Załącznik 4

Paweł P. Zagożdżon, Ph.D.

Summary of Professional Accomplishments

description of scientific achievements
and output, particularly those 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, no. 65, item 595, as amended)

in English

Wrocław, February 2019

1. Names and surname

Paweł Przemysław ZAGOŻDŻON

2. Diplomas and scientific degrees

master's diploma

- University of Wrocław, Faculty of Natural Sciences
- specialty: basic and exploration geology
- obtained: 1 August 1994
- master's thesis entitled
Geological mapping of granitoids from the Krogulec region in the Jelenia Góra Valley
(thesis supervisor: Prof. Michał P. Mierzejewski, Ph.D.)

Ph.D. in technical sciences

- Wrocław University of Science and Technology, Faculty of Mining
- obtained: 26 September 2001
- Ph.D. thesis entitled
"Sunburn" ("Sonnenbrand") in Tertiary basalts of Lower Silesia and possibilities of utilizing them
(thesis supervisor: Prof. Irena Wojciechowska)

3. Professional path

Since the beginning of my professional work, I have been employed at the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology (formerly – Faculty of Mining):
- in the years 1994–2001 as an assistant lecturer,
- from 2001 until now as an assistant professor,
- in the years 1997–2001, I completed doctoral studies.

4. Indication of scientific and research achievement resulting from article 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 2017, item 1789)

4a. Title of scientific achievement

As a scientific and research achievement that constitutes the basis for applying for the postdoctoral degree, the work is presented, which was published in full in the form of a monograph.

4b. Data on scientific and research achievement

author: Paweł P. Zagożdżon

title of the publication:

Use of relics of underground mining workings located in the Polish part of the Sudety Mountains for scientific purposes

the year of publishment: 2019

name of the publishing house: Oficyna Wydawnicza Politechniki Wrocławskiej

publishing reviewers:
Prof. Marek Nieć, Ph.D., Eng., Associate Professor Tadeusz A. Przylibski, Ph.D.

4c. Discussion regarding scientific purpose of the work and the achieved results

The monograph presents the results of cross-sectional research carried out in selected underground anthropogenic objects located within the Sudetes. When considered jointly, they represent an interesting extensive and strongly differentiated environment, which however has been very poorly identified so far. The **scientific purpose** of this work was to determine the possibilities of scientific use of these objects, in the scope of geology and the history of mining technology. I documented their importance as a reservoir of geological and historical-mining data. I indicated the need to use them as underground test areas that provide the capability to conduct multidirectional research.

The underground observation stations mostly consist of remnants of the mining activity (adits, exploitation chambers, etc.), however sometimes they were created as objects of military or technical purpose. Their cognitive significance is determined by their considerable quantity (about one thousand within the Sudetes) and a variety of issues that can be studied in them.

In terms of geology, the Sudetes area is characterized by a complex structure. Its elements are relatively well exposed on the surface of the earth, while the climatic factors cause quick degradation of exposures. Against this background, the underground excavations constitute high-quality observation stations that allow to study the elements of rock mass structure, which are not available on the surface or which are available to a very limited extent. Excavations after the exploitation of variously developed deposits of ores, chemical and rock minerals, allow to identify the elements of deposits' geology, as well as document historical methods of exploitation and their changes over time to a very good extent.

I have been conducting geological studies in anthropogenic underground objects together with Katarzyna Zagożdżon since 1997 and they are documented with a series of publications (see Annex 5 - List of scientific achievements). These works covered e.g. the region of Kowary, Kletno and Janowa Góra, Krobica-Gierczyna-Przecznica, Złoty Stok and Świeradów-Zdrój. Among others, their effect was the detailed presentation of the contact form of the granitoid Karkonosze massif with metamorphic cover in the Kowary region (Zagożdżon & Zagożdżon, 1997, 1998, 2002a), as well as preliminary geological characteristics of a series of post-mining underground objects (Zagożdżon & Zagożdżon, 2002b, 2006a, 2009a, b, 2012 et al.). I drew attention to the importance of cartographic works conducted in such objects, in order to expand knowledge about the geological structure of the Sudetes (Zagożdżon & Zagożdżon, 2013).

