Developing bauxite projects – balancing technical and logistical considerations

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Abstract

Bauxite projects around the world share many similar characteristics: a perceived understanding that the geology is relatively simple and that mining is straightforward; and also, many are located in remote areas that may require significant infrastructure solutions to bring the ore to a port or refinery. This paper sets out to explain the issues and provide an understanding of the competing pressures on where to focus effort when undertaking the technical evaluation of bauxite projects. Getting the balance right is making sure that sufficient geological exploration and resource evaluation are undertaken to appropriately characterize the deposit and allow an optimal mine plan to be developed, versus the logistical analysis and infrastructure design required to understand the capital and operating cost implications of bringing the bauxite to market. Bauxite resources are not particularly difficult to explore or exploit; however, because of the long distances from the deposit to the nearest port, construction of roads, railways, and barging solutions need to considered and the capital for these solutions should not be underestimated. There is a risk that too much focus on logistics and infrastructure diverts attention away from the real issue of the quality and quantity of the resource proposed for exploitation.

Keywords: Bauxite exploration; bauxite mining; development; logistics; production.

1. Introduction

The aim of this paper is to discuss how to correctly bring a bauxite project through the different study levels without losing focus on the key drivers. At present, there are well developed international best practices as well as various international reporting codes which enable work to be progressed while maintaining the key features of transparency, materiality and competence.

A project development path (including various study levels as presented in Figure 1) is dependent on the individual company's or investor's approach driven by their specific objectives, timeframes, marketing etc. In both buoyant and stressed market conditions it is often attractive to fast track or skip a particular technical study stage (for example scoping or PFS). However, in order to do so it is always important for the company to understand both the opportunities (potentially reduced cost and timescale) and the risks (selection of a non-optimal solution, requirement to do rework, or, in the worst case, even project failure). In order to understand these risks it is imperative that the company assess each of the technical disciplines to identify where the risks lie and the potential probability and magnitude of the impacts. This paper aims to introduce the different technical disciplines, their relative importance and the potential risks and opportunities that are presented when considering a typical West African bauxite project at a scoping study level of development.

