Mine Water Management in the Ruhr coalfield

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Abstract Today, the RAG Corporation is the last hard coal mining operator in Germany. In the Ruhr coalfield it is operating one active mine and 11 dewatering stations. At the end of 2018 the subsidized hard coal mining is finally ceasing but the mine water management will continue for an unlimited period of time. Therefore the RAG Corporation was obligated to develop a new sustainable mine water management system for the post-mining era to protect the ground surface and drinking water reservoirs.

Key words Mine water management, Post-mining mine water management, hard coal mining

Introduction

In 1968, the RAG Aktiengesellschaft (RAG Corporation) was founded as a consolidation company of the Ruhr mining industry and is nowadays the last hard coal mining company in Germany. Today it is operating two remaining collieries, one in the Ibbenbüren coalfield and one in the Ruhr coalfield. Coal mining in the Saar coalfield ended in 2012, but the mine workings are still open and used for mine water management. In 2016, 104.5 million m³ mine water were pumped in the three coalfields by the RAG Corporation (fig. 1). This paper is focussing on mine water management in the Ruhr coalfield.

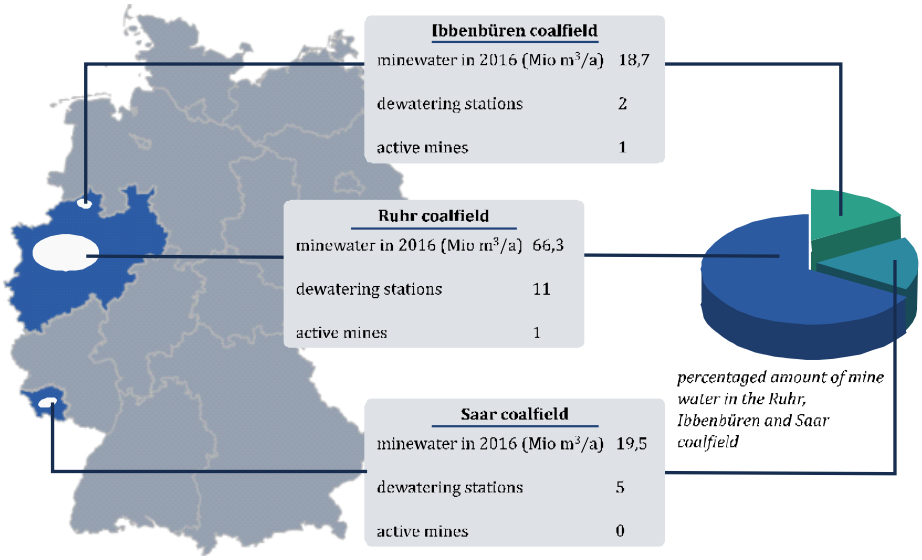

Figure 1 *Hard coal mining and mine water management in Germany.*

The Ruhr coalfield is located in north-west Germany in the state of North Rhine-Westphalia.

It lies in the catchment of the tributaries Ruhr, Emscher and Lippe of the River Rhine. The occurrence of vast coal deposits has led to the development of one of the largest polycentric metropolitan areas in Europe. The Ruhr area extends over 4,430 km² and consists of several large industrial cities. It is one of the most densely populated mining areas worldwide.

The Ruhr coalfield contains 3,000 m of Upper Carboniferous coal-bearing strata and nearly 300 coal seams with a thickness ranging from <0.5 to 3 m. The carboniferous strata are outcropping in the southern part of the Ruhr area in the valley of the river Ruhr and are dipping towards the north. Due to that geological condition mining in the valley of the Ruhr dates back to medieval times. Following the dip of the carboniferous sequences, and with ongoing industrialization and new technical developments in mine water management, mining activities moved towards the north. In the northern part of the Ruhr Area, within the range of the river Lippe, the cretaceous overburden reaches a thickness of 1000 m (Henningsen and Katzung 2006).

Status Quo

At the time of the foundation of the RAG in 1969, 56 collieries were in operation. 52 collieries were passed to the RAG Corporation and 4 collieries remained independent (Huske 2006). This number declined steadily so that in 2017 only one active colliery remained in the Ruhr coalfield (the colliery Prosper-Haniel located in the city of Bottrop). Due to combined mining, most of the collieries where connected in the underground at several levels by mine workings. If underground pumping stops at one colliery, the rising water will flow to the adjacent mine. Therefore, a network of pumping stations is still active in the whole Ruhr coalfield – even with reduced mining activities. Today and in the past, the main task of the mine water management was to keep the mine dry and guarantee safe working conditions for the last remaining collieries.

