Povrchový důl Maczki-Bór

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Abstrakt

Parametry archivních a aktuálních geologických, hydrogeologických, báňských a environmentálních údajů byly stanoveny na základě analýzy zdrojových materiálů, tj. zejména vlastních materiálů provozovatele pískovny Maczki-Bór.

Maczki Bór open-pit

The characteristics of archival and current geological, hydrogeological, mining-technical and environmental data were developed on the base of analysis of source materials, i.e. mainly the entrepreneur's own materials, the Maczki-Bór Filling Sand Mine.

Tagebau Maczki Bór

Die archivalischen sowie aktuellen geologischen, hydrogeologischen, bergbaulichen und environmentalen Datenparameter wurden auf Analysenbasis von Quellenmaterialien, d.h. hauptsächlich aus eigenen Materialien des Betreibers der Kiesgrube Maczki-Bór festgelegt.

Klíčová slova: povrchový důl, rekultivace, geologické podmínky, hydrogeologické podmínky, odpady po těžbě.
Key words: open pit, reclamation, geological conditions, hydrogeological conditions, post-minig wastes.

1 General informations

The Maczki-Bór Filling Sand Mine is located within the cities of Sosnowiec and Jaworzno in the Silesian Voivodeship (Poland). The sand deposit is located in the bifurcation of the Biała Przemsza River and its right-bank tributary - the Bobrek River. Its range covers mining areas of four liquidated hard coal mines (Fig. 1).

The mine has been working since 1952. The original excavations of the Maczki-Bór mine were located in the area of over 558 ha, of which nearly 65% (358.7 ha) covered the Bór-West field, and 35% (199.3 ha) the Bór-East field (ERM Polska, 2008). The western part of the Bór-West field with an area of about 230 ha has been reclaimed by filling it with post-mining waste from hard coal mines and is now mostly investment area, while the north-eastern part has been designated as a municipal waste landfill for the city of Sosnowiec. The remaining part of the Bór-West field with a total area of about 120 ha is undergoing reclamation. In the eastern part of the mine, parallel to the reclamation, there is still residual exploitation of the Quaternary sands associated with the proglacial valley of the Biała Przemsza River. Currently, mining and reclamation works are carried out in the territory consisting of three mining areas with a total square of 325 ha.

Reclamation has been carried out continuously since 1976, using waste from mining and hard coal processing as the basic material filling the pit of the opencast mine. Currently, the pit was filled with post-mining material in the area of approximately 230 ha - mainly in its central and north-western part - and it was transformed into the investment areas. The north-eastern part of the Bór-West field was designated as a municipal waste landfill for the city of Sosnowiec. During the reclamation of the Bór-West field, the mining material was supplied by rolling stock, and the embankment was formed by the gravitational pouring of material from a high height. In order to avoid the risk of spontaneous combustion, it became necessary to use appropriate fire prevention technologies, consisting primarily of sealing the solid of the landfill with clay material, and then (since 1994) using the so-called ash pulp. In the case of the Bór-East field, so far, the reclamation covered an area of about 220 ha. As in the case of the Bór-West field, fire prevention is used. Ultimately, complete filling of the post-mining excavations is foreseen, mainly with post-mining material with the participation of waste and mineral materials approved for this type of work, until the original elevation of the area will be restored.

Fig. 1: Location of the study area – Maczki Bór.

2 Site morphology

Before commencing operation, the area of the Maczki-Bór mine location was characterized by moderate morphology. This region (part of the Silesian Upland) is a slightly sloping south-west plain with altitudes varying from 250 m asl up to 275 m asl The morphology of the southern and south-western parts of the area is associated with the valleys of the Biała Przemsza River and its right tributary - the Bobrek River, where ordinates range from 260 m asl up to 255 m asl The original surface of the terrain (before sand exploitation) is pre-served only in the safety pillars on the outskirts of the mining area, where the elevations of the area are from 250 m asl up to 264 m asl in the East and from 250 m asl up to 255 m asl in the West of the area (Fig. 2) (ERM Polska, 2008).

The current relief has been shaped as a result of the industrial activity of man. The artificially transformed surface includes, first of all, clear areas of the opencast exploitation of filling sand, which was led to the ordinate of impermeable sediments lining the sand and gravel bed, i.e. up to about 222.0 m asl The areas depleted since 1977 are subject to reclamation by filling empty spaces with post-mining waste from hard coal mines. The reclamation is carried out in the range of ordinates from 222-230 m asl up to 255 m asl, i.e. to the ordinate representing the surface similar to the original one. Currently, within the boundaries of the Bór-West field, land reclamation has almost been completed by filling the excavation with post-mining waste from the underground mining sector. The Bór-East field was originally intended for recreational areas. Within the excavation boundaries, it was planned to create a water reservoir, for which profiling of its future bottom and slopes was carried out. During the works, a decision was made to make the reservoir shallow by filling the excavation to an ordinate of about 240 m asl, and finally, its construction plans were abandoned and the concept of completely filling the pit with rock material was adopted. The morphology in the sand mine area as of 2017 is presented by a numerical surface model (Fig. 3).

3 Geology

The area of the Maczki-Bór mine is characterized by a medium diversified geological structure, which was identified on the base of numerous boreholes carried out in this area and mining excavations of the opencast mine, and hard coal mines. The Quaternary, Triassic and Carboniferous formations occur within the boundaries of the filling sand deposit of the Maczki-Bór mine and in its immediate vicinity.

The Quaternary filled the riverbed of the Biała Przemsza River proglacial valley and is represented by the Pleistocene river sediments, filling an extensive erosion basin of the East-West extent. It is shaped in the form of gravel and fine, medium and coarse sands. Permeable sediments are locally separated by several clay-silt lenses with a thickness of 0.1 m to 8.2 m. The Quaternary sediments which are the subject of exploitation within the deposit are characterized by thickness from several meters in the south and north-west and north-east of the area to more than 50 m in the north and east. Generally, two layers of permeable sands and sands mixed with gravel are clearly visible in the Quaternary sediment profile, the upper with a thickness of 4 m to 10 m, and the lower with a thickness of 18 m. They are separated by clay-clayey sediments with an admixture of dust and silts of variable thickness from 0.2 m to 3.6 m. The whole is lined with impermeable stagnant sediments up to 12.7 m in thickness, which line the bottom and slopes of the proglacial valley of the Biała Przemsza River. As a result of many years of exploitation in the western part of the Bór-West field, the deposit was excavated to an ordinate of 236 m asl, and in the central and eastern part to an ordinate of +222 m asl (Fig. 4).

