

REPORT

1. Name: Justyna Małgorzata Ciesielczuk

2. Scientific titles and degrees

2000 Diploma and PhD degree in earth sciences, Faculty of Earth Sciences, University of Silesia, Katowice.

PhD thesis: Hydrothermal alteration of granites from Borów (the Strzegom-Sobótka massif) and Strzelin. Supervisor: Prof. Janusz Janeczek

1990 Diploma and M.Sc. degree, specialization: geochemistry, mineralogy, petrography; Faculty of Earth Sciences University of Silesia.

Master thesis: Secondary oxyminerals from the Miedzianka polymetallic deposit, Sudetes Mts. Supervisor: Prof. Kazimierz Kozłowski

3. Education and Employment

1.10.1990 Research assistant, Department of General Geology, Faculty of Earth Sciences, University of Silesia.

30.01-3.06.1994 Geochemical methods and interpretation. TEMPUS training scheme at the Department of Geology, Keele University, UK.

1994 PhD: Fundamentals of the Natural Environment.

1995 Maternity and parental leave.

1998 Maternity leave.

2000 PhD defence: Hydrothermal alteration of granites from Borów (The Strzegom-Sobótka massif) and Strzelin. Faculty of Earth Sciences, University of Silesia.

2000 Adjunct, Department of General Geology, Faculty of Earth Sciences, University of Silesia.

2003 UNESCO scholarship for geochemical workshop in International School of Geochemistry in Izmir, Turkey.

2007 Accessory minerals in-situ. Workshop– microanalytical methods and petrological applications, Kraków, Poland.

2008 Scientific expedition to Nigeria.

2008, 2010, 2012 Polish Scientific Expeditions to Peru

2010 Workshop on Raman spectroscopy, Geocentrum, Vienna, Austria.

4. Scientific achievement (according to art. 16 ust. 2 from 14 march 2003 - Dz. U. nr. 65, poz. 595 ze zm.):

Title of the scientific achievement:

„Thermal alteration of the silesian coal-waste dumps. Basic and experimental study.”

The articles chosen to demonstrate scientific achievement are the result of research started in 2007. The research was financially supported by projects KBN N N307 427034 (leader), NCN 2011/01/B/ST10/07588 (leader), NCN 2011/03/B/ST10/06331 (participant), and 2007 BW WNoZ UŚ (leader). The results were initially presented and discussed at nine international conferences abroad, four national conferences with foreign attendees and two Polish conferences. Almost all 19 conference abstracts are available to readers and some of them are included in the list of scientific achievements below.

Leading articles (in chronological order)

- [1] J. Ciesielczuk, Ł. Kruszewski, J. Majka, 2014 - Thermally-changed coal waste as an analogue of natural-environment rocks – a comparative study of dump and experimental materials. International Journal of Coal Geology, DOI information: 10.1016/j.coal.2014.08.013; on-line since 7.09.2014; in print
IF (2014) = 3.313, MNSiW 35 points
My contribution to the work is estimated for 45%.
- [2] J. Ciesielczuk, 2014 - Coal mining and combustion in the coal-waste dumps of Poland. Elsevier Publication: Coal And Peat Fires: A Global Perspective, Volume 3, Edited by Glenn B. Stracher, Anupma Prakash, Ellina V. Sokol <http://dx.doi.org/10.1016/B978-0-444-59509-6.00016-8>, in print
- [3] J. Ciesielczuk, G. Bzowska, M. Paszkowski, 2014 - Mineral transformations and actinide transport: combustion metamorphism in the Wojkowice coal waste dump, Upper Silesian Coal Basin, Poland. Elsevier Publication: Coal And Peat Fires: A Global Perspective, Volume 3, Edited by Glenn B. Stracher, Anupma Prakash, Ellina V. Sokol <http://dx.doi.org/10.1016/B978-0-444-59509-6.00017-X>, in print
My contribution to the work is estimated for 80%.
- [4] M. Misz-Kennan, M. Fabiańska, J. Ciesielczuk, 2014 - Thermal transformations of waste rock at the Starzykowice coal waste dump, Poland. Elsevier Publication: Coal And Peat Fires: A Global Perspective, Volume 3, Edited by Glenn B. Stracher, Anupma Prakash, Ellina V. Sokol <http://dx.doi.org/10.1016/B978-0-444-59509-6.00014-4>, in print
My contribution to the work is estimated for 30%.
- [5] J. Ciesielczuk, M. Misz-Kennan, J.C. Hower, M.J. Fabiańska, 2014 - Mineralogy and geochemistry of coal wastes from the Starzykowice coal-waste dump (Upper Silesia, Poland). International Journal of Coal Geology, 127, 42-55. <http://dx.doi.org/10.1016/j.coal.2014.02.007>
IF (2014) = 3.313, MNSiW 35 points
My contribution to the work is estimated for 55%.

- [6] M. Fabiańska, J. Ciesielczuk, Ł. Kruszewski, M. Misz-Kennan, D. R. Blake, G. Stracher, I. Moszumańska, 2013 - Gaseous compounds and efflorescences generated in self-heating coal-waste dumps – A case study from the Upper- and Lower Silesian Coal Basins (Poland). *International Journal of Coal Geology*, 116–117: 247-261. *IF (2013) = 2.976*, *MNSiW 35 points*, *Web of Science citations: 2*.

My contribution to the work is estimated for 22%.

