of old mining works, identification, detailed recognition, and - after an assessment of the historical value and state of preservation of individual objects - their protection or liquidation. In selected cases such objects are revitalized and adapted for tourist usage, such as underground tourist routes, which are the subject of a lot of interest presently.

As a result of mining and archaeological works, in connection with analysis of preserved source materials, valuable information is obtained on the development of methods of searching for and extracting mineral deposits. The relics of historical mine excavations and surface infrastructure of old mines identified and then examined by interdisciplinary research teams are invaluable sources of information about centuries-old methods of excavation and preparation of deposits for exploitation, drainage and ventilation of mines, rock mining methods and systems of extraction, casings of underground excavations, transport equipment and systems, sources of driving energy for machines and mining devices, as well as methods of minerals processing and metallurgical processes (scrubbers of ore and metallurgical sites were formerly located in the immediate vicinity of metal ore extraction sites).

An interesting aspect of the issues related to historical heritage of mining exploration is the present-day usage of properly protected and adapted excavations and technical infrastructure of former mines as industrial tourism and geotourism attractions, mainly consisting of underground routes. This is connected with the rapid development of new branches of tourism: *post-industrial tourism* and *geotourism*, both in Poland (particularly Lower Silesia) and in Europe.

The current state of knowledge about old mining sites in Lower Silesia seems to be insufficient. Further research work should aim to strengthen interdisciplinary scientific cooperation⁷ in order to

⁶ Stolarczyk T. *Górnictwo rud metali nieżelaznych na Dolnym Śląsku od XIII do początku XVII wieku [Mining of non-ferrous metal ores in Lower Silesia from XIII to early XVII century]*. University of Wrocław. Wrocław, 2009, unpublished.

⁷ Interest in the relics of former mining activities between people associated with the mining industry has been present for centuries. The history of research of non-ferrous metal ores mining in Lower Silesia has a very long tradition. Already in the documents and descriptions from the sixteenth century there was information about the remains of earlier works, which were made by miners of that time. The first professional and methodical archaeological research at sites related to past mining was carried out in the 1960s in Germany and Czech Republic (continued in the 70s, 80s and 90s), when German archaeologists implemented long-term interdisciplinary programs in this field. The initiator of archaeological research on sites related to former gold mining in Lower Silesia was J. Kaźmierczyk from the *Department of Archaeology, University of Wrocław*. The research was also participated in by Dr. R. Grodzicki, at that time an employee of *Institute of Geology, University of Wrocław*, which gave it its interdisciplinary nature. Already the first excavations (1973, 1974) showed how serious the challenges and problems faced by archaeologists are as researchers at former mining sites. The complete lack or very small amount of historic material and its nature seriously hinder determination of the chronology of discovered objects. At that time the sites of extraction and rinsing of secondary gold deposits were discovered in Lower Silesia in the area of Złotoryja, Legnickie Pole, Wądroże Wielkie, Lwówek Śląski, Jelenia Góra, Głuchołazy and Lubawka. A wide range of research, especially from the 1970s, gave us relatively rich material associated with this part of Lower Silesia mining. The 1970s saw activity by historians working in the field of mining. The most active was D. Molenda, whose works give very valuable comments on the application of archaeological methods in the study of historical mining, shown using the example of the site in Altenberg, in southern Westphalia. Archaeological research on the problem of mining in Lower Silesia entered a new stage in the early 1980s. Expansion of knowledge about the sites associated with medieval and contemporary mining in Lower Silesia was contributed to by the Polish programme "*Archaeological Photo*". A significant contribution to the development of research on medieval and contemporary mining of non-ferrous metal ores was made by research conducted in the years 2008 - 2009 by archaeologist Dr. T. Stolarczyk (which I was also involved in). The works included the main centres

create a comprehensive research programme for the many centuries of mining heritage, its protection and preservation.

Work carried out before obtaining the title of PhD of Technical Sciences

I began scientific and research work concerning issues of the heritage of the mining industry and technology in of Lower Silesia on my own initiative during doctoral studies at the Wrocław University of Technology Faculty of Mining (alongside basic scientific and research activity in the area of mining transport issues covered by my doctoral dissertation). I started collaborating with the *Institute of History of Architecture, Art and Technology at the Wrocław University of Technology Faculty of Architecture*. For the Foundation of the *Open Museum of Technology in Wrocław* I elaborated (in cooperation with MSc. Eng. E. Liber) a number of abstract cards for industry and technology monuments from former metal ore mines in the northern part of the Sowie Mountains and a chromite mine in the massif of Ślęza Mountain. Therefore I became acquainted with the methodology of documenting objects of industrial and technological heritage. We have prepared the following abstract cards:

- Liber E., Madziarz M.: *Kopalnia rud ołowiu i srebra. Bystrzyca Górna. Karta ewidencyjna zabytków architektury i budownictwa (Lead and silver ore mine. Bystrzyca Kłodzka. Record card of architecture and construction monuments)*. The Office of Studies and Documentation of Monuments. Wrocław, 1994, unpublished;
- Liber E., Madziarz M.: *Kopalnia rud ołowiu i srebra. Złoty Las/Lubachów. Karta ewidencyjna zabytków architektury i budownictwa (Lead and silver ore mine. Złoty Las/Lubachów. Record card of architecture and construction monuments)*. The Office of Studies and Documentation of Monuments. Wrocław 1994, unpublished;
- Liber E., Madziarz M.: *Kopalnia rud ołowiu i srebra. Bystrzyca Górna – Góra Widna. Karta ewidencyjna zabytków architektury i budownictwa (Lead and silver ore mine. Bystrzyca Górna-Góra Widna. Record card of architecture and construction monuments)*. The Office of Studies and Documentation of Monuments. Wrocław 1995, unpublished;
- Liber E., Madziarz M.: *Teren robót poszukiwawczych rud srebra i ołowiu. Modliszów. Karta ewidencyjna zabytków architektury i budownictwa (An area of prospecting works for lead and silver ores. Modliszów. Record card of architecture and construction monuments)*. The Office of Studies and Documentation of Monuments. Wrocław 1995, unpublished;
- Liber E., Madziarz M.: *Kopalnia chromitu. Góra Czernica. Karta ewidencyjna zabytków architektury i budownictwa (Chromite mine. Góra Czernica. Record card of architecture and construction monuments)*. The Office of Studies and Documentation of Monuments. Wrocław. Wrocław 1995, unpublished.