In 2016 66.3 million cubic meters of mine water where pumped to the surface by a network of 11 dewatering stations and one active mine in the Ruhr coalfield (fig. 1). Almost half of that water is pumped in the southern part of the coalfield where the carboniferous strata are outcropping and mining activities stopped in the 1960ies. Pumping can here take place at shallow depth and the water is only slightly mineralized. The water is discharged directly into the river Ruhr. Without pumping the water in the southern part of the coalfield would flow northwards following the dip of the strata and reach adjacent mines or dewatering stations. There it would have to be pumped from greater depths and with a higher amount of dissolved minerals.

Going to the north, the cretaceous overburden and consequently the pumping height are gradually increasing. Water is discharged into the rivers Emscher and Lippe (fig. 2).

Today's underground pumping stations at the rivers Ruhr, Emscher and Lippe are consisting of a system with two open shafts for mine ventilation and connecting roadways. Centrifugal pumps are installed in the roadways and are pumping the water to the surface. In the western part of the Ruhr coalfield the pumping station Walsum has already been re-

constructed as a well-operating pumping station. It is using submersible pumps and maintenance works take place from the surface. Mine workings have been closed completely. The pumping station Walsum started working in June 2016 and is discharging directly into the River Rhine.

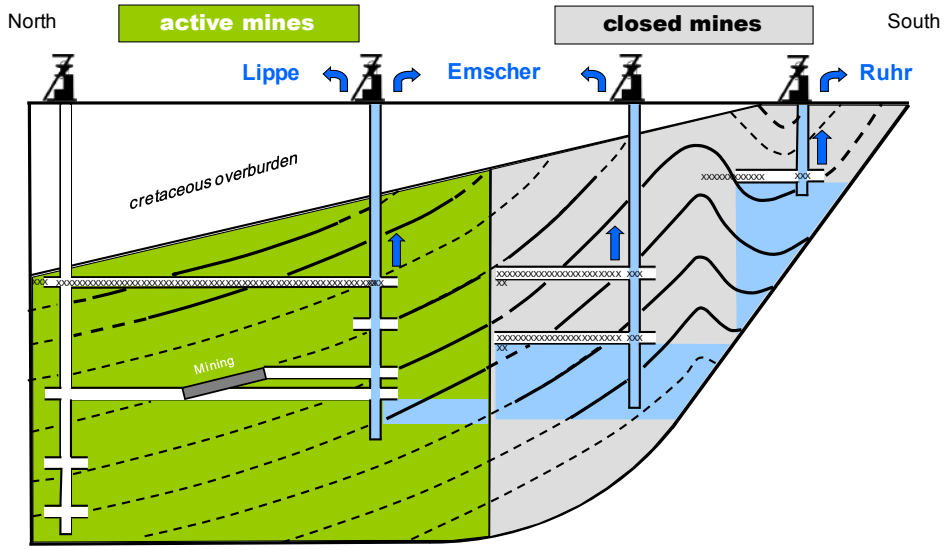

Figure 2 *Cross-section of the Ruhr coalfield – mining activities and mine water management*

Post-mining mine water management

At the end of 2018, when hard coal mining operations will finally be ceasing in the Ruhr coalfield, the dewatering of the carboniferous strata is no longer necessary with regard to safe working conditions for the miners. Anyway, mine drainage in this densely populated region is regarded as a perpetual obligation resulting from the coal-mining operations. For that reason mine drainage is regarded as a task for an unlimited period of time to maintain the water level at a pre-determined safe level. In the future, the most important objective of mine water management will be the protection of the ground surface and especially of groundwater reservoirs. Nevertheless the RAG Corporation was obligated to develop a new concept to operate mine drainage in a responsible, efficient and cost-effective way in the post-mining era.

