RUN OF MINE ORE UPGRADING – PROOF OF CONCEPT PLANT FOR XRF ORE SORTING

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ABSTRACT

Over the 2012 to 2014 period, Anglo American Platinum (AAP) has been investigating the application of ore upgrading using XRF sensor technology sourced from Rados International, at Mintek South Africa. This has been in parallel with a more comprehensive sensor sorting investigation at the Anglo American Research facilities.

Major drivers for this programme have been the attractiveness of mechanised mining and bulk mining for the PGM industry from a labour cost, productivity and safety perspective. Key to the optimisation of value is the removal of waste from the run of mine production. The scale of mining in this industry and distribution of PGM's permit the effective economic application of rock by rock sorting.

An initial programme of bulk sample testing through a single commercial scale sorting unit supplied from Rados has been successful on several PGM ore types and source materials. The metals used for the sorting determinations have been optimised for the various PGM ore types.

Arising from this in first quarter 2015, a 25,000 tonne per month, 4 sorter, proof of concept plant, has been commissioned at the Mogalakwena Mine of AAP in the Limpopo province of South Africa. This plant will be used to determine the economic cases for multi-site applications of the technology at several potential sites. The opportunity to develop and improve the operating parameters jointly with the technology suppliers is a key component of the agreement with Rados International.

This paper will present the early results and findings from the programme on various ore samples.

KEYWORDS

XRF, upgrade, sorting, selectivity; pre-concentration; Rados; liberation

INTRODUCTION

The SA Mining Industry Context

Mining has been a major factor in shaping South Africa's history and has been a key economic activity for more than the last century. The region has an exceptional mineral resource wealth, with an appraised reserve value of more than US$2.5 trillion. The country has the largest share of global deposits of platinum group metals (PGMs; 88%), chrome (72%), manganese (80%) and gold (13%) (Department of Mineral Resources, 2011). This makes SA the world's richest country in terms of mineral wealth.

Despite this notable advantage, the world market is not controlled by the SA mining industry. Similar to other global commodity or metal producers, SA-based mining companies are price takers who have to accept whatever the market is willing to pay for their goods. Companies who operate at the strongest margins are the ones that survive the short term instabilities in global prices because their main competitive advantage is cash cost (Tholana, Musingwini, & Njowa, 2013).

The South African mining industry, with particular reference to Platinum Group Metal (PGM) producers, finds itself in a very volatile business environment. Resource grades decrease progressively as the higher grade deposits are depleted early on to generate cash flow, but also as a result of increased emphasis on safety and ergonomics underground. Typical PGM ore bodies exist as a visible reef of high value mineralised rock, often less than 1m in thickness. Extracting only the reef is impractical when people are required to work in the cavity left behind for several hours at a time. The solution is to extract a large enough portion of reef sandwiched between barren hanging wall and footwall to allow mining activities to take place afterwards. This barren waste dilutes the ore hoisted to surface, occupying space that rich mineral could have taken up. Grade dilution directly affects the productivity of the mine (Neingo & Cawood, 2011).

As reefs become thinner or lower grade in less valuable sections of an ore body, and the need for ergonomic working conditions becomes business critical, the value of the final mined product reduces continuously. The downstream processing plants only have a certain fixed capacity, so if the ore from the mine reduces in grade it will result in less metal produced at the end of the value chain. A continuous downward trend in resource grades is observed globally across multiple commodities and metals (Hancox & Götz, 2014; Rutledge, 2011; Sverdrup, Koca, & Ragnarsdottir, 2014).

The ore type and grade profiles for Anglo American Platinum (AAP) echoes the global observations. In the last 20 years the profile of AAP operations has changed dramatically as illustrated in Figure 1. In 1995 the company treated mostly Merensky reef with small amounts of UG2 and Platreef, two ore bodies that are more difficult to treat and yield lower recoveries overall. Today the total production in tonnes milled has roughly doubled, but it is now dominated by UG2 with open cast mining of Platreef in a close second place. Merensky is almost non-existent as it has been depleted over time, and other feed sources range from Great Dyke ore (MSZ) treated at Unki mine in Zimbabwe to reclaimed tailings from the older operations. The average plant feed grade across the group has decreased from ~5.5g/t to just under 3g/t.