Cooperation with the *Foundation of the Open Museum of Technology* demonstrated the absolute necessity of joint efforts in documenting objects and post-mining areas with the participation of historians, archaeologists and a specialist mining engineer. This is due to the unique nature of mining heritage objects of industry and technology⁸, requiring an interdisciplinary approach to such work.

of historical exploitation of gold, silver and lead ores, copper, and tin (Stolarczyk T.: *Górnictwo rud metali nieżelaznych na Dolnym Śląsku od XIII do początku XVII wieku [Mining of non-ferrous metal ores in Lower Silesia from 13th to early 17th century]*. University of Wrocław, Wrocław, 2009, unpublished).

⁸ The correct interpretation of the relics of former mining activity is extremely complex. The complete lack or very small amount of historic material and its nature seriously hinder determination of the chronology of discovered objects. Researchers of old mining works face serious challenges and problems, among which the most important are the transformations of the areas associated with historical mining activities.

I was the initiator and co-author of the first scientific study in the history of the Wrocław University of Technology Institute of Mining on the state of preservation of the remains of old mining objects by Liber-Madziarz E. and Madziarz M., titled *Historia górnictwa kruszcowego w Górach Sowich wraz z dokumentacją zachowanych obiektów (The history of ore mining in the Sowie Mountains and documentation of preserved objects)* (reports of the Institute of Mountains. Wrocław University of Technology. 1996, Series. SPR No. 79, unpublished)⁹. The results of this work were then published in materials from mining conference *Uczniowie Agricoli (Students of Agricola): Liber-Madziarz E., Madziarz M.: Pozostałości dawnych kopalń rud srebra i ołowiu w północnej części Gór Sowich (The remains of old mines of silver and lead ores in the northern part of the Sowie Mountains)* (Kowary, 1999).

Apart from the subject of old mining relicts, during my doctoral studies I was also interested in introducing issues related to traditions in the mining industry to the instructional programme at the Faculty of Mining, particularly in light of the negative image of this activity presented at that time by the media in Poland. The products of this interest included participation in the scientific conference *Problemy humanizacji techniki w programach nauczania polskich wyższych uczelni technicznych (The problems of humanization of technology in teaching programmes at Polish higher technical universities)* in Duszniki (1997), where I gave a lecture related to the centuries-long history of ore mining in Lower Silesia, Liber-Makowska E., Madziarz M. *Historia i tradycja górnictwa w kształceniu inżynierów górników na Wydziale Górniczym Politechniki Wrocławskiej (History and mining tradition in the training of engineers and miners at the Wrocław University of Technology Faculty of Mining)*.

Work carried out after receiving the degree of PhD of Technical Sciences

After starting work as a lecturer at the Department of Underground Mining at the Wrocław University of Technology Institute of Mining, I continued work on issues related to old mining relicts. I placed special emphasis - due to the significant historical value, rich source of materials and numerous, well-preserved relicts of old mining and metallurgical works - on research devoted to historical ore mining and metallurgical areas in Lower Silesia:

- sites of historical tin and cobalt ore mining in the vicinity of Gierczyn and Przecznicza, Izerskie Mountains, near Świeradów Zdrój (16th-19th century),
- sites of historical lead and silver ore mining in the northern part of Sowie Mountains, in the vicinity of Bystrzyca Górna, Dziećmorowice, Modliszów and Witoszów, near Świdnica (16th – 19th century),
- sites of historical exploitation and metallurgy of copper and arsenic ores in the vicinity of Miedzianka and Ciechanowice, near Jelenia Góra - the oldest area of copper mining and metallurgy in Poland, where the documented history of mining goes back over 700 years (14th-20th century),
- sites of historical exploitation of copper and arsenic in the vicinity of Radzimowice, near Jelenia Góra (13th – 20th century),
- sites of historical exploitation of copper and arsenic in the vicinity of Czarnów, near Kamienna Góra (18th – 20th century),
- chromite mine in Tąpadły, massif of Ślęza Mountain (19th-20th century),

⁹ Based on the results of this pioneering research (inventory works in the area of the *Sowie Mountains*), at the end of the 1990s there was an attempt to provide the preserved underground workings of a small historic lead and silver ore mine for tourist traffic in the area of *Walimska Pass, Sowie Mountains*.

- iron ore mine *Carl Friedrich Gustav* in Stanisławów (XIX century).

I addressed broader issues of numerous preserved objects of mining heritage with significant historical value, but which also constituting a source of serious threats while exhibiting potential tourist value for Lower Silesia, for the first time in 2004 in the publication Madziarz M: *Relikty dawnych robót górniczych na Dolnym Śląsku jako źródło wiedzy o rozwoju techniki eksploatacji złóż* (*Relicts of old mining in Lower Silesia as a source of knowledge about the development of ore exploitation technology*) Scientific Papers of the Institute of Mining, Wrocław University of Technology, 2004.

In order to undertake interdisciplinary scientific research involving studies and protection of mining heritage in Lower Silesia, I initiated collaboration with the *Faculty of Historical and Pedagogical Sciences and the Institute of Archaeology*, as well as the *Institute of History at the University of Wrocław*, leading (on my own initiative) to the conclusion of an agreement concerning the joint conducting of scientific research work at former mining sites in south-western Poland.

I started scientific collaboration with the *Museum of Copper* in Legnica, working together with specialist archaeologist Dr. T. Stolarczyk on scientific research concerning the history of mining and metallurgy of copper in the Sudety Mountains and their foothills.

I undertook international scientific cooperation with German researchers dealing with the issues of identification, protection and preservation of the heritage of industrial mining and technology. As a result of this cooperation, I organized the conference *Dziedzictwo i historia górnictwa oraz wykorzystanie pozostałości dawnych robót górniczych* (*The heritage and history of mining and the utilization of the remains of old mining works*), of which I was the initiator and chief organizer, together with 11 sessions of the conference *Altbergbau – Kolloquium* at the Wrocław University of Technology in 2011. I was involved in the scientific committee of *Altbergbau - Kolloquium*, the largest international conference on issues related to remains of old mining works, which is among my most important scientific achievements and which provides recognition for my work in the field of identification, protection and preservation of mining heritage in the international arena.