- [7] M. Misz-Kennan, J. Ciesielczuk, A. Tabor, 2013 - Coal-Waste Dump Fires of Poland. Elsevier Publication: *Coal and Peat Fires: A Global Perspective*, Volume 2, Edited by Glenn B. Stracher, Anupma Prakash, and Ellina V. Sokol <http://dx.doi.org/10.1016/B978-0-444-59412-9.00015-6>, p. 234-311.

My contribution to the work is estimated for 40%.

Reviewed articles in Polish

- [8] J. Ciesielczuk, J. Janeczek, S. Cebulak, 2013 - The cause and progress of the endogenous coal fire in the remediated landfill in the city of Katowice. *Polish Geological Review*, 61, 12: 764-772. *MNSiW 7 points*

My contribution to the work is estimated for 80%.

- [9] J. Ciesielczuk, A. Czyłok, S. Cebulak, 2011 – Plant succession and gigantism observed on the burning coal waste dump in Katowice-Wełnowiec, Poland. *Documenta Geonica* 2011/1, 51-54.

My contribution to the work is estimated for 55%.

- [10] J. Ciesielczuk, S. Cebulak, 2011 - Oxyreactive Thermal Analysis application to the investigation of the thermally affected coal-waste rocks deposited on dump in Wojkowice, Upper Silesian Coal Basin, Poland. *Documenta Geonica* 2011/1, 43-50.

My contribution to the work is estimated for 70%.

Selected conference abstracts:

- [A3] Ł. Kruszewski, J. Ciesielczuk, 2013 - Anthropogenic analogues of geological processes – a case of burning post-mining dumps as shown by natural samples and thermal experiments. 30th Annual Meeting of The Society for Organic Petrology, 1-4th September 2013' Poland: 32.

My contribution to the work is estimated for 50%.

- [A4] J. Ciesielczuk, Ł. Kruszewski, J. Majka, 2013 - Experimental study of the thermal transformation of siderite from the coal waste dump in Katowice-Wełnowiec, Poland. *Mineralogia - Special Papers*, 41: 36.

My contribution to the work is estimated for 45%.

- [A5] J. Ciesielczuk, 2013 - Behaviour of mineral phases during combustion of coal waste dumps – experimental study. Goldschmidt 25-30.08.2013 Florencja, Italy; DOI: 10.1180/minmag.2013.077.5.3: 889.
- [A17] J. Ciesielczuk, 2008 - Ellestadite-(F) - a mineral formed in the overburned coal dump (Upper Silesian Coal Basin). Mineralogia, 32: 54.

Description of the scientific value of the above papers and results of my investigations

The presented scientific achievements focus on the behaviour of mineral matter during and after combustion metamorphism of coal wastes, and the influence of its presence, kind and amount on dump selfheating, burning, cooling and weathering. It is based on research of selected coal-waste dumps located in Upper- and Lower Silesia which I started in 2007, and on experiments conducted on samples collected from dumps.

Coal-waste dumps were typically situated next to coal mines, as were settlements for miners which escalated in towns overtime. Burning coal-waste dumps are common in Poland, particularly those built up to the 1980s because of the high coal content in the wastes and incorrect construction. Selfheating and selfignition are long-term processes that tend to recur periodically. Burning coal-waste dumps are environmentally burdensome and harmful; fire gases and effluents are emitted which can contaminate surface- and underground water, and soils.

The problem of burning coal-waste dumps is one that is commonly investigated worldwide (e.g., Sokol et al., 2005; Stracher 2009; Stracher et al., 2011, 2013). These investigations address three aspects. (1) Scientific investigations focus on the causes of selfheating, the factors that influence fire initiation, its progression and its effects, and on the mechanisms of waste alteration. (2) Practical studies center on the question of how to prevent dump fires, methods for extinguishing them, and on subsequent dump reclamation. (3) Environmental projects examine the influence of burning coal-waste dumps on water, soil, plants and people. Although the quantity and scope of the research that has been carried out is enormous, a full explanation of the problem remains elusive; everywhere they exist, coal-waste dumps still burn.

Almost all coal-waste dumps are unique in their compositions. Local conditions are specific to each. These factors decree that the properties of altered burnt waste change from place to place. As overburned wastes are of practical use, e.g., for road making, it makes sense to precisely investigate as many samples as possible so as to better characterize any proposed raw material from a dump.

The main subject of my investigations is mineral matter which should dominate in coal-waste dumps. Mineral compositions are generally well known, as are the temperatures of any structural changes in particular minerals. Nevertheless, coal contents in deposited wastes are much higher in practice and can significantly influence the changes in mineral matter that occur during burning.

The aim of my investigation was to (1) demonstrate the influence of the amount of coal, pyrite and siderite on alterations to mineral matter, (2) show the mechanism of thermal

alteration of rocks and minerals due to pyrometamorphism, (3) explain, on the basis of selected identified mineral phases, which of them can be indicators of thermal processes and (4) to determine if it is possible even in the light of the individuality of burning coal-waste dumps, to simplify the recognition of the thermal processes involved. Additionally, while monitoring burning dumps, I noted how thermally active places spread and migrated, and efficient or otherwise of extinguishing methods used. I collaborated with other investigations on burning coal-waste dumps by biologists, geophysicists, coal petrologists and chemists to obtain a more complete picture of what was happening in the dumps. A final aim was to help add well-described examples of burning coal-dump case studies from Poland to the world literature.

My investigations resulted in articles of differing rank. The order of their publication did not follow the order of their preparation. Below presented guide through leading articles is arranged in order of majority.

