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MINING AT GACKO OPENCAST MINE, BOSNIA-HERZEGOVINA A QUESTION OF ECONOMICS

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(10 figures and 1 table)

ABSTRACT. Gacko opencast mine is situated in the northeast of Bosnia-Herzegovina in the Republic of Srpska. The lignite is of Tertiary Neogene age and is preserved in an elongate NW-SE trending synclinal basin surrounded by limestone of Cretaceous age. The basin is fault bounded, with the northeastern limb of the syncline containing the bulk of the lignite reserves.
Mining the lignite has proved difficult in terms of equipment performance and in maintaining quality consistency in the coal product. The lignite is for sole use in the neighbouring 300MW Gacko Power Plant, and the required annual production is 1.8Mtpa.
Geological complications such as hard cemented overburden and limestone interbeds within the principal coal section have hindered mining and caused extensive wear on equipment. For a number of years financial constraints have meant that the mine has been under capitalised with poor maintenance and few spare parts. In order to re-vitalize the mine and to guarantee supplies of acceptable quality lignite to the Power Plant for 20 years, the method of mining has been reviewed and a new reserve area targeted for future exploitation.

Keywords: lignite, bucketwheel excavator, Yugoslavia.

1. Introduction

The Gacko coal basin is situated in the southeastern part of Bosnia-Herzegovina in the Republic of Srpska, approximately 140 km south of Sarajevo in the valley of Gatačko Polje (43°15N 18°30 E). It extends for 40 km^2 at an altitude of 940m asl. The area experiences extremes of climate, -30ºC in the winter to +37ºC in the summer, with an average precipitation of 1,750mm/a.

The coal basin forms a flat area composed of Tertiary Neogene sediments preserved in a fault bounded syncline surrounded by Cretaceous limestone upland.

Opencast lignite mining first started at Gacko in 1954, and has continued since that time. The 300MW Gacko Power Plant came into operation in 1984 and has supplied electricity to the Republic of Srpska regularly since then apart form some disruption during the Balkans War.
The breakup of the Former Yugoslavia has resulted in the State electricity Board of Croatia still retaining an equity share in the Gacko Power Plant and lignite mine complex. The Republic of Srpska is closely linked to Belgrade and as a result of the recent political situation in Serbia, the power plant and mine have suffered from an acute shortage of funds.

The current requirement for the Gacko Power Plant is 1.8Mtpa of lignite at an average Net Calorific Value of 9,500 kJ/kg. This production level and quality requirement has not been maintained for the last 10 years, and as a consequence, the power plant has suffered under performance, shutdowns and excessive wear on equipment.

It is important that the power plant is producing and selling electricity and be able to maintain a financial return. In order to achieve this, a technical and financial review of the Gacko complex was instigated to decide the future strategy, i.e. to invest in Gacko or relinquish the asset.

2. Geology of Gacko mine

The geology of the Gacko Basin has been mapped and evaluated by personnel of the Gacko Mine and Power Company, part of the Electricity Company of the Republic of Srpska (Fig.1). The basin is an elongate synclinal fold trending northwest-southeast. Both the northeast and southwest sides are faulted against older cretaceous limestones. The basin contains a sequence of Tertiary sands, marls, limestones and lignites, the principal lignite seams being preserved in the northeastern limb of the syncline in the northern sector of the basin. Minor lignites are present in the upper part of the sequence in the central part of the basin but at this stage are not considered to be economic for exploitation.

The current opencast lease area (Pit B) is topographically flat with minor undulations, the elevation varies only by two metres across the lease area of 0.96 km^2.

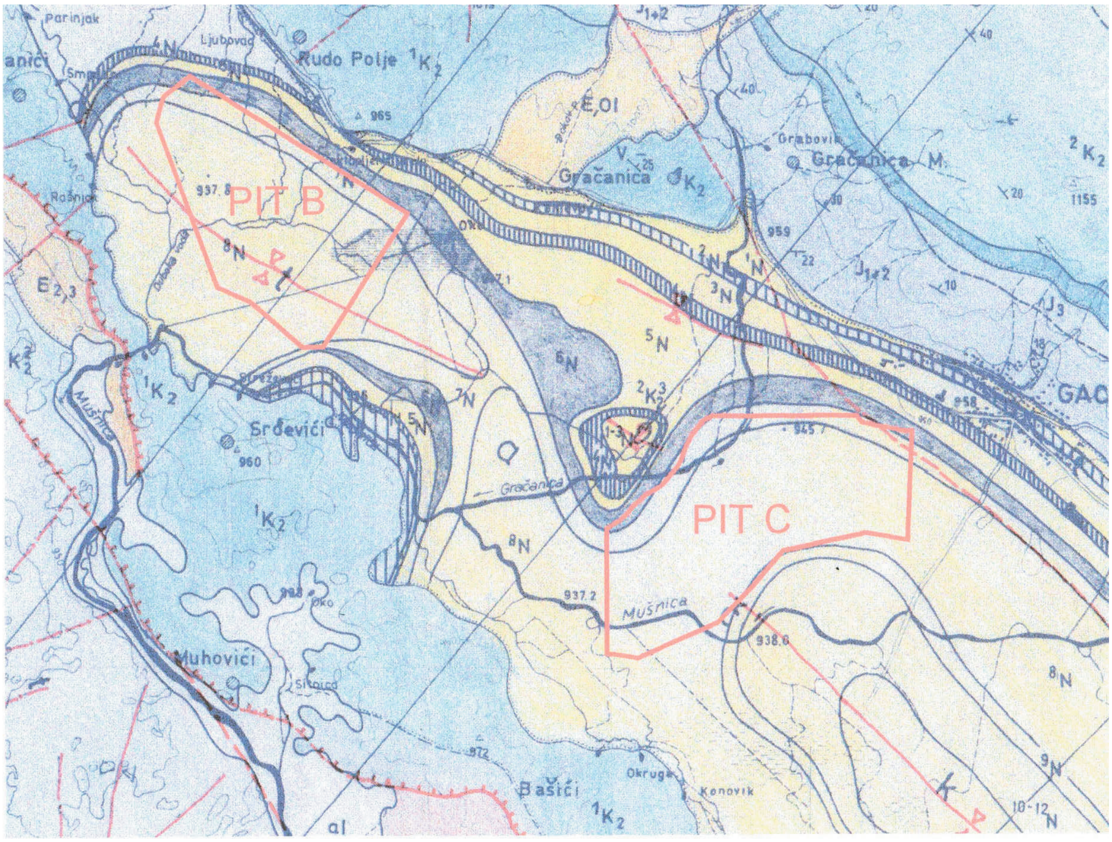

Figure 1. Geological Map of the Gacko Basin, showing folded Tertiary sediments (yellow) surrounded by Cretaceous limestones (blue). The main lignite seam (grey) and two subordinate lignite seams (striped) are preserved along the northern limb of the syncline (produced by Gacko Mine & Power Company). Map Scale 1:25,000.

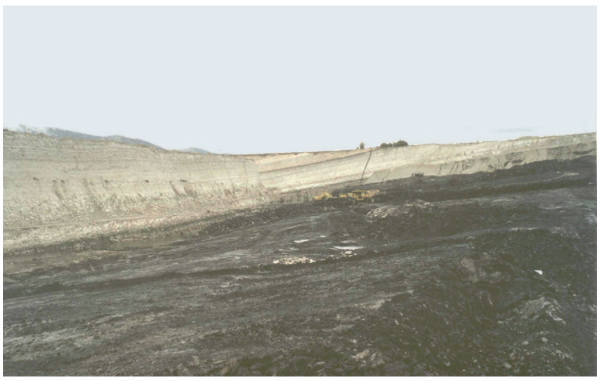

Figure 2. Lignite and light coloured overburden dipping at 7° to southwest, Pit B, Gacko mine.

Figure 3. Fault downthrowing overburden on the right against banded lignite on the left of the photograph, producing highwall termination. Height of face 10 metres.

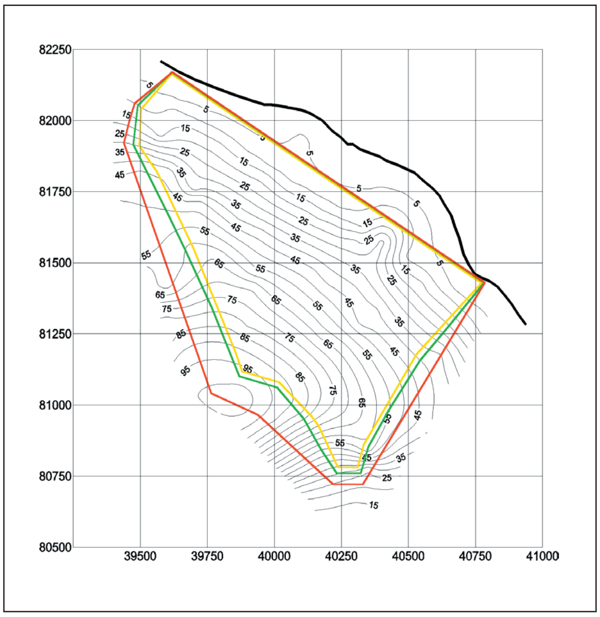

Figure 4. Depth to the top of the main lignite = thickness of overburden (5 metre contour interval), Pit B, Gacko Mine. Scale 1:25,000.

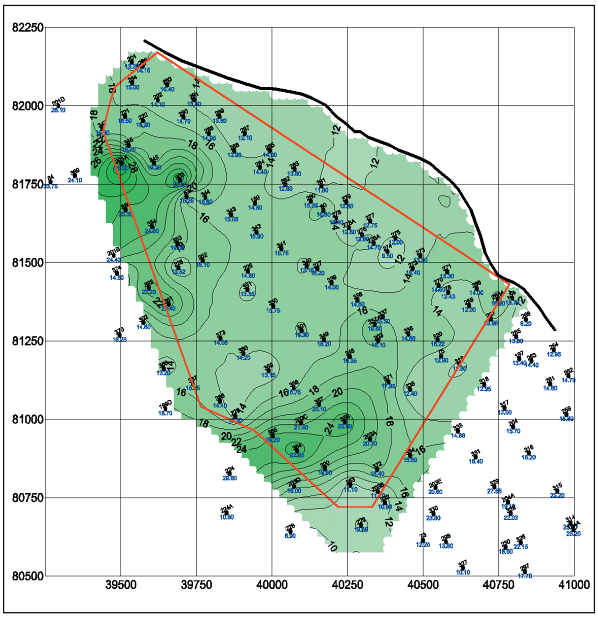

Figure 5. Total thickness of the main lignite seam in Pit B (2 metre contour interval), Gacko mine. Scale 1: 25,000.

Figure 6. Ten metre highwall showing lignite with numerous light coloured calcareous interbeds, Gacko Mine.

The Tertiary sediments dip to the southwest at 6-7° (Fig.2), and there is little disruption to the seam top configuration, except for the local effect of two small dip faults with throws of less than 10m on the northeast subcrop area. The older initial mining area (Pit A) now worked out, situated immediately to the south, is separated from Pit B by several faults as shown in Fig.3.

The depth to the main lignite runs from the subcrop just below the surface to a depth of 90m in the southwest corner of the lease area (Fig.4). The total thickness of the main lignite seam is shown in Fig.5, and can be seen to increase from 14m up to 28m in the south and west. This increase is due to the development of non-lignite interburden within the main seam, present as thick partings (Fig.6). for the majority of the pit area, the main lignite thickness (minus partings) ranges from 10-14m. The character of the main lignite with the development of interbeds varies across the pit area, to illustrate this, seam profiles from boreholes drilled across the pit area are shown in Figs. 7 and 8. When the lignite is mined as a whole seam section, the interbed development has a significant influence on the quality of the lignite feeding into the power plant. Not only does the included non-lignite material reduce the calorific value of the fuel, but owing to the fact that it is lime-rich, this uses heat from the boiler causing a further heat loss.

The overburden consists of grey marls and yellow sands, whish vary from soft, poorly cemented material to hard cemented sediments, this is particularly true of the marls. This has led to difficulties in excavation of the overburden, and it was clear that the areas of hard, indurated sediment needed to be identified prior to mining. This was successfully determined in Pit B by resistivity traverses across the pit area. The geophysical results were then plotted to show the likely configuration of the resistant rock.

The proposed additional Pit C area (Fig.1) has identical geology, the main seam lignite and overburden characteristics being similar. The strike of the seam swings from northeast to east and the sequence dips at 7° to the east and south. The main seam thins to the northeast from 22m in the southwest to 8m for much of the northeast part. The total seam thickness ranges from 24m in the southwest to 16m in the northeast, due to interburden development and no major faulting is anticipated.

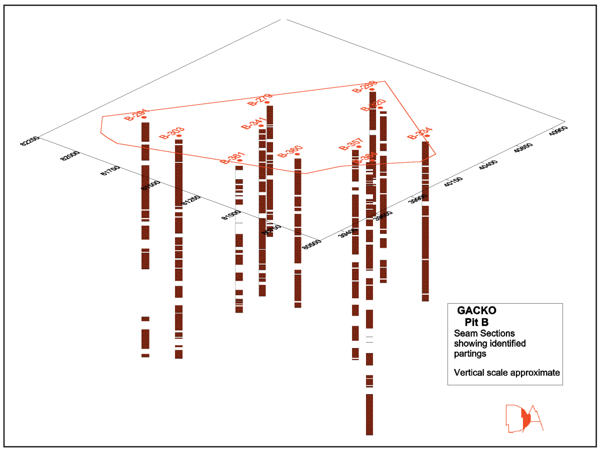

Figure7. Borehole profiles in the main lignite seam, Pit B, Gacko mine. Grid co-ordinates as for Figures 4 & 5. Horizontal Scale 1:25,000, vertical scale 1:200.

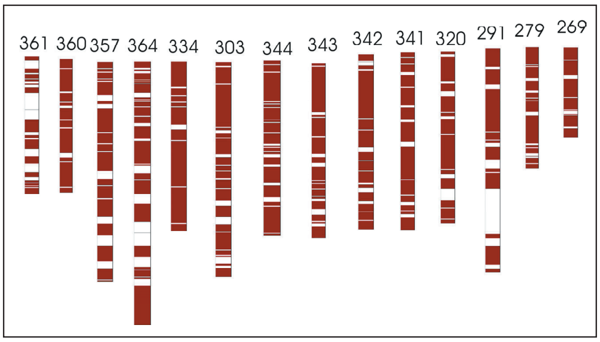

Figure 8. Sections through the main lignite seam (dark), showing the development of non-lignite interbeds (light), Gacko Mine. Vertical scale 1: 1,000.

3. Opencast Mining

In recent years, the mining operation at Gacko has suffered from old and worn out equipment, some unsuitable for the small size of the working area. In addition, poor maintenance principally due a lack of spare parts has exacerbated the problem. The low number of man-hours per year together with the extremes of climate, in particular the very cold winters, have all contributed to low productivity and lack of quality control.

The Pit B area is now well defined and contains over 20Mt of lignite at an average stripping ratio of 1.9:1 at a depth cut-off of 100m, and including batter volumes (at 60º from the horizontal). The stripping ratio increases in the extreme western and southern edges of the lease area, but they are unlikely to be mined. Reserves for the lignite including interburden are estimated at 24Mt, of which 16Mt is clean lignite.

The current mining method is to strip the softer overburden directly using bucketwheel excavators (BWE's) (Fig.9), and then using a bulldozer to rip the hard overburden in advance of the BWE. The lignite has been mined in the pas using a back hoe shovel, but it is planned to use a Wirtgen stripping machine (Fig.10) to selectively mine the lignite and discard the limestone interburden. It remains to be seen if sufficient productivity can be achieved using this method. Overburden and other mine waste is to be dumped in the void left by the old mine workings (Pit A).

The new mine lease area known as Pit C, contains a similar sequence to Pit B with no obvious geological structure problems. The principal constraints are the distance from the power plant, the area of influence around Gacko town, the influence of the River Musnica which crosses the southwestern part of the lease area (see Fig.1), the character of the main seam itself, and the distances required to out of pit dumping of waste.

The estimated reserve for the Pit C area is 37Mt for seam plus interburden, representing 20 Mt of clean lignite using a 100m depth cut-off. The stripping ratio has an average value of 1.5:1 (Fig.10). In the southeastern part of the lease, there is an increase in the seam interburden thickness, which will make this area less attractive to mining.

Figure 9. Bucketwheel Excavator cutting overburden at Gacko Mine.

Figure 10. Wirtgen Machine stripping lignite in Pit B, Gacko mine.

From the experience of using BWE's in constricted mining space and the inflexibility of this system in small mines, it has been proposed that for Pit C the introduction of a truck and shovel mining system would be the most practical and economic method. The system would be used to mine both overburden and lignite and could mine those areas inaccessible to the BWE system. Traditionally all mining in this region has been by BWE technology, but elsewhere in the world truck and shovel operations have proved to be more economic with high rates of productivity. However, such levels are only achieved by working a large number of man-hours per year, well above the current levels of working at Gacko.

4. Coal Quality

Table 1 shows a summary of the average lignite quality present in Pit B and in the proposed Pit C. In addition, the quality of the selected mining section in Pit B i.e. lignite plus interburden, is also given. The inclusion of non-lignite increases the ash content and lowers the calorific value of the mined product. The selection of the mining section in Pit C will be critical in providing lignite with a calorific value not less than 9,500 kJ/kg to comply with the power plant's fuel specification.

5. Conclusions

To satisfy the required demand for fuel by the existing power plant, plus the possibility of the construction of a future additional unit to the power plant, the development of the new mine site is crucial to the future of the mine and power plant. In order for mining to continue in Pit B and in the new Pit C, the following measures are necessary:

1. To re-equip and refurbish existing equipment in order to excavate the overburden using BWE's, and to selectively mine the lignite using the Wirtgen machines.
2. At the same time, open up Pit C and operate with the favoured method of a truck and shovel system for both overburden and lignite excavation, or as a less favourable alternative, use BWE's for overburden and truck and shovel for lignite excavation.
3. Re-establish quality testing of the lignite, and monitor whether the lignite needs to be selectively mined or not, i.e. the mining section including interburden may still give an acceptable quality for the power plant, but in this instance would need to be crushed prior to entering the plant to avoid excessive wear on the plant machinery.
4. These measures are strongly influenced by the availability of finance to revitalise the mine.

   a. The capital will be influenced by the selection of equipment. The selection of BWE machines will mean a large capital investment at the outset, whereas selection of a truck and shovel system would mean a smaller capital outlay but would be followed by equipment replacement after seven years use.

   b. Finance will also be required to carry out regular maintenance of equipment and provision of spare parts.

   c. Finance again will be needed for engineering works necessary to access future lignite reserves, e.g. surface drainage diversions.

   d. Operating costs must be lowered, these are strongly affected by productivity per man shift and number of hours worked. This will involve the re-organisation of labour working patterns and yearly hours worked.
5. Finally, the bottom line for investors will be the cost of the electricity from Gacko Power Plant. The cost per unit KW/h will be critical, and it should be borne in mind that the price of fuel makes up around 60% of the cost. Therefore the improved running of the mine is an integral requirement for the generation of electricity at Gacko.

6. References

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Area	Total Moisture % a.r.	Ash % a.r.	Calorific Value Gross kJ/kg	Calorific Value Net kJ/kg	Total Sulphur % a.r.
Pit B	39.1	13.2	12,055	10,700	1.25
Pit B mining section	37.4	15.1	10,956	9,623	1.22
Pit C	40.0	11.2	12,023	10,641	1.43

Table 1. Average lignite quality for Pits B & C.