Developing Bauxite Projects – Planning for Quality Product

Filip Orzechowski
Senior Consultant (Mining Engineering)
SRK Consulting (UK) Ltd, Cardiff, Wales, United Kingdom
Corresponding author: forzechowski@srk.co.uk

Abstract

The development of bauxite projects is focused primarily on such important aspects as in-country available infrastructure, logistics, mineral processing, or deposit geology. These disciplines play an important role by having significant impact on project economic viability, technical feasibility or the capacity to raise funds for project development. Nevertheless, when all these important aspects are finally determined, the project still needs to deliver a quality and profit-generating product, therefore a study should be undertaken to incorporate appropriate mine planning techniques to determine the product quality range. It should define the bauxite product quality achieved from the deposit over the Life of Mine period and how this aligns with the project's strategic objectives in terms of project minimum mine life or head grades. Some fundamental factors, known as Mining Modifying Factors, will influence the production profile and should be appropriately incorporated into the study at an early stage. These modifying factors include mining dilution and recovery, processing recovery, cash costs, and their effect on the economic value of a mining block. They are inherently linked to the deposit characteristics, the mining method to be applied, in situ grades, strip ratio, and other technical or economic characteristics influencing the quality of the final product.

Keywords: Bauxite quality; bauxite mining; mine planning; production planning; losses and dilution, margin ranking.

1. Introduction

Progressing a bauxite project through the different study levels without losing focus on the key drivers is fundamental to developing a successful project. Well-developed international best practice and various international reporting codes facilitate progress while maintaining the key features of transparency, materiality and competence. In that process, disciplines such as geology, mining, hydrology and hydrogeology, infrastructure, geotechnics, waste management, environment and social, and logistics are involved and have low to high [1] influences which should be properly assessed. At the end of the day, costs, revenue, and economic outcome determine a project's economic viability.

Usually, and especially in undeveloped countries, project logistics is the primary focus. It is common that more than 60% of the total operational costs over the Life of Mine ("LoM") are related to logistics [1]. It is therefore critically important when paying high rates for transport, that the project can be assured it is of the required quality and satisfies client requirements and will not be subject to penalties which impact revenue. It is consequently important to have an understanding of the deposit in terms of mining and other technical drivers which could impact product quality. To achieve this, it is necessary to identify economic mining blocks and to extract them at the right time and in the right manner. At present, a broad range of methodologies and mining software packages are available which enable the quick and efficient preparation and analysis of mine planning scenarios. Based on experience gained on numerous bauxite projects recently completed by the author, the main limitation in the early (Scoping Study) stages in this process is the availability of input data and a fairly poor level, or utter lack, of marketing studies covering planning horizons beyond the first five years of the LoM. This

paper summarises the most appropriate modelling and mine planning techniques and aspects considered by the author as crucial for developing and operating bauxite projects.

2. Mining Modifying Factors

As stated above, mining modifying factors incorporate mining, processing, metallurgical, infrastructure, economic, marketing, legal, environmental, social and governmental factors used to convert Mineral Resources to Ore Reserves [2].

Estimating appropriate mining modifying factors such as mining dilution and recovery can have a significant impact on the Run of Mine ("RoM") qualities. However, mining dilution and recovery tend to be neglected in some mining studies, especially those related to industrial minerals, while they receive much more attention in metal mining. This is perhaps driven by a tendency towards lower grades and higher selling prices for metals. It is arguable however, that RoM grades, and qualities (available alumina, reactive silica, etc.), have a far more important role and greater impact on bauxite projects, especially where the Mineral Resource is not extensive or grades are generally low when compared to the product specification. Furthermore, there is a whole set of other technological and economic factors influencing the production process which are analysed outside of the mining study, but must be included and used in mine planning to make the results realistic. The most common of these are; mining cost, processing/washing recovery and cost (if required), alumina production cost, transportation and logistics costs, royalties, and selling price. These factors, though the most common, are absolutely fundamental and, ideally, should include other aspects of the production process such as, for example, cost of energy required to crush the bauxite, behavior in the Bayer process (dependent of the mineralogy and grades), red mud production levels and treatment costs, or land rehabilitation costs. Possibilities here are practically unlimited and should be defined on a case by case basis, but, from the author's experience, it is usually the case that very little of the required input information is available at the Scoping Study or Preliminary Economic Assessment stage when developing bauxite projects. In such cases it is common to use benchmarked values. This exercise can, however, be successfully implemented in operating mines as part of their long term mine plans. Obviously, different sets of the input parameters will be required for a bauxite export operation than for a bauxite mine with an integrated alumina plant.

