Povrchový důl Lubstów

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Abstrakt

Bývalý povrchový důl Lubstów, jeden z dolů v těžební oblasti Konin v Polsku, s jezerem vzniklým po ukončení těžby, byl vybrán za jednu z hlavních výzkumných oblastí v projektu RAFF. Tato studie pojednává o komplexních geologických, hydrogeologických a morfologických vlastnostech studovaného území, poskytuje také krátký přehled použitých rekultivačních metod a probíhajícího procesu napouštění jezera po ukončení těžby.

Lubstów open-pit

Former Lubstów open pit, one of the pits located in the Konin mining area, Poland, with its post–exploitation lake has been selected as one of the main research sites in the RAFF project. The present study discusses complex geological, hydrogeological and morphological features of the study area, it also gives a short overview of the applied reclamation methods and an ongoing process of the post–exploitation lake flooding.

Tagebau Lubstów

Der ehemalige Tagebau Lubstów, ein der Tagebaue auf dem Gebiet Konin im Polen,mit dem See, der nach dem Einstellen des Bergbaus entstand, wurde für ein der hauptsächlichen Forschungsgebiete im Projekt RAFF ausgewählt. Diese Studie behandelt komplexe geologische, hydrogeologische und morphologische Eigenschaften des geprüften Geländes und bietet auch eine kurze Übersicht der eingesetzten Rekultivierungsmethoden und des laufenden Prozesses der Füllung des Sees nach dem Stilllegung des Kohleabbaus.

Klíčová slova: povrchový důl Lubstów, oblast Konin, morfologie, geologie, zvodeň, rekultivace dolu.
Key words: Lubstów open pit, Konin area, morphology, geology, aquifer, mine reclamation.

1 General informations

Administratively, the Lubstów deposit area is located in the Wielkopolska Region, in the Konin County, within the Sompolno municipality, while a fragment of the western and northern parts of the mining area is situated within the Ślesin and Wierzbinek municipalities. The deposit is 3.8 km long in the NW - SE direction and is 4.3 km wide.

Construction of the Lubstów open-pit was completed in 1982 and until the end of exploitation on the 7th of April 2009 it was the largest open-pit in Konin area, characterized by the most favourable mining and geological conditions in KWB Konin company. During its operations, mining activities caused a significant land surface transformation such as:

- creation of an external dump with a height of ca. 30 m reclaimed as forests,
- creation of an internal dump up to the level of neighbouring area,
- creation of a final pit of a depth of ca. 80 m.

The open-pit dump is an example of agricultural and forestry remediation - 70 ha of forests were planted there. The predominant direction of reclamation of the internal waste heap is agricultural, while a water reservoir of an area of approximately 480 ha is being created in the final excavation pit. The slope of the reservoir was strengthened with bushes and grass, and additional protection in the form of a hydrogel was used. Bicycle and walking paths have already been marked. The land development project around the lake, agreed with the authorities of the Sompolno municipality, provides for creation of a base for tourism, sailing and motorboat sports.

1.1 Site morphology

According to geographical division of Poland, the research area is located in the sub-province of the Wielkopolska Lakeland, in the macroregion of the Wielkopolska-Kujawy Lakeland and belongs to three mesoregions: the Gniezno Lakeland, the Inowrocław Plain and the Kujawy Lakeland.

In the morphology of the land, two most important types of land forms can be distinguished. They are: moraine plateaus with indistinct hills, and great valleys such as ice-marginal valleys or tunnel-valley lakes. The plateaus are associated with the Baltic glaciation period, with terminal moraines of the Leszno and Poznań phases. They form hills of a height of 100-140 m asl. The hills of the W - E direction is crossed by tunnel valleys of the Grójec Canal (80-86 m asl), lakes formed in a tunel valley along a line of the Warta - Gopło Canal (80-85 m asl) and tunel valleys of the Powidzkie and Wilczyńskie lakes. The surface of the area generally shows a slight, gradual decline towards the north, rising within terrace levels of the Noteć River.

The drainage axis in the southern part of the area is the Warta River Valley, the northern part is drained by the Noteć

Tab. 1: Basic characteristics of lake Lubstów.