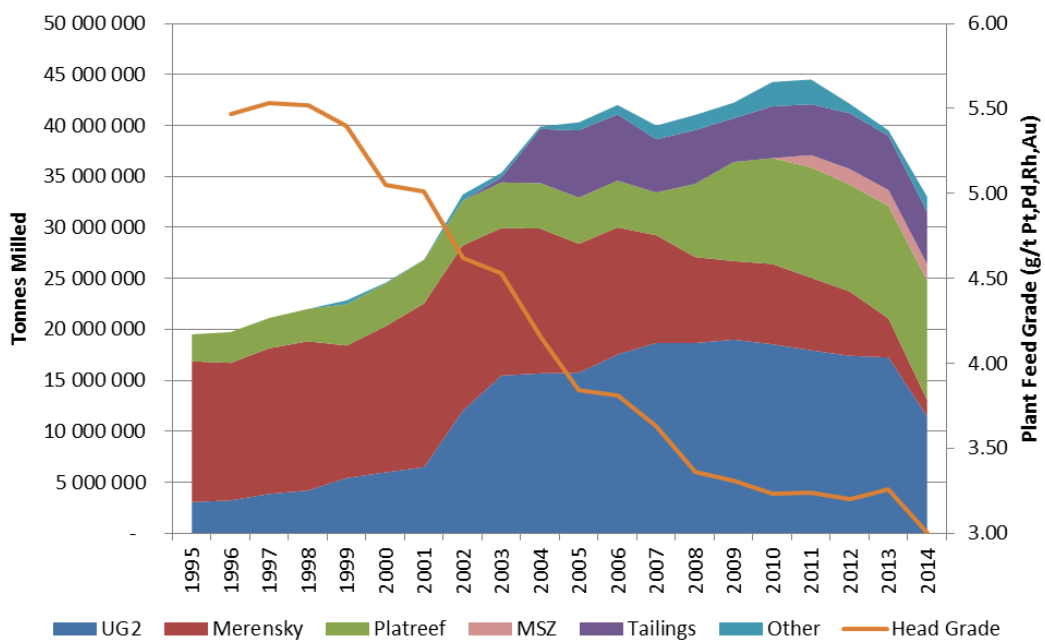

Figure 1 - AAP ore types and overall grade change from 1995 to 2014 (annual report data)

The sharp decrease in tonnes milled in 2014 was a result of a 5 month long strike which affected the underground production of UG2 and Merensky.

Reliability of Production and the Option to Mechanize

In 2012 a wave of wildcat strikes crippled the SA mining industry, which included the Marikana shootings that featured on the global news stage. Strike season, when wage increase negotiations take place, is often characterised by bloody turf wars between rival unions, especially at the older operations in the Platinum Belt in the North West Province. Culture invariably plays a major role during times like these, and is often an aspect overlooked by corporate leaders when interacting with communities on socio-economic aspects (Farrell, Hamann, & Mackres, 2012). The result is exorbitant annual increases achieved by unions proving their superiority over rivals, often at the expense of several weeks or months of lost production as strikes rage on.

Conventional underground mining, by its nature, is also an inherently dangerous activity with fall of ground and vehicle-pedestrian interaction featuring on the list of high risks activities. The Inspector of Mines regularly visits mines to inspect the working conditions, ensuring compliance with safety legislation. If non-compliance is observed, or if an accident happens, the Inspector issues the operation with a stoppage order in terms of Section 54 of the Mine Health and Safety Act 29 of 1996. The stoppage order is only revoked after an investigation into the incident has taken place, and corrective measures have been put in place to prevent a repeat. This could take anything between a couple of hours and several weeks, again resulting in more production lost.

In order to achieve a safe mine, one must understand and manage the core risks associated with certain mining systems, which includes technical and technological risks (Hebblewhite, 2009). One method of making mines inherently safer (and more productive) is to use technology, such as mechanised mining (Neingo & Cawood, 2011), to minimise the exposure of people to dangerous underground conditions. Mechanisation unfortunately comes at the cost of grade, because machines require pathways to move in that are higher than the reef mined, resulting in additional barren waste extracted. Two options exist to mitigate this dilution effect in an effort to keep the value chain profitable. The first is lower profile machines (ULP – ultra low profile, or XLP – extra low profile) that require less waste to be mined, while the second is ore sorting technology to remove the waste from mined ore prior to processing.

Profitability

Costs escalate disproportionally with fixed items such as electricity and labour leading the charge. This is not a positive indicator for future cash flow considering that fixed costs can contribute up to 60% of the cash costs of a typical mining operation. Security of electricity supply is a further cause for concern, forcing mining companies to relook at their activities to find innovative ways of improving efficiency.

In contrast, commodity or metal prices, at some point in time, usually decrease in absolute terms due to price cycles but also in relative terms when prices stay constant but inflation continues to erode the value of cash. This makes companies face a certain doomed negative cash flow future unless they can function outside their familiar limits. The result is a large proportion of PGM mines operating at a loss, impairing the performance of the larger company when profit making operations need to carry the loss making ones through economic downturns. This can simply not be sustained in the long run. Demanding stakeholders further place significant external pressure on companies, costs rise excessively and regulations become stricter by the day. These factors limit the growth of traditional operations, or even drive them into situations where they become non-profitable.