During the study of post-mining underground objects, I also collaborated with other authors (e.g. Lorenc & Zagożdżon, 2002a, b; Zagożdżon & Łagowska, 2006; Sienicka & Zagożdżon, 2010; Moczydłowska & Zagożdżon, 2013; Heflik et al., 2016). Since 2014, I have been participating in microbiological studies in selected underground objects, together with employees of the Wrocław University of Environmental and Life Sciences and the Jan Kochanowski University in Kielce (Pusz et al., 2014; Ogórek et al., 2017; Pusz et al., 2017; Czerwik-Marcinkowska et al., 2017) and I have been responsible for the selection of optimal research stations and providing a comprehensive recognition of the substrate. I also participated in the works aimed at testing the SLAM digital imaging technology in one of the excavations with a complex spatial form (Wajs et al., 2018).

The presented monograph constitutes a continuation and development of these works, as well as demonstrates the author's conclusions from the study of objects, which in the majority have not been described by me before or which have been recognized only initially.

The specificity of conducted geological research (constituting the dominant layer of the study) was determined by the necessity to analyse very diverse indicated below issues in objects, which mostly have not been described in the literature, and which have no geological documentation. This forced the use of basic research methods, while the main goal was to create cartographic studies, supported by a broad characteristics of individual stations.

I examined the undertaken issue on the basis of multidirectional analysis of approximately 30 selected objects, presented in Chapter 4, which constitutes the essential part of the study. These objects are located in 19 areas that clearly differ in geological structure, type of deposits and the nature of conducted underground works. The study discusses them in the order resulting from the location in individual tectonic and structural units of the Sudetes. In crystalline units, there are 9 excavations in the Karkonosze-Izera massif area, 4 from the Orlica-Śnieżnik dome area, 2 in the Owl Mountains massif area and one from the green schists Kaczawskie range area and one from the Kłodzko metamorphic. Among the units built of sedimentary rocks, the Mid-Sudetic synclinorium was identified - in 3 objects, the Świebodzice depression - in 2, as well as the Nysa trench and the Bardzkie structure - single research stations.

In individual objects, due to the different structure of the rock mass, I analysed various **geological issues** concerning the structure of magma and metamorphic massifs, as well as sedimentary units, tectonics, mineralogy and geology of deposits. In many cases, I described long continuous non-weathered rock profiles. Numerous perfectly preserved fault zones, which allow for detailed tectonic and mineralogical analysis of their internal structure, were particularly interesting. The advantage of the researched stations is the good condition of the rock preservation, associated with a small impact of weathering and the possibility of conducting *in situ* observations.

I recognized the elements of the structure of **igneous bodies**, based on the works carried out in the excavations that made available the granite Karkonosze massif. On the basis of research in Rudawy Janowickie, Jagniątków, Szklarska Poręba, and especially in Bobrów, I demonstrated the elements of the structure and tectonic evolution of the granite Karkonosze massif. I described the close contact facies variability of granite and the diversity of rock varieties occurring in the depths of the massif - both granites, as well as the so-called episyenites and a series of intrusive rocks. I traced the structure of the contact zone of this massif, as well as its metamorphic cover in the excavations, in the middle part of the Rudawy Janowickie (Bielec Mountain) and on the slopes of the Wysoki Grzbiet over Szklarska Poręba. This constitutes a continuation of the works that were previously carried out primarily in the Kowary region (Zagożdżon & Zagożdżon, 1997, 1998a, 2001b). I described over 100-metre long profile of the **Chełmiec rhyodacite** in the adit underground water intake in Boguszów-Gorce. This excavation makes available a contact fragment of the intrusion with distinctive zone of strong near-surface weathering of the rock. In some excavations in the Karkonosze-Izera massif, I described the occurrences of carboniferous **intrusive rocks** (lamprophyres and microgranites). Particularly interesting occurrence can be observed in the adit above the Rozdroże Izerskie, it includes (dominant) kersantites, as well as spessartine and minette. These veins exhibit variable orientation and thickness (as small as 10 cm). Comparison of the recognition scale of these rocks on the detailed geological map of the Sudetes 1:25000 and the presented map of this adit, perfectly illustrates the purposefulness of conducting research in former underground excavations and the level of detail of the obtained data.