Flooding	since 2009
Surface level of the lake	83,5 m asl
Surface area of the lake*	480 ha
Max depth	55 m
Location of the lake	The Lubstów lake is situated in the Konin area in the basin of Kanał Grójecki
Cadastral territories	Sompolno municipality; Police and Zofia geodesic precincts
Water source	Water from the turned off mine drainage system; water transfer from the Lubstowskie Lake, water from the Wierzbie Canal and mine waters from the Drzewce open-pit
Limnologic characteristics	Anthropogenic exorheic lake

River, which height to the north of the open-pit ranges from 82.4 m asl up to 86.0 m asl, and at the river mouth by the Gopło Lake is 77.0 m asl The largest surface water reservoir in the area of the existing excavation pit is the Lubstów Lake.

The original morphology of the study area was transformed in some places as a result of brown coal opencast mining. The main element that changes the morphology of the land are the opencasts reaching down to almost 70.0-80.0 m below sea level. - Lubstów Mine and 30.0-40.0 m below sea level - Drzewce Mine – Bilczew Field. Many hills were also formed by mining waste material or material from ditches and drainage channels.

1.2 Climatic conditions

The Lubstów opencast area is located at the border of Wielkopolska and Kujawy regions, which is subject to both oceanic weather influences i.e. inflows of air masses from the west and continental weather influences from the east. The influences of polar air masses coming from the Atlantic prevail here. According to the agroclimatic division of Poland by Gumiński (), the area in question is located within the range of the Central District (VII). It is a region with the lowest annual precipitation in Poland, which is around 500-520 mm. Evaporation is about 440-470 mm. The average annual air temperature is about 8°C. The number of air frost days varies from 100 to 110, and the snow cover duration is 50-80 days. The growing season lasts from 210 to 220 days. Western winds with an average speed of 2.5-2.7 m/s dominate. According to the division of the Wielkopolska Lowland into climate regions by Woś (1993), the analysed area is located in the Central Wielkopolska Region (XV), where the weather is warmer than in other climatic regions and at the same time cloudy without precipitation (on average 38.7 days). There are also often days with moderate frost and cloudy weather without precipitation. On the other hand, moderately warm and sunny days without precipitation (on average 9.4 days a year) and moderately warm days with large cloud cover without precipitation (on average 11.6 days a year) are observed less frequently.

1.3 Reclamation

In 1980 Head of the city and municipality of Sompolno made a decision determining the di-rections of reclamation and development of post-mining areas of the Lubstów open-pit. For certain parts of the mine the following reclamation measures have been planned:

- slopes of the external dump – forest reclamation;
- surface of the external dump - forest reclamation;
- surface of the internal dump - agricultural reclamation;
- slopes of the internal dump - forest reclamation;
- the final pit – water reclamation;
- auxiliary areas – forest and agricultural reclamation.

In 2009 internal dumping was finished. The southern and eastern slopes of the dump are the slopes of the water reservoir.

Final shape of the slopes and possibility of erosion, aesthetic and economic considerations caused that the following biological restoration method was adopted:

- above the water level in the reservoir:
  - slopes of the water reservoir – thorny bushes and wicker,
  - benches - sodding by sowing a mixture of grass and papilionaceous plants,
  - area adjacent to the reservoir slopes – sodding and afforestation,
  - underwater slopes – sodding by sowing papilionaceous plants, wicker.

Overall idea of reclamation was adopted in such manner that the reclaimed areas can be used for recreation, retention, fishing, water sports etc. It is planned that near the pit lake water sports centre, places for children to play and relax, holiday facilities and transportation routes will be created. Ultimately, Lubstów pit lake will have area of ca. 480 ha, water level in the lake will be at 83.5 m asl and maximal depth - 55 m.

2 Geology

The study area is located within the Mogilno-Łódź Basin, which is characterized by relatively shallow Mesozoic sedimentation.

The Tertiary bedrock consists of Upper Cretaceous (Maastrichtian) sediments such as marls, sandstones, limestones and the youngest sediments - mudstones. Marl series shows severe cracking. The total thickness of the Cretaceous deposits is unknown, according to data obtained from drilling, it is estimated at 800 - 3000 m. The top surface of the Tertiary deposits dips northward.

The Upper Cretaceous deposits are covered by a transitional series, which are older Tertiary deposits represented mainly by weakly compacted, grey-green, fine-grained sandstones with a significant content of calcareous grains, as well as mudstones and clay deposits. The thickness of this series does not exceed 70 m.

Fig. 1: Lubstów open-pit during operations (KWB Konin).

Fig. 2: Preparation of final slopes in Lubstów open-pit (KWB Konin).