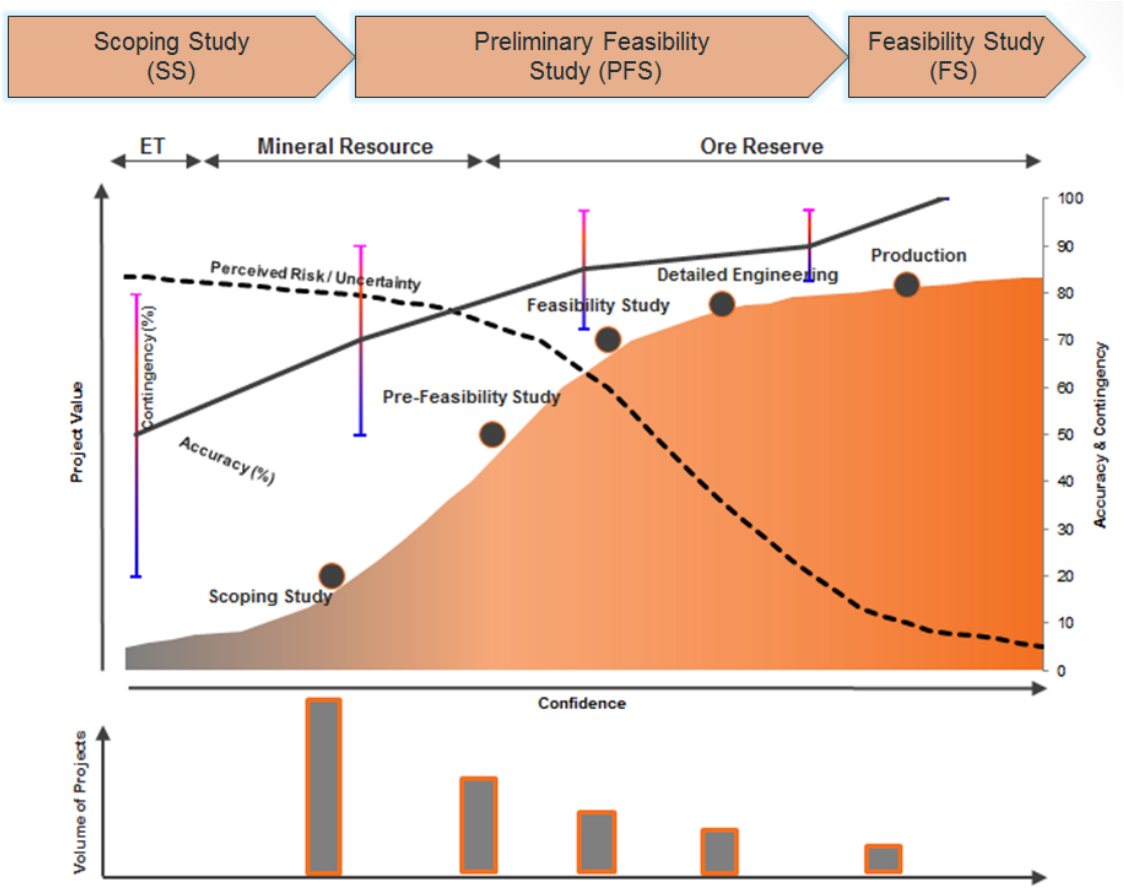

Figure 1. Fundamentals of technical study levels.

The SRK Group has an established track record in delivering technical studies and reports for the bauxite and alumina industry. Table 1 presents a summary of recent bauxite and alumina projects completed by SRK split by geography, asset and mandate type. In terms of the competent persons reports (CPR) and multidisciplinary studies, this would often include broad multidisciplinary assessment concluded with economic modeling to support the declaration of Ore Reserves. The nature of such multi-disciplinary consulting work very often leads our clients to choose SRK to ultimately manage the whole study process, benefitting from hosting all of the studies under one roof and an understanding of the interdisciplinary dependencies critical to managing the process efficiently. As a result, SRK has developed a robust understanding of the different decision points and projects phases, differing client requirements, reporting standards, permitting and regulatory requirements and overall market.

Table 1. Bauxite Studies by SRK Consulting (UK) Ltd 2005 – 2015.

Studies by Asset Location		Type of Studies and Operations	
India	1	***Mandates*** ***	
Kazakhstan	2	MRE** or MRE Update	26
Italy	1	CPR* & Due Diligence	45
Greece	2	Multi - or Discipline Technical Study	35
Guinea	20	Ore Reserve Estimates	8
Jamaica	4	***Asset Type***	
Russia	2	Open Pit Mine	21
Guyana	1	Underground Mine	1
Saudi Arabia	1	Exploration Property	24

Sierra Leone	7	
Suriname	4	
Vietnam	1	

[*] Competent Person Report
[**] Mineral Resource Estimate
[***] Some studies involved more than one objective or were repetitive

2. A Consultant's Perspective

Without doubt, studies related to developing projects that come across a consultant's desk are always at differing stages and supported by differing levels of detail. No two bauxite (or other commodity) projects are identical; some are rich in information and well documented, while others have only limited data. Quite often there is limited information beyond the immediate problems the client is experiencing. For example, for one such bauxite project, SRK was requested to do a series of technical reviews covering a span of a few years, focused mainly on the logistics and economics associated to exporting the project, but was provided with limited geological information of low confidence. Ultimately, it was discovered that the quality of the deposit was poor and that the Mineral Resource much lower than expected and unlikely to be sufficient to develop a new project. On the other hand, some projects may have been subject to extensive exploration and resource development, whereby the total resource delineated may be far in excess of the requirements of a typical lending scenario of 20 - 30 years, and therefore the funds expended could have potentially been funneled in to more immediate goals to bring the project to market in a more timely manner.

There may be almost unlimited situations, but typically SRK deals with technical studies where the main objective would be:

- declaration of Mineral Resources to be used for funding further investigations and project development;
- technical review to determine fatal flaws and define a work program to take the project forward to the next developmental stage;
- technical review and study in order to apply for a mining licence; and/or
- undertaking a Scoping, Pre- or Feasibility Study (including the definition of Ore Reserves) to demonstrate the technical and economic viability of the project in order to support project financing.