Possibilities of precise examination of the **internal variability of metamorphic series** are provided by continuous rock profiles, which I described in a number of stations. The Ciechanowice adits provide profiles of the amphibolites of the Rudawy Janowickie unit, as well as the greenschists and isolated lens of crystalline limestone of the Dobromierz unit (in the southern part of the Kaczawskie range). On the basis of research of the objects located in the Owl Mountains massif, I demonstrated the diversity of gneiss varieties in the former *Amelie* mine in Srebrna Góra and reomorphic granites in the Osówka object. Variously preserved rock profiles of the Orlica-Śnieżnik dome have been described from Marcinków (mica schist and graphite schist) and Młoty (gneisses and mica schist), while the drainage adit in the Kłodzko Fortress provides schists and phyllites of the Kłodzko metamorphic. The adit over Rozdroże Izerskie is currently the only station providing access to the full non-

weathered profile of the Rozdroże Izerskie dislocation zone, from the Izera gneisses, through a complex of strongly quartz rocks, to shorn-dried mica schist of the Szklarska Poręba range. It should be noted that dynamic metamorphism occurs very often in the studied rock excavations - mainly breccia and cataclasites.

Within the sedimentary units, I characterized well-preserved **lithological profiles** of certain stratigraphic levels of upper and lower Carboniferous, middle Permian and the lowest Cretaceous.

Conglomerates and sandstones of the Tournaisian formation from Książ are available in the underground of the Książ Castle. I presented the structural details of lower level of the late-Visean formation from Szczawno on the basis of profiling of well-developed excavations in Kamienna Góra. The domination of conglomerates containing mud and clay schists is clearly visible in the Arado object. The narrow zone of the Visean sandstones, as well as mud and clay schists, is revealed in the adit in Janowiec. In the so-called Daisy Adits, it was possible to present a profile of various conglomerates, sandstones and mudstones of formation with Pogorzała. This unit, which is traditionally dated to Frasnian and Famennian, is currently placed in the middle part of the Carboniferous (serpuchov). The rocks of upper Carboniferous are visible only in one of the adit water intakes in Boguszów-Gorce. The full profile of one of the cyclothems of formation from Wałbrzych (Namurian A) is available there. It includes conglomerates, variously developed sandstones and carbon schists with a small carbon layer.

I have described the fragment of the mid-Permian sediment profile in the Uniemyśl chamber excavations. The variously formed carbonate rocks that occur there are part of the so-called layers from Chełmsko. I presented the continuous profile of basic sediments of the upper Nysa trench based on the studies of two adits in Różanka near Międzylesie. It includes the basic breccias, as well as sandstones and carbonate-silicate rocks of Cenomanian and Turonian.

In some of the researched stations, I described the *in situ* **rock variations**, which are rare on the surface, not recognized in these areas or known only from weathering. The best examples are mudstone conglomerates from the Książ castle, or basic quartz breccia from Różanka. It is also possible to indicate e.g. a group of gneisses from the *Amelie* mine in Srebrna Góra, graphite schists in Marcinków, or limestone and calcareous breccias from Uniemyśl. In certain cases, the studies in underground excavations made it possible to precisely describe the **contact zones** of individual rock varieties. These limits are usually poorly available during geological surface works. In the Lime Adit in Ciechanowice, it is the contact of the crystalline limestone and the greenschists of Kaczawskie range. A set of different fold deformations and an insert of scintillated chlorite schist are visible there. Other examples of readable surfaces or contact zones of various lithological varieties can be found in the exploration adit on the slopes of the Bielec mountain in Rudawy Janowickie (contact facies of the granite) and in the above-mentioned adits in Różanka (sedimentary rocks of the upper Nysa trench), or at the Rozdroże Izerskie (quartz rocks, gneiss hornfels).

Many times, I have described various types of **mineralization** in the research stations. In this case, it was also important to be able to study it in an unchanged position in the rock mass.

The manifestations of ore mineralization occurred in most excavations - both those associated with the historical mining and exploration of metal ores, as well as those created for other purposes. I described the mineralization with iron sulphides several times, which is clearly differentiated in terms of genesis, form and intensity. Pyrite in a significant amount occurs in the former *Friedrich Wilhelm* mine above Szklarska Poręba. It forms there dispersed impregnation aggregates, as well as larger masses with thick-crystalline quartz. In Janowiec, this mineral extensively mineralizes the sandstones and schists, which were exploited as a raw material for the production of alum. In other cases, pyrite occurred e.g. in the lamprophyre vein (Rozdroże Izerskie) or created relicts in the central part of goethite concretion (Różanka). Other *in situ* occurrences of iron compounds include, among others, hematite mineralization accompanying episyenites in the Karkonosze granite and in the underground of the Książ castle. I described the occurrence of primary and secondary copper minerals in Ciechanowice and Srebrna Góra, while polymetallic mineralization with arsenopyrite - in the adit on Bielec Mountain.