In the study area Tertiary is represented by Oligocene, Miocene and Pliocene deposits. The thickness of Tertiary deposits is a result of sedimentation influenced by the Mesozoic surface morphology and erosion, which led to significant destruction of the sediments until their complete removal. The thickness of the Tertiary deposits ranges from a few to about 100.0 m. There is a total lack of Tertiary deposits mainly in the Warsaw-Berlin ice-marginal valley in the area from Konin Town through Kramsk, Krzymów and Koło towns and north of it in the region of Osiek Mały, Dęby Szalcheckie and Sompolno.

Above, there are the Lower Oligocene deposits built of fine-grained glauconitic sands of a thickness of several to several dozen meters. Above, there lies a several-meter thick series of fine-grained grey sands of the Middle and Upper Oligocene.

In the Lubstów region, the brown coal deposit series consists of two coal seams separated by a layer of sands, silts and brown coal lenses from a dozen centimetres to a dozen meters thick.

The lower coal seam (I) - Oligocene, reaches the greatest thickness up to several dozen meters in the central part of the basin, and outside from it the thickness of the coal seam gradually decreases in all directions until it was completely gone. This coal seam is compact and homogeneous, only in the marginal parts it is split into several interlayers.

The upper coal seam (II) – Miocene, is separated from the lower seam by a series of sandy sediments, consisting of fine-grained and silty sands, locally carbonaceous, with a thickness of several to 10 meters. The coal seam is developed in the form of a compact layer of a thickness of 3-11 m, intercalated in places with fine-grained sands, silts and clays. It is characterized locally by strong sheet erosion connected with ice-melt water processes. Miocene coal-overlying series is not spread nor thick. It is formed by clays and clayey silts, belonging to the Poznań layers of the Middle and Upper Miocene.

The Pliocene deposits closing the Tertiary sedimentation cycle in this area were, apart from a few fragments, destroyed as a result of a dynamic activity of the ice sheet. These are clay deposits with fine inserts of fine-grained sands of a total thickness of up to 35 m.

Quaternary deposits are located on heavily eroded deposits of Neogene, Paleogene or directly on the Upper Cretaceous and occur throughout the entire study area. The Quaternary is represented by the sediments of the South Polish Glaciation, Masovian Interglacial period, Central Polish Glaciation, Eemian Interglacial period, Baltic Glaciation and Holocene.

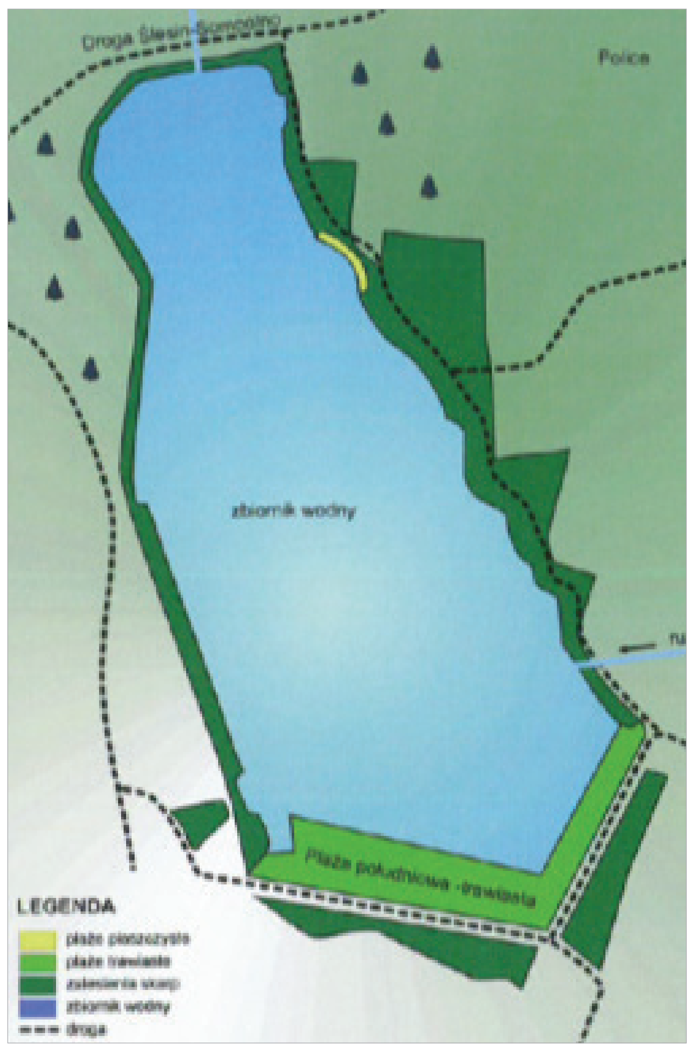

Fig. 3: Lubstów pit after reclamation and flooding (Kasztelewicz, 2010).