There are no Triassic deposits directly within the deposit. A few hundred meters south of the deposit boundaries, just behind the left bank of the Biała Przemsza River, there is the marginal part of the Chrzanów Triassic sediments. It is represented by variegated sandstone and shell limestone. In this zone, there is a dense network of tectonic faults, within which erosive

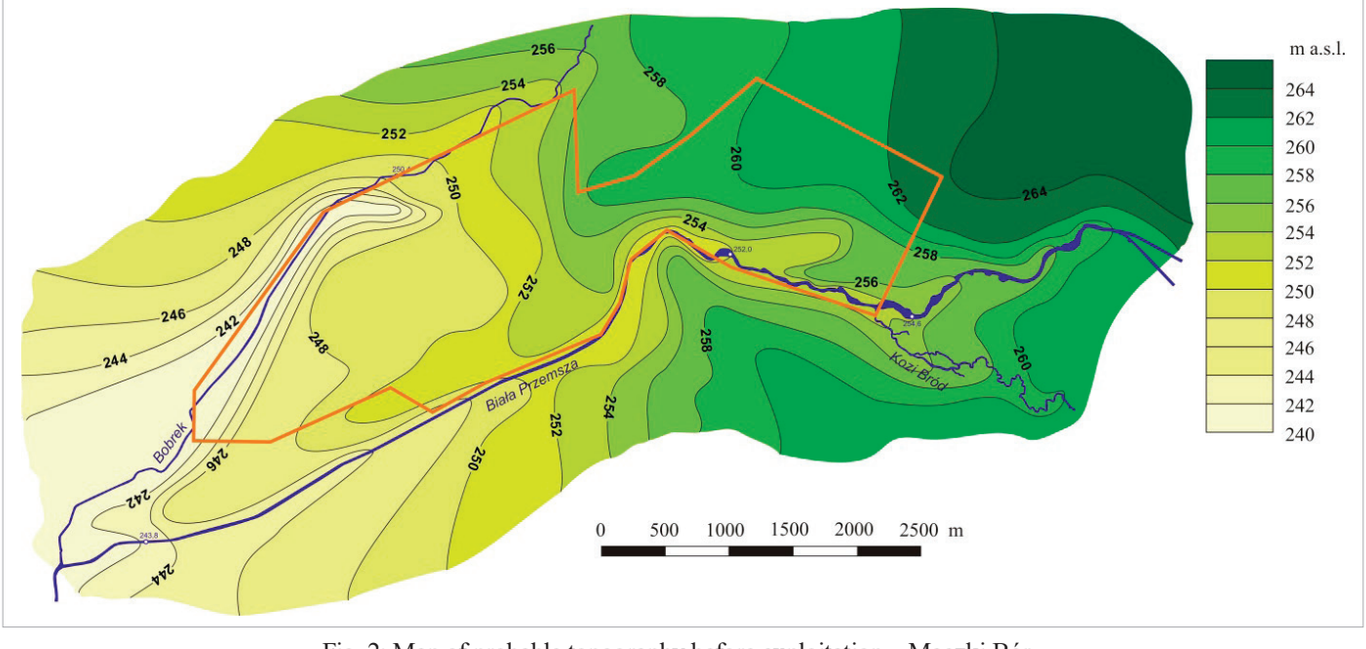

Fig. 2: Map of probable topography before exploitation – Maczki Bór.

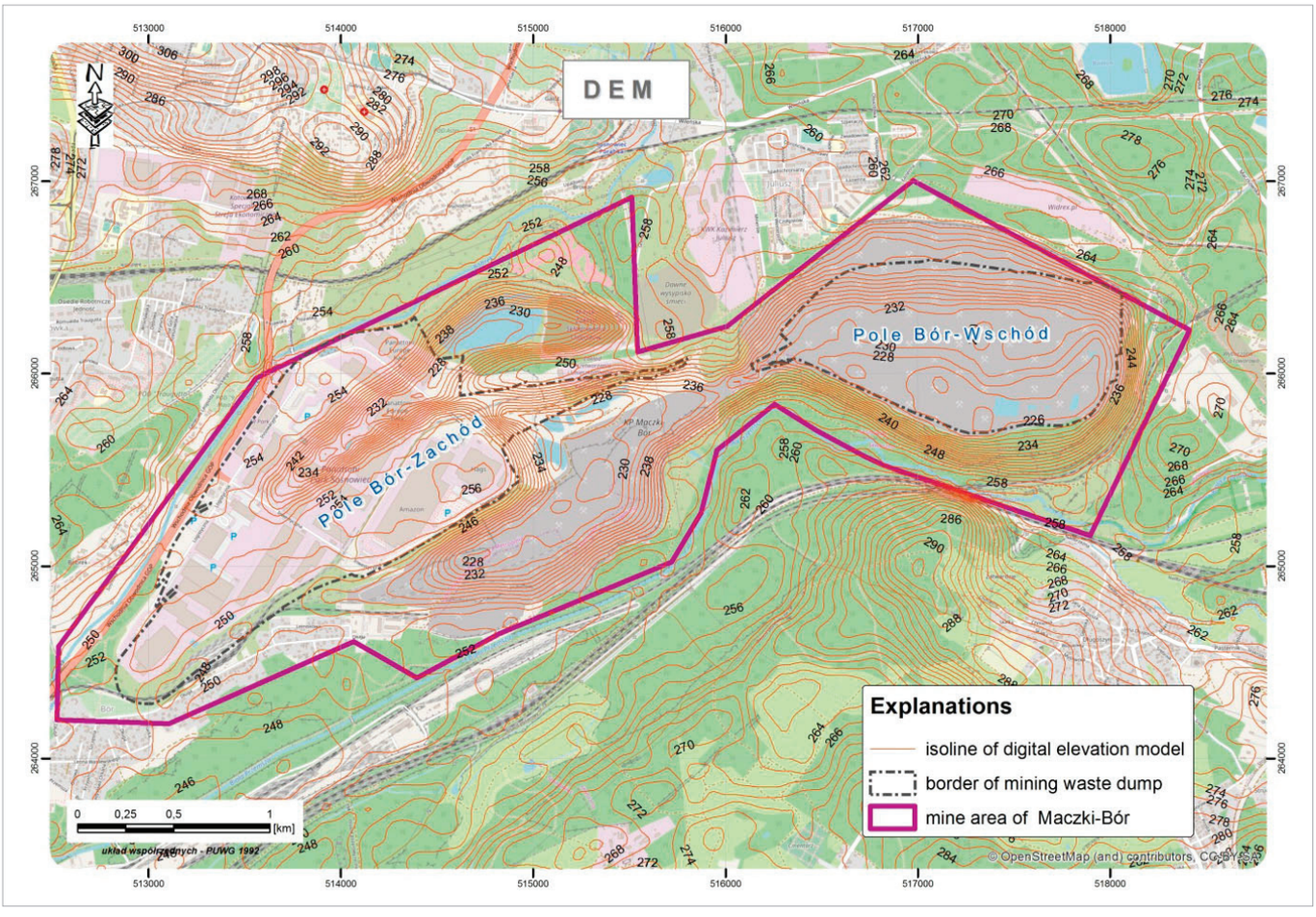

Fig. 3: Maczki Bór - numerical surface model - as of 2017.