Quartz mineralization is common in the examined excavations. It was particularly interesting in the adit above Rozdroże Izerskie, where the series of its generation are clearly visible. The observation station in the old adit in Różanka, where I described the green quartz, is unique.

A large number of mineralogical observations concerned the **contemporarily created** carbonate, iron and ice infiltrates, as well as crystallization of gypsum. In this respect, the research stations in Marcinków and Młoty stand out.

Some of the examined stations allowed to describe in detail the **structure of the rock mass**. The best example is a set of excavations within the Książ Landscape Park, known as the quarry in Lubiechów and Daisy adits. In this case, I presented a complex folded structure, in the axis of the so-called Pogorzała syncline, which I described as synclinorium. In the adit in Janowiec, I determined the fact of a strong reorientation of the system of rock layers in the near-fault zone.

The nature and structure of **fault zones** is an issue, which based on research in underground objects can be recognized more clearly than on the basis of surface works. The faults of very different scale are perfectly preserved. I described the largest of them, with a width up to 3 m, in the underground of Książ castle and in the *Amelie* mine in Srebrna Góra. In many cases (Jagniątków, Ciechanowice - *Gesellen Glück* adit, Bielec), it was possible to track the internal variability of such structures along their course, on sections reaching several dozen metres.

In some cases, the observations allowed to verify older literature data. The described system of disjunction in the *Gesellen Glück* adit is consistent with the results of surface cartographic research presented in the 60s of XX century by Prof. Juliusz Teisseyr, while the fault occurring in the Osadowa adit in Boguszów-Gorce was correlated by me with the

dislocation shown in various cartographic materials. In individual objects, I described both the mid-formation faults of various scale (Ciechanowice, Srebrna Góra), as well as dislocations constituting the boundaries of various geological units (boundary of the granite massif and metamorphic cover on Bielec, frame fault of the upper Nysa trench in Różanka).

In the majority of objects, the internal structure of faults is clearly visible, with many slip surfaces and a varying degree of advancement of tectonic deformations. Within them, I described the occurrence of various rocks of dynamic metamorphism and loamy fault meals (which I am currently studying in terms of mineralogy).

Most of the described stations are the remains of a search or exploitation of various minerals. They illustrate the diversity of Sudetic **mineral deposits and occurrences.** I presented the elements of ore deposit structure based on the observations in Ciechanowice, Srebrna Góra and under Bielec (polymetallic ores), in Złota Sztolnia and Różanka (Fe ores), and the former *Hilfe Gottes* mine in Szklarska Poręba (Co). The Marcinków deposit can be described as polimineral, containing the accumulations of Pb, Ag, Cu and U ores and graphite ores. Uranium concentrations were recognized via excavations in Bobrów and Jagniątków.

A series of described stations are associated with extraction of rock raw materials. Mainly, they are the remnants of exploitation of various limestones and marbles for the needs of limestone mining. Moreover, I have characterized the structure of pegmatite deposits and vein quartz. I described the deposits of chemical raw materials based on the studies of old pyrite mines in Szklarska Poręba and alum schists in Janowiec. The excavations described in Boguszów-Gorce constitute intakes of underground waters (the so-called water adits).

In selected research stations, it was also possible to recognize certain **hydrogeological** issues. I described the small faults in the adits in Ciechanowice as effective filtration barriers, which result in water lifting in the depths of the rock mass. Wide fault zones in the *Amelie* mine in Srebrna Góra turned out to be an extremely efficient structures of this type. Observations carried out at an interval of 13 years in the adit under the Bielec mountain in Rudawy Janowickie also demonstrated a significant reduction in the level of groundwater.