The thickness of the Quaternary deposits is variable and depends on the extent of erosion. The average thickness of the overburden is about 50 m. The exception are areas of sheet and tunnel erosion, where the maximum Quaternary depth is 120.0 m. The location of eroded tunnels generally imitates tectonic zones of the coal deposit.

The oldest glacial sediments here are one or two layers of till of the South Polish Glaciation, locally separated by sands and fluvioglacial mudstones. The deposits of the South Polish Glaciation reach a thickness of several to several tens of meters. During the Masovian Interglacial period, denudation and erosion processes dominated, sedimentation occurred mainly in river valleys, which were filled with sands and gravels of a varying thickness, on average ranging from a dozen to 20.0-30.0 m.

In the study area fluvioglacial sands and gravels and tills form two main levels: the lower level consists of sandy tills of the Central Polish glaciation, separated by a layer of sands up to several meters of thickness, and by clays and silts of ice-marginal lakes, of a total thickness of up to 30 m; the upper level is formed by sandy tills of the Main Baltic Glaciation stage.

Above the level of the lower tills, over a significant area spread ice-marginal lake deposits (mainly silts - Eemian interglacial period) of a variable thickness. Above, there are fluvioglacial sand and gravel sediments, underlying the upper level - the Baltic Glaciation deposits. Holocene deposits are soils formed on tills and sands, in the area of river valleys they are mud, peat and gyttja. The thickness of these deposits is on average 5.0 m, locally up to 10.0 meters in the river valleys.

3 Hydrological and hydrogeological conditions

The area of the Lubstów brown coal deposit and currently the final pit belongs to a drainage basin of the Warta and Noteć rivers with a drainage divide running through the centre of the area (latitudinally across the pit).

Warta River is located approximately 18.0 km south of the centre of the open-pit, and Noteć around 2.5-3.0 km north of the centre of the open-pit. The main watercourses occurring in the area of the open-pit are: the Warta - Gopło Canal (Ślesin Canal), the Noteć (Noć) with the tributaries of Pichna River and the Grójec Canal.

The Warta- Gopło Canal (Ślesin Canal) connects the Warta, Noteć and Wisła waterways - it was built in 1950. Its length is 32.0 km. In the study area, the Ślesin Canal connects the Warta River with the Noteć River. The waterway consists of: Ślesin Canal (Morzysławski) connecting the Warta River with Pątnów Lake and the lakes: Pątnów, Mikorzyn (Wąsowsko - Mikorzyńskie), Ślesin and Czarne Lakes. In the northern part of the Ślesin Lake, at the Gawrony watergate, a drainage divide was located separating the Warta and Noteć basins (the peak position of the canal). The canal performs navigable functions and is also a receiver of post-mining waters from the opencasts of the Konin Brown Coal Mine. A complex of water reservoirs constituting the central section of the Ślesin Canal, the so-called Konin Lakes, was included in the cooling system of the Pątnów and Konin power plants. The water flow in the canal, regulated by culverts and pumping stations, takes place in two directions - south to the Warta River or north to the Noteć River by a system of lakes or discharge and inlet channels. The water level in the Ślesin Lake is also regulated by the discharge channel, which supplies cooling water from the Licheń Lake.

The northern part of the area is drained by the Noteć River and its right tributary, Pichna River. The Noteć River flows from the Brdowskie Lake at the elevation of 101.6 m asl, and from the elevation of 91.3 m asl it takes an outflow from the Lubotyński Lake, then below the town of Sompolno it flows into a latitudinal peatland valley and flows in a north-west direction until it connects with the Warta-Gopło Canal. In periods of high-water levels, the Noteć River valley in this region is a zone of potential flooding. Along this section, the Noteć River has only one tributary, the Pichna River - its waters are regulated by a weir located in the vicinity of Rudki brickyard. The Noteć River, after connecting with the Warta - Gopło Canal, goes north and flows into the Gopło Lake at an altitude of about 77.0 m asl

The south-west part of the area is drained by the Grójec Canal, which forms, together with the Mostkowskie, Mąkolno, Szczekawa and Lubstowskie lakes, one system of the Grójec Valley (so called in the area starting from the Lubstowskie Lake and divided in the northern part by the outer mining waste dump of the Lubstów open-pit). Some of the water from the Lubstów open-pit was discharged via a network of mine ditches north to the Noteć River, the other part via the Lubstowskie Lake, along the Grójec Canal to the Warta River. The water level in the Lubstowskie Lake is regulated by a weir located in its eastern part, while water flows in the Grójec Canal are additionally regulated by a weir located below the opencast mining area.