This change in operational conditions is similar to the transition between technology s-curves, except that it is forced upon the operation by external influences rather than disruptive technologies or self-initiated improvement. The concept of s-curves can be used to illustrate the life cycle of a mine, because s-curves show the degree and rate of growth very well for conditions where resources are limited and competition exists from the outside (Kucharavy & De Guio, 2011), both of which being characteristics of the mining industry. Some companies can successfully move between consecutive s-curves, but those who can't often don't survive for much longer. For mining companies to reposition themselves for continued future success, they will have to make the jump successfully. Ore sorting provides the opportunity for mining operations to realise significant savings in operating cost and capital expenditure, effectively improving their overall profitability (Cutmore, Liu, & Middleton, 1998; Lessard, de Bakker, & McHugh, 2014; Wills & Napier-Munn, 2005).

BENEFITS OF ORE SORTING (PRE-CONCENTRATION)

Ore pre-concentration technology promises to be a method of addressing several of the problems facing SA mining companies. It makes existing operations more profitable by reducing the amount of waste processed in the value chain downstream of mining, provided that there is additional mining capacity available to replenish the mass of barren material discarded. This will ensure the processing plant remains running at its capacity. If mining rate is the constraint, the majority of the benefits still hold true but the magnitude of increased profitability will depend on the specific case.

The benefits for PGM processing operations:

- Processing becomes more energy efficient in terms of kWh per unit of metal output.
- Cost per unit of metal output will be lower, despite an increase in total cost as a result of the additional equipment deployed to sort the ore.
- Higher feed grades lead to increased flotation recoveries, as much as +4% absolute based on regression of operating data from AAP sites over the last 2 years.
- Ore hardness decreases as the proportion of harder waste material is removed, thereby increasing the comminution capacity downstream of the sorting section.
- On UG2 ore specifically, ore upgrading will result in not only a higher PGM grade to the mill but an increase in chromite spinel concentration measured as % Cr_2O_3; as silicate waste is rejected. The benefit is an increase in chromite by-product yield in the associated chromite spiral recovery plant, with higher mass yields and hence revenue

Further to the benefits listed above, ore sorting also enables the development of mechanised mining technologies as the waste dilution effects can be largely mitigated or even reversed prior to processing. In the long term this will undoubtedly reduce the exposure of people to dangerous underground conditions, incidence of working at the face, while simultaneously improving overall productivity.

PREVIOUS AAP WORK ON RUN OF MINE ORE UPGRADING

An extensive programme of work was conducted in 2000-2003 investigating various technologies for UG2 ore upgrading. This included screening, dense media separation, and sensor sorting.

Screening is an effective method of upgrading UG2, but it is dependent on the natural fragmentation characteristics of the ore body. The theory dictates that the highly mineralised chromitite seam will break finer than the harder silicate rich hanging wall and footwall during the blast. The low grade material can then be removed through simple screening of the run of mine material. However, in practice the two resulting particle size distributions overlap. The low grade fines is not as much the fatal flaw of this concept, but rather the presence of high grade material in the screen oversize.

Dense media separation (DMS), can and is, successfully employed in UG2 ore upgrading. It is based on the notable difference between chromitite, SG ~ 4.5 and silicate, SG ~ 2.9-3.2. In practice the composite particles that emerge on the interface between the chromitite layers and silicate prove to be the most challenging for DMS application, to minimise PGM loss to reject floats. DMS is commercially used in the PGM industry to treat UG2, having first been employed at AAP's Ivan Concentrator in the 1990s. Sorting is favoured as an economic solution for ore upgrading based on DMS operating costs due to media, the requirement for a finer DMS feed and hence crushing and screening, the potentially higher floats PGM content in multilayered chromite feed ores, the non-association of PGMs with chromite – footwall mineralisation and mixed in Merensky ore feed.

As a result, in 2003/2004, an ore upgrading trial facility was installed at Waterval UG2 concentrator, in the form of the MikroSort™ plant. The objective of the plant was to upgrade ROM ore from the mechanized Bathopele mine product using optical sorting and reject waste material. The MikroSort™ plant used an optical measurement differential between mineralized chromitite and waste silicates to sort sized ore. The actual mechanism of separation for sorting used pulsed jets of directed high pressure air to remove unwanted rocks from a moving ore stream. Unfortunately the economics were not favourable in that application; principally due to low reject rates, availability of downstream plant capacity at the time and higher than target tails values and was compounded by relatively high maintenance costs. Its use was discontinued.

XRF SORTING TECHNOLOGY SUPPLIED BY RADOS

The Rados™ sorter, in contrast to the Mikrosort™ technology, addresses both concerns that emerged in the early work. It uses x-ray fluorescence to analyse and differentiate between individual rocks, which otherwise can visually appear identical. The algorithm identifies the chrome, copper and nickel content (which have proven to be a successful proxy for PGMs), and then rejects particles that contain amounts below the predetermined, set threshold value. The technology has repeatedly proven itself commercially, running in 53 Russian and CIS mines, some for more than 20 years already. The setup is shown in Figure 2 below.