In the scope of issues concerning **mining technique and history**, I carried out, among others, systematic observation of the forms (cross-sections) of excavations and I documented the relicts of using different methods of exploitation (headings, chamber, pillar-chamber, multi-level exploitation, etc.). In the case of the *Amelie* mine in Srebrna Góra and *Friedrich Wilhelm* mine above Szklarska Poręba, I was able to demonstrate a clear dependence of the form and system of excavations on the geological structure (the form of deposits). For the latter and for the Daisy excavations, I presented the analyses of used exploitation systems, as well as their development over time.

In **chapter 5** of the study, I synthetically discussed the issues that I recognized in the described observation stations, as well as in the previously studied underground objects.

I proposed a **typology** of anthropogenic underground objects of the Sudetes. Apart from mining objects, I also distinguished those created as part of the military operations (created for fighting, as well as underground production plants and command stations) and constituting infrastructure for other sectors of the economy (e.g. railway tunnels, pumped storage power plant). I indicated the examples of changes in the functions of underground objects – e.g. their adaptation for the needs of medical care or tourism.

I presented geological issues in the scope of which it was possible to **specify the image of the rock mass structure**, based on the conducted research.

I demonstrated the examples of cartographic image specification by comparing fragments of geological maps of the Sudetes in the scale of 1:25000, as well as original maps of objects in Kamienna Góra, Srebrna Góra and Różanka. I indicated the examples of studied excavations, in which it was possible to precisely describe the lithological diversity of stations located within the granitoid range of the Karkonosze mountains, the Owl Mountains massif, the Orlica-Śnieżnik dome, the upper Nysa trench, mid-Sudetic synclinery, or the Świebodzice unit. While examining the elements of tectonic structure, I put emphasis on the analysis of faults - their forming and course, the nature of mineral filling and symptoms of multistage mineralization. I demonstrated the diversity of geological-deposit issues recognized in the studied objects, e.g. types of exploited minerals, forms and origins of deposits.

I broadly presented the issue of various **contemporary mineral processes**, which are observed in many underground objects. I demonstrated the examples of environments, in which gypsum crystallization takes place. I described the form variety of infiltrates and carbonate caltemites. I focused on the characteristics of mainly ferric infiltrates and precipitates of AMD (acid mine drainage) environments. I demonstrated a very large variety of their forms, which can be compared to the elements of cave infiltration cover. I described the types of mineral substances that form these infiltrates (mainly sulphates and oxides, as well as ferric amorphous substances), as well as the results of measurements of the growth rate of ferric infiltrates. Also, I indicated the fact of the periodic formation of rich ice infiltrate covers, as well as the presence of organic and mineral structures, such as biofilms or the so-called snottites.

Among the **hydrogeological** issues, I put emphasis, among others, on the role of certain adits as drainage pathways for the rock mass (among others, during periods of catastrophic precipitation) and on the strong diversification of the chemical composition of waters occurring in underground objects.

While discussing the preserved **relicts of mining technology**, I presented the comparison of cross-sections of selected excavations, pointing out that until the beginning of the XX century, only small-sized adits were created. The preserved remains of the rock mining technique constitute an interesting issue. Rarely they consists of different size traces of using hammers and picks, while the remains of blast holes of various diameters are occurring commonly. On the basis of the preserved remains of some of them, I estimated the mass of used powder charges and I described the types of waddings. I also demonstrated the

preserved examples of remains of the methods of conducting exploitation, transport and lighting of excavations.

5. Discussion of other scientific and research achievements

After commencement of my scientific work at the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology (formerly – Faculty of Mining), I initially continued the **geological research within the Karkonosze granite massif**. Within the above-mentioned research, I recognized the elements of tectonics in the Bukowiec region near Kowary (Zagożdżon, 1995, 1996). Very quickly (in 1996), I started to conduct this research in former underground excavations, initially in the Kowary adits, crossing the contact zone of the plutonium and its metamorphic cover, later also in other regions (see section 4.2).

I dealt with certain issues associated with this geological unit also in the later years, when I described atypical examples of movement direction indicators in intrusive rocks (Zagożdżon & Zagożdżon, 2003), recognizing the national resources of this granite (Zagożdżon & Kuchta, 2007), or trying to find a station, which has been known from historical scientific studies, the so-called orbic granite under the Chojnik castle.