The Lubstowskie Lake originally had an area of about 0.79 km^2. The original location of the water level was between 85.8 and 86.1 m asl In the early 1970s, the lake was partially embanked and artificially raised. A minimum elevation of water damming is +84.0 m asl and for a maximum damming the water level is elevated up to +88.0 m asl The lake's capacity is about 2,142.7 thousand. m^3 with a surface area of approx. 85.3 ha. The depth of the lake ranges from 0.5 m to a maximum of 6.0 m in the western part, with an average depth of about 2.5 m.

The purpose of the lake embankment and increasing its damming was water storage for spring and summer irrigation in the valley of the Grójec Canal. From the Lubstowskie Lake, water is drained through the 1 130 m long Lubstów Ditch, to the Grójec Canal going into the Warta River. The bottom of the Grójec Canal valley is located below the average water levels of the Warta River, so a pumping station in Wola Podłężna was built for continuous drainage of the water from the valley. From the upper part of low water levels of Warta River, it pumps the waters of the Grójec Canal beyond the Warta River embankment.

Locally in the valley of the Grójec Canal, among others in the area of the villages of Bilczew, Strumyk, Niwka, Brzózki and Smolniki Racięckie there are numerous wetlands with ponds and water reservoirs of natural and artificial origin (e.g. ponds created due to peat exploitation).

The Noteć River flows north of the Lubstów deposit and is characterized by a wide range of water levels and flows. Water levels and flows of the Noteć River were measured in water gauge profiles in Łysek and Noć - Kalina villages located closest to the Lubstów deposit.

The flows of the Grójec Canal and Lubstów Ditch was significantly influenced by water dis-charges from the Lubstów open-pit drainage, and from the end of 2004 also from the Drzewce open-pit and the damming of the Lubstowskie Lake (flow control).

According to the collected data, it appears that there are two anthropogenic factors changing the natural (formed by the inflow from the drainage basin) flows of the Noteć river. The first is the water discharge into the Noteć River (from outside its drainage basin) through the Gawrony weir built in the Warta - Gopło Canal (Ślesin Canal). The weir is located at 24.06 km of the Warta - Gopło Canal and is intended for regulating the level of damming at the top location of the Warta - Gopło Canal and for draining flood waters to the Noteć River through the Lake Mielno. The second anthropogenic factor was the discharge of mine waters from the Lubstów open-pit until April 2009, which also increased the Noteć River flow. This impact was most pronounced during periods of low flows of the Noteć River, when the discharge of mine waters exceeded several times the volume of river flow at the place of discharge.

On the other hand, the factor that could reduce the Noteć River flow is a cone of depression resulting from dewatering of the Lubstów opencast mine. Thus, the impact of the Lubstów open-pit on river flows was a result of a number of discharges and outflow losses caused by the development of the cone of depression.

In the study area, fresh groundwater found in Quaternary, Tertiary and Cretaceous deposits up to a depth of about 200.0-250.0 m is well known and used economically. There are numerous hydraulic contacts through zones of sedimentary and structural disturbances, mainly in sheet erosion areas reaching in the deepest places to the coal-underlying sands and Cretaceous deposits.

3.1 Groundwater in Quaternary deposits

Unsaturated zone waters subject to circulation occur in river sands and gravels, glacial sands and gravels, tills and sandy silts of various genesis. Groundwater, due to the geological structures of the Quaternary, form a multi-aquifer system, which consists of:

- shallow ground aquifer,
- upper till-interlying aquifer,
- lower till-interlying aquifer,
- till-underlying aquifer (occurring locally).

The shallow ground aquifer is associated with river sediments of the Holocene, the Baltic Glaciation, and partly the Eemian Interglacial period in the Warsaw-Berlin ice-marginal valley and tunnel-valley lakes, while the underlying aquifers - with interglacial and older glaciation deposits.