When clients are looking for external financing the focus is typically towards authoring technical reports (and associated studies) which comply with International Reporting Codes, such as the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves, the JORC Code, 2012 Edition ("JORC"); the Canadian National Instrument 43-101; South African Code for Reporting of Exploration Results, Mineral Resources and Mineral Reserve ("SAMREC"); the Pan-European Reserves & Resources Reporting Committee ("PERC"), etc. The advantages of using internationally recognized reporting codes is that they impose a specified approach to reporting which is aimed at presenting the work conducted in a transparent manner, whilst placing the reliance on a competent person (suitably qualified and experienced) to extract and present those aspects which are material to the project.

Figure 1 presented earlier illustrates the progression through the different technical study stages, highlighting the degrees of engineering, basis of design, accuracy of cost estimation, and level of contingency typically deemed applicable. The progression from one stage to another is designed to transition from a low confidence and high risk position through to high confidence and low risk perspective. Each study stage should conclude with a decision whether or not to proceed into subsequent stage and a plan in regards to the next steps.

As discussed above omitting milestones in this process can lead to delays and unforeseen difficulties, which is usually expressed as an extra cost to the investor. In some cases, however, such practices may take place, but with the understanding of the inherent risks and potential negative effects in order to expedite the project, and take advantage of short-term demand.

At the Scoping level stage of the project development process, the available options for each discipline need to be analyzed and the materiality of the discipline assessed. Consequently, certain options can be excluded and others can be accepted for more detailed consideration at the subsequent stage and built into the overall project schedule. Gradually, as the Project progresses through the study stages typically it starts with a cost estimation accuracy of ± 40 % to finish at level of around ± 10 to 20 % at Feasibility Study level.

Overprinted on this generalized study progression should be a consideration of the relative importance of the individual disciplines associated to the specific project. Table 2 presents a summary of the key focuses and perceived impacts based on SRK's experience for a typical West African bauxite project at a Scoping level of development.

Table 2. Discipline Matrix - Bauxite export only- Scoping Study level.

Discipline	**Key focuses**	**Perceived impact**	**Comments**
Geology	Develop a robust understanding of the style and extents of mineralization. To define sufficient Mineral Inventory/Mineral Resource to support the project life base case/ Life of Mine ("LoM"). Bauxite characterization (including mineralogy) sufficient to support the definition of the product quality and potential processing options available (market potential).	High	Foundation for confirming project scale and ability to produce a marketable product. Driver for mining method, processing requirements and methods.
Geotech	Excavatability	Low	Excavatability feeds into mining method selection. Slope stability typically has minimal impact on mine design.
Hydrology	Identification of any potential Surface water management ("SWM") issues	Low	Plateau and flank deposits typically avoid large drainage features and as a consequence SWM is typically reduced to managing run-off and direct precipitation. Intense wet season climatic conditions may impact product moisture content and transportability.
Hydrogeology	Establishing ground water level relative to pit depth	Low	Bauxite mines are typically strip mines operating at shallow depths, therefore no/minimal de-watering is required.

Water Supply	Defining potential water sources	Low (assuming no washing)	Only critical where bauxite washing/ processing may be required.
Mining	Definition of mining method - to consider free dig or blasting. Strategic mine planning to analyze blending requirements and quality management in order to satisfy product specification over the LoM. Preliminary mine sequencing relative to the multiple plateaus involved, considering haulage distances etc.	Low to Moderate	Cost of mining is usually relatively small when compared to logistics; however, insufficient studies (see Geotech) present a danger of selecting non-optimal mining method. Typically, low strip ratio, where overburden waste is backfilled.
Mineral Processing (washing) and Waste Management	Definition of whether beneficiation (washing, crushing or sizing) is required to meet product specification.	Low (assuming beneficiation is not required)	Where beneficiation is required, appropriate recoveries and resultant product qualities should be defined.
Logistics	Option study to define potentially viable export solutions. Understanding of existing infrastructure, third party agreements in place and realistic assessment of whether the complete interconnected logistic solution(s) could be secured, have sufficient capacity and what investment (upgrades/additions) may be required. Development of preliminary operating and capital costs associated to each option to be taken forward.	High	This is often a flaw for the project; many known deposits remain in remote areas. Cost to export the product is typically a significant part of the overall operating and capital cost for the project.
Infrastructure	Consideration of potential supply options.	Low	Minimal power requirements taken from the local grid or on-site diesel power generation
Environmental and Social Study	Environmental and Social Scan	Moderate	Relatively large areas impacted by mining operations, which have the potential to impact on the environmental and social setting