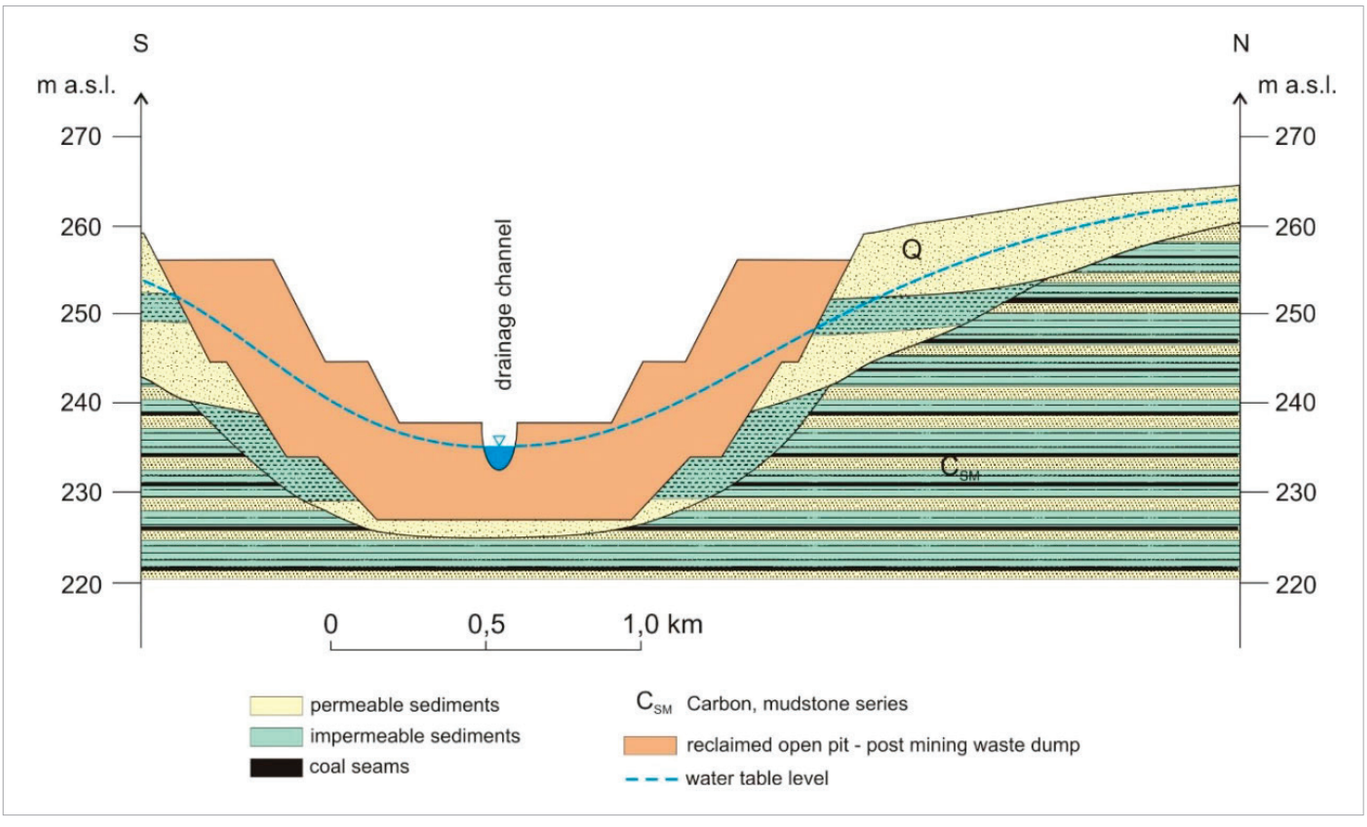

Fig. 4: An ideological geological and hydrogeological cross-section through the Maczki Bór open pit.

gutters are created, often used by surrounding surface watercourses, including Kozi Bród and Biała Przemsza. The Triassic carbonate sediments were also documented in the distance of one kilometre north-west of the Bór-West field. They are represented by various-grained, light sandstones with inserts of variegated clays (variegated sandstone), marls and dolomites (ret) as well as limestones with marl inserts (shell limestone). The Triassic sediments in this area do not build a dense cover but occur in the form of erosive patches with a thickness of 0 m to 150 m.

The Carboniferous has been documented throughout the Maczki-Bór mine. It is represented by the sediments of the Orzesze, Ruda, saddle, and older layers. In the significant part of the area, the surface of the Carboniferous roof at the same time forms the surface of the floor of the Quaternary formations.

The complex of Orzesze layers with a thickness of up to 205 m is represented by low-density, often sandy claystone as well as fine- and medium-grained sandstones up to about 16 m in thickness, with coal inserts, of which a dozen or so with a thickness of up to 2 m are classified as seams. Within the opencast, there were documented outcrops of seams directly below the Quaternary formations.

Below the Orzesze layers, there are Ruda layers with claystone and sandstone formation. They are usually grey claystone and fine- and medium-grained sandstones, forming banks with a thickness of a few to several dozen meters. Within the Ruda layers, there are hard coal seams up to 2.5 m thick, which are separated by thick sandstone banks about 28 m thick. The total thickness of the Ruda complex in the area of the filling sand deposits ranges from 37 m in the northern part of the Bór-West field to 136 m in its central part. In the northern margin of the mine, hard coal outcrops were documented.

The saddle layers are sandstones and claystone along with several coal seams. The 510 seam is characterized by a thickness of 1.9 m to 7 m, and its outcrops are located in the northern boundary of the opencast.

Within the boundaries of the Maczki-Bór mine, there is a network of intersecting tectonic faults in the Carboniferous and Triassic formations. Of the larger tectonic structures within the Carboniferous sediments, the Niwec and Bobrek fault zones with a 70 m drop to the north-east and the Helena, and Bora faults, with 20 m and 170 m drop to the south-west can be distinguished. In the tectonic fault network zone in the Triassic sediments, most often erosion gutters occur, used by surface watercourses (e.g. the Kozi Bród River and fragmentary the Biała Przemsza River).

