Underwater Exploitation of Coal and Gravel on the Bank of the Danube River, at the Kovin Mine, Serbia

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Abstract

The Kovin coal deposit and the Kovin Mine are located on the left bank of the Danube, 18 km east of the town of Kovin and 70 km from the capital, Belgrade. The Kovin deposit has been thoroughly investigated and defined based on exploratory wells that were periodically drilled from 1975 to 2025. During more than 3 decades of underwater exploitation of coal and associated sediments at the Kovin Mine (since 1992), from the experimental phase to full development, numerous mining facilities have been built in order to improve and round off the process of exploitation, processing and commercialization of coal and gravel. The aim of this article is to present underwater exploitation of coal and gravel applied in the conditions of the Kovin deposit and some of the positive experiences in the field of mining and environmental protection.

Keywords: underwater exploitation, coal, gravel

1. Introduction

In the early 1990s, underwater exploitation of coal and associated sediments began at the Kovinsko coal deposit. Prior to this, 15 years of preparations were carried out in the form of: exploratory drilling, laboratory tests, preparation of studies and analyses (geological, hydrogeological, and mining), selection of equipment manufacturers, training of workers, and preparation of project documentation. The selected equipment manufacturer, the German company Orenstein & Koppel (O&K), delivered a floating suction dredger with a cutting wheel UCW 450 and a steel pipeline (floating and onshore) Ø900.

At the very beginning, the underwater exploitation of coal and associated sediments at the Kovin deposit location was designed as an experimental one, with the intention of testing the equipment and proving or disproving the technical and economic feasibility of the project.

Due to political and economic difficulties in Serbia in the mid-1990s, the Kovin Mine independently continued with the so-called trial operation and later with full development and production.

Underwater exploitation of coal and associated sediments in the conditions of the Kovin deposit has proven to be a technically and economically viable project. By 2005, facilities were built and installed to complete the process of production and commercialization of coal and gravel at the Kovin Mine.

2. Basic data about the deposit

The Kovin deposit and mine are located in the northeastern part of the Republic of Serbia, on the left bank of the Danube River, 18 km from the town of Kovin and 70 km from the capital, Belgrade, Fig. 1.

Fig. 1. Location of the Kovin Mine/ This map was created by the author, as part of the article

The Kovin coal deposit belongs to the group of sedimentary deposits and is part of the Kovin-Kostola coal basin separated by the Danube River.

The Kovin deposit is characterized by the existence of a coal series with 2 layers, sand and gravel with clay lenses in the outcrop, as well as sand with clay interlayers in the interlayer tailings and the bottom of the coal series (Fig. 2).

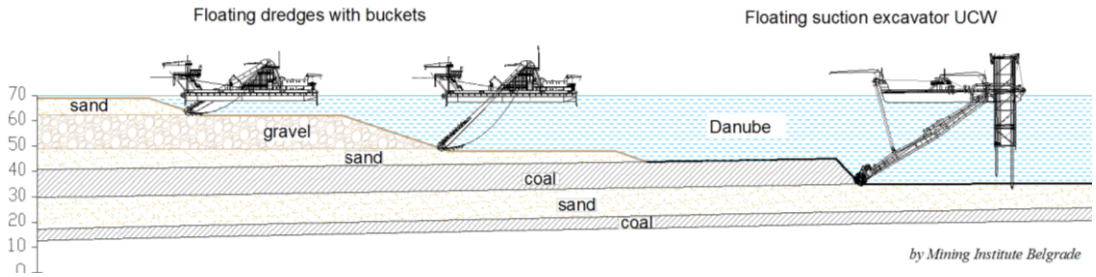

Fig. 2. Geological-technological profile of the deposit [1]

At the Kovin Mine location, only the first coal seam, 8-10m thick to a maximum depth of 45m, is exploited. The second coal seam is not exploited due to the great depths at which it is found, which is also of lesser thickness and greater stratification with barren interlayers.

Based on quality parameters and according to international standards, it was determined that the coal from the Kovinsko deposit belongs to the group of lignite coals, or humic coals of the xylite type. The cleaned and classified coal is used for private and industrial boiler plants.

The results and analyses of laboratory tests have shown that the gravel from the Kovin deposit is usable as a raw material in the production of concrete and in road construction. The analyses have also shown that separating the gravel would significantly improve the quality and utilization of the gravel.

