

Environmental Reclamation Practice in a Brazilian Coal Mine — An Economical Approach

J C Koppe¹, A Grigorieff² and J F Costa¹

ABSTRACT

Coal mining reclamation is a worldwide concern. This paper presents a Brazilian example where the economic aspects of reclamation are considered. The basic goal of the study is to transform the reclamation procedures into an economic process by integrating the use of land after reclamation and developing profitable post operations. Some of the activities considered in this case study include:

1. using of the coal pit as a landfill, considering appropriate landfill design and construction;
2. using the area for forest development; and
3. developing grassland, forests of native species and the construction of ponds for fishery.

This study will conclude that the mined area is:

1. capable of storing large quantities of waste at a competitive cost and at a low environmental risk;
2. commercial forest development is economically feasible; and
3. the lakes and other reclaimed areas can be integrated into the landscape creating a fresh water supply and an area to raise cattle.

INTRODUCTION

Coal mining has been occurring in Rio Grande do Sul since 1883. The previous surface coal mines usually disturbed large areas (Teixeira *et al*, 1996) and until 1980 little was done on coal mining reclamation practices. At that time, a conservative environmental law was introduced and mining companies started to develop their environmental programs. As a result, Brazilian

1. Mining Engineering Department, Federal University of Rio Grande do Sul, Av Osvaldo Aranha 99, 504, Porto Alegre RS 90035 190, Brazil.
2. Copelmi Mineração Ltda, Largo Visconde de Cairu, 12, 3º andar, Porto Alegre RS 90030-110, Brazil.

coal companies have increased their understanding, awareness and expertise. They have particularly learnt from some very costly past environmental mistakes.

Economic factors have a strong influence on environmental decision-making. The sustainable supply of mineral commodities requires a balance between development, environmental, social and cultural objectives (Lambert, 1996). The development of profitable activities after the rehabilitation of the mined area is very important for the sustainability of mining operations.

To obtain high standards of environmental reclamation expected by the community, coal mining companies must perform beyond the levels determined by the imposed regulations. Consequently, the high costs associated with the reclamation process, particularly in impacted areas, has introduced the necessity of developing new practices in the field.

This paper presents examples of coal mine reclamation in Brazil, where economic factors are being taken into consideration. The basic goal is to transform the reclamation procedure into an economic process, integrating the final land use into the reclamation design to develop profitable post operations. The use of coal pits as landfill, reforestation and ponds for fishery are practices that will be discussed.

SITE LOCATION AND MINING ASPECTS

The coal mining site in this study is located 80 km west of Porto Alegre, Rio Grande do Sul, the capital city and one of the largest cities in the southernmost state of Brazil (Figure 1). Several coal beds are mined by strip mining using a back-hoe hydraulic excavator/truck system at the Recreio Coal Mine, one of the mining operations of Copelmi Mineração Ltda. The mine's annual production is 1 800 000 tonnes at a stripping ratio of 7:1 (m³/t). The total material (coal + waste) excavated per annum exceeds 25 000 000 tonnes.

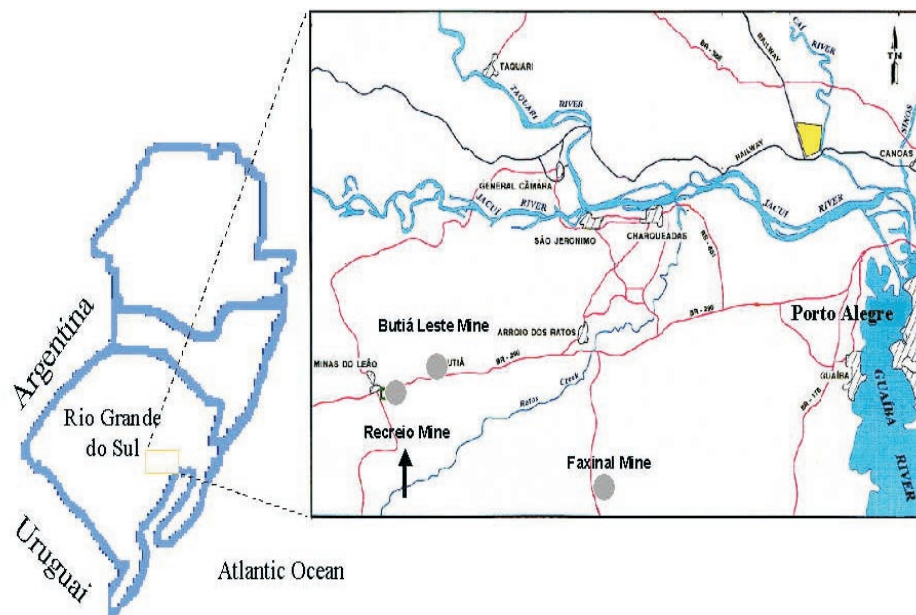


FIG 1 - Recreio Coal Mine location.