It is noticeable that despite many disciplines having low impact on the overall project, there are two major areas not to be overlooked, namely geology and logistics, which require investment of significant effort at the Scoping level of study. That geology is the project's fundamental starting point feeding into all disciplines may seem obvious, but the apparently simple nature of bauxite deposits can mean that sometimes it is overlooked. All too often logistics are found by SRK to be a fatal flaw in bauxite projects, due to the lack of major infrastructure like railway and sea ports which are large capital investments occurring at the early stage of development.

The following sections discuss the two disciplines of geology and logistics in further detail to show why are they so crucial in developing bauxite projects.

2.1. Geology

Taking West African bauxite deposits as an example it may be said that they usually consist of a series of plateaux, subdivided into smaller mining blocks. It is worth mentioning that this kind of placement is often associated with deposits covering a large surface area and with potentially significant mineral resources, largely exceeding requirements for around 20 years of the LoM, the period usually required to support the project financial base case. SRK often sees projects where significant effort has been made to cover the entire license area with exploration drilling in order to declare the maximum possible MRE. Whilst this may be a company directive it should be realized that for the majority of those projects, a 20 year LoM is sufficient to support the business case, and therefore attempts to explore a wider area which would exceed the required finance period may result in delays to the project and misallocation of funds which could be better focused on other aspects of the project, such as characterization testwork or logistics.

It is also noticed that in many projects an important amount of historical information in the form of data and technical studies is available, but too often it is in poor shape and requires significant efforts to validate the results prior to them forming part of a Mineral Resource estimate in line with current international best practices.

In support of the resource definition the project should also focus on defining a saleable product and as such the following characteristics should typically be investigated:

- Mineralogical profile;
- Total Alumina and Available Alumina % ("TAA");
- Total SiO_2 % and reactive SiO_2 %;

In terms of bauxite sales and alumina production it is generally understood that bauxite with TAA grade exceeding 45% is considered to be high grade bauxite. These parameters will ultimately dictate the processing route (if considered in the project), generally low or high temperature Bayer refining to produce alumina, and the associated processing costs.

For the purposes of defining that the bauxite has reasonable prospects for eventual economic extraction (required when declaring a MRE) an economic assessment of the project must be considered. In the case of bauxite deposits this typically takes the form of a stripping ratio assessment, whereby thickness cut-offs are typically applied to waste and bauxite.

Depending on the study level under investigation and accordingly to the reporting codes, the MRE should define which classification applies to the different parts of the deposit. At the Scoping or preliminary assessment stage it is acceptable to include resources falling into the Inferred classification category. However, more advanced prefeasibility or feasibility studies are expected to have at least indicated resources, which allow the declaration ore reserves when all requirements/modifying factors have been derived or tested and satisfied.

2.2. Logistics

The logistics aspects of bauxite export projects are often the largest contributing factor to the cost and therefore the main drivers for the technical study requirements and investigations. The extent to which the project costs associated with logistics are dictated by logistics depends on factors such as project location in undeveloped countries and proximity to existing logistics infrastructure such as roads, railways, or ports. At early stages of the development process it is

important to evaluate all of the "reasonable" options available to the project, in order to discount those which are technically and economically unfeasible and to identify those options which are worthy of further investigation. For example, many different options to export the material may be visible and should all be considered as long as they seem to be "reasonable" in relation to current levels of project knowledge and confidence. The purpose of any subsequent study stage, post Scoping study, would be to focus in on one or two of the most attractive options and then select the most optimum solution and study it in more detail.

It is therefore common within a Scoping study to make a series of technical and organizational assumptions as an economic viability check. Those assumptions will need to be verified later in the process for the option(s) taken forward. Typically, such a list of assumptions related to logistics may consider the following:

- Level of moisture in the final product;
- Location of the sea port, use of existing stock yards or developing new infrastructure;
- Different transport corridors/routes including existing and non-existing haul routes, railways, ports and barging connections;
- Use of existing third party infrastructure to reduce the capital expenditure required for the project; and
- Use of contractors leading to minimizing the capital but increase in operating costs.

In the early project stages, financial analyses are made around these assumptions to understand the project sensitivity and impact for each of them. It is noted that often in the case of bauxite projects there is a requirement for significant investment in infrastructure. The nature of this type of mining and exporting project does not allow for delay in those investments and all infrastructure needs to be ready prior to production of the first exported tonnes. That means money needs to be spent upfront, which is never a preferred option. As a result, often the preferred solution incorporates a scenario with minimal capital costs committed upfront using existing facilities, which are then expanded once the project has started generating cash flow.
From SRK's experience of a large number of bauxite projects located in undeveloped countries around the world, cost related to logistics and materials handling is a significant proportion of the development and operating costs. Operating costs can contribute to as much as 60 to 80 % of the overall operating cost, calculated over the LoM.

Dependent on whether the project is able to utilize existing infrastructure or construct its own, capital costs can also play a major role. New infrastructure would usually mean developing new road(s), railway line, stockyard or barging port etc. In other words, these are always major elements.

Therefore, contracting those services is a potential option to be considered. It would help to minimize the capital costs, time for construction and relay on services provided by third parties. Potentially, it may also save time needed to make the development completed.

3. Conclusions

As has been discussed, one of fundamental aspects in a mining project is geology and the way it has been documented and with what level of confidence. Depending on the study level, a Mineral Resource Estimate should be declared and contain resources assigned to appropriate classifications, defined by internationally recognized Reporting Codes. For scoping level studies, at least Inferred category should be present in the MRE with the potential for improving it to Indicated and/or Measured. It is clear that in light of the MRE being a foundation to the entire project it has a serious influence on the overall study and outcomes from other disciplines. Unfortunately, very often in case of the West African bauxites there is usually a reasonable

volume of historical geological information but it has reported in a way that is insufficient to satisfy current internationally recognised reporting standards. Once the geological situation has been clarified, subsequent technical considerations come into play.

Disciplines such as mining, hydrology and hydrogeology, infrastructure, geotechnics, environment and social have low to moderate influence and are often not significant to this type of project. Despite that, they should be properly assessed as otherwise there is a risk that the selected solutions or scenarios will not be optimal to the project.

At the end these are costs and economic outcome which decide the project's economic viability. The biggest focus in that regards is to the project logistics. It appears to be very common that more than 60 % of the total operational costs over the LoM are related to logistics. This demonstrates that logistics potentially have a huge economic impact on the project's economics and therefore all possible options should be considered to define the optimum scenario brought forward to more detailed studies.

So, what should be the most important areas to focus on in the early stages of developing a bauxite project? First of all, available options and scenarios should be defined with a clear set of assumptions. The assumptions will influence the level of confidence, which is typically high in that part of the process, but will be confirmed or eliminated in the subsequent studies. Obviously, without the bauxite mineral resource there can be no project. The fact that mining bauxite is usually relatively simple and cheap when compared to the overall cost should also not decrease its importance in the technical assessments carried out. On the other hand, the location and remoteness of a deposit can indeed act as a fatal flaw to the project because of the huge capital required to start production or the significant operating costs relating to the transportation of the product. Therefore, the answer to this question is probably somewhere in between. It will strongly depend on the situation specific to the individual project; but generally, based on SRK observations and experience, this paper reaches the following conclusions:
Geology and logistics are the main big areas for consideration, especially for West African bauxite projects. Quality of the bauxite resource is critical, given the potentially large areas and volumes that are available in many deposits, and activities should be focused on understanding the portion of the deposit that is of the best quality an thickness to provide the Life of Mine feed for the project, rather than simply trying to define as big a tonnage as possible. Logistics play a major role in costs and economic analysis, and for very remote sites that require completely new infrastructure, logistics may be the controlling factor, but a comprehensive geological assessment and thorough assessment of the resource will still be needed in order to influence whether it worth undertaking extensive logistical and infrastructure assessments.

4. References

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