



KOLUBARA COAL MINES SERBIA - 75 YEARS OF OPEN PIT EXPLOITATION AND 3B m³ OF OVERBURDEN PROBLEMS; RESOLVING

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ABSTRACT

Mining activities on Western Serbian lignite's start in late XIX century, by underground mining in a small scale. There were 12 separate shafts in area which cover more than 200 km². That kind of activities run until early 1970's, when last shaft was closed. After WWII, based on industrialization needs, in 1950 start first open pit "field A" with manual work and horse power lifting. The open pits epoch starts, and in mid-50's and early 60's runs the next open pits.

Until these days, on 80 km² under 10 separate OP mining activities, KCM³ done more than 1,35B t of lignite and nearly 3B m³ of overburden which seat on 60 km², under 9 mining waste heaps. There are a few overburden heaps problems, which needs geology, mining and environmental solving.

Key Words: lignite, overburden, mining, environment

1. INTRODUCTION

The open-pit mines of the KCM have been in operation since 1950 and have been operated with overburden disposal for 75 years. During the period of operation of the open-pit mines, starting in 1950 (when the first open-pit mine, Field A, began operation), about 1.3 billion tons of coal and about up to 3 billion m³ of mining waste (overburden) were excavated from all of them. In general, all of the coal was used in thermal power plants for combustion and electricity generation, and all of the waste were disposed of in the overburden dumps of the KCM. Waste from surface mines are disposed of in the immediate vicinity next to active mines (outside) or in internal (inside mines) disposal sites. In this way, nine overburden dumps were formed, of which 3 of them are outside and additional 6 are inside of open pits (Figure 1).

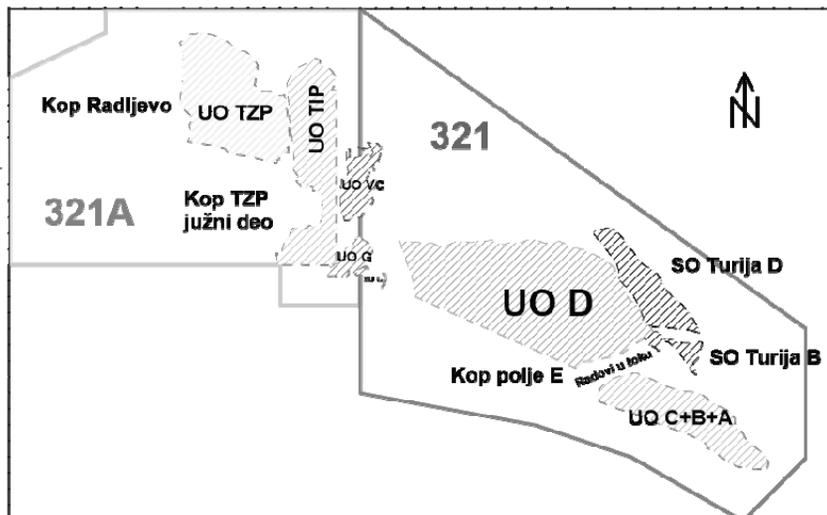


Figure 1. Overview map of the wider area of activity of the KCM, with the location of mining waste/overburden of open pit mines, as of 31.12.2024; 321, 321a – exploitation fields, UO – internal/inside OP⁴ landfill, SO – external/outside OP landfill

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The waste in the internal/inside OP dumps are disposed of in several separate locations (figure 1):

1. OP "A+B+C" – three closed open pits nowadays are merged into one; it is the oldest overburden dump (internal dump) in the KCM; it has been in operation since 1950 and is still in operation. It is located in the eastern part of the basin with the surface area of about 6 km².

2. OP "D" – open pit is temporarily closed. The overburden dump (inside OP and partially outside of OP) is the largest in the KCM. OP has been in operation since 1960 and overburden heap is still in operation. It is located in the eastern part of the basin, and is considered to have about 1.6 billion cubic meters of waste. It is still in operation, currently used for the disposal of waste from the OP "Field E". Its area is more than 20 km².

3. OP "Tamnava-East Field" - the open pit mine was closed in 2006. It was in operation from 1980 to 2006, an inside OP overburden disposal site was formed. It is still in operation today, used for the disposal of waste from other active mines around it (mines "Veliki Crljeni", "G", "Tamnava-West Field", "Radljevo"). Its area is about 8 km².

4. OP "Tamnava-West Field" - the open pit mine is active and has been in operation since 1990. Despite numerous geotechnical problems, the overburden dump (inside OP landfill) is still in operation. Its area is about 9.5 km².

5. OP "Veliki Crljeni" - its tailings were disposed of inside the closed OP, as well as the waste from the OP "G" which is currently in operation. Its area is about 1.8 km².