4 Hydrological and hydrogeological conditions

4.1 Hydrological conditions

The opencast area is located at the bifurcation of two rivers: Biała Przemsza and Bobrek. In the vicinity of the pit, another smaller stream connects with Biała Przemsza River, i.e. Kozi Bród, which is a left-hand tributary. The Biała Przemsza River flows along the southern boundary of the Maczki-Bór mine in a latitudinal direction from East to West. It is a tributary of the Przemsza River, and connects with it in the district of "Jęzor", in the area of the former Niwka-Modrzejów hard coal mine. Due to the intensive activity of the underground and opencast mining in this area, the right bank of the Biała Przemsza River was protected by a flood embankment within the eastern field boundaries. In the area of the Bór-West field, it flows through a regulated, concreted riverbed, slightly moved south of the original location. The characteristic flow of water, average from

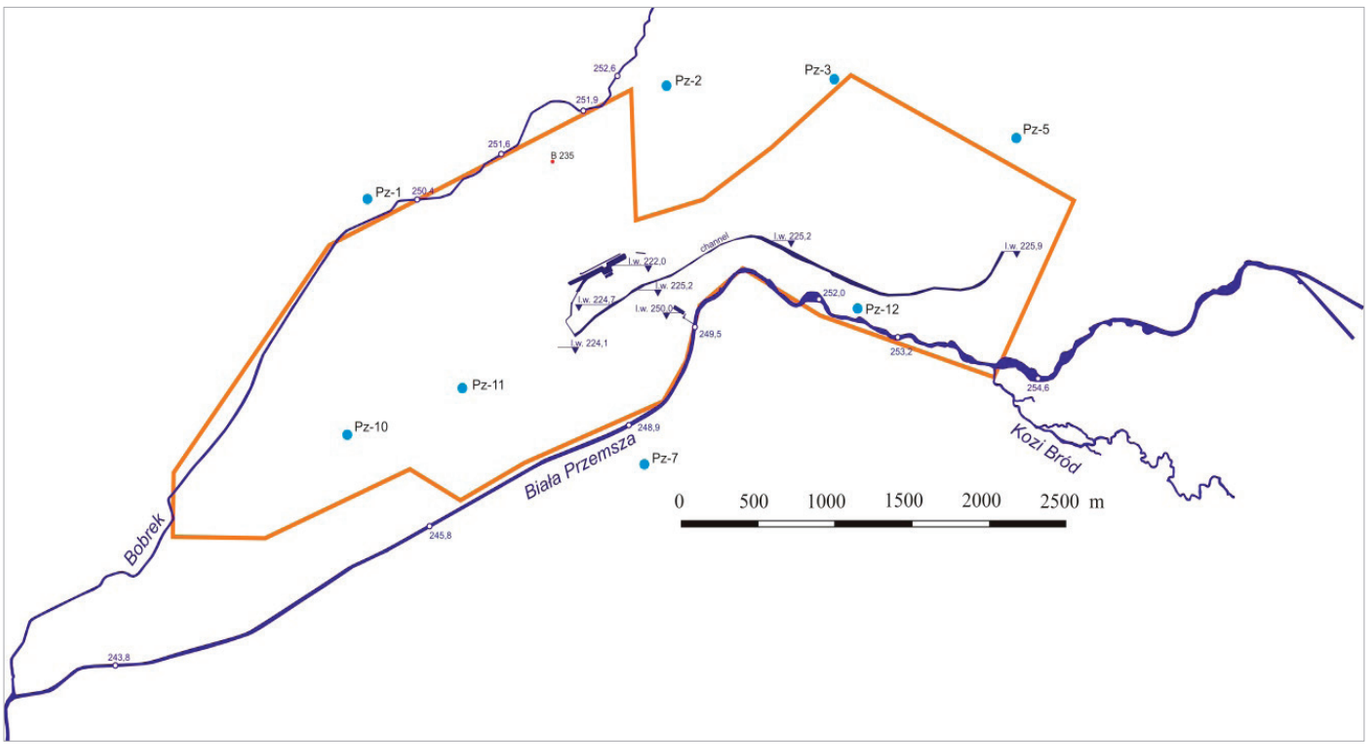

Fig. 5: The course of the hydrographic network in the area of the reclaimed opencast and the mine drainage system.

many years, at the gauge station at the mouth of the river to Przemsza River is about 7.5 $m^3 \cdot s^{-1}$. The characteristics of changes in flows in the river at the gauge glass below the point of water discharge from the opencast drainage are summarized in Fig. 6.

The Bobrek River makes a right-bank tributary of the Biała Przemsza River, with which it connects above this water gauge. The middle and lower course of the river was regulated, embanked and sealed. This ensures the protection of adjacent areas against flooding during high water levels in the river. According to the measurement data, the average water flows in the river at its mouth to the Biała Przemsza River are about 1.25 $m^3 \cdot s^{-1}$. The characteristics of changes in flows in the river at the water gauge station just before inflow to the Biała Przemsza River are summarized in Fig. 7

The drainage of the Maczki-Bór mine is carried out by a system of ditches converging in the central part to the East-West main channel. The water flowing into the opencast is drained to the Bór-West area through this channel to the main drainage sump, and from there is pumped to the Biała Przemsza River. The average water flow at the mouth of the channel into the river is approximately 0.38 $m^3.s^{-1}$ (Uniwersytet Śląski, Wydział Nauk o Ziemi, 2013a).

The course of the hydrographic network and the mine drainage system is shown in Fig. 5

4.2 Hydrogeological conditions

Within the boundaries and in the direct vicinity of the Bór-West and Bór-East fields of the Maczki-Bór filling sand mine there are aquifers associated with the permeable Quaternary, Triassic and Carboniferous formations. They are all characterized by different conditions of water supply, collection, and conduction, as well as diverse chemistry and water quality. Due to the intensive mining activity in this area, both opencast and underground, the original hydrogeological conditions in the Quaternary and Carboniferous underwent significant trans-formations. The extraction of a significant part of the sand deposit and filling the created space with post-mining waste resulted in the creation of an anthropogenic aquifer built of allochtonic sediments, which are different in terms of age and lithological, petrographic, hydrogeological, and physicomechanical formation from the primary deposits in the Qua-ternary. For the purposes of this study, the hydrogeological conditions in the Quaternary were characterized in two stages: for the area adjacent to the pit and for the conditions with-in the heap.