Basic options to meet the demands of the post-mining mine water management are the rebound of the water-level to a pre-determined safe level, the reduction of pumping stations and well-operated pumping from the shaft with submersible pumps. The post-mining mine water management is shown in Fig. 3. It is planned to reduce the number of pumping stations to a total number of six: In the south of the coalfield, the dewatering stations discharging into the river Ruhr will remain (Heinrich, Friedlicher Nachbar and Robert Müser). In the east, the only remaining dewatering station will be Haus Aden. The dewatering station Walsum is already reconstructed and will continue dewatering the western part of

the coalfield in the post-mining era. After closing the last mine Prosper-Haniel in 2018, the water management in the central part of the coalfield can be adapted. Therefore the former mine Lohberg will be reconstructed as a dewatering station. Mine water can directly be discharged into the river Rhine. There will be no more discharge of mine water into the river Emscher (RAG AG 2014).

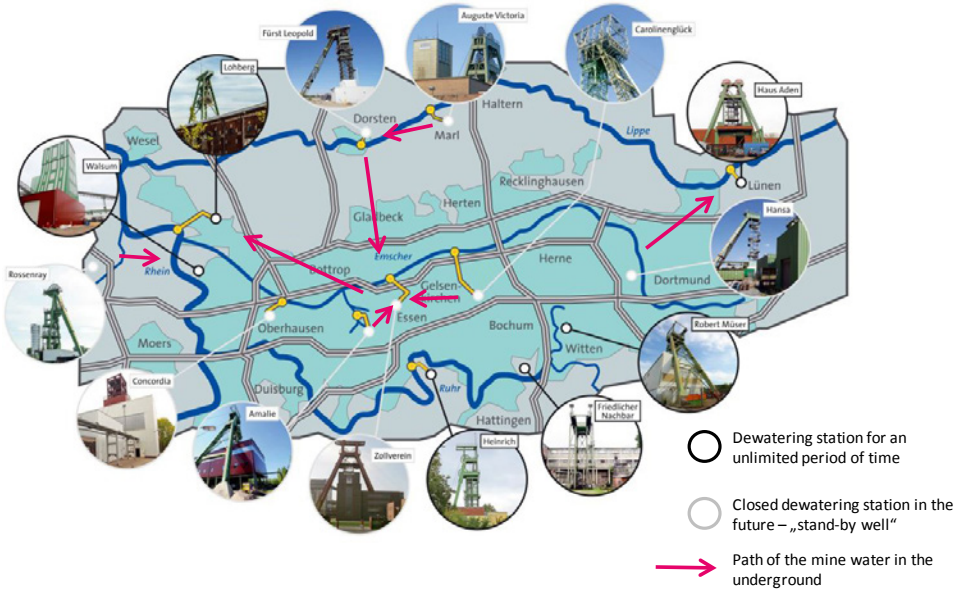

Figure 3 *Post-mining mine water management*

The connecting mine workings between the different dewatering stations can then be used to transmit the water in the underground to the next active pumping station (fig 3). Indispensable for the underground transmission is the rebound of the mine water – at least to the level of the connecting mine workings. Simultaneously the pumping stations will be reconstructed into well-operating stations: The remaining mine workings of the dewatering station will be closed. With the backfilling of the shaft a system pipes is installed, so that pumping could restart from the shaft with submersible pumps. In case the pumping station is dispensable in the post-mining mine water management, the shafts will be backfilled as a “stand-by well”. This means, that there will be either a pipeline in the backfilling or that the backfilling is realized in a way that allows reopening. Underground blockages or roof falls can stop or limit the underground discharge to the next pumping station. In this case the “stand-by wells” can be activated to access the mine water table. If necessary the rise of the mine water can be controlled by using submersible pumps. To avoid an uncontrolled rebound of the water table, mine water levels in the Carboniferous are constantly monitored. Currently there are nearly 50 monitoring sites in former shafts (RAG AG 2014).

Opportunities of the mine water management concept

Implementing the new mine water management concept is not only an important contribution to meet responsibilities resulting from the coal-mining operations of the RAG Corporation but also an active contribution to environmental protection. The rebound of the mine water level and a reduced pumping height result in a reduced energy use. This implies not only financial benefits but also a reduction of CO_2-emissions. Numerical modelling also predicts the restriction of highly mineralized geogenic water flowing into the carboniferous aquifer with higher water levels. Hence a better water quality will be pumped and discharged into the rivers. With the additional reduction of pumping stations and the concentration of pumping activities discharging directly into the River Rhine, a better water quality in the surface water will be achieved. Especially the river Emscher will completely be free of mine water discharge. Overall 240 km of watercourse will be free of mine water discharge. This would be an important contribution to fulfill the requirements of the Water Framework Directive (RAG AG 2014).