6. OP "G" - its overburden is disposed of in the area of the active OP which is currently in operation. Its area is about 1 km².

7. TOTAL area under overburden dumps (internal landfills) in the KCM is about 47 km², with huge quantities of up to 3 billion m³ of disposed waste.

Overburden at external/outside OP landfills are disposed of at several separate locations:

8. External landfill of the mine "Field B–Turija/Strmovno" – located immediately north of the mine "Field B". It was formed at the beginning of the opening of this mine in the mid-1950s. Its area is about 0.75 km². It has been reclaimed with forest plantations and is no longer managed as an overburden dump.

9. External landfill of the mine "Field D–Turija" – the largest external landfill in the KCM. It is located immediately north of the mine "Field D", it was formed at the beginning of the opening of this mine in the mid-1960s. Its area is about 3.5 km². It has been reclaimed with forest plantations and is no longer managed as an overburden dump.

10. External landfill of the mine "Field G" - is located directly next to this active mine, it was formed during several years of operation of this mine, at the beginning of the 21st century. It is active and the waste from that mine are disposed of there. Its area is about 0.3 km².

The entire observed area, as well as the masses of deposited tailings, are located within mining license/exploitation fields number 321 and 321a.

2. GEOLOGY COMPOSTION OF WASTE

The type of material deposited in the tailings dumps is known based on the geological structure within the surface mines where exploitation was carried out. The entire amounts of tailings are of anthropogenic origin. Neogene sediments are most widespread in the Kolubara Coal Basin. Stratigraphically, it is composed of Middle Miocene, Sarmatian, Pannonian and Pontic sediments. The geological structure of the rim and the Kolubara Basin itself includes all three basic rock groups: metamorphic rocks of Paleozoic age, sedimentary rocks of Triassic, Cretaceous and Neogene age, and igneous rocks represented by dacite-andesites and their effusive (Figure 3.1.). The inner part of the basin is filled with Neogene Mio/Pliocene sediments with coal. Quaternary formations (clays, gravel) lie over them. No processes of intra-mine or post-mine tectonics have been registered in tailings/dumping sites. The tectonic conditions of the tailings do not differ from the overall geotectonic setting of the wider area. Essentially, the tailings are not characterized by any special tectonic features that should be emphasized here.

⁴ OP – open pit



3. OVERBURDEN HEAPS PROBLEMS

All of the above-mentioned overburden sites are subject of technical and biological reclamation. Over the past 50 years or more, geotechnical problems in overburden heaps - landslides and rockfalls within open pit mines - have been successfully resolved. As such, since they occur within an open pit, they are not considered an environmental risk, but rather are classified as production problems of the mine. Over the past 50 years or more, extensive geotechnical, hydrogeological and ecological explorations have been conducted on all of the listed overburden sites. Over the past twenty years, technological and geotechnical problems have accumulated, and have been successfully solved through numerous projects and classical engineering works. Occasionally, alternative stabilization methods are also applied, such as draining of overburden masses under additional rocks pressure. The problems for solving can be classified according to their causes:

GEOLOGICAL ISSUES

- a. geological characteristics of the masses being irregularly deposited - primarily consisting of sand and clay, locally with gravel present. There are no other types of rocks (hard igneous, sedimentary or metamorphic rocks) that could disrupt the consistency of the deposited material. The said material is deposited without a "geological" order, primarily respecting the geometry of the landfill and the working capabilities of the dumpers.
- b. occasionally, entire levels/layers of homogeneous material, ranging from 10 to 30 meters thick, can form within a tailings dump. They behave uniformly and are easy to manage.

These geological problems are solved by careful planning of the excavation and disposal of various types of waste and by directing them to zones prepared in advance for this. In the past ten years, quartz sands and gravels from the waste in the deposit have been treated as useful mineral non-metallic raw materials. KCM is exposed to several hundred million m³ of these raw materials, which must be excavated anyway due to coal exploitation. As such, in recent few years they have been selectively excavated and selectively disposed of at predetermined locations, reaching up to 10 million m³. This approach significantly reduces the mass of "real" waste and achieves significant economic benefits.

HYDROGEOLOGICAL ISSUES

- c. the presence of groundwater aquifers in the sides of open pits and especially in the unexcavated bed - these groundwaters continuously soak the stacked masses of tailings, forming an inclined slushy sliding plane. This creates very unfavorable conditions for the stability of the tailings pit. These problems are solved by well pre-drainage before, during and after the end of exploitation in the open pit.
- d. the presence of floating groundwater aquifers - they are difficult to register. They appear occasionally, they are drained by constructing trenches and water reservoirs for the so-called surface drainage.
- e. disposal of very wet (after heavy rains, due to melting snow, groundwater breakthrough, poor pre-drainage of an open pit...) tailings masses that drain extremely poorly once they have been deposited in the tailings pond

These hydrogeological problems are solved by constructing a large number of drainage and pre-drainage wells; as well as with the creation of drainage channels and trenches with water collectors.