The aquifers of the Quaternary aquifer in the vicinity of the opencast occur within the Pleistocene sands and gravels that fill the proglacial valley of the Biała Przemsza River. In the region of the Bór-West field excavation, before commencing exploitation only one aquifer was documented, separated locally by a 1.5 m clay layer. The upper horizon with a thickness of about 7.5 m had a free water table, while the lower horizon with a thickness of 26 m and a tight water table was separated from the higher one by a clay layer. In the Bór-East field, there was one Quaternary aquifer with an average thickness of about 24 m. The slopes and bottom of the proglacial valley of the Biała Przemsza River are lined with a clay-clayey layer, forming an

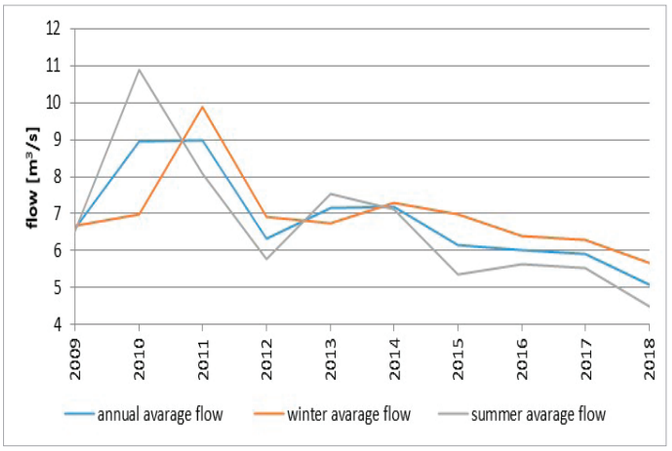

Fig. 6: A change in the average water flows in the Biała Przemsza River (average annual, average summer and average winter) in 2009-2018.

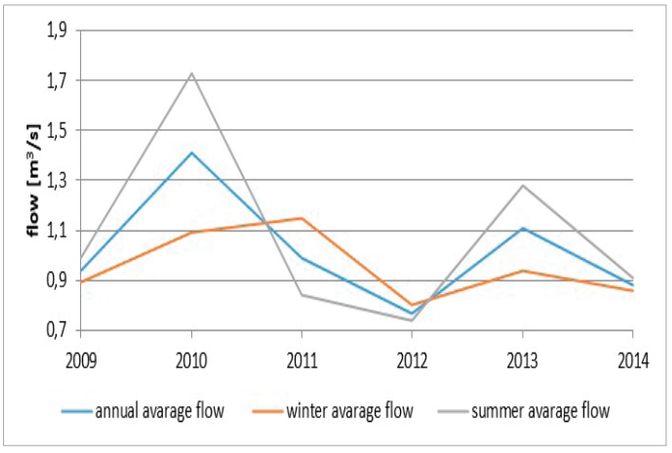

Fig. 7: A change in the average water flows in the Bobrek River (average annual, summer average and winter average) in 2009-2014.

impermeable cover on the almost entire surface of the filling sand deposit. It is lacking only in the north-west and south-east part of the Bór-West field and fragmentarily in the north part of the Bór-East field (Frolik et al. 2006).

The Quaternary formations (outside the opencast boundaries and also those that are subject to exploitation inside the opencast) are characterized by relatively high permeability. The value of the filtration coefficient ranges from $1.85 \cdot 10^{-4}$ $m \cdot s^{-1}$ in the Bór-East field area to $2.11 \cdot 10^{-4}$ $m \cdot s^{-1}$ for the lower horizon of the Bór-West field and $3.34 \cdot 10^{-4}$ $m \cdot s^{-1}$ for the upper horizon. The feeding takes place directly through the infiltration of precipitation, and the drainage of aquifers occurs through a system of ditches and channels draining water from the pit and heap to the mine sump, in which the water table is located on an ordinate of about 222 m asl In the deposit area, the original hydrogeological conditions have changed as a result of many years of exploitation and drainage. A forced groundwater regime was established, creating an ellipsoidal depression crater measuring 6.5 km by 2-3 km, roughly reflecting the shape of the pit. The flow direction of the Quaternary waters stabilized here radially towards the sump of the main drainage pumping station. In this region, the lowering of the groundwater table relative to the original level is nearly 27 m. In the remaining area, the

groundwater table is on the ordinates from 225 m asl up to 235 m asl, and the depression relative to the original location is 24 m. Water flowing into the mine excavations is not used economically and is drained through the drainage systems to the Biała Przemsza River.

The quantitative and qualitative monitoring of groundwater is carried out in an observation network, in which elements (wells and piezometers) are located inside the opencast and on its foreground. In addition, the manager of the municipal landfill (Sosnowiec City Hall), located inside the opencast, monitors the state of water around the landfill in a separate piezometer network. Fig. 8 presents a chart of changes in the depth of the groundwater table at the selected observation points. The groundwater table is measured twice a year. The observation network for the filling sand mine includes 10 piezometers:

- 5 in the foreground of the Bór-West field and 5 in the Bór-East field (Projekt monitoringu wód, 1994).

East of the Bór-East field, in an area with very favourable parameters, a quaternary main groundwater reservoir was separated - GZWP 453 Biskupi Bór. The maximum thickness of the aquifer is 45 m, and the water table mainly of a free nature lies at a depth of 5 m to 30 m. The filtration coefficient for this area ranges from $2{,}7 \cdot 10^{-5}$ m·s^{-1} to $7{,}1 \cdot 10^{-5}$ m·s^{-1}. This reservoir is characterized by high storage capacity, resulting from the high renewability of resources.

The Triassic aquifers occur within the Upper Triassic sediments, shell limestone, ret, as well as the lower and middle variegated sandstone. The Upper Triassic aquifer is associated with a claystone and mudstone complex with small layers of sandstone and limestone. These are most often levels with a lightly tensioned water table. Shell limestone level occurs within the limestone and dolomite. It is a crevice-karst centre with the predominantly tight water table, lying at a depth of 5 m to over 100 m. The feeding takes place directly on the outcrops or indirectly through the higher placed Quaternary sediments. Under natural conditions, this level was drained through streams and deeply indented river valleys. The level of shell limestone is separated from the ret formation by a marly series. Both of these levels make an aquifer complex of the carbonated

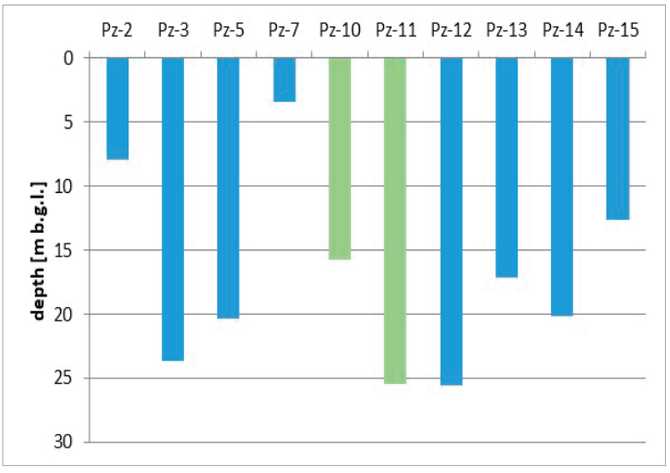

Fig. 8: Depth to the groundwater table measured in piezometers of the sand mine observation net-work. The piezometers located inside the heap within the Bór-West field are marked in green.

series with very good hydrogeological properties. Within them, two fracture-karst-porous main groundwater reservoirs were separated: GZWP 329 Bytom and GZWP 452 Chrzanów. The level of the lower and middle variegated sandstone occurs within sandstones located between a series of clay and mud sediments. The groundwater table has most often a tight character. This level is often in hydraulic connection with the lower located Carboniferous levels.