In searching for methods of proper location and identification of inaccessible or unknown historic underground excavations, I focussed my interests on modern geophysical exploration methods: the electro-resistance method, the gravimetric method and the georadar method (GPR - Ground Penetration Radar) - for seeking and locating inaccessible or unknown historic underground excavations. Using the GPR method I conducted tests of a series of post-mining areas and facilities¹⁰.

Particular attention should be paid to studies using the GPR method for the needs of the interdisciplinary project titled: *Badania stanowisk dawnego górnictwa i hutnictwa miedzi* (*Tests of the sites of former mining and metallurgy of copper*), which was implemented by the *Museum of Copper* in Legnica (financed by the *Ministry of Culture and National Heritage*), in collaboration with the *Academy of Mining and Metallurgy in Krakow*, *Institute of Archaeology at the University of Wrocław* and *Institute of Mining at the Wrocław University of Technology*. They were focused on three regions of historical copper ore mining in Lower Silesia:

¹⁰ As a result of my efforts the Institute of Mining at the Wrocław University of Technology purchased a modern georadar set together with advanced processing software. Due to the simplicity of measurement the GPR method appears particularly useful in the study of objects and post-mining areas, although the interpretation of the obtained results is in many cases extremely difficult and time consuming. Working with representatives of the humanities (archaeologists and historians) I also participated in research on other historical buildings - mainly basements of churches, where, using the GPR method, I located many unknown and inaccessible rooms (crypts). Using the GPR method I also led a study to search for other underground facilities, including historical objects of a military nature.

- I. the vicinity of Leszczyna, Kondratów, Nowy Kościół, Biegoszów and Chełmiec,
- II. Jerzyków (Kaczawskie Mountains foothills),
- III. vicinity of Miedzianka.

The main objective of the studies was the documentation and inventory of historic mining and metallurgy sites, including the location of historical excavations (shafts and tunnels), as well as places of processing and smelting of copper ore (mills, scrubbers). Beside typical archaeological documentation work, for selected sites of greater significance we also executed measurement plans using ground penetrating radar and a gradiometer. These tests were designed to identify the structure of sites and the presence of archaeological objects within them before the start of excavations. Their results are presented, among others, in the elaboration Madziarz M. *Opracowanie planów pomiarowych wybranych stanowisk archeologicznych z wykorzystaniem georadaru (GPR)* (*Elaboration of measurement plans for selected archaeological sites with the use of ground penetrating radar (GPR)*). Report of the Institute of Mountains, Wrocław University of Technology. 2012, SPR Series No. 26, unpublished. The results of tests I conducted using the GPR method were interesting, confirming the presence of younger layers of cultural relics from ancient mining and metallurgical operations. The project was an extension of previous research work, and also served as a preliminary stage for undertaking excavation works within the described former mining regions.

In the years 2006 - 2010, in cooperation with the *Institute of Archaeology, University of Wrocław* I initiated and led mining and archaeological works on the sites of former mines in the massif of Widna Mountain, near Bystrzyca Górna in the Sowie Mountains¹¹. This work was performed as part of a research project of the Institute of Mining, Wrocław University of Technology, titled: *Inwentaryzacja relikwów dawnych robót górniczych na obszarze Dolnego Śląska wraz z dokumentacją wybranych obiektów* [*Inventory of old mining relics in Lower Silesia together with documentation of selected objects*], of which I am the initiator, manager and leader. The objective of the work was to locate and then conduct historical research on excavations of ancient lead and silver ore mines¹². The mining and archaeological works were based on the results of an archival query¹³ I performed. The test results yielded a significant extension of knowledge about the history of the

¹¹ The group of excavations of old mines in the vicinity of Bystrzyca is vast, has great historical value and requires further research and inventory, being an example of the development of mining works over the last 500 years; also, the state of preservation of historical excavations was not affected as a result of exploration works for uranium ores, as was the case in many similar centres of historical mining of metal ores in Lower Silesia. At a distance of approx. 500 m from the buildings of the village, in the area formerly called *Goldener Wald (Golden Forest)*, specifically in the area known as *Silber Wiese (Silver Meadow)* the following mines operated sequentially: *Segen Gottes, Christinenglück, Victor Friedrich, Wilhelmine, Beathe* and possibly *Berthe*. It can be assumed that this is where the mining works were led by the oldest Bystrzyca mine trade unions of *St. Stefens Achter and Geistliche Hülff Gottes* (16th century). Although the documented data concerning mining works in the vicinity of Bystrzyca Górna concern the period from the year 1539, the shape and dimensions

of the cross-section of excavation made accessible again during the described archaeological and mining works show that it is impossible to exclude a much earlier date for their beginnings. As is clear from the preserved documents, during the execution of excavations in the sixteenth century the "old works" were found, which confirms that their origin might be much earlier.

¹² After mapping and execution of photographic documentation, the historical excavations were protected and backfilled again.

¹³ It showed that the tested area with quartz-barite veins of polymetallic mineralization (mainly in the form of lead and silver minerals) was a site of (periodically) intensive prospecting and exploration works in the 16th – 19th centuries. Their development was a subject of interest of the director of the *State Mining Authority (OBB)* in Wrocław Frederick von Reden (2nd half of the 18th century).

development of mining in Lower Silesia and preserved remains. I published the results of the tests in the following papers:

- Madziarz M.: *Untersuchungen an der ehemaligen Relikten Erzabbaugruben in Bystrzyca Górna* (Ober Weistritz, Eulengebirge, Polen). 9 *Altbergbau-Kolloquium*, 05. bis 07. November 2009, Leoben.
- Madziarz M.: *Rozwój prac badawczo-inwentaryzacyjnych dawnego górnictwa kruszców w Bystrzycy Górnej (Góry Sowie) [Development of research and inventory works on former mining of ores in Bystrzyca Górna (Sowie Mountains)]*. The history of mining - an element of European cultural heritage. Vol 2 / edited by Paweł P. Zagożdżon and M. Madziarz. Wrocław, 2009.
- Madziarz M.: *Tereny dawnych robót górniczych w Bystrzycy Górnej, Modliszowie i Dzieńmorowicach w świetle danych archiwalnych i badań współczesnych (The areas of former mining works in Bystrzyca Górna, Modliszów and Dzieńmorowice in the light of archival data and contemporary research)*. The history of mining - an element of European cultural heritage. Vol.1 / edited by Paweł P. Zagożdżon and M. Madziarz. Wrocław, 2008.