TECHNOLOGY AND MINING DISPOSAL ISSUES

- f. an inappropriate approach to tailings disposal at the landfill - although there is always (legal obligation) a designed type and dynamics of tailings disposal works, sometimes forced solutions are applied in practice that disrupt the planned nature of the works. As such, they regularly disrupt the geotechnical assumptions about the stability of these tailings' masses.
- g. overhang of the highest levels of the landfill - due to the lack of accommodation space, instead of going "wide", they go "high", that is, they overhang the designed landfill levels. This forms



significantly larger masses of tailings, which additionally burden the sliding plane and the masses slide lightly towards the front of the site.

- h. the presence of a steep sliding plane that forms the base of the deposited masses - the formation of the open pit started from the shallowest parts of the deposit going to the deepest. In this case, a sliding surface was formed along which the overburden masses slid gently. Numerous extensive geotechnical investigations (several hundred geotechnical boreholes with numerous laboratory analyses) of the overburden masses are being carried out and systems of measures are being designed to eliminate the consequences of the landslide. Fortunately, all these landslides take place within the open pits, so they do not threaten the surrounding environment.

These mining problems are solved by better planning and execution of works on the disposal of overburden masses. For the rehabilitation of triggered internal landslides, in addition to classical ones, modern new, yet unconfirmed methods of landslide rehabilitation are also applied.

4. CLASSIFICATION OF OVERBURDEN HEAPS

The characterization and classification of mining waste/tailings from open pit mines was carried out in 2025, during which it was concluded that the waste from the open pit mines of KCM are chemically inert waste and do not pose a threat to the environment (figure 2). In total, at 48 km² overburden area, 88 individual samples were taken at seven tailings dump locations, from which 27 composite samples were formed (Figure 2).

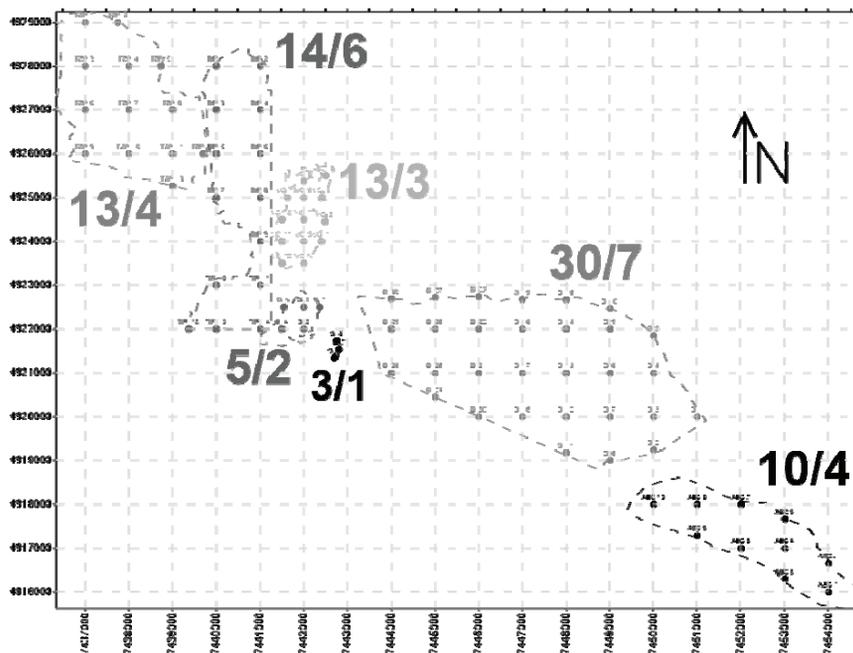


Figure 2. Overview of the designed exploratory excavations at all tailings dumps of the Kolubara mine; 5/2 – number of individual samples taken/number of composite samples formed

5. MANAGING OVERBURDEN HEAPS PROBLEMS

After problems with waste were observed, expert services for mining waste management were formed. In accordance with the law and numerous regulations. KCM has developed a Mining Waste Management Plan document. Each of the above-mentioned tailings ponds has a separate document. In addition to the classification of mining waste, monitoring has also been defined. It primarily refers to the continuous monitoring of the chemical composition of the tailing's masses in the upcoming period, as well as the quality of drainage and leachate waters that are formed in the tailing's ponds. The scope and dynamics of monitoring work are specific to each tailings pond.



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