The Carboniferous aquifer is associated with packages of sandstone and conglomerate formations of varying thickness. In the area in question, the formations of the mudstone series and the Krakow sandstone series have been documented. This level, lying at a depth of 28 m to 290 m, is usually characterized by a tight water table. Locally, the water table may be free within the outcrops. The value of the filtration coefficient ranges from $2{,}0 \cdot 10^{-7}$ m·s^{-1} to $1{,}5 \cdot 10^{-5}$ m·s^{-1}. The hydrogeological studies have shown the existence of three aquifers. The first and second levels are within the sandstones of the mudstone series. They are characterized by a thickness of 9 m to 23 m and of 5 m to 18 m, respectively. The third level is located within the Ruda layers and is characterized by a thickness of 3 m to 12 m, and a filtration coefficient of about $9.45 \cdot 10^{-5}$ m·s^{-1}. The Carboniferous aquifer is fed through the Quaternary sediments in the areas where there are no insulating formations in the Quaternary floor and in the Carboniferous roof. The amount of infiltration depends on the lithological formation of the deposits found in the Carboniferous roof and on the type of layers building the floor of the located above the Quaternary level. In places where the thickness of the insulating layer in the Quaternary floor exceeds 2 m, the infiltration is clearly difficult. The areas with convenient infiltration occur in the places without any isolation. These zones are located in the south, in the centre and in the east of the mine. The drainage of the Carboniferous floor takes place through the mining excavations and the deeply indented valley of the Biała Przemsza River (Uniwersytet Śląski, Wydział Nauk o Ziemi, 2013b).

5 Climatic conditions

There is a transient climate in the Maczki-Bór mine area with a large impact of the oceanic and continental climate. The inflow of variable baric systems and tropical, arctic and polar air masses cause great variability and variety of weather. The air temperature in the Maczki-Bór mine is developing in a manner characteristic of the highlands of Poland. The average annual air temperature is 8 °C. The hottest month is July with an average temperature of 18.1 °C and a maximum temperature of 35.8 °C. The coldest month is January with an average temperature of -3.2 °C, and the lowest temperature reaching even -30 °C. The average annual total precipitation is about 660 mm. The highest average rainfall is recorded in July and reaches 100 mm, while the lowest total rainfall occurs in February and amounts to an average of 31 mm. Summer rainfalls are often heavy. The changes in the amount of precipitation in the years 1989-2019, on the base of data from the meteorological station located in Jaworzno, are summarized in Fig. 9.

In the vicinity of the mine, the average snow cover time is up to 115 days a year, while the thickness of the snow cover is small and amounts to an average of 8 cm (15 cm in February).

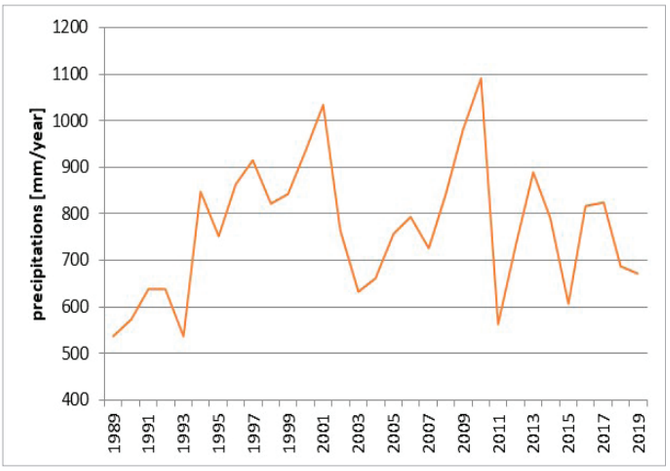

Fig. 9: Changes in the amount of precipitation in the area of the Maczki-Bór mine, in the years 1989-2019.

Western winds dominate in this area (NW, SW, and W), which blow for nearly half a day of the year. East winds have a 14% share, and silence accounts for 12% of the annual time. The duration of the growing season is 210-220 days.

6 Geotechnical problems

The lump heap is formed in a safe manner, ensuring optimal escarpment stability and an appropriate degree of anthropogenic soil compaction and its load-bearing capacity, enabling the land to be transferred for investment purposes in the future. Laboratory tests indicate (regardless of the storage time of the material) its good susceptibility to compaction during the formation of the heap. Also, based on the results of testing the geotechnical conditions of the ground, carried out in the reclaimed area of the Bór-West field (Wojnar 2002), it can be stated that the values of boundary resistance and deformation modules of the ground of the reclaimed area are close to the values characteristic for the natural soils. Therefore, the reclaimed area can be the base for investment activities.

Geotechnical tests carried out at the request of the entrepreneur (Łączny et al. 2011) allow the separation of four geotechnical layers within the waste area within the reclaimed part of the Bór-West field, each with a different state of consistency. Depending on the time of their storage, depth of occurrence, their irrigation, petrographic and mineralogical composition, the waste occurs in a semi-compact, hard-plastic, plastic and soft-plastic state. The differences in geotechnical parameters are clearly visible between the layers (GIG, 2010).

7 Reclamation

Technical reclamation of the opencast excavation consists of filling the empty space after the excavated Quaternary sand deposit with Carboniferous compact rock material. It is the waste from mining and processing works in almost all hard coal mines in the Upper Silesian Coal Basin. Since the beginning of reclamation, i.e. from 1977, over 100 million tonnes of waste have been deposited in the excavation. The power plant waste, i.e., ash and slag from hard coal combustion, was also used until 2006, to which the mine returned after 2010. Currently, 233 ha of the land has been reclaimed, and a further 306 ha is reclaimed.

A part of the reclaimed area of the Bór-West field was designated for investment purposes and the remaining area (including a part of the Bór-East field) is intended for green areas.