2.1. Mining recovery and dilution

It has been assumed that the reader of this paper has basic mining knowledge, so only basic definitions of mining dilution and losses are given, following Bertinshaw and Lipton [3]:

"Mining Dilution is lower than economic cut-off grade material (waste) that is taken with the ore as part of the mining process (...). Mining loss is that part of the Mineral Resource that is above the economic cut-off grade and was intended to be mined as ore but is not sent to the mill or placed in an ore stockpile, i.e. it is lost to waste".

Dilution and losses generated from operational errors are harder to predict and much less substantial than those resulting from deposit geometry and applied mining method. This paper focuses on the latter.

While selecting an approach to deal with mining dilution and recovery, some key project related facts are always taken into account:

- the size of the Mineral Resource versus expectation of LoM duration; and
- in situ grades/qualities.

process and perhaps determine that delaying waste striping is not necessarily the most economic option, especially if there is much richer ore (more product) in a higher strip ratio area. Whatever the case for a project is, the key conclusion is not to focus on one mine planning driver only, but to take into consideration various parameters and analyse their influence on the project.

4. Conclusions

Bauxite mining is often considered to be fairly straight forward, with relatively small associated mining costs compared to those in subsequent phases of the production chain, including processing, transportation and logistics. Proper mine planning however, enables equally easy control of the economic drivers from the early stages of project development and in an existing operation. It is fundamental for the entire exercise, and before starting any technical work, to define the business objectives. In most cases, the answer to that question is generating profit, but on a case by case basis this may be achievable in different ways. Mining Modifying Factors are always part of the process, regardless of the final saleable product. Two factors, losses and dilution, are used to transition a geological model into a mining model and can be introduced by using appropriate techniques, depending not only on the format of the existing model but, more importantly, what is most suitable for a given geological deposit.

It can be concluded that for planning bauxite operations, grid models have probably the most flexibility in use. There are some very good tools designed to work with these types of deposits and these generally have fewer limitations compared to block models, including margin ranking techniques and seam compositing tools. On the other hand, grid models appear to be less common these days, so identifying those with the skills required to generate grids may not be simple.

Once the model is established, the next step is to define the pit limits based on economic and technological factors. Understanding the profit of each mining block in the project/operation can simplify the mine planning process. However, to make it practical and applicable, a set of good input parameters is required. Typically, this should cover the entire production chain and may be split into sub-groups to the required level of detail. Bringing the mine planning processes to that level is likely to show that the mining process, even though relatively cheap itself, drives the processing costs, which are significantly higher and impacted by RoM quality.

An optimised solution is only achievable when all the key technical and economic input information is used in margin ranking to define the pit limits definition and guide mine production scheduling. It is recommended therefore that the input parameters, modifying factors, and margin ranking factors are reviewed periodically throughout the development and life of the project to incorporate the data which is constantly being generated and react to current technical or market conditions.

5. References

1. F. Orzechowski, Developing bauxite projects – balancing technical and logistical considerations, *33rd ICSOBA Conference and Exhibition*, Dubai, United Arab Emirates, November 2015, *Travaux*, *No. 44*, 2015, Paper BX 06, 113-120;
2. Australasian Joint Ore Reserves Committee, *The Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves*, (2012).
3. R. Bertinshaw, I. Lipton, Estimating Mining Factors (Dilution and Ore Loss) in Open Pit Mines, *Large Open Pit Mining Conference*, Perth, Australia, September 2007;

4. P. Westcott, G Pitkin, T Aspinall – Monograph 12 – *Australasian Coal Mining Practice*, Chapter 18, Open – Cut Mining, p. 430
5. Dr E. Goldratt, J Coax, *The Goal: A Process of Ongoing Improvement – Gower; 3 edition*, November 2004;
6. A. Fardell, Grid Models 101: Gridding Stratiform Deposits, *SRK Internal Workshop*, Cardiff, United Kingdom, June 2015.