To realize my aims, I conducted experiments at known temperatures and duration times, with and without oxygen access and catalysts, on coal waste collected from a variety of dumps. Thus, unknown factors were limited and the compositions of heated samples known. The experiments allowed analysis of alteration processes, their mechanisms, and verification of temperatures of mineral formation. The results were partly published in: [1] J. Ciesielczuk, Ł. Kruszewski, J. Majka, 2014, “Thermally-changed coal waste as an analogue of natural-environment rocks – a comparative study of dump and experimental materials” and in conference abstracts: [A3] Ł. Kruszewski, J. Ciesielczuk, 2013 – “Anthropogenic analogues of geological processes – a case of burning post-mining dumps as shown by natural samples and thermal experiments”; [A4] J. Ciesielczuk, Ł. Kruszewski, J. Majka, 2013 – “Experimental study of the thermal transformation of siderite from the coal waste dump in Katowice-Wełnowiec, Poland” and [A5] J. Ciesielczuk, 2013 – “Behaviour of mineral phases during combustion of coal waste dumps – experimental study”.

Three coal-waste samples were collected from the Wełnowiec dump for experiments. These were (1) a black siltstone (20W) containing 53% coal, 24% kaolinite, 21% illite/muscovite and 3% quartz, (2) a grey siltstone (20B) containing 11% coal, 29% kaolinite, 22% illite/muscovite, 28% quartz, 2% of feldspars and 1% siderite, and (3) a siderite concretion (Sd). Pyrite (Py) was collected from the coal layer of Miechowice mine in Bytom. 46 portions (1.6 g) of samples 20W, 20B, 20W+Py, 20W+Sd, 20B+Py and 20B+Sd were heated in a Czylok PRC 65 pipe furnace 65 mm in diameter and 125 cm long, with and without oxygen access, for 5 hours at 400, 700, 900 and 1000°C. The temperatures were established on the basis of Oxyreactive Thermal Analysis standards for water- and OH release for clay minerals and for thermal decomposition of pyrite and carbonates. Additionally 6 samples (20W, 20B, 20W+Py, 20B+Py, 20W+Sd and 20B+Sd) were heated for 74 hours, from ambient temperature up to 960°C with temperature increasing at 10°C/minute to enable, by extending the reaction time, the formation of larger crystals. Rain water collected in the meteorological station in Sosnowiec was added to 4 samples (20B, 20W+Py, 20B+Py and 20B+Sd) during heating for 5 hours to obtain melt.

In another pyrometamorphism experiment conducted in a radiation-type thermal chamber, four samples (Sd, 20B and 20B+Sd) weighing from 0.035-0.07 g were placed on a PtRh heater for in-situ powder X-ray diffraction to identify particular mineral

transformations and the temperatures at which they occurred. They were heated to 1200°C at a heating rate of 5°C/s. Diffractograms collected every 20°C registered almost continuously the times when a mineral phase appeared, dominated and faded.

On the basis of these experiments, I showed that the presence of large amounts of coal in coal waste influences its structure and changes in its mineral matter. Coal matter accelerates changes in coexisting mineral phases. As it burns during the first stage of fire, coal matter provides moisture and the space for newly-formed mineral phases. Under oxidizing conditions, oxygen and heat more easily circulate in the sample, locally increasing the temperature.

After the experiments, siltstone with coal (20W) was more intensely cracked than siltstone with lesser amounts of coal (20B) which was less compact but homogeneous. Although both primary samples contained similar amounts of clay minerals, twice as much mullite was produced in sample 20W than in 20B. Additionally, euhedral mullite needles formed only in 20W, as did layers of varying hematite- and magnesioferrite contents.

I also proved that the amount of quartz also influences locally-generated temperatures. Compared to the black siltstone (20W), the grey rock (20B) contains much more quartz. After heating, 20B contained half the quartz originally present, and 20W one third. Furthermore, quartz in 20W sample altered to cristobalite whereas, in 20B, silica glass dominated. After heating, less quartz remained in samples that had been mixed with pyrite than with siderite.

Small amounts of diopside were produced in 20B samples mixed with pyrite or siderite, much more in 20W. There was no diopside in the original 20B and 20W samples.

During pyrometamorphism, processes altering coal wastes do not act uniformly. For example, the outer parts of heated 1.6 g samples were sintered, whereas inner parts were loose. Likewise, the presence of siderite or pyrite made 20W more compact while burning, limiting oxygen access.

The experiments demonstrated that common mineral phases with unusual compositions could form. Anorthite, for example, formed in black siltstone heated at 960°C for 74 hours with oxygen access, is enriched in Mg, Fe and P. The plagioclase structure allows this.

Indialite is an ubiquitous product of pyrometamorphism. As it can crystallize from the melt, it is common mainly in paralavas. But XRD analyses reveal its presence in clinkers and other overburned rocks showing no signs of melting. In pipe-furnace experiments involving heating up to up to 1000°C for 5 hours, even 74 hours, with or without oxygen access and with or without additional water, no indialite crystallized. However, experiments conducted in the thermal chamber showed that the formation of indialite starts at 1070°C, dominates at 1200°C and that indialite amounts remain constant after up to 30°C cooling.

I described and presented the results of combustion metamorphism occurring in burning coal-waste dumps in Poland in articles [3] J. Ciesielczuk, G. Bzowska, M. Paszkowski, 2014, "Mineral transformations and actinide transport in silicoclastic rocks due to combustion metamorphism in a coal waste dump in Wojkowice, Upper Silesia, Poland", [4] M. Misz-Kennan, M. Fabiańska, J. Ciesielczuk, 2014, "Thermal transformations of the waste rocks at the Starzykowice coal waste dump, Poland", [5] J. Ciesielczuk, M. Misz-Kennan, J.C. Hower,

M.J. Fabiańska, 2014, “Mineralogy and geochemistry of coal wastes from the Starzykowiec coal-waste dump (Upper Silesia, Poland)” and in conference abstracts e.g. [A17] J. Ciesielczuk, 2008, “Ellestadite-(F) – a mineral formed in the overburned coal dump (Upper Silesian Coal Basin)”.