The results of the scientific research works led to the concept for an educational tourist path presenting the attractions of the Bystrzyca river valley, in which a special role is played by the remains of old mining works with a group of well-preserved underground excavations from the period from the 16th to beginning of the 18th century, in the vicinity of Bystrzyca Górna. I presented perspectives for use of the mining heritage surrounding Bystrzyca Górna in the publication Battek M., J., Madziarz M.: *Utworzenie Szlaku Doliny Bystrzycy sposobem popularyzacji unikalnych zabytków regionu. Turystyka kulturowa w świetle badań interdyscyplinarnych (Creation of the Bystrzyca Valley Trail as a way to popularize the unique monuments of the region. Cultural tourism in the light of interdisciplinary research)*, edited by J. Szczepankiewicz-Battek and M. Dąbrowska. Legnica, 2010. Moreover, based on the results of research and inventory work in the northern part of the Sowie Mountains, at KGHM CUPRUM Sp. z o.o CBR we elaborated the idea of an educational-tourist path *Śladami srebra Gór Sowich (Following silver in the Sowie Mountains)*.

Currently my interests are mainly focussed on the historical basin of mining and metallurgy of copper and arsenic ores in the vicinity of Miedzianka and Ciechanowice (Rudawy Janowickie) and the vicinity of Leszczyny (near Jawor), where, in the middle of the 19th century, the *Ciche Szczęście (Quiet Happiness)* mine initiated exploitation of the deposits of copper ores of sedimentary origin.

I have previously indicated the richness of the remains of old mining works in the above-mentioned areas, in such publications as Madziarz M : *“Cuprifodina in montibus”: o historii i pozostałościach dawnych robót górniczych w rejonie Miedzianki - miasta zrodzonego i unicestwionego przez górnictwo* (“*Cuprifodina in montibus*”: about the history and the remains of ancient mining works in the area of Miedzianka - the city born of and annihilated by mining). The history of mining - an element of European cultural heritage. Vol. 3, 2008, edited by P.P. Zagożdżon and M. Madziarz, and *“Cuprifodina in monitibus” bis zur Uranerzgrube-Relikte alter Bergbauarbeiten in der Umgebung von Miedzianka (Kupferberg) und Ciechanowice (Rudelstadt)*. 10. *Altbergbau-Kolloquium*, 2010, Freiberg.

Conceptual work concerning protection and usage in education and tourism of the relics of former mining works preserved in these areas has already been performed, and the results are incorporated in an elaboration titled *Koncepcja zagospodarowania wybranych obiektów pogórnich na terenie Zagłębia Miedziowego, Etap I (The concept of usage of selected post-mining objects in the Copper Industrial Area, Stage I)*. KGHM Cuprum Sp. z o.o. CBR, 2010, unpublished.

I am the author of an elaboration titled *Wieloaspektowa analiza problematyki zabezpieczenia i adaptacji wybranych obiektów pogórnictwa Dolnego Śląska dla celów geoturystyki oraz turystyki przemysłowej (Multiaspectual analysis of protection and adaptation issues of selected mining objects in Lower Silesia for geotourism and industrial tourism)* KGHM Cuprum Sp. z o.o. CBR, 2013, unpublished¹⁴.

Currently I am involved in mining and archaeological research at the site of the historic mine *Ciche Szczęście (Quiet Happiness)* in Leszczyna (19th century)¹⁵. I have previously presented issues surrounding the need to protect the remains of this mine and its tourist use in the publication by Kobyłańska M., Madziarz M. *Możliwości utworzenia podziemnej trasy turystycznej "Kopalnia Ciche Szczęście" w Leszczynie, w świetle aspektów technicznych i ekonomicznych takiej inwestycji (The possibilities to establish a tourist route at Quiet Happiness Mine in Leszczyna in the light of technical and economic aspects of such an investment)* The history of mining - an element of European cultural heritage, Vol. 4, edited by P.P. Zagożdżon and M. Madziarz, 2009.

I initiated and am presently engaged in interdisciplinary research work concerning recognition, assessment of the state of preservation, protection and adaptability for tourist purposes of one of the most important tourist attractions, the *Helena* hereditary historical drainage tunnel in Lower Silesia, in Ciechanowice (18th century).

At the request of the *Lower Silesia Conservator of Monuments* in Wrocław, I supervise mining and archaeological research carried out at a group of recently discovered historical excavations in Złoty Stok, whose origins may be related to the oldest historical period of local mining activities (probably the 13th century).

7.2. Scientific and research work concerning underground mineral deposits mining techniques

After starting my work as a lecturer at the *Department of Underground Mining of the Institute of Mining, Wrocław University of Technology*, I choose to pursue further scientific development. During doctoral studies I was associated with the *Department of Mining Transport*, where I dealt with issues of conveyor transport (my dissertation concerned this topic).

Because of the nature of my education in the specialty of *Underground mining of deposits* and my professional experience in the mining industry, particularly in the *Department of Rock Formation Mechanics and Casings* of the Polkowice mine, I decided to associate my further scientific work with the issues of stability and casings of underground mining excavations, based on the site for laboratory tests of mining anchors in the *Institute of Mining at the Wrocław University of Technology*¹⁶. The scientific and research work I undertook concerning site tests of mining anchors

¹⁴ The concepts of utilization of historical mining sites in geotourism and industrial tourism was developed, on my initiative and with my significant participation, in KGHM Cuprum Sp. z o.o. CBR for objects and post-mining areas located in the area of Miedzianka and Ciechanowice and around Jawor (Stanisławów, Leszczyna, Prusice).

¹⁵ The works are financed with support from *Fundacja Polska Miedź (Polish Copper Foundation)*.

¹⁶ The history of research concerning anchor casings led at the Institute of Mining, Wrocław University of Technology, dates back to the 1970s. As a result of those works, a universal device was designed and manufactured for laboratory tests on mining anchors (protected by patent No. 125869). The device was designed to enable simulation of the work of the anchor with various constructions built into rocks with different properties, in conditions of impact of static and impact loads.

were of a fully independent character. As a result of my modifications¹⁷ the site received a modern hydraulic and control arrangement¹⁸ (fully automatic measurement cycle). I presented the results of the aforementioned works in such publications as Madziarz M. *Badania kotwi górniczych w Laboratorium Instytutu Górnictwa Politechniki Wrocławskiej (Tests of mining anchors in the Laboratory of the Institute of Mining at the Wrocław University of Technology)* Scientific Papers of the Institute of Mining at the Wrocław University of Technology. Mining and Geology VI. Wrocław, 2002.