From a hydrogeological point of view, all sediments of the Kovin deposit are directly connected to the Danube River, and in the outcrop zones of coal seams (which are insulators) they are also connected to each other.

The Kovin Mine exploitation zone is located in a Danube arm, in the so-called undefended area, south of the defensive embankment (position 10 in Fig. 4) and the drainage system. The defensive embankment serves to protect the settlement and agricultural land on the northern side from the flood waves of the Danube. The drainage system (with canals, wells and pumping stations) draws water and maintains the groundwater level at a depth of 1 - 1.5 m from the surface of the terrain, thus enabling the use of the alluvial plain for agricultural production throughout the year. The existence of the defensive embankment and the drainage system is the reason why state authorities (for now) do not allow exploitation north of the defensive embankment.

3. Underwater exploitation

At the very beginning, the concept of exploitation of coal and associated sediments in closed, lake conditions was adopted, with the construction of a protective embankment (position 8 in Fig. 4) towards the Danube in the function of protecting the exploitation zone from high waves and currents of the Danube River and protecting the riverbed from the deposition of material from the mine.

The basic exploitation system of the Kovin Mine consists of a floating suction dredger-pipeline Ø900-plant for receiving and processing coal (or sand and gravel dumps), Fig. 3. Given that gravel is an extremely abrasive material, the Kovin Mine often engages subcontractors with bucket dredgers and barges for gravel exploitation, Fig. 2.

Fig. 3. Kovin Mine, main facilities: Dredger with cutting wheel UCW 450 and Coal reception and processing plant

The basic characteristics of the UCW 450 cutting wheel suction dredger are: cutting wheel diameter D=4,5m, length of the cutting wheel carrier (and one pump) L=58,6m, maximum digging depth H_{MAX}=45m, 3 pumps with a power of 3x3MW, a straight-line movement system with 2 pylons (working and fixed), circular movement around the working pylon and a system of ropes and pulleys. The dredger is powered by electricity via a power cable, with a floating and land part, from the dredger to the drum and the substation on the shore.

The floating suction dredger (position 1 in Fig. 4) excavates sediments in depth, in parallel blocks and in horizontal belts, from top to bottom. The width of the block is determined by the maximum digging depth in one zone (B=50-60 m). The belt height is adjusted to the type of material, from h=1 m for coal to h=3 m (and more) for sand and gravel. The material separated by the UCW

cutting wheel is sucked in together with water and transported by dredging, floating and land pipelines (2 and 3), coal to the reception and processing plant (4) and sand and gravel to their landfills.

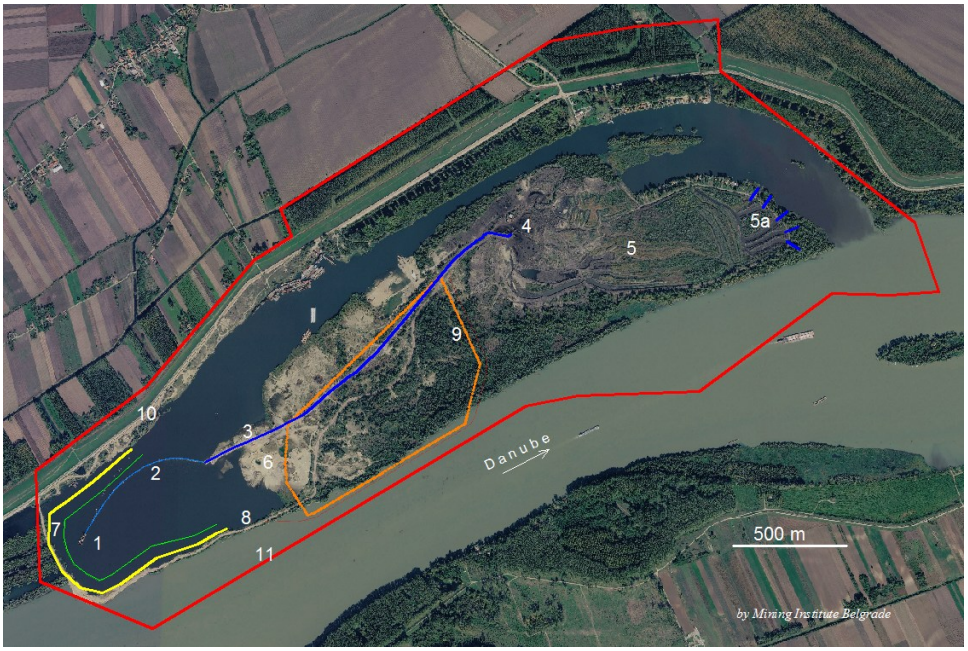

Fig. 4. Kovin Mine [1]