In article [4], I summarized the mineralogy of 73 samples chosen from a total of 140 collected from the burning Starzykowiec dump at the active Chwałowice coal mine. Based on XRD and the colours of powdered samples, I divided them into 8 groups differing in the severity of thermal transformations. The samples were also divided into five smaller groups on the basis of changes observed in organic matter. However, some samples did not fit to both divisions as the processes which change the deposited wastes can overlap.

Having experienced the great diversity in the mineral composition of thermally-altered wastes deposited on the Starzykowiec dump, I took on the research of the dump of the closed coal mine Jowisz in Wojkowice. This dump is a good example of one where processes of mineral transformation can be studied. It covers an area of approximately 7 ha and reaches a maximum height of 21.5 m. It contains about 1,200,000 t of waste deposited there for 20 years up to the 1980s. The dump has a history of self-ignition but, today, there are no signs of thermal activity and as a part of the dump has been exploited for road building material, its inner part is exposed. To know at least some of the factors involved in the thermal transformation of waste, I divided the dump into three zones, namely, (1) a core zone with red and yellow rocks associated with combustion including slag, paralava, and slate, (2) an aureole zone surrounding the core zone where no slag is present and the rocks contain hematite and (3) an external zone where the rocks are black, contain laminae of coal, and are unaffected by combustion. Rock types of differing grain sizes, i.e., sandstones, coarse-grained siltstone, siltstones, and very fine-grained siltstones, were collected from each zone. In addition, slag from the core zone was examined. In collecting samples, I avoided any containing coal as these could locally distort the overall temperature regime prevailing during selfheating and, consequently, the distribution of individual mineral phases. Samples of similar sizes, located next to each other, were collected from the central parts of the zones.

I demonstrated in article [3] that mineral transformations and actinide transport in the fire field reflect the thermal decomposition of primary phases in the high-temperature, oxygenated environment of the core zone, active transport in the steep thermal gradient of the aureole zone and hydrothermal leaching by steam in both core and aureole zones. Samples from the same zone but of different lithology show different degrees of alteration. The most thermally-changed rocks on the Wojkowice coal-waste dump are very fine-grained siltstone and slag in the fire core. Less altered are siltstones showing a marked thermal influence reflected in changes in mineral composition. Thermal change in the sandstones is expressed only by modified clay minerals and the presence of hematite. The occurrence of mineral phases that seem to be formed under different conditions is to be expected on burning coal-waste dumps; these are dynamic, unstable and changing pyrometamorphic environments. In such a setting, a key factor influencing the degree of alteration of waste in a zone is the amount of quartz in the rock. Quartz has an extremely high heat capacity and easily captures the heat and, in doing so, can lower the temperature locally. This is why accompanying clay minerals in sandstones are altered at lower temperatures than those in very fine grained siltstones, even in the same zone.

Paper [5] describes the interdependence of chemical composition (main- and trace elements) and mineral-phase composition for coal wastes from the Starzykowiec dump. Apart from the pyrometamorphism, other processes, e.g., weathering were taken into account which have an influence on the final composition of the waste. This is critical as the wastes are frequently used for road building. Samples were collected from the bottom-, middle- and upper part of the dump, but their original composition was unknown. In general the behaviour of main elements is similar for all samples although their mineral-phase is different. In this case, I demonstrated that most processes affecting the deposited wastes had not caused element migration except in rocks containing organic matter and, thus, much more C, H, N, O and S. Elevated amounts of calcium in some samples is due to the presence of gypsum (weathering) or anorthite (pyrometamorphism). Iron contents reflect the presence of hematite and/or hercynite, the highest Al_2O_3 contents the presence of spinels and sulphur concentrations (probably derived from pyrite) the occurrence of secondary sulphates, e.g., gypsum or alunite/jarosite.

Some trace elements in the coal-waste may be derived from coal. They may reflect the original coal-forming environments and/or changes that occurred during the decay of organic substances and coalification. They may also be associated with minerals composing the coal-bearing rocks. Geological processes, e.g., faulting can also redistribute trace elements within the deposited coal-bearing rocks. Trace-element analysis aided reconstruction of the original waste rocks now overburned, especially the extremely altered rocks in which any primary structures were obliterated.

My research shows that after combustion metamorphism, contents of Rb, Sb, Ba, Mn, Zr, Co and Cr in the wastes increase, whereas those of Zn, Cu, Sr, Pb and Mo decrease. Furthermore, rubidium, which usually shows correlation with potassium occurred to be mobile during the thermal alteration.

Precise analyses of the mineral- and chemical composition of wastes were compared with the macroscopic appearance of the rocks using a small suite of 16 samples collected from the Starzykowiec dump in Chwałowice [5]. I found dependencies with potential for use in the investigation of dumps not described yet, although selfheating- and selfignition processes are uncontrolled. Macroscopically, the same wastes should have similar primary mineral- and chemical compositions, and influencing processes should also be the same. Coal wastes derived from the same coal basin should be similar in petrology, kind of coal and its rank. There is no correlation between main-element contents in a given sample and its location at the bottom, middle or top of the dump but more trace-element contents, e.g., V, Co, Ni, As, Rb, Sb, Ba and Pb, show an increase toward the top of the dump.