For the purposes of modelling of dynamic loads¹⁹ (in post-tests) of mining anchors, in consultation with experts in the field of force hydraulics, I elaborated an initial concept for a measurement device generating this kind of impact on anchors using only modern hydraulic equipment - pumps, hydraulic accumulators and digitally controlled servo-valves. However, due to the very high estimated costs of the prototype of such an innovative device (and the anticipated technical problems with its design, execution and start-up), its implementation proved impossible in the existing conditions²⁰.

In order to test the work of the anchor casing under the influence of dynamic manifestations of rock formation pressure under actual mine conditions, I engaged in cooperation with the *Department of Mining*, KGHM Cuprum Sp. z o.o CBR²¹. I conducted tests to identify and evaluate the impact of dynamic phenomena caused by shocks of rock formations on anchors of basic casing in conditions of underground mining excavations at KGHM Polska Miedź S.A. mines²².

To enable the measurement and recording of the changes in anchor load directly during the strike of a seismic wave at the location of its casing I developed a concept of a measuring system for continual monitoring cooperation between anchors and rock formations, allowing for measurement and recording of rapidly variable loads of casings caused by vibration of roof rocks (in real mining conditions)²³. This was an innovative solution in relation to visitation measurements with the previously used so-called instrumented anchors.

After conducting laboratory tests, the described measurement system was applied in a selected field of the *Polkowice - Sieroszowice* mine characterized by high seismic activity. The

¹⁷ The test site located in the Laboratory of Casing of Institute of Mining, which I took over, was in very bad technical condition. After the necessary repairs and start-up, I found that the applied hydraulic system does not allow tests of anchors on this post in accordance with the requirements of standard PN-G-15092 *Mining anchors. Tests*.

¹⁸ Characteristics of changes in the load of anchors was determined by computer.

¹⁹ The cycle of pilot tests for expansion and joint anchors I carried on the modernized device showed significant deformations of the superstructure of the post, occurring even at low strength of the loads on anchors (several dozen kN). Despite the equipment of the post with its mechanical system theoretically allowing for simulation of dynamic loads on anchors, the insufficient stiffness of the superstructure of the post combined with excessive complexity and imperfection of the percussion device (hammer and arrangement of levers) undermined the reliability of the results of such measurements.

²⁰ Currently, at KGHM Cuprum Sp. z o.o CBR I manage a team elaborating an innovative testing method for the work of anchors under the impact of dynamic manifestations of rock formation pressure, based on the previously developed concept of the testing post.

²¹ Including for the preparation of initial design assumptions for an innovative testing post.

²² The impetus for starting these works were reservations concerning the effectiveness of the protection of ceilings using expansion anchors in conditions of dynamic manifestations of rock formation pressure.

²³ Conducting long-term measurements of a continuous nature was possible thanks to the use of modern measuring equipment combined with specialized, dedicated software. The elaborated device allowed for continuous measurement and recording of the size and changes in loads on measurement anchors (instrumented), over many months from their building in. According to the assumptions, high sampling frequency (several hundred Hz) allowed capturing the dynamic changes of the anchor load with very fast timing, immediately after the casing was reached by the seismic wave.

executed measurements were experimental, but their results confirmed that it is possible to carry out continuous²⁴ static and dynamic measurements of the changes of load on anchors in real mining conditions. This represented a significant advance in research methodology in the field of cooperation between anchors and rock formations, in conditions of occurrence of seismic phenomena (in situ), and significantly increased the possibility to determine the resistance of the currently used anchor casings to dynamic loads.

Using the methodology I developed, long-term tests of the impact of seismic phenomena on changes in loads of basic casing anchors in underground mining excavations were conducted in the *Polkowice - Sieroszowice* and *Rudna* mines in the years 2004 - 2011. The results are presented in a number of unpublished studies by KGHM Cuprum Sp z o.o. CBR which I co-authored or guided, including Madziarz M. et al. *Badania wpływu drgań skał stropowych wywołanych wstrząsami sejsmicznymi na zmiany obciążeń żerdzi kotew spoiwowych (Tests of the influence of roof rock vibrations caused by seismic loads on changes of loads of joining anchors)*. Stage III. 2011, unpublished.

As part of the following projects:

Innovative Technologies for Deep Mine of Future Using Intelligent Management Tools "I2Mine", carried out between 01.11.2011 and 31.03.2016, financed by the European Commission, under the Seventh Framework Programme, and the Polish Ministry of Science and Higher Education (in which I acted as an assignment manager of an inter-company team in the KGHM CUPRUM Sp. z o.o. CBR), developing an innovative method – of my authorship – of testing rock bolts interaction with rock mass under the influence of dynamic rock mass pressure manifestations,

and

The development of conception and general technical solutions of an innovative test station designed to model the influence of dynamic rock mass pressure manifestations on the roof bolting of underground mining excavations. KGHM CUPRUM Sp. z o.o. CBR. 2014.

I have developed, in collaboration with a team under my leadership, an innovative, prototypic laboratory station, designed to model the influence of dynamic rock mass pressure manifestations on the roof bolting of underground mining excavations.²⁵

²⁴ For the first time, using specially developed measurement system, tests of anchor load changes and vibration characteristics of the roof rock were conducted continuously (not by visits as done previously) over several months, enabling measurement and recording of the impact of dynamic phenomena on anchors in real time. Apart from continuous measurements and recording of the changes of anchor loads, the essential significance for the assessment of their interaction with rock formations was the simultaneous monitoring of location, size and roof rock stratification changes (because you cannot interpret the results of anchor load changes without comprehensive knowledge in this field). Obtaining the additional necessary information was possible by periodic endoscopic tests (peep-hole testing) of the ceiling combined with the use of electronic stratification meters characterized by continuity and high accuracy of measurements.

²⁵ The issue of influence of vibrations caused by mining tremors on the rock bolting of underground mining excavations is one of the key research and engineering problems in the field of underground mining. Occurrence of high energy or high frequency seismic phenomena affects strength parameters of roof bolting, which can eventually lead to its damage and loss of excavation stability. Taking into account all the factors affecting roof bolting performance severely hinders the correct projection of interaction between rock bolts and rock mass, both in laboratory conditions and numerical modelling. So far, the dynamic tests of individual rock bolts, or less often more complex rock bolt systems, have been carried out with pulse load – caused by a falling few-tonnes weight or an explosion supposed to simulate a so-called seismic impact.