1-floating dredger, 2 and 3 floating and land pipeline, 4 coal processing plant, 5-coal deposit, 5a-overflow pipes, 6-internal sand and gravel dump, 7-designed final western slope of the pit, 8-protective embankment towards the Danube, 9-new, eastern exploitation zone, 10-defensive embankment, 11-Kovin Mine field approved by state authorities

The main coal receiving and processing plant operates on the basis of inclined vibrating screens through which the coal-water mixture is separated and the coal is classified into 3 commercial classes. The sub-screen class (-1mm) together with water is settled in a limited space called the settling tank (5). Relatively clean water, through a system of channels, travels from the plant to the overflow pipes (5a) through which it returns to the Danube arm.

Sand and gravel in the opencast of the I coal seam a) excavated by the UCW dredger are hydraulically deposited in the excavated area or the so-called internal dump (6) and b) excavated by bucket dredgers are deposited by dredger barges in the excavated area or are transported outside the Mine site by transport barges.

4. Environmental protection

During the underwater exploitation of coal and associated sediments at the Kovin deposit, the main impacts of exploitation on the environment were detected:

a) occupation of space and changes in landscape characteristics of the area
b) impact on the Danube flood defence system
c) impact on the drainage system
d) impact on the quality of groundwater and subsurface waters

The exploitation of the Kovin Mine area, which was originally a marshland, has created: a lake in the Danube arm, sand and gravel dumps and a coal deposit. Through technical and biological reclamation measures, the degraded area will be returned to approximately the original appearance of the natural ecosystem of the Danube coast. In some zones of the dumps and deposit, there are phenomena of self-renewal of plant species and the appearance of animal species. The newly created lake and the arm connecting it to the Danube are known as places for fishing.

1-Danube River, 2-defensive embankment, 3-original appearance of the Danube coast 4-agricultural land, 5-newly created lake, 6-protective embankment towards the Danube, 7-internal sand and gravel dump, 8-coal deposit

The possible impact of underwater exploitation at the Kovin Mine on the construction of the defensive embankment (position 10 in Fig. 4) is prevented by the prescribed (by state institutions) minimum distance L_{MIN}=100m from the embankment foot to the edge of the underwater mine and the geomechanical stability of the mine slopes, with a minimum safety factor F_{MIN}=1,4.

The impact of exploitation on the drainage system north of the defense system is assessed by monitoring groundwater levels using piezometers and hydrodynamic modeling of groundwater flow under conditions of underwater exploitation in Kovin. The latest hydrodynamic modeling conducted within the Mining Project showed that at the end of exploitation, with the existence of the eastern pit (position 9), the groundwater level would be raised by 10-20cm and the operation of pumping stations would be increased by 0.3%.

The Kovin Mine is located in a wider zone of potential water sources. The results of periodic tests of the quality of these waters have shown that their quality depends mainly on the quality of the Danube waters, as the main source of recharge to the source.

Only previously purified overflow waters (by settling in regulated channels) that correspond to the prescribed Danube water class may be discharged from the coal deposit into the Danube arm (position 5a in Fig. 4) . Water quality analysis at the Kovin Mine site is carried out twice a year in several places: in the lake next to the dredger, in the arm, at the location of the overflow pipes from the deposit, on the Danube River upstream and downstream of the arm, and at the location of the Danube waterway. The results show that the mine waters do not affect the quality of the Danube.

The Kovin Mine has established environmental monitoring at the Mine site, which monitors all significant sources of environmental pollution caused by the effects of underwater coal mining and associated sediments, analyzes measured parameter values, and implements environmental protection measures.

5. Conclusion

Underwater mining of coal and associated sediments at the Kovin Mine has proven to be a viable project from the perspective of mining technology, economic effects and environmental protection. The project is still being developed and improved.

This article aimed to present an atypical mining project to the general public, with an emphasis on underwater mining technology and environmental protection.

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