3.1 Shallow ground aquifer

In addition to geological conditions, the occurrence of the shallow ground aquifer is strongly influenced by: geomorphological conditions of the area, river network, climatic factors (rain-fall, temperature) as well as the existing development of the Warsaw-Berlin ice-marginal valley, river valleys and glacial outwash plains. This aquifer is discontinuous and irregular.

The shallow ground aquifer is characterized by a very high variability of water regime and various recharge and drainage conditions over time. A water level rises in winter half-year and drops in summer half-year. In addition, the water level shows fluctuations related to alternating dry and wet years with an amplitude of 1.1-1.3 m. The hydraulic conductivity for aquifers is as follows: sands and gravels- 3.0-200 m day, silty and fine-grained sands- 0.9-9.0 m/day. The storage coefficient is in the range of 0.03-0.24; most often for sandy and gravel sediments it is 0.12-0.22.

The shallow ground aquifer is fed mainly by rainfall infiltration and drainage of deep aquifers within river valleys and tunnel-valley lakes. These waters capture 10-15% of rainfall and are drained into watercourses, or seep down into the lower Quaternary and Tertiary layers as well as the Mesozoic fractured bedrock.

The thickness of the shallow ground aquifer varies. Generally, areas with thicknesses of up to 10 m dominate, a maximum thickness sporadically exceeds 20-30 m (within the ice-marginal valley).

The hydroisohypses of this aquifer clearly refer to the morphology of the area and the network of rivers and glacial valleys.

Due to the relatively low thickness of aquifers in the most elevated areas, as well as seasonal fluctuations, the water of the shallow ground aquifer is only locally collected from wells.

3.2 Upper till-interlying aquifer

The occurrence of the aquifer is associated with sand and gravel layers separating tills of the North Polish Glaciation from the tills of the Central Polish Glaciation. The thickness of the aquifers is low, from a few to 15 m. The groundwater may be saturated in places, and in other places due to the erosion of the till overburden, it is unsaturated. This applies mainly to the Warsaw-Berlin ice-marginal valley, river valleys, glacial outwash plains and tunnel-valleys. The piezometric pressure is generally similar or equal to the one of the shallow ground aquifer. The upper till-interlying aquifer is fed by infiltration through adjacent thin layers of till from the shallow ground aquifer, or connects directly with it, especially in the ice-marginal valley, showing similar periodic fluctuations in the annual cycle. Its drainage is based on river valleys and glacial tunnel valleys, similarly to the shallow ground aquifer. The parameters of the aquifer are as follows: hydraulic conductivity is usually 0.7×10^{-5} - 7.0×10^{-4} m/s, transmissivity 0.5 - 40 m^2/h.

3.3 Lower till-interlying aquifer

The occurrence of this aquifer is associated with sand-gravel layers of the Great Interglacial period and fluvioglacial periods of the Central and South Poland glaciations. The thickness of aquifers in the area of river valleys is 10-65 m (most often 20-40 m), while within fluvio-glacial period deposits is up to about 10-20 m.

This aquifer is characterized by sub-artisan pressure; in places where the till is eroded and it connects to the shallow ground aquifer, it is unsaturated.

The aquifer is fed through sandy tills or through a direct contact with overlying aquifers. This fact generally reflects similar water level fluctuations in this aquifer and the overlying ones.

The lower till-interlying aquifer is drained by the Noteć River and its main tributaries as well as the deep Warta River glacial valleys. In a regional circulation system, it transfers water through hydrogeological windows or filtration through clays, silts and brown coals, usually in zones of their reduced thickness, to the underlying Miocene aquifer or to Mesozoic aquifers. According to modelling tests, this water recharge is 5.9 m^3/h km^2 and 6.8 m^3/h km^2, respectively. Good granulation makes the aquifer hydraulic parameters favourable – hydraulic conductivity ranges from 6.0 m/day in fine sands to 300 m/day in gravels.

3.4 Till-underlying aquifer

The till-underlying aquifer is a locally occurring aquifer. Its occurrence is associated with a system of the Kromerian Interglacial period valleys or with fluvioglacial and river sediments separating the tills of the South Polish glaciations or it lies under these tills.

In the water circulation system, this aquifer is connected either to the lower till-interlying aquifer, or locally to the Miocene or Mesozoic aquifers. The thickness of the layers varies from 1 to 20 m, on average it is 5-10 m.

3.5 Groundwater in Tertiary deposits

Within the Tertiary deposits, there is mainly the Miocene aquifer and, in some places, the Oligocene aquifer, of the regional Wielkopolska - Kujawy reservoir.

The occurrence of the Miocene aquifer is strictly dependent on the morphology of the Mesozoic bedrock, tectonics and sub--Tertiary erosion. Within land elevations the aquifers are ab--sent or have reduced thickness.

The Miocene aquifer includes waters of sub-artisan and artesian nature. The regional water recharge zones of the Miocene aquifer are located within moraine plateaus. The aquifer is fed by water filtration of from the Quaternary, mainly in the zones of significant reduction of clay overburden, or locally by inflow through hydrogeological windows. According to the modelling tests, the recharge ranges from 0.8 to 3.0 m^3 / h km^2. Drainage zones are: Warsaw-Berlin ice-marginal valley, tunnel valleys with lakes and the Noteć River valley with the Gopło Lake.

According to hydrogeological studies, the hydraulic parameters of the aquifer are as follows:

- hydraulic conductivity: 2.4 - 25 m/day,
- storativity 0.0001 - 0.0009.

The storage coefficient is 0.08-0.16 and elastic-storage coefficient is 0.0027.

The Oligocene aquifer is formed by glauconitic, usually fine, sands of a thickness of a few to about 20-30 m, occurring locally in the Mesozoic bedrock depressions (Lubstów region). The Oligocene aquifer is often connected through overlying hydrogeological windows to the Miocene aquifer or is separated from this aquifer by several meters of poorly permeable sediments.

This aquifer has similar recharge and drainage conditions as the Miocene aquifer; hence its hydrodynamic conditions are comparable and, in this respect, they can be generally described as one aquifer.

3.5 Groundwater in Cretaceous deposits

This aquifer occurs in Upper Cretaceous deposits, formed as marly-calcareous facies, sporadically sandstone. These deposits are basically very poorly permeable, however, due to the existing network of cracks and fractures, they constitute a vast but very hydrogeologically diversified aquifer. They are located at various depths, depending on the hypsometric differentiation of the sub-Quaternary surface. The top of marls is usually located at a depth of 25-100 m. The water quantity depends on the depth of the deposits, system of fractures and hydraulic connection with the groundwater of Tertiary and Quaternary deposits and with surface waters. The most water-bearing is the zone of weathering and tectonic fractures, occurring up to a depth of about 90 m.

In the area of Tertiary river valleys, the groundwater of the Cretaceous is combined with the groundwater of the Tertiary deposits, hydrodynamically creating one aquifer, a fractured--porous system as well.

The fractured bedrock has very variable hydrogeological parameters. Specific capacity varies between 0.1 and 200 m^3/h/ 1m, most often it is 1 - 15 m^3/h/1m; very high values are associated with fault zones and values lower than 1 m^3/h/1m

Fig. 4: Water outflows from the Quaternary sand and gravel layers (Z. Olejnik, KWB Konin).

are associated with the elevated areas and or the occurrence of the overburden of poorly permeable tills and Tertiary clays. The transmissivity of the fractured rocks is very variable, from 0.4 to over 100 m^2/h, on average it is 10-20 m^2/h. The average hydraulic conductivity ranges from 2.7 to 20 m/day. Elastic-storage coefficient is 0.0012 on average.

The groundwater in the upper part of the Mesozoic aquifers, is hydrodynamically included in the circulation system of the groundwater from the Cenozoic sediments, without creating an independent aquifer.

4 Geotechnical problems

As already mentioned above, the exploitation of lignite in the Lubstów open-pit continued until the end of March 2009, when the existing mine drainage system was turned off and the final excavation actually switched to the natural filling system.

This caused water outflows from the Quaternary sand and gravel layers from the northern escarpment which could turn into a more serious threat similar as in the Pątnów final pit.

This was prevented by water intake from the Upper Cretaceous and Miocene levels at the northern edge and their discharge into the emerging reservoir (protection against land--slides). The water intake continued until the end of 2009. At the beginning of 2010, the reservoir was filled with water from the water transfer from the Lubstowskie Lake in the amount of 50 m^3/min, fed with water from the Wierzbie Canal and mine waters from the Drzewce open-pit.

Currently, only minor issues are taking a place in the Lubstów pit. Most of them are connected with waving effect and natural erosion. However, bathymetry of underwater slopes and the bottom of the lake has not been completed yet and there is no data about geotechnical state of the lake in the underwater parts.

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