Based on my knowledge of the coal-waste dump in Wojkowice (article [3]), I concluded that the behavior of the mineral matter could be predicted on the basis of investigations limited to macroscopic observations and a single analytical method. I used oxyreactive thermal analysis for all samples collected from the three zones in the overburned dump. In the article [10]: J. Ciesielczuk, S. Cebulak, 2011, "Oxyreactive Thermal Analysis application to the investigation of the thermally affected coal-waste rocks deposited on dump in Wojkowice, Upper Silesian Coal Basin, Poland" I showed that the identification procedure can be simplified. Oxyreactive thermal analysis is the best method for investigating

unaltered- or slightly thermally-altered coal-waste samples. It precisely defines the amount of coal in the sample, the kind of coal, its chemisorption tendency, the degree of coal weathering and the temperatures of exo- and endothermic reactions. No other single method provides the same range of data. On the basis of reactions of water or OH release from clay minerals, pyrite oxygenating and thermal decomposition of carbonates, I established amounts of these minerals that were convergent with previous XRD results [3]. Additionally moisture was detected as was the possibility of pyrolysate migration even into newly-formed paralava [10].

To understand the processes of selfheating and selfignition in coal-waste dumps, it is crucial to recognize as many factors as possible that may potentially influence the initiation of heating and its intensity. On the basis of my field observations and analytical research, I can confirm, that the main cause of waste ignition are changes in coal structure caused by oxidation. The reaction is exothermic and the released heat can accumulate and reach the ignition temperature [10]. The tendency and intensity of reaction depends on (1) the kind of coal macerals with their different tendencies to oxygen chemisorption, (2) degree of coal weathering, (3) degree of coalification, (4) coal chemical composition, (5) forms of coal occurrence in wastes, e.g., as laminae, dispersed, whole coal pieces, (6) location of coal laminae inside the waste rock piece or on its surface, (7) lamina thickness and its mass, (8) oxygen access, (9) amount of coal in waste, (10) the fineness of the waste material and its sorting, (11) degree of waste-rock weathering, (12) presence of iron minerals, mainly pyrite and marcasite, (13) presence and amount of iron carbonates, especially siderite, (14) mineral composition of the waste rock (amounts of quartz and feldspars, kinds of clay minerals and micas), (15) shape and height of dump, (16) the degree of waste compaction, (17) exposure to climatic factors, e.g., wind direction, intensity of the rainfall and snowfall and (18) geographical factors, e.g., location and orientation of the dump slopes. My scientific achievement is the development of factor (14); the amounts and kinds of mineral phases present in coal-waste rocks strongly influence the temperatures generated during selfheating and, as a consequence, differences in the alteration of the wastes.

Since 2008, I have monitored the municipal waste landfill in the city of Katowice-Wielowiec, which has been remediated with coal wastes. The research has been supported by the Department of Environmental Protection of the City Office in Katowice. Here, I focus on the way thermal activity begins, and its duration, migration and extinction. I also observe the efficiency of methods used to extinguish the fire. This is described in article: [8]: J. Ciesielczuk, J. Janeczek, S. Cebulak, 2013, "Cause and progress of the endogenous coal fire in the remediated landfill in the city of Katowice".

The dump is located in Wielowiec, 1 km from the center of Katowice city, the capital of the Silesia region. It was opened in 1991 and closed in 1996. 1.6 mln t of wastes were deposited there of which 22.5% was coal waste. It covers an area of 16 ha and was reclaimed in 1998. Since 2001, biogas was exploited for few years, but its amount was overestimated. Subsequently, endogenic thermal events started; the methane exploitation may have enhanced exothermic oxidation of coal waste. Bad smells and toxic fumes emanating from overburned places impinge on the environment and, potentially, the health of the nearby population. Thermal activity is typically located on the dump slopes. In only one place does it reach the

top of the of the dump. Hot spots are characterized by a marked temperature gradient – falling up to hundreds of degrees Celsius over 1 m.

Slope fires usually start at 2/3 of the way from the top, although even waste distribution. The highest temperatures, ca 690°C, are maintained there at 30 cm subsurface for few months before the fire migrates towards the top of the slope where it also remains active for a few months. My observations of the processes occurring here confirm the influence of rain or snow falls which, though believed to reduce the fire, actually intensify it by penetrating to inner parts of the dump and changing redox conditions. Other activities on the burning dump, e.g., slope stabilization by stakes or assembly of the methane-recovery apparatus also intensifies the fires.

Though different methods for extinguishing the fires were used by experienced firms in Welnowiec dump, none proved effective. The first method used involved excavation of burning wastes and cooling them on the surface, putting fly ash at the bottom of the trenches to cut oxygen access to the dump interior and putting the cooled wastes back. Though there are, in fact, no signs of thermal activity in this area up to now, the lack of insulating material isolating the thermally inactive part of the dump caused fire migration. The least successful method used involved excavation of the burning wastes, pouring water and water mixed with lime into the trenches before putting the cooled wastes back. Thermal activity was reduced for a few months but, after 1 year, the problem returned. Currently, temperatures measured at 1 m subsurface reach 470°C.

Major factors causing the fire on Welnowiec dump were numerous. Too much coal waste was used for reclamation. The coal content in the reclamation material was too high (> 5%). The coal wastes contained whole coal pieces and numerous coal laminae. It was possible for heat to accumulate within the dump up to coal ignition. The presence of pyrite and easy oxygen access were crucial.

Oxyreactive thermal analysis of the deposited coal showed some of it to be prone to selfignition. It was a primary coal with a strong tendency to chemisorption and thermal decomposition. In addition, the wastes were not compacted, allowing coal oxygenation and heat accumulation [8].