As part of the implementation of the subject of my Ph.D. thesis, I have started to study since 1997 the phenomenon of **sunburn** in the paleo- and neogene basaltoids of south-western Poland. In a number of articles, I presented its definition, development of views on the genesis, form of occurrences and the impact on the physical and mechanical properties of basalt (Zagożdżon, 1998, 2000, 2001, 2002, 2003, 2004, 2008).

As a person with current field recognition knowledge of basaltoid occurrence positions in the Lower Silesia region, I was included into the team of Prof. Birkenmajer, which carried out systematic studies of these rocks for several years. The works have been documented in a series of publications (*Radiometric dating of the Tertiary Volcanics in Lower Silesia*... II–VI). The subsequent papers presented the structure of basaltoids occurrences, results of petrographic research, radiometric dating (K-Ar) and paleomagnetic analyses. The stations located in the region of Lądek-Zdrój (Birkenmajer et al., 2002 a), near Jawor and on the Pre-Sudetic block (Birkenmajer et al., 2002b, 2004), as well as within the North-Sudetic depression (Birkenmajer et al., 2007), the Western Sudetes and their foothills (Birkenmajer et al., 2007, 2011), were examined.

The interest in the geology of basaltoid bodies also resulted in carrying out the detailed cartographic research on the unique occurrence of basalt in the Mały Kocioł Śnieżny in the Karkonosze Mountains. Traditionally, it is described as a basaltic vein, while the paper and conference materials (Zagożdżon & Zagożdżon, 2006a, b) include reinterpretation of its form, as a sub-volcanic intrusion with a complicated form.

Moreover, I conducted a study on the use of silty waste (meals) from the processing of basalts in agricultural and related applications, as means of improving soil properties. The published paper (Zagożdżon, 2008) remains the only one of this type of study in Poland to this day.

In the recent years, I have undertaken a research cooperation with scientists from Spain regarding the basalt sunburn (concerning Gibert et al., 2016).

In the years 1998-2005, I participated in the **meteorite research**, the results of which were presented in several co-authored papers, published among others in the Meteoritics & Planetary Science journal. As the first one, an unusual object from the Regional Museum in Jawor was analysed, which previously was described as a "pseudo-meteorite". The results of the chemical composition research allowed to unambiguously quality it as an intermediate product obtained during the fire processing of copper ores in Leszczyna, in the second half of the XIX century (Przylibski & Zagożdżon, 2000).

Subsequent research concerned two new Polish meteorites. In the case of L5 Baszkówka chondrite, its very high porosity was demonstrated on the basis of microscopic examination. This fact, along with the results of microprobe analyses, allowed to present specific processes that took place in the near-surface zone of the mother body. We presented them as analogous to the processes of formation of terrestrial pyroclastic rocks (Przylibski & Zagożdżon, 1999; Przylibski et al., 2001, 2003).

We subjected the Zakłodzie meteorite to macro- and microscopic tests, cathodoluminescence tests and diffraction analysis. The obtained results allowed for detailed description of its mineral composition and presentation of its genesis. We described it as a fragment of igneous rock with a cumulate structure, which underwent relatively rapid crystallization. Magma was created from remelting of the material with the composition of enstatite chondrite. We proposed a new classification for this meteorite (Przylibski et al., 2003, 2005).

Another topic undertaken by me consists of selected issues concerning the **history of mining**. In this scope, for the area of Lower Silesia, I presented studies regarding the history of extraction and application directions of the basalt of the Lubań region and the quarries in selected mountain areas of the Sudetes.

On the basis of literature data and the results of fieldwork, I presented the outline of exploitation history and examples of the use of basalt as a building stone in the architecture of the city of Lubań and its surroundings, in the period from XIII century to the beginning of XX century. I indicated various examples of application of this stone in monuments, such as city walls, Dom Solny (Salt House) or City Hall, as well as in nearby farm buildings. I presented the variability of the scale of extraction and applied exploitation technology over time, as well as treatment and processing of basalt, including the production of basalt casting (Zagożdżon & Kukułka, 2007).

I presented the issue of small excavations (not observed in studies on the history of mining of rock raw materials) remaining after the period of intense construction of local roads, on the example of model areas from the area of Stołowe Mountains and Bialskie Mountains. After this activity, in addition to excavations, the sections of original road surface, which is a specific type of pavement, have been preserved from vertically embedded stone elements with a plate-like cross section. I indicated the environmental

advantages of such local exploitation (compared to the so-called "in situ resource utilization") in relation to the contemporary concentrated production of stone materials - associated with strong constant emission of pollutants and the necessity of multi-kilometre transport of raw material to the recipient (Zagożdżon & Zagożdżon, 2017).