The strip mining starts with the removal of the top soil which is stored for rehabilitation of the area. Next, the overburden is removed by a mobile equipment fleet consisting of hydraulic back-hoe excavators and trucks. Interburden is removed using a similar method to overburden removal. The waste fill is placed in the previous strip mined area and is dumped in accordance with the original stratigraphy, thus ‘recomposing’ of the original terrain. Coal is hauled to the processing plant where distinct products are obtained. Figure 2 shows the main operations during the coal mining process.



FIG 2 - Coal strip mining – (top) shows the mining advance, (middle) the coal seams being mined and (bottom) the waste disposal in the previous strip.

Several piezometers surrounding the mining area show that there is no problem with acid drainage or other local contamination of the groundwater.

RECLAMATION PROCEDURES

The Copelmi Environmental Program started in 1980 and comprises not only reclamation activities but also environmental education policies. This program is directed by the Brazilian and state government environmental laws and regulations and includes the involvement of local community and environmental agencies.

During the mine planning stage, all possible environmental impacts are taken into consideration. For example, delay between the stripping operation and reclamation is minimised, with continuous monitoring. Standard reclamation procedures are described in more detail below.

The mined area is ‘recomposed’ to the approximate original contour soon after the stripping process is completed. Next, the waste material is covered with the stockpiled topsoil. An erosion control system is developed as well as pH soil quality correction consisting of calcareous addition. Planting of perennial grasses takes place in an appropriate manner followed by reforestation. Monitoring and maintenance are carried out on a continuous basis. Figure 3 shows a general picture of the main reclamation procedures used.

THE ECONOMICAL APPROACH

The basic goal of Copelmi Ltd, considering the sustainability of the coal operation, is to transform the reclamation process and procedures into a viable economic process. The idea is to integrate the use of land after the reclamation process as a way to develop profitable post operations. Some of the activities are:

1. using the coal pit as a landfill,
2. using the area for forest development; and
3. the establishing of grassland, forests (involving native species) and ponds for fishery.



FIG 3 - Reclamation procedures undertaken during coal strip mining. At the top left, the pit developed during mining, at the centre erosion control and grass planting, at the top right *Acacia Sp* forested area.

Finding appropriate areas for domestic waste disposal is a worldwide problem, especially in large cities. All countries worldwide are facing the solid waste disposal dilemma at various degrees. For instance, Porto Alegre (the capital of Rio Grande do Sul), located 80 km from the mine, has a daily solid waste generation of approximately 1800 tonnes and there is no available land nearby to construct a new municipal solid waste landfill (MSWL). Considering this situation, Copelmi Ltd proposed a large MSWL in the mined out pit of Recreio Coal Mine.

The deposition of domestic and industrial waste requires an appropriate landfill design and construction where certain geotechnical and hydrogeological constraints must be met, and both economical and environmental factors need to be considered (Koppe *et al*, 2002). The mined out open pit provides a large storage capacity and meets the required geotechnical and hydrogeological constraints for the installation of the MSWL. Given the area was initially impacted by mining activities, the regional environmental impact is potentially reduced considering that the excavation for a new MSWL in virgin areas close to urban regions will cause a worse impact. Figure 4 represents a cross-section of the MSWL and the main geological units involved. The MSWL underlain material consist of waste dumps and sedimentary rocks, some of these materials (waste dumps and sandstones) are permeable and need a liner to avoid solutions infiltration. The liner comprises 2.5 m of clay soil with very low permeability intercalated by 0.2 m of sand layer covered by a geomembrane and another 0.2 m of clay soil. The permitted capacity of the MSWL is 1000 tonnes per day of domestic waste and the operation commenced in September 2001. The MSWL construction cost approximately US\$ 300 000. Presently, 92 municipalities are sending their domestic waste to the MSWL and the landfill is working at 80 per cent of its daily capacity.