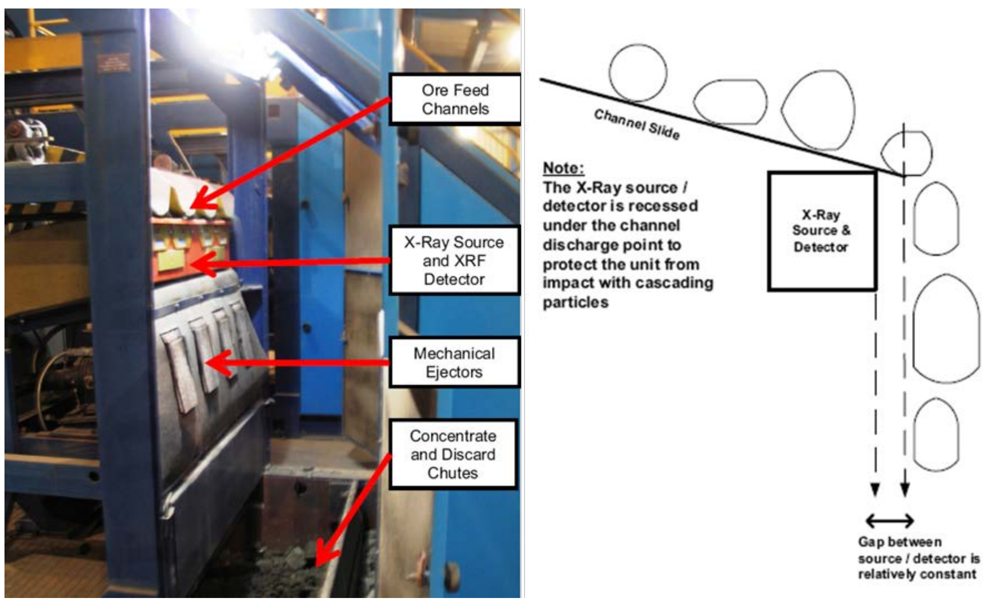

Figure 2 - Rados™ XRF ore sorter setup

Sorter Operation

Individual particles travel down the ore feed channels, which vibrate at an appropriate frequency to perform two functions. The first is to align the particles so each particle lies along its length in the channel ensuring maximum area is visible to the measurement process once the particle starts its freefall trajectory. The second function is to control the linear velocity of the particles, thereby controlling the freefall trajectory. This, in turn, influences the measurement process (distance from the detector) and the controllability of rejection (impact point).

Once the particle is analysed a decision is made in real time to keep or reject the particle. If it is rejected it will be diverted into the discard chute by an actuated mechanical ejector, else it falls into the concentrate chute directly below the discharge point. The concentrate and discard chutes are interchangeable by inverting the algorithm output depending on the mass fraction of the two respective streams. The lower volume stream is actuated and ejected to maximise actuator life.

The Russian variants of these sorters are equipped with electro-mechanical actuators capable of operating consistently at 2-3 actuations per second, with short bursts of up to 8Hz possible. Unfortunately the actuator temperature increases at such high work rates, which may become a throughput constraint in the warm South African climate. The decision was taken to improve the AAP machines through the introduction of high speed hydraulic actuators. Actuators are designed to be modular assemblies that can be easily and swiftly pulled out in the event of a failure and replaced with a functional assembly while the failed actuator(s) are repaired.

Surface measurement

X-ray fluorescence is a non-destructive analysis technique capable of measuring the surface chemical composition of particles. The individual particles are irradiated, the resulting emissions detected, analysed and evaluated based on a selected and calibrated algorithm. The technique is applicable to atomic number elements above 20, and above that, is more effective at measuring higher atomic mass elements due to the lower energy required to excite an electron to a higher energy level. The result is both qualitative and semi-quantitative. It provides a list of elements detected as each element emits at a unique wavelength during fluorescence, and an indication of the relative amount of the element is inferred based on the relative intensity of the observed value corresponding to that wavelength (Holler, Skoog, & Crouch, 2007). Where possible the elements to be analysed for should be selected such that their measured wavelength peaks do not have a likely probability of overlapping and therefor influencing the readings of one another.

The Rados XRF sorter in this application measures 5 elements online: copper, nickel, chromium, iron and calcium. Cu, Ni and Cr are used as proxies for PGMs: The relative amount of base metals is several orders of magnitude larger than the PGM tenors, thereby making the analyses of the base metals easier and more accurate.

For the proxy measurement to be successful there has to be a definite association between base and precious metals for the ore being investigated. This is the case with UG2 where the PGMs are typically found in proximity to the chromite spinel in the chromite rich reef. Where the PGMs copper, nickel and iron sulphides