The device developed within the scope of the said work is markedly superior to other devices used so far, as it offers greater flexibility in simulation of virtually any fast-changing load. It enables testing of expanding, adhesive, and yielding rock bolts in set, diverse kinematic extortion regimes (static and dynamic). This is indicative of the uniqueness of the station structure and potential possibilities of its future uses in innovative and exceptionally valuable tests of roof bolting. As demonstrated by the performed tests, the structure and performance of the prototypical station fulfils the design assumptions and requirements specified in the proposed test method. Effective use of the station prototype in the projects that have been carried out so far in the cooperation with the mining industry (inter alia Madziarz et al.: *“The development of a method for continuous monitoring of the changes in the roof bolting load...”* and Madziarz et al.: *“The development of a method for evaluation of roof bolting condition...”*) proves that the preparation, execution and realization of rock bolt tests with use of the aforementioned device is purposeful.

Resulted in an invention, of which I am a co-author. Patent rights for this solution are granted to the KGHM CUPRUM Sp. z o.o. CBR. A decision was made to apply for a patent on the invention in the Patent Office of the Republic of Poland. To this end, I have produced material for documentation of the invention and I cooperate with a patent attorney preparing the documentation for the purpose of applying in the Patent Office of the Republic of Poland for a patent on the invention called: *“Test station for evaluation of rock bolts under dynamic load conditions”*. Further proceedings aimed at obtaining patent protection of the solution in question come within the competence of the KGHM CUPRUM Sp. z o.o. CBR.

As part of the project:

The development of a method for continuous monitoring of the changes in the roof bolting load in order to evaluate the cave-in hazard in exploitative excavations. Stage I – IV. KGHM CUPRUM Sp. z o.o. CBR. 2013 – 2016.

I have developed, in collaboration with a team under my leadership, a prototypical measurement system for continuous monitoring of load changes in rock bolts within basic roof bolting,²⁶ using innovative, prototypical, autonomous measuring devices built into roof bolting assembly and a related wireless reader – programmer (enabling wireless programming and control of monitoring devices installed in underground conditions, as well as transfer and storage of the recorded measurement data). The prototypic monitoring device, constructed according to the specified assumptions and solutions, fulfilled strict requirements and proved to be serviceable and usable for continuous monitoring of the load of rock bolts within basic roof bolting in underground mine excavations under the conditions of copper mines in LGOM area and other mines utilizing roof bolting. The performed tests confirmed full and reliable operation of the developed system for continuous monitoring of rock bolts load condition and its resistance to mechanical damage (within specified impact load limits) and difficult mining conditions. It is expected that the developed method for continuous monitoring of rock bolts within basic roof bolting will be implemented in the underground mine excavations of KGHM Polska Miedź S.A.

²⁶ The issue of control of the rock bolts load condition encounters considerable technical difficulties. It is necessary to use specialistic measuring devices for controlling the interaction of rock bolts with the rock mass. The method for testing the load of the roof bolting, having currently a wide range of application, is the use of resistive strain gauges, which allow to measure load and strain distribution in specially designed and installed for the test purposes instrumented rock bolts. A simple solution, enabling direct monitoring of stress in rock bolts with mechanical anchoring or indirect monitoring of other types of rock bolts (e.g. adhesive) is an autonomous device mounted in the roof bolting assembly. Such device, enclosed in a housing resistant to mechanical damage and unfavorable underground conditions (moisture, dustiness), can be mounted on typical rock bolts of basic roof bolting.

Resulted in an invention, of which I am a co-author. According to the agreement, patent rights for this solution are granted to the KGHM Polska Miedź S.A. I have prepared and handed over to the entitled to the patent right – the materials for applying in the Patent Office of the Republic of Poland for a patent on the invention called: “*System for continuous monitoring of the roof bolting load changes*”. Further proceedings aimed at obtaining patent protection of the solution in question depend on the decision of the Ordering Party and remain within the competence of the KGHM Polska Miedź S.A.

As part of the project:

The development of method for evaluating the condition of roof bolting subjected to long-term use.
Stage I–III. KGHM CUPRUM Sp. z o.o. CBR. 2014-2016.

I have developed, in collaboration with a team under my leadership, a device for non-invasive diagnostics of roof bolting.²⁷ A prototype measuring system, comprising two equivalent and closely related to each other layers – hardware and software, was developed. The software layer covers not only the constructed hardware, but also extended analysis and storage of data on a personal computer. Advanced data analysis methods have been used. Laboratory tests and measurements in real underground conditions have confirmed the practical applicability of the proposed rock bolts diagnostic method. It is expected that the developed method for continuous monitoring of rock bolts within basic roof bolting will be implemented in the underground mine excavations of KGHM Polska Miedź S.A.

Resulted in an invention, of which I am a co-author. According to the agreement, patent rights for this solution are granted to the KGHM Polska Miedź S.A. I have prepared and handed over to the entitled to the patent right – the materials for applying in the Patent Office of the Republic of Poland for a patent on the invention called: “*Non-invasive method for evaluation of roof bolting condition based on a specialized measuring device*”. Further proceedings aimed at obtaining patent protection of the solution in question depend on the decision of the Ordering Party and remain within the competence of the KGHM Polska Miedź S.A.

Apart from work devoted to issues of anchor casings, I do research on the use of the GPR method in mining, geology and archaeology. In particular, I am interested in the use of this non-invasive method to diagnose rock formations in the immediate vicinity of underground mines, in conditions of LGOM copper ore mines. One of the most important issues related to the safe execution of underground mining works is to identify the rock formations surrounding the excavation. The basic method for such diagnosis is to perform core test drilling, which is a costly, technically and organizationally difficult process, and in addition, only provides information about selected sites (where test drillings are located). The principal advantage of the GPR method is the possibility of non-invasive recognition of the layered composition of rock formations (GPR tests do not cause any damages in the tested place)²⁸.

²⁷ The issue of control of the rock bolts load condition, especially those installed in long-term excavations, encounters considerable technical difficulties. The long-term impact of various factors (e.g. corrosion) can adversely influence the protection of underground mine excavations provided by such support. Mechanical damage to the rock bolts may also occur, due to their overload or shear. It is necessary to develop special control and measuring devices, which enable diagnostic of the condition of the installed rock bolts. The evaluation methods used to date are impractical and full of numerous imperfections, and given the current state of the art, it is possible to develop a mobile device enabling non-invasive diagnostics of the underground mine excavations roof bolting in the aspect of correctness of interaction of rock bolts with rock mass and occurrence of possible damages.