I measured CO and CO₂ contents at the surface and at 1 m subsurface on the burning slope. At most measuring points, CO₂ concentrations exceeded the scale of the measuring pipe; concentrations were > 18% vol. There is the dependency between the temperature and CO concentration. In places where temperatures were < 50°C, CO concentrations were a few hundredths of a percent whereas, in hotter places (> 100°C), CO concentrations exceeded 1%, reaching 2.5% at a maximum. Smoldering, a prevalent and persistent form of coal combustion in the landfill, is responsible for high emissions of CO, CO₂, methane and a suite of gaseous hydrocarbons. High CO₂ contents mainly reflect CO oxidation.

Emitted gases from the burning parts of coal-waste dumps in Poland were measured at four dumps in the Upper Silesian Coal Basin and two in the Lower Silesian Coal Basin and published in article [6] M. Fabiańska, J. Ciesielczuk, Ł. Kruszewski, M. Misz-Kennan, D.R. Blake, G. Stracher, I. Moszumańska, 2013, “Gaseous compounds and efflorescences generated in self-heating coal-waste dumps – A case study from the Upper- and Lower Silesian Coal Basins (Poland)”. Together with Łukasz Kruszewski, I described the phase

compositions of efflorescences blooming within- and around the vent mouths from which the gases were collected. Although efflorescences differ greatly in their phases, amounts, and chemical compositions, we found convergence between them and gas compositions. In total, we identified 24 mineral phases, mainly sulphates and chlorides, and some very rare organic efflorescences. Blooming phases are scarce in dumps where measured temperatures were low and abundant where temperatures were high. They form due to evaporation or condensation from the gases on the surface or, beneath the surface, as a result of gas interaction with coal waste.

While visiting burning coal-waste dumps, I drew attention of the behaviour of vegetation growing in extreme conditions. My part in paper [9] J. Ciesielczuk, A. Czylok, S. Cebulak, 2011, "Plant succession and gigantism observed on the burning coal waste dump in Katowice-Wielowice, Poland" was to note the phenomenon and initiate investigations conducted by biologist Prof. A. Czylok. Burning coal waste dumps create new specific sites settled by plants with high requirements of temperature, lighting, humidity, CO₂ and nitrogen content. I observed that vegetation cycle is out of adjustment; at the same time, seedlings, flowers and fruit of one species are observed. Heated places on the dump favor vegetation even at winter time. I noted zoning in plants growing at burning sites – as is explained as the rule of the first colonizer; in the overburned soil, the natural seeds banks have been liquidated and after soil cooling, the plant recently sown would dominate the zone. I also noted the exaggerated giant heights of some plants, reaching and exceeding maximum heights recorded in the literature. This gigantism is caused by the high CO₂ concentration.

Starting my research on coal waste dumps, I examined sociological-, geoeconomic- and geoenvironmental maps of Poland, satellite images and the literature. In paper [2]: J. Ciesielczuk, 2014, "Coal mining and combustion in the coal-waste dumps of Poland", I describe coal mining and waste management in Poland in the past and at present, and fifty of the largest (> 1 mln tons) coal-waste dumps in Upper Silesia. Additionally, fire prevention methods are reviewed with examples of dumps in Poland which had undergone selfignition. Article [7]: M. Misz-Kennan, J. Ciesielczuk, A. Tabor, 2013, "Coal-Waste Dump Fires of Poland" is a book chapter presenting the most spectacular dumps fires in Poland documented by macro- and microphotos of municipal landfill reclaimed with coal waste in Katowice-Wielowice, Starzykowice dump at the Chwałowice coal mine, "Szarłota" at the Rymer coal mine, the dump at the Marcel coal mine in Radlin, the dump at the coal mine Rydułtowy and the coal-waste dump at the Anna-Wrzosy mine in Pszów. Moreover, dumps thermally active in the past and cool now are presented, namely, the dumps at the Jowisz mine in Wojkowice and the Saturn mine in Czeladź, and the reclaimed dumps at Siemianowice and Cieczott.

I am continuing my investigations of all of the waste dumps mentioned above. New research directions as the team of coworkers/coauthors enlarges. The best polygon is the dump in Katowice-Wielowice where a 'synchronization' of mineralogical-, geochemical-, biological- and geophysical observations can be envisaged.

Changes observed on burning coal-waste dumps can be compared with natural analogues where temperature gradients are high and pressures low – as is the case in contact

aureoles and in xenoliths. Currently, I have started research on thermally altered host rocks surrounded a dacite intrusion in south Peru. I identified there a rare mineral belonging to the apatite-ellestadite group which I also found at the burning coal-waste dump in Czeladź [A17].

Summarizing I would like to state that my basic- and experimental research on burning coal-waste dumps has contributed to an understanding of them in a number of areas. (1) The importance of the presence and amount of coal, pyrite and siderite on changes in mineral matter in waste rocks. (2) The relationship between the amount of quartz and the degree and extent of thermal alteration in coal wastes. (3) The importance of a kind and amount of all mineral phases on combustion. (4) The mechanisms of coal-waste alteration caused by fire. (5) The recognition of mineral phases that can be indicators of the processes occurring in burning parts of dumps. (6) Simplification of the recognition of the combustion processes occurring in coal wastes, notwithstanding the multiplicity of alteration possibilities. (7) I have helped bring a knowledge of the effects of pirometamorphism on coal waste in Poland to the international literature. (8) I have monitored the spread of thermally active sites in dumps, their migration and the effectiveness of methods used to extinguish them. (9) I have initiated a study on the burning dumps involving experts from other disciplines such as biology, geophysics, coal petrology, organic- and inorganic chemistry in order to obtain a fuller understanding of them.