Abandoning the remaining mine workings and using submersible pumps is another important factor of meeting the demands of the post-mining era. The expensive maintenance of the mine workings will be obsolete. In addition less manpower is needed to operate the pumping stations and mine drainage will work in a more cost-effective way (RAG AG 2014).

Financing

In 2007, the German federal state, the coal mining states North Rhine-Westphalia and Saarland, the RAG Corporation and the Union IG BCE (Mining, Chemical and Energy Industrial Union) agreed to discontinue government subsidies for hard coal mining with the end of the year 2018. They agreed to find socially acceptable means of ending hard coal mining, and measures to finance the continuing obligations from the coal mining operations. Beginning in 2019, an annual €220 million will be needed to finance the measures for a permanent management of mine- and groundwater in the former Saar, Ruhr and Ibbenbüren coalfield. Therefore the RAG-Stiftung ("RAG Foundation") was established in June 2007. To provide the financial means in the future, the RAG-Stiftung is investing its assets in a safe and profitable manner (fig 4). With the beginning of 2019 the foundation will pay for mine water management, polder measures and groundwater purification. The correction of mining-related damage will not be paid by the RAG-Stiftung but directly by the RAG Corporation.

Besides financing the perpetual obligations from mining, the foundation is supporting projects in education, science and culture in the former mining regions. Its aim is to preserve the mining heritage for future generations and help to develop new opportunities for the former industrial regions (www.rag-stiftung.de).

Conclusions

Closely linked to the extraction of hard coal is the management of the mine water. Without any measures to control the inflowing water into the mine, coal extraction is not possible. Therefore mine water management in the hard coal mining districts in Germany has been

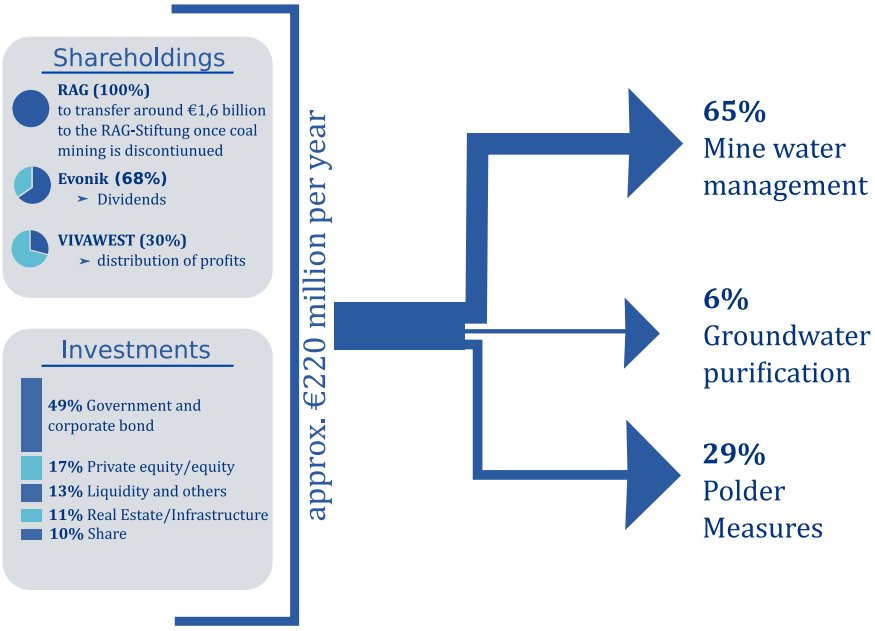

Figure 4 *Financing of the perpetual obligations from mining by the RAG-Stiftung (after RAG-Stiftung Infograph "The RAG-Stiftung at a glance")*

taking place for more than 250 years. With the closing of the last hard coal mines in Germany in 2018, an important chapter in German industrial history is coming to an end. Nevertheless there are obligations from hard coal mining operations with unlimited duration like the mine water management. The RAG Corporation will take charge of these responsibilities. The development of the post-mining mine water management is an important contribution to fulfill these obligations especially with regard to environmental protection and financing.

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