I presented the specific remains of historical mining activity on the example of the Canary Islands and the Longyearbyen region (Svalbard). In the first case, I described works conducted in the XIX and XX century, whose relicts consist of several thousand kilometres of the so-called water adits (galerias del agua), existing on the above-mentioned archipelago. In addition to data regarding parameters and techniques of digging these excavations, I also presented their hydrogeological situation. I compared the literature data with field observations of objects preserved on the Lanzarote island (Zagożdżon, 2015a). During two polar expeditions to Spitsbergen, I conducted the recognition of relicts of the XX-century coal mining in the Longyeardalen valley. I characterized the state of preservation of the remains of five mines of various ages (from Gruve 1 operating in the years 1906-1920 to Gruve 4 – carrying out extraction from the 60s to 90s of the XX century). In addition to the five well-known main mining complexes, I pointed out a number of isolated adits with preserved inlets. The penetration of these small objects demonstrated the possibility of observing the rate of destruction of the wooden protecting housing, the dynamics of retraction of the ice filling these excavations, or the development of fungal colonies (Zagożdżon, 2013, 2015b).

Moreover, I analysed the issue of working outfit of the Lower Silesian ore miners at the end of the Middle Ages. I considered this issue in the context of diversity of mining clothing in various mining centres of central Europe, on the basis of analysis of the iconographic materials (among others, *De re Metallica* by Georgius Agricoli, Kutna Hora cantional, series of mining altars), which demonstrate this issue with exceptional details. Thanks to this, it was possible to document the essential difference between the outfits used in Germanic countries (Germany, Lorraine, Italy - everyday clothes) and those characteristic for the Slavic cultural circle, where miners used the so-called 'perkytle', which is one of the first working uniforms in Europe (Zagożdżon & Zagożdżon, 2008, 2014).

I have been dealing with selected **geotourism** issues since 2010, focusing on the use of anthropogenic underground objects and the development possibilities of this section of tourism in urbanized areas (urban geotourism).

I developed the detailed characteristics of geological and mining issues, which can be presented within the proposed geotourism route, for excavations of underground tourist route of the "Kopalnia Zlota" in Złoty Stok. On 16 observation stations, the tectonic structures, petrographic, mineralogical, hydrogeological issues, as well as those concerning the deposit geology, and problems in the scope of rock mass mechanics and mining technology, were described (Zagożdżon & Zagożdżon, 2010). Together with K. Zagożdżon, we also presented a broader discussions concerning the issues of Lower Silesian underground routes with geotourism values. Above all, we indicated the importance of the objects in

Krobica, Kowary, Kletno and extensive underground complexes in the Owl Mountains (Koźma et al., 2011; Zagożdżon & Zagożdżon, 2013, 2016; Zagożdżon, 2016).

I develop the issues of urban geotourism primarily in Wroclaw and I also implemented, together with K. Zagożdżon, the project of a network of geotourism routes with the city of Kłodzko. The results of these works are presented in scientific papers (e.g. Zagożdzon & Śpiewak, 2011) and popular science papers in local and industry journals (see Annex 6, section 5.2), as well as at conferences (among others, the Polish Geological Congress, Modern Technologies and features of quarrying, processing and use of natural stone in Kiev, the National Scientific Conference of Mineral Deposits), and meetings of the Wrocław branch of the PTG. In my papers, I draw attention to the diversity of geological issues, which are visible in architectural and decorative stone. In addition to basic petrographic problems (types of used rocks), also mineralogical problems (e.g. in pegmatites), tectonic (phases of granite massif evolution, fold and fault deformations), sedimentological problems, those concerning metamorphic phenomena or weathering and deterioration, can be presented, as perfectly preserved fossils. Additionally, I present issues in the scope of deposit geology and techniques of stone mining and processing.

In the case of Kłodzko, I could demonstrated a wider range of issues, enriched with the geology of the crystalline and sedimentary substrate, the activity of the river, as well as issues concerning historical and contemporary opencast excavations (Zagożdzon & Zagożdżon, 2015). Also, I presented the results of analysis of the military activity traces, which are unique today (the siege of *Festung Breslau* in 1945) and preserved in stone building elements (Zagożdżon, 2012).