The land reclamation began in 1977 in the western exploitation field and its purpose was to fill the excavation from an ordinate of 222-230 m asl to an ordinate 255 m asl, i.e. to an ordinate close to the original ground surface. Originally, i.e. until 2003, the waste was deposited using stackers, and the initial mixing of waste took place in the excavation ditch. The heap was formed about 60 m from the axis of the stacker and then was filled the void formed between the place before the heap and the escarpment. From 2003, the stackers were abandoned in favour of the wagon-bulldozer technology, which was also moved to the eastern field of the mine. In order to prevent spontaneous combustion, fire prevention is used in both fields. In 1994, to improve the effectiveness of fire prevention on a reclaimed facility, it was developed and implemented jointly with the Central Mining Institute in Katowice a fire prevention technology using power plant waste in the form of fly ash. This technology consisted of sealing the body filling the excavation with fly ash distributed on the heap fronts in the form of water suspension, so-called ash pulp. It was placed in the escarpment ditches 500 m long and 4-5 m wide, which constantly rose up towards the topsoil of the reclaimed area.

When spreading by escarpment ditches, the ash pulp penetrated the heap and filled in the inter-grain voids of the lump formed from coal waste. This procedure caused the effective

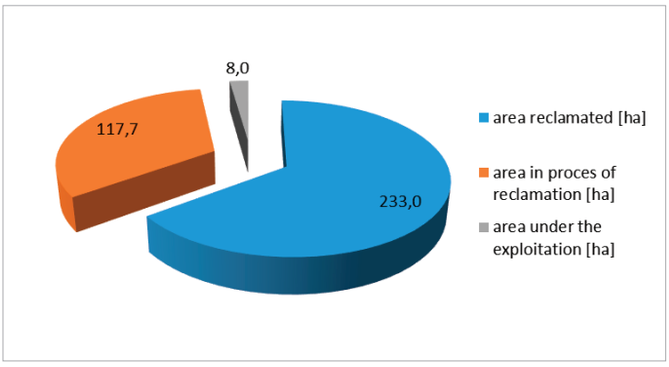

Fig. 10: Bór West field - areas covered by exploitation and recla-mation.

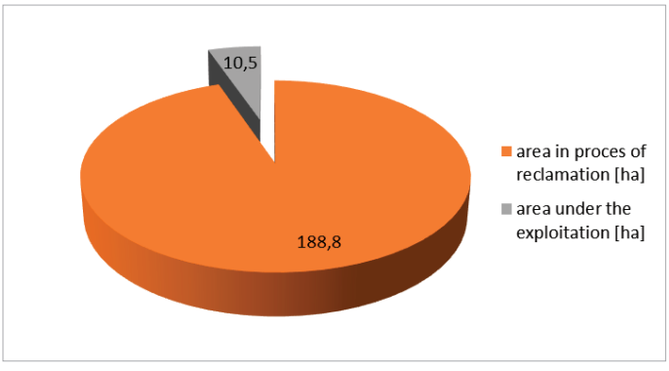

Fig. 11: Bór East field - areas covered by exploitation and recla-mation.

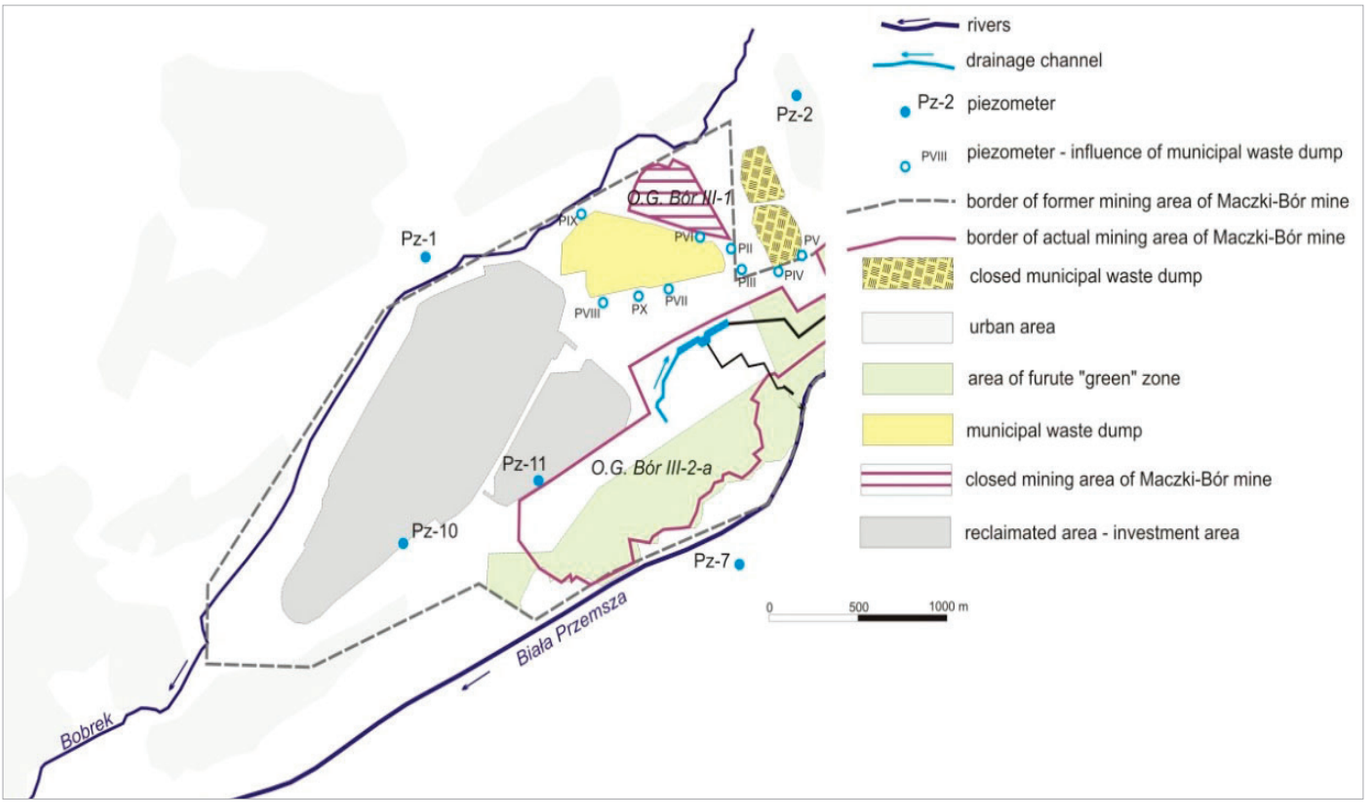

Fig. 12: Bór-West field - map of the excavation development.