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5. Other scientific achievements published before PhD defence

At the beginning, my scientific activity was focused on secondary oxyminerals formed in polymetallic ores in Miedzianka and Radzimowice, Sudetes Mts. The characteristics of pseudomalachite, previously wrongly identified as malachite, were defined in [35] J. Ciesielczuk, J. Janeczek, 1991, "Pseudomalachite from Radzimowice and some comments on its occurrence in Miedzianka (Sudetes Mts.)". Pseudomalachite at Radzimowice contains arsenic which substitutes for phosphorus, proving the possibility of the existence of a pseudomalachite–cornwallite solid solution. In the Miedzianka deposit, oxyminerals crystallized from alkali fluids with high Eh in the sequence chrysocolla – first generation of malachite – pseudomalachite – second generation of malachite.

Looking for the subject of a PhD thesis, I established the mineral composition of karst funnel fillings in middle Triassic limestones of the Silesia Upland, published in [33] J. Lewandowski, J. Ciesielczuk, 1997, "A case to study karst regoliths in the Silesian Upland". They are products of subtropical Oligocene-Miocene karstification.

The Tempus scholarship resulted in a geotectonic-environment reconstruction of formation of amphibolite from the Orlica-Śnieżnik Dome. It was published in [31] P.A. Floyd, J.A. Winchester, J. Ciesielczuk, A. Lewandowska, J. Szczepański, K. Turniak, 1996, "Geochemistry of early Palaeozoic amphibolites from the Orlica - Śnieżnik dome, Bohemian massif: petrogenesis and palaeotectonic aspects" and [34] A. Lewandowska, J. Ciesielczuk, J.A. Winchester, P.A. Floyd, 1995, "Amphibolites from the Zimne Wody area, west Stronie series (SW Poland)".

I also started investigations on the hydrothermal alteration of granitoids which resulted in the publication of preliminary paper [32] J. Ciesielczuk, J. Janeczek, 1999, "Hydrothermal alteration of the Strzelin granite".

6. Other scientific achievements published after PhD defence

I continued working on the projects initiated earlier. I described the hydrothermal alteration of the Strzelin granite, indicating changes in its mineral- and chemical composition. I also demonstrated that the volume of altered part of the granitic body had been previously underestimated. I showed that at least 20% of the Strzelin granite is hydrothermally altered in [16] J. Ciesielczuk, 2007, "Hydrothermal activity in the Strzelin granite (Poland)" and [17] J. Ciesielczuk, J. Janeczek, 2004, "Hydrothermal alteration of the Strzelin granite, SW Poland". Mineral associations identified in both the altered Strzelin granite and in hydrothermal veins are the same and were formed under the PT conditions of the zeolitic- or incomplete prehnite-pumpellyite facies. Mass balance calculations show, that calcium and water were supplied to the altered granite and silica removed to the hydrothermal fluid, resulting in an overall reduction in the volume of the altered granite.

I described alterations of the primary granite mineralogy to within a 40 m shear zone in the Borów granite in papers [30] J. Ciesielczuk, 2000, "Geochemistry of the

hydrothermally altered granite from the shear zone in Borów (Strzegom - Sobótka massif)” and [29] J. Ciesielczuk, 2001, “Chemical reactions proceeded in minerals affected by hydrothermal fluid (based on the Strzelin and Borów granites)”. I also described the behaviour of major- and trace elements during the alteration and demonstrated the existence of linear dependencies for K/Rb, Fe/V, Al/Ga, K/Ba and Ba/Rb in [23] J. Ciesielczuk, 2005, “The interdependence of elements in the hydrothermally altered Strzelin and Borów granites”. By etching euhedral pyrite crystals present in hydrothermally-altered Borów granite with HNO₃, HCl and an 1:1 HNO₃:HCl acid mixture, I demonstrated their metasomatic origin as alkali fluids dissolved quartz prior to other primary minerals in [24] J. Ciesielczuk, J. Janeczek, 2004, “Metasomatic pyrite from hydrothermally altered Borów granite (Strzegom-Sobótka Massif). Preliminary report”. The metasomatic pyrite developed after K-feldspar albitisation and biotite chloritisation had resulted in an increase in fluid alkalinity.

I precisely described and used chlorite, a ubiquitous product of hydrothermal alteration, as a geothermometer in [14] J. Ciesielczuk, 2012, “Chlorite of hydrothermal origin formed in the Strzelin and Borów granites (Fore-Sudetic Block, Poland)”. The chlorite occurs in these granites in two forms, i.e., as secondary post-biotite chlorite 0.1-1.5 mm in size and smaller (< 0.05 mm), primary spherulitic chlorite, which crystallized straight from the fluid in fractures, interstices and cleavage planes. Chlorite in the Strzelin granite contains less iron than that in the Borów granite which reflects the chemical composition of the host rocks; MgO/FeO of the Strzelin granite is higher. Its location within the granites, and its frequency, is strongly related to the impact of hydrothermal fluids. Temperatures of chlorite formation were calculated on the basis of chemistry. Only chemically pure chlorite grains not interstratified by smectite or berthierine were taken into consideration. Thus, chlorite from veins in the Strzelin granite was glycolated and heated to 180°C and to 550°C for 2 hours and high-resolution transmission electron microscopy (HRTEM) applied to check purity. Although the chlorite geothermometer is discredited, calculated temperatures of chlorite formation in the Strzelin granite are 334°C in unaltered granite, 349-355°C in altered granite and 376°C in hydrothermal veins. Postbiotite chlorite formed at lower temperature (354°C) than did spherulitic chlorite (388°C). The same was observed for chlorites from the Borów granite (346°C and 350°C, respectively). My results show that the chlorite geothermometer has potential for use with chlorites in granite.