Discussion concerning the contemporary state of urban geotourism throughout the country has been demonstrated in the paper prepared in connection with the 3rd Polish Geological Congress (Zagożdżon & Zagożdżon, 2016).

Also, I presented a study showing a large variety of geotourism issues on the beaches of the Baltic coast in the Ustka region, recognizing it as an area with significant educational potential. In addition to erosion, transport and sedimentation processes, which are typical for the beach conditions, in the marine and aeolian environment, it is also possible to observe the following processes in the miniature: river erosion processes, formation of scattered deposits of heavy minerals. In the blocks of Strzegom granite used for stabilization of the shore and pier, I described the elements of the tectonic evolution of the magma massif, but also the remnants of the use of rock mining techniques (Zagożdżon & Zagożdżon, 2017).

In 2012 and 2015, I participated in **polar research** in the Hornsund and Longyearbyen area on Spitsbergen. They were carried out as part of expeditions of the Faculty of Geoengineering, Mining and Geology of the Wrocław University of Science and Technology. In total, the fieldworks lasted seven weeks and they were carried out at the Polish Polar Station in Hornsund and Stanisław Baranowski Spitsbergen Polar Station. Above all, the research concerned the geodetic determination of the retreat rate of Werenskiold glacier's forefront and the deformation of the surface of its terminal moraine. Moreover, we analysed

the possibilities of using thermal imaging in arctic conditions for environmental studies (location of thermal sources and outflows of cold glacial waters, mixing of sea waters and meltwaters from the front of the Hans glacier, determination of the depth of permafrost in the summer season, counting of birds in bird colonies) and for determining the state of infrastructure of the research bases. In addition, I carried out the micro-mycology sampling at the front of the Werenskiold Glacier and the recognition of mining relicts in Longyearbyen. Together with the co-authors, I presented the results of these works in papers (Zagożdżon, 2013; Ciężkowski et al., 2018) and in a number of conference studies at the Arctic Science Summit Week and Polar Symposium.

As a consequence of continuous carrying out research works in the area of Sudetes and the Pre-Sudetic block, I also recognized a number of **other** issues. I presented the results of these observations in publications.

In 1998, together with K. Zagożdżon, as part of interventional research, we characterized the effects of surface mass movements, which occurred within the reclaimed opencast mine of fire clays in Jaroszów. We described the progress of landslide phenomenon and the dynamic development of a set of fault structures, which occurred within a month. We presented the interpretation of this phenomenon, indicating that it was characterized by the so-called cylindrical shear (Zagożdżon & Zagożdżon, 1998).

In 2000, I published the results of a preliminary recognition of the so-called forest glassworks in Młynowiec in Kłodzko Land, which has not been previously described (Zagożdżon, 2000). I presented the characteristics of a complete set of findings - fragments of raw material, slag, remnants of the furnace, glass crucible and small fragments of glass. I indicated the supposed period of operation of the glassworks (the turn of the XV and XVI century or first half of the XVI century), thus documenting the earliest stage of settlement in the Młynowiec village.

Together with K. Zagrodny, we presented the results of digital modelling of the Bear Cave and its surroundings (Zagożdżon & Zagrodny, 2009, 2012). The individual models reproduced the terrain morphology and the complex geological structure of the area of approx. 2 km^2. We presented the strongly deformed lenses of marble and the set of faults, as well as the complex system of underground karst areas in the middle level of the cave.

I worked in a team that researched the concentrations of radon 222 Rn and 226 Rn in the surface waters of the western part of the Bialskie Mountains. In the years 2009-2015, I developed mappings, sampling and measurements of the sources in the Młynówka and Mała Młynówka catchments, as well as sampling along the watercourses, in order to determine the rate of radon content decrease. The results of these studies were presented in conference materials and in the Journal of Radioanalytical and Nuclear Chemistry (Przylibski et al., 2011, 2014).

While participating in the international project entitled "Caves of the Orlycke hory and Góry Bystrzyckie Mountains", I developed, together with M.W. Lorenc, materials concerning objects located in the Polish territory of these mountain ranges (Pokorny, 2013).