²⁸ In mining geophysics georadar can be useful for determination of fault zones, location of tectonic discontinuities, voids and other anomalies of the geological structure. The use of the GPR method in underground mines can contribute

The results of my work concerning application of the GPR method in conditions of LGOM underground copper mines, including tests I guided, are in publications titled *Ocena przydatności metody GPR (georadarowej) w badaniach górotworu w otoczeniu wyrobisk podziemnych (Evaluation of the usefulness of the GPR (georadar) method in studies of rock formation surrounded by underground excavations)* KGHM CUPRUM Sp z o.o. CBR, 2013 (unpublished) and *Przeprowadzenie badań górotworu z bezpośrednim otoczeniu wyrobisk podziemnych metodą GPR (georadarową) (Conducting tests of rock formation in the immediate vicinity of underground excavations using the GPR method)* Reports of the Institute of Mining, Wrocław University of Technology, 2011, SPR series, no. 44).

Analysis of the importance of the GPR method in the work *Ocena przydatności metody GPR (Evaluation of the usefulness of the GPR method)*, the state of the art concerning its usage in mining industry, and the results of pilot tests confirmed that usage of GPR tests for testing rock formations in the environment of underground works is beneficial and justified. I demonstrated the possible applications of GPR measurements in mining with a special focus on the usage of this modern measurement method in KGHM Polska Miedź S.A. mines.

In addition to technical issues concerning underground exploitation of mineral deposits, I actively participated in the years 2006 - 2009 in the work of the Committee on Mineral Resources of the Ministry of the Environment. I had the opportunity to familiarize myself in detail with issues related to assessment of geological designs and documentation and elaborations concerning mineral resources economy, in particular:

- substantive and formal assessment of the preparation of designs of geological works,
- substantive and formal assessment of the preparation of geological documentation of mineral deposits,
- substantive and formal assessment of the preparation of criteria for mineral deposits balance,
- assessment of determination of industrial resources taking into account their optimal usage and protection of the resources of liquidated mines,
- assessment of the substantive scope of geological works to be carried out to the orders of the *Minister of the Environment*,
- evaluation of designs, documentation and other geological studies and others ordered by the Minister of the Environment concerning mineral deposits,
- analysis of the methods of the execution of geological works related to testing of deposits, giving opinions related to design and performance of geological works and documentation of mineral deposits,
- initiation of studies related to the methodology of design of geological works and documentation of mineral deposits and issues concerning their publication.

to improvement of work safety due to expansion of the methods for preventing the burst threat. GPR tests carried out in underground excavations may supplement the results of geological exploration of subsurface rock construction in their environment. Any exposed section of the rock surface available in the excavation can be subject to georadar profiling. The recognition concerns not only the immediate surroundings of exploratory openings, but also the spaces between them. It will also be possible to use GPR equipment to identify specific geological formations within the mine workings. The possibilities for expansion of the GPR device with antennas of different types, with different operating parameters, widen the range of possible applications of the GPR method in underground mines, e.g. with screening of the pillars, recognition of deposit compositions.

8. SUMMARY OF SCIENTIFIC AND ENGINEERING ACTIVITIES

I conduct extensive scientific, research and engineering activity, including interdisciplinary work on the mining heritage of industry and technology and issues concerning underground exploitation of mineral deposits. In both these areas I have a substantial scientific output.

I cooperate with scientists representing many fields of science, especially in the field of humanistic sciences in such disciplines as archaeology and history, and in the field of natural and biological sciences, environmental protection and ecology, as well as in the field of earth sciences in such disciplines as geology and geography.

Both of the primary directions of my research work, in connection with interdisciplinary scientific cooperation, were focussed on the preparation and implementation of original project titled *Rekultywacja obszarów zdegradowanych działalnością górnictw na terenie Gminy Mirsk, z utworzeniem ścieżki turystycznej "Śladami dawnego górnictwa kruszców"* (*Reclamation of areas degraded by mining activities on the area of Mirsk commune with the creation of tourist and didactic path "In the footsteps of the old ore mines"*). It is based on my years of scientific and research efforts concerning the heritage of the mining industry and technology, publications and propagation of their results, and comprehensive organizational activities (including the cycle of conferences *Dziedzictwo i historia górnictwa oraz wykorzystanie pozostałości dawnych robót górniczych* (*The heritage and history of mining and the usage of the remains of old mining works*) and the edition of a series of multi-author monographs *Dzieje górnictwa – element europejskiego dziedzictwa kultury* (*The history of mining – an element of European cultural heritage*).

The effect of the implementation of the project was significant progress in both humanistic sciences, especially in the field of knowledge about the history and heritage of former mining which is best described by term "*mining archaeology*", and in the area of technical knowledge, in the scope of recognition, protection and adaptation of historical mine excavations of significant historical value for tourism purposes (including the issues of geophysical surveys, geomechanics, mine ventilation and drainage, and specific types of threats related to post-mining objects when making them available to the public). The utilitarian effects of the project must also be considered, combining research work with implementation of its results. The project "*Reclamation of areas degraded ...*" is a typical example of practical applications of the results of interdisciplinary scientific research work (applied research).

Taking into account my extensive and well-established knowledge of the mining heritage of Lower Silesia and the rich experience I have gained during implementation of innovative project of examination, conservation and utilization of a complex of post-mining objects and areas of significant historical value, carried out using interdisciplinary research methods, titled: *Reclamation of areas degraded by mining activities in Mirsk commune, with creation of a tourist and instructional path "In the footsteps of the old ore mines"* I have reason to believe that the comprehensive and systematic activities I have conducted will lead in the future to detailed exploration and protection of other historically valuable former mining areas in Lower Silesia, and the final result will be the use of selected post-mining facilities for educational and recreational purposes (in industrial tourism and geotourism, as in the case of the described project).

In addition to the implementation of the described project, I was in charge of implementation of a number of projects (or participated in their execution) in the field of applied research carried out at the Institute of Mining, Wrocław University of Technology and KGHM CUPRUM Sp. Z o. o. Research and Development Centre, in cooperation with several enterprises (primarily KGHM Polska Miedź S.A.

