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Coarse waste rejection through size based separation

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ABSTRACT

The mining and processing industry relies on the avoidance of waste during mining, followed by the progressive removal of waste and contaminants via comminution and beneficiation during processing. Unfortunately the low grade of valuable content in most metalliferous operations dictates that vast quantities of associated host rock and gangue accompanies the valuable material to the processing plant.

Waste rejection can be considered the flip side to mineral extraction, with the focus being on the development of a barren material stream that is rejected by the process, with minimal valuable metal contained. The key to a mine's economic success lies in the liberation of the metal from within the host rock with the smallest possible investment in capital expenditure and energy.

Newcrest Mining Ltd., initiated an investigation into how waste rejection could be employed across their various operating mine sites and how it could be used in future operations. The total project examines a range of waste rejection techniques capable of deployment at coarser size ranges and these include systems based on, size, gravity, physical and chemical properties. This initiative is a component of the ongoing Newcrest strategy of re-working the research area of "mine to mill", to truly make it a system wide approach that looks at all the latent value opportunities.

This paper provides analysis of sized based waste rejection work undertaken at the Newcrest Telfer site. The results of this study show that some process streams offer significant potential for waste rejection, but in most cases there is no 'one pass' waste rejection option. Rather the rejection process becomes a series of liberate-separate cycles. At each stage the altered physical characteristics of the material open different possibilities for rejection techniques.

1. Introduction

The application of waste rejection is not new to the mining industry; all operations by definition must reject waste in order to convert a rock mass to a saleable metal concentrate. However in many operations, waste rejection is considered only at the extreme coarse end through mine planning and the selective mining of high grade ore, and the finer end through beneficiation methods such as flotation, which follow extensive energy intensive comminution.

At each stage of the process in a mining operation there is the opportunity to exploit the known characteristics of the rock to reject waste and in doing so, concentrate the feed to the next stage.

This paper reports on the first stage of a broad project being undertaken by Newcrest Mining Ltd. across their operations to explore the opportunities in coarse waste rejection to not only maximise the economic effectiveness of existing operations, but also to prove up technologies and their application to future Greenfield sites.

This first phase of the study has focussed on two main areas. Firstly an investigation of existing processing facilities to identify waste streams suitable for rejection rather than further processing or recycling. Secondly, the extensive field testing of coarse screening equipment to determine the size by grade behaviour of the ore body at ROM scale. The exploitation of size by grade behaviour is not new; indeed it has been used successfully in large mining operations before, such as the pre-screening of feed at the Bougainville Copper mine (Burns and Grimes, 1986). Another example (from author's personal experience) is the use of a fixed grizzly scalping device in front of the primary crusher at the Mt Tom Price iron ore mine to determine the processing path for material – if to the high grade or low grade plant.

2. Strategic imperative

The gradual decline in ore grades and increasing complexity of ore body extraction, coupled with declining discovery of new ore bodies has been well documented (Batterham and Elvish, 2009). One of the key restrictions on ore body development is the capital and energy required to recover the valuable metal contained. This reliance on engineering capital to undertake the full extraction of

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the metal is based on the traditional view of metal extraction and tailings generation, as per Fig. 1.

This traditional path of metal extraction sees two basic stages of waste rejection. Firstly, the demarcation of ore and waste for development and execution of the mine plan. Secondly, the liberation by comminution of all material deemed 'not waste' (hence delivered to the processing plant) to the necessary size for effective extractive metallurgy. In a typical SAG mill based operation there are three overall waste streams generated: ROM mine waste, milling scats and tailings. This list is not exhaustive or exclusive, as mill scats are not always fully rejected, they can be re-crushed and re-introduced into the process. Similarly tailings is not always a single rejection point. Tailings can be generated at various points in the finer processing, but they are accumulated into a single stream for disposal.

The broad range of materials fed to a modern comminution circuit ensures process plants today are designed to handle the full range of expected ore types. Many of these broad feed sources come from deep underground which tend to be significantly harder. The result of this is the constant development of larger grinding mills and associated equipment to achieve the throughput at the target liberation size. The acceptance of using non-renewable energy to achieve sufficient comminution for liberation of all materials in the ore body will become less acceptable.