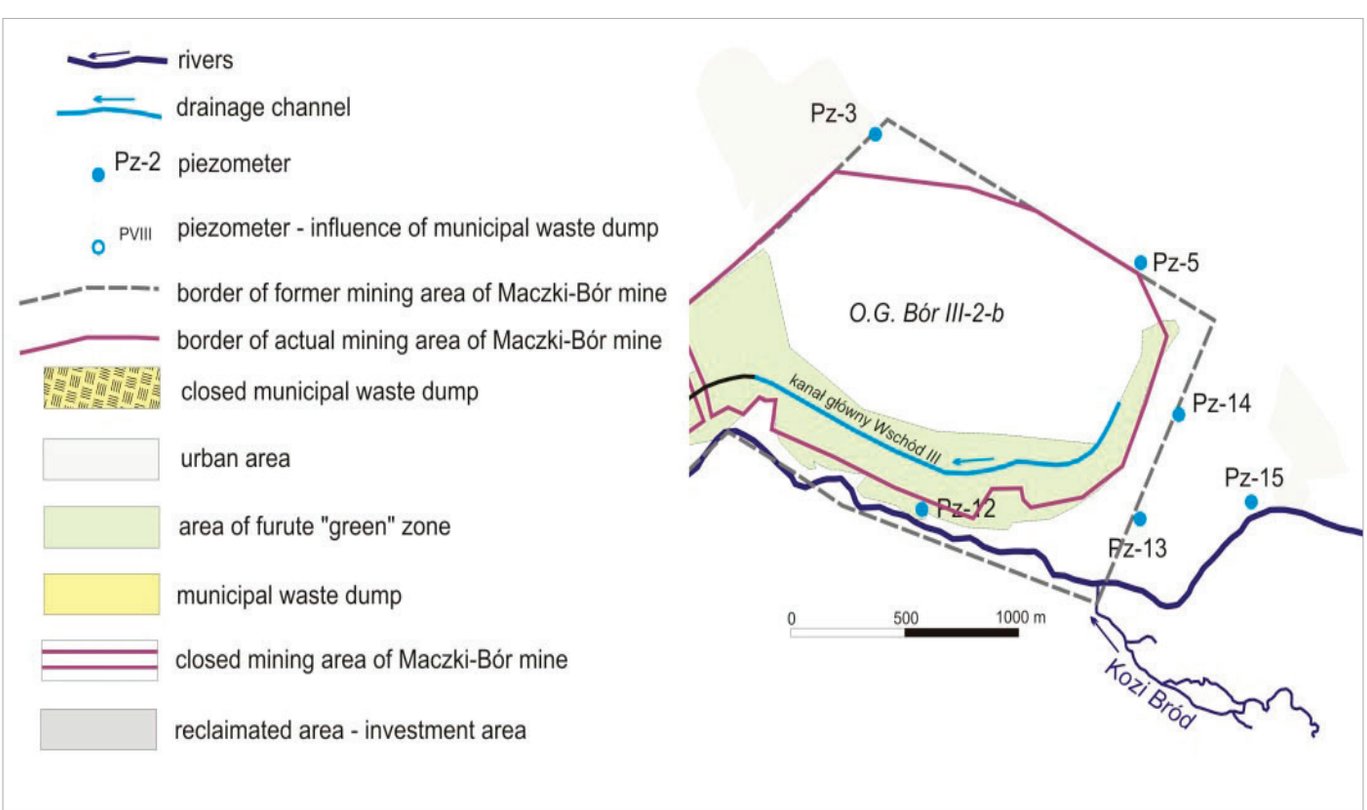

Fig. 13: Bór-East field - map of the excavation development.

Fig. 14: The reclaimed part of the Bór-West field for investment purposes.

protection of the lump heap against the self-ignition. Within the Bór-West field, the selected fragments of topsoil were covered with a 30 cm layer of soil-forming material.

Within the Bór-East field, the reclamation is carried out in parallel with residual exploitation. According to the current design, filling the excavation basin with waste will be carried out to an ordinate of about 250 m asl The original plans for reclamation and land development plans assumed the creation of a water reservoir in this area, the bottom of which was to be on an ordinate of about 240 m asl Ultimately, this concept was abandoned, and the area in the future is to be allocated to forest and investment areas. According to the design, the reclamation is carried out by creating embankments made in layers up to 3.0 m thick. After laying the layers, they are compacted by driving several times with a crawler bulldozer or/and a vibrating roller "along the trail" until the required compaction coefficient Is $\geq$ 0.95 is achieved. The compacting is aimed at minimizing the filtration of rainwater through a lump of waste, filling it. Similarly to the Bór-West field reclamation process, in order to prevent self-ignition, the appropriate fire prevention technologies are used. Since October 2006, for about 4 years it was applied only fire prevention technology with the use of clay material coming from local sand exploitation. After 2010, the mine returned to the use of fire prevention based on pyrogen--free materials produced on the base of ashes and slags from hard coal combustion (ERM Polska, 2008).

So far, in the reclaimed opencast area as part of fire prevention, in addition, the following were used (GIG, 2007):

- the technology for incorporating clay-clayey material into the body filling the excavation,
- the technology of fire prevention using ash-water pulp (a patent belonging to the Company),
- the technology of fire prevention using inert materials and power plant waste,
- the technology of fire prevention using the waste of slime consistency,
- the technology of layered embedding of building debris using fine-grained mining waste,
- the technology of layered embedding of building debris using soil from excavations,
- the technology of layered embedding of building debris using fine-grained moist power plant waste,
- the technology of embedding of moist power plant waste
- the technology of embedding of building debris using ash-water pulp
- the technology of embedding soil from excavations.

During the first stage of filling the basin of the Bór-West and Bór-East excavations, the post-mining waste came from a dozen or so coal mines and represented the formations of several lithostratigraphic series:

- Krakow Sandstone Series (KSP),
- Mudstone Series (SM),
- Upper Silesian Sandstone Series (GSP).

Currently, the post-mining waste comes from two lithostratigraphic series (KSP) and (GSP), and their suppliers are about 5 mines.

The waste suppliers are obliged to provide the entrepreneur managing the opencast with information on, among others, their origin and mineralogical, petrographic and granular composition. Fresh material is dominated by fractions <30 mm and 30-80 mm. In the total rock mass, they constitute about 80%. The granulometric diversity of fresh waste resulted from the presence of various petrographic varieties of coal rocks in the material. In petrographic terms (Łączny et al., 2011), the waste composed from Carboniferous mud-stone, claystone and sandstone dominate in the reclaimed Bór-West field. Clay minerals, feldspar and quartz are dominant components. Pyrite, siderite, dolomite and calcite are less common. As a result of weathering transformations of iron sulphides and carbonates, the secondary minerals such as gypsum and halite, and iron oxide-hydroxide group minerals were formed.

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