The following table presents indices summarizing my scientific achievements (after obtaining my Ph. D. degree):

SCIENTIFIC AND RESEARCH ACHIEVEMENTS LIST (as of July 2017)		
No.	Index	Index value
1.	Authorship or co-authorship of academic publications in journals included in the <i>Journal Citation Reports</i> (JCR) database	4
2.	Authorship or co-authorship of realized original project, construction or technological achievement	3
3.	Patents, inventions, utility models and industrial designs	3*
4.	Authorship or co-authorship of monographs, academic publications in international or national journals:	
	– books, monographs and chapters of collective works	24
	– monograph editing	5
	– academic publications in journals without <i>Impact Factor</i> (IF)	26
	– publications in materials from international conferences included in internationally recognized publication database (such as <i>Wos</i> , <i>Scopus</i> , <i>ProQuest</i> , <i>EBSCOHost</i> , <i>CrossRef</i>)	5
	– publications in materials from conferences not included in publication databases	20
1	– delivered, unpublished conference lectures	11
5.	Summary impact factor of academic publications according to the Journal Citation Reports (JCR) list, as per publication year	2.032
6.	No. of publication citations: – acc. to the <i>Web of Science</i> – acc. to the <i>Publish or Perish</i> ²⁹	14 182
7.	<i>H</i> -index of published publications: – acc. to the <i>Web of Science</i> – acc. to the <i>Publish or Perish</i>	2 ³⁰ 7
8.	Authorship or co-authorship of collective works, research work documentations and expert opinions	48
9.	Management of international or national research projects or participation in such projects	17
10.	Awards for research activities	8

(*) – I have prepared and handed over to the Contractors – KGHM Polska Miedź S.A. and KGHM CUPRUM Sp. z o.o. CBR, entitled to the patent right (according to the Contract) – the materials for applying in the Patent Office of the Republic of Poland for a patent on the inventions, of which I am a co-author. Further proceedings aimed at obtaining patent protection of the solution in question come within the competence of the Contractors.

²⁹ In the competition documentation from 15 June 2012 NCN included an information, that the questionnaire concerning the scientific output of partner from foreign scientific institution for HS panels (humanistic and social sciences) should demonstrate total number of citations from all previous publications (without autocitations) and index H (source: Web of Science or Publish or Perish).

³⁰ *H*-index is given according to the Web of Science database (counted with auto-citations, exclusively for works indexed in the WoS database).

I am an authorized expert on mining traffic, group XIII - anchor casings and Group XXI - tests of technical solutions prior to introduction of new exploitation systems for copper, zinc and lead ores or variations of these systems.

Detailed information concerning my scientific achievements is included in the Appendix 3b to the application for habilitation proceeding entitled: *List of published scientific works or creative professional works, part II – List of other works not included in the achievement referred to in the Article 16 Section 2 of the Act and indices of scientific achievements.*

I have significant organizational, educational and popularization achievements:

I am the founder, lead organizer and member of the scientific and organizational committee for the series of scientific conferences *Dziedzictwo i historia górnictwa oraz wykorzystanie pozostałości dawnych robót górniczych (Heritage and history of mining and the usage of the remains of old mining works)*.

I was a co-organizer, secretary and member of the scientific committee of the combined international scientific conference *Altbergbau-Kolloquium and Dziedzictwo i historia górnictwa oraz wykorzystanie pozostałości dawnych robót górniczych (Heritage and history of mining and the usage of the remains of old mining works)* at the Wrocław University of Technology in 2011. The conference was organized on my initiative, as a result of my efforts and was a product of my international scientific cooperation concerning the mining heritage of industry and technology.

I was a member of the scientific and organizational committee of the international conference *GEOTOUR & IRSE (Strategies of Bundling Geotourist and Geoheritage Attractions)* in 2013.

I belong to the scientific and organizational committee of the *Conference of Doctoral Candidates and Young Scientists*, organized cyclically under the auspices of the Dean of the Faculty of Geoengineering, Mining and Geology, Wrocław University of Technology.

I am the founder and co-editor of the multi-author monograph series *The History of mining - an element of European cultural heritage* (2007-2014).

I am deputy editor-in-chief at the new scientific journal *Hereditas Minariorum (Mining Heritage)*. The journal was created on my initiative.

I have reviewed a number of publications published in the *Journal of Science and Technology of Ore Mining CUPRUM* and a series of monographs by multiple authors titled *The history of mining - an element of European cultural heritage*.

I participate (or participated) in works of a few scientific committees and expert teams, among which the most important are:

- *Mining Committee, an assisting authority of the Ministry of the Environment*
- *Polish Geological Institute Scientific Council*
- *Mineral Resources Committee of the Ministry of Environment*
- *Commission of Mining Sciences, Division of Polish Academy of Sciences in Wrocław*
- *Section of Metal Ores of Mining Committee of Polish Academy of Sciences*
- *Central Committee of Museology and Mining Traditions SITG*

The following table presents indices summarizing my didactic and popularizing achievements and information on international collaboration (after receiving my Ph. D. degree):

SUMMARY OF DIDACTIC AND POPULARIZING ACHIEVEMENTS AND INFORMATION ON INTERNATIONAL COLLABORATION (as of July 2017)		
No.	Index	Index value
11.	Participation in European programmes and other international and national programmes	2
12.	Active participation in international and national scientific conferences	31
13.	Participation in organization committees of international and national scientific conferences	19
14.	Received awards and distinctions (other than for scientific achievements)	8
15.	Management of projects realized in cooperation with scientists from other Polish and foreign centres and in cooperation with entrepreneurs	14
16.	Participation in editorial committees and scientific councils of journals	2
17.	Membership in international and national organizations and scientific societies	4
18.	Didactic and science popularization achievements	
	– authorship of curricula	9
	– giving lectures and classes	17
	– achievements in field of popularization of science	9
19.	Academic support for students	160
20.	Academic support for doctoral students as an academic supervisor or an assisting supervisor	2
21.	Expert opinions or other analyses on request	9
22.	Participation in expert and competition teams	6
23.	Review of publications in international and national journals	41

Detailed information concerning my didactic and popularizing achievements and information on international collaboration is included in the Appendix 4 to the application for habilitation proceeding entitled: *Information on educational achievements, cooperation with institutions, organizations and scientific societies and activities popularizing science.*



Maciej Madziarz, lipiec 2017 r.