The main contributor to the energy consumption profile of a metalliferous mine site is the comminution required to reduce the ore bearing material to a size where traditional beneficiation and concentration techniques can be applied. Bearman (2012) suggested that the whole view of comminution should be redefined and suggested two alternative definitions, namely:

- The application of minimum size reduction to value bearing material, whilst still generating a saleable product or a product requiring minimum further upgrading.
- The preferential application of energy into value-bearing material to generate a saleable product or a product requiring minimum further upgrading.

This view was reiterated by Lynch (2012) in his prediction that comminution will be the area of focus and innovation in the current century as much as floatation dominated the last century.

A key part of any such redefinition is the ability to only present to the comminution process, material that absolutely must be processed, i.e. waste material should only be exposed to the minimum possible level of comminution.

Inherent in the requirement to reduce the comminution requirements, but also above and beyond, is the need to reduce operating costs. Less comminution equals less energy and less cost, but this improvement can be easily cancelled-out by a concomitant increase in materials handling, or other costs associated with taking waste out of a system.

Such associated costs include:

- Extra equipment to reject the waste.
- Maintenance and operational costs of waste rejection equipment.
- Mobile equipment costs.
- Conveyors and associated chutes, transfers, bins and hoppers – capital and operating costs.
- Waste storage and encapsulation costs if material is deemed potentially acid forming.

The reduction in waste management costs when compared to the traditional approach comes through the reduction in tailings production, deferring wall lifts and extending existing dam life.

The philosophy pursued in the overall Newcrest study was to seek coarse waste rejection techniques that introduce the minimum equipment and cost into the system, whilst still removing considerable quantities of mill feed. Using these approaches the tonnages exposed to comminution and generally treated and handled, would be minimized.

In considering such an approach, the use of the word "coarse" is critical. Most beneficiation and concentration technologies for metalliferous mines use separation sizes in the range 80–200 μm. As shown in Fig. 2, the energy consumed in size reduction increases as a power relationship and hence the ability to reject mass at a coarser size removes the need to apply higher per unit energy rates (Wills, 1992).

The other consideration, when seeking to target coarse waste rejection, is the potential loss of value by the rejection of material at a size that still contains the target mineral. It makes logical sense for size vs. grade behaviour to be heavily linked to the geological mode of formation. The range of behaviours spans a significant space from massive, competent disseminated ores with a uniform spread of grade and strength to incompetent deposits, where not only does the grade sit within a localised and defined 3D space, but also where the poor competency naturally concentrates grade to the finer sizes. As with most topics, there is also a considerable middle-ground whereby the host material can display variable behaviour, with no discernible bias towards the concentration of grade. Such behaviour should not be dismissed as inappropriate for waste rejection, but rather it should be examined to determine if this is a function of the particle size of analysis or the treatment it has received. It is believed that a proportion of such materials may still display useful size vs. grade characteristics, but it may need to be initiated by extra breakage, or through alternative breakage mechanisms. At this point it is also appropriate to consider the application of sensor based separation methods.

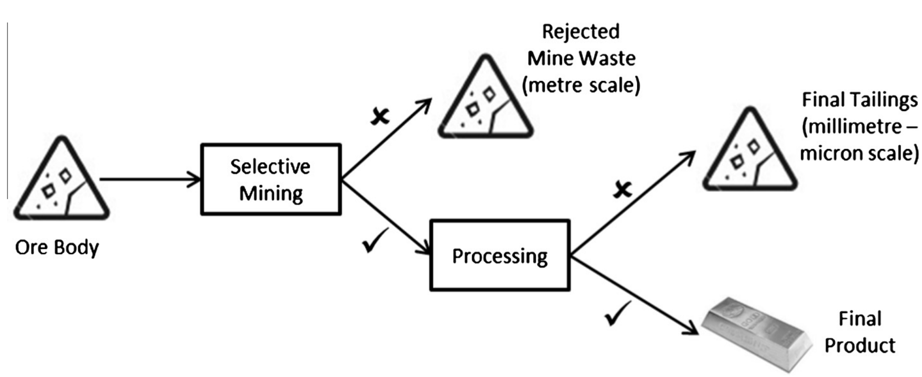

Fig. 1. Traditional 'two step' waste rejection pathway.