The products of hydrothermal alteration are usually small and hard to see using standard microscopy. I tested a cheap catodoluminescence method to study hydrothermal alteration in the Karkonosze, Strzelin and Borów granites – reported in [20] J. Ciesielczuk, M. Sikorska, 2007, “Suitability of the catodoluminescence method in the investigations of hydrothermal alterations of granitoids”. I showed the presence of two calcite and prehnite generations, otherwise invisible, the luminescency of titanite containing more aluminum in its structure and clinozoisite with higher Fe₂O₃ content in its core. The blue luminescence of fluorite revealed tiny grains in unaltered granite. Feldspar alteration was also exposed.

I compared hydrothermal alteration in the Strzelin and Borów granites with that in granitic massifs in Maine (USA), Aspö and Stripa (Sweden), Beauvoir and Auriat (France), Ashio (Japan) in [27] J. Ciesielczuk, 2002, “Hydrothermal alteration of the Borów and

Strzelin granites (the Sudetes Mts) in comparison with other granitic massifs”. In general, the mechanism of alteration is similar in all, differing only in detail. Factors influencing final granite composition are petrography, host-rock mineralogy and chemistry, tectonics, changing compositions of hydrothermal fluids, their temperature, pressure, oxygen fugacity, CO₂ content, pH, Eh, and the duration and frequency of fluid incursions.

Continued investigations by me on oxyminerals formed within the polymetallic ores in Miedzianka established the presence of additional elements in their structures as reported in [26] J. Ciesielczuk, Z. Bzowski, 2003, “Secondary (Cu, Zn)-oxyminerals from the Miedzianka copper deposit in Rudawy Janowickie, Sudetes Mts. Preliminary report” and [25] J. Ciesielczuk, E. Szełęg, M. Kuźniarski, P. Bylina, 2004, “Preliminary data of erythrite from Ciechanowice (Miedzianka deposit, Sudetes Mts.)”. Apart from the possible existence of limited solid solution for cornwallite and pseudomalachite, I also proved such for cornwallite and legrandite, pseudomalachite and legrandite and eritrite and kottigit; these also exhibit Cu substitution.

The geotectonic environment of amphibolites in the Polish part of the Opava Mts was published in [22] J. Ciesielczuk, J. Żaba, 2006, “The palaeotectonic environment of amphibolites from the Polish part of the Desna and Vrbno series, Opava Mts., East Sudetes”. A long-term volcanic episode in an extension regime lasted from Middle Devonian to Early Carboniferous during which rocks of tholeiitic basalt composition intruded into rocks of different ages and degrees of alteration.

My task in the preparation of publications [13] P. Premović, J. Ciesielczuk, G. Bzowska, M.G. Djordjević, 2012, “Geochemistry and electron spin resonance of hydrothermal dickite (Nowa Ruda, Lower Silesia, Poland): vanadium and chromium” and [15] P.I. Premović, J. Ciesielczuk, B.Ž. Todorović, D.M. Đorđević, N.S. Krstić, 2010, “Geochemistry of Fe³⁺ in the hydrothermal dickite from Jedlina Zdroj (Lower Silesia, Poland)” was the field work, sample collection, literature review, geological background and, in the main, the identification of minerals of kaolinite group by XRD and SEM-EDS. These reflect hydrothermal activity.

Other scientific achievements consist of articles written as a result of my participation in three Polish Scientific Expeditions to Peru. I described sulphate mineralization in the vicinity of the Pinchollo geyser located at 4,353 m a.s.l at the foot of the Hualca Hualca volcano (6025 m n.p.m.) in [11] J. Ciesielczuk, J. Żaba, G. Bzowska, K. Gaidzik, M. Głogowska 2013, “Surface mineralization at the geyser near Pinchollo, southern Peru”. Thermal activity in southern Peru is caused by Nazca plate subduction under the South American plate. The geyser involves a local fault fractures network cut by a young latitudinal fault. Sulphates of various habits and of various yellow, orange and white colours were collected from the soil and plants close to the geyser, from the walls of a 1 m diameter pothole filled with boiling water and from a site some 100 m to the west of the geyser. Their chemical composition is fairly simple, consisting of Al, Fe, K, Mg, Ca, S, NH₄ and O, and all display chemical zoning. However, the phase composition is more complex. Alunogene, copiapite, coquimbite, tschermigite and gypsum occur everywhere. Close to the geyser,

magnesium-containing sulphates, namely, boussingaultite and pickeringite, also occur. Iron sulphates such as mohrite and rozenite precipitate on the walls of the pothole. Sulphates containing potassium such as jarosite, alunite and voltaite - voltaite (Mg) dominate among the efflorescences at the distant site, where hematite was also noted. The sulphur may derive from volcanic H₂S, pyrite in the siliciclastic Yura formation or gypsum in the Cretaceous formation. Most likely, as the present-day thermal waters do not involve a juvenile-water component, the geyser waters derive from a relatively shallow source.

I also participated in tectonic research for which the first results have been published in [12] J. Żaba, Z. Małolepszy, K. Gaidzik, J. Ciesielczuk, A. Paulo, 2012, "Fault network in Rio Colca valley between Maca and Pinchollo, Central Andes, southern Peru" and presented at conferences [A21], [A22], [A24], [A25], [A29], [A31] and [A32].