Some of these towns are more than 200 km from the mine site. The average cost to store the waste including transportation is US\$ 6.00/tonne for towns within an 80 km radius. Figure 5 shows the MSWL daily operation. The trucks transporting the domestic waste dump it into the MSWL and a dozer helps to level and cover the waste with silty rock available in the mine site.

In some areas, where mining occurred during 1987 - 1991 the reclaimed areas were used for the development of demonstration forest projects. *Eucalyptus Sp* and *Acacia Sp* were selected for planting (Figure 6). The first commercial cut of these forests was carried out in 1999 and the wood was sold to a nearby paper mill. The planting of these species resulted in a very profitable operation, with an internal return rate of 50 per cent.

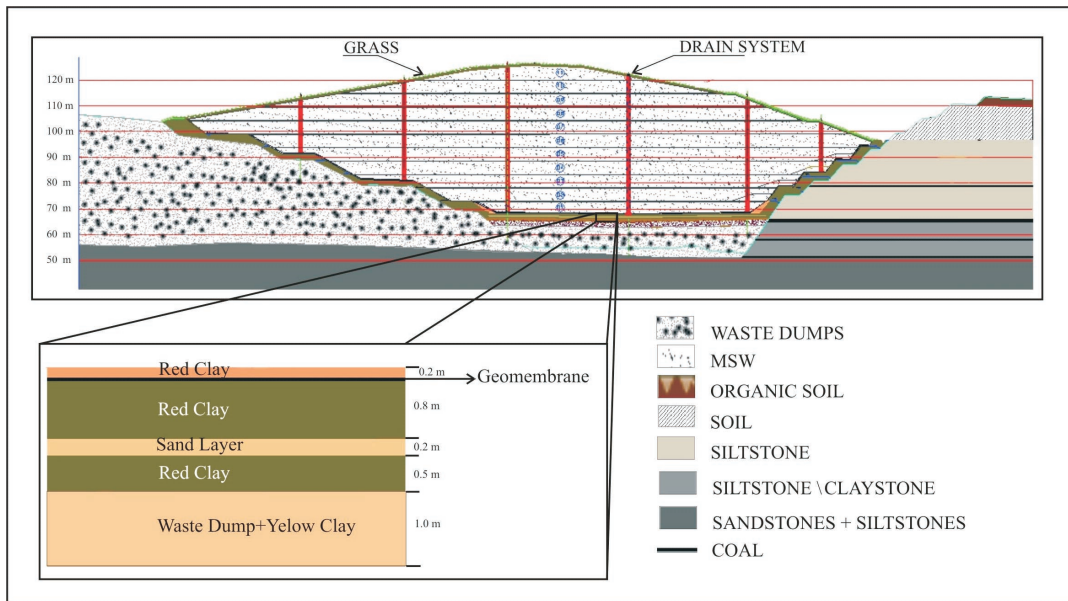


FIG 4 - MSWL cross-section and geological units.



FIG 5 - MSWL daily operation. At the centre the landfill is receiving the domestic waste transported by trucks and it is covered by silty material levelled by a dozer on a daily basis.



FIG 7 - Reclaimed area returned to the land owners for raising cattle.



FIG 6 - *Acacia Sp* forestation area.



FIG 8 - Pond developed in an open pit where an experimental fisher farm was carried out.

Other areas followed approved reclamation plans, by planting native grass species and plants for general landscape rehabilitation. These areas were returned to their former owners for cattle farming (Figure 7). A few ponds were also constructed as a source of water for animals.

In one specific area of the Recreio Coal Mine, a large pond was built and it is used during the dry season to supply fresh water for a nearby town. The quality of the water from this pond meets drinking water regulations. In the same pond an experimental fishery facility was also developed (Figure 8). Although this experimental project obtained good results the project was not continued, the local demand was not able to sustain the fish production.

CONCLUSION

Reclamation procedures viewed as an economic process, by integrating the use of land after reclamation, can lead to profitable post operations for mining companies, even if the economic factors were not taken into consideration during the feasibility studies or when the reclamation plan was developed. It is important to note that this is particularly beneficial to the sustainability of mining operations as well as achieving a balance between development, environmental, social and cultural objectives.

The study concludes that the mined area can:

1. economically be converted to a landfill at a competitive disposal cost and at a low environmental risk;
2. support commercial forests which represents a competitive business for the company; and
3. be integrated into the landscape by establishing grassland, native forests and ponds, producing grazing and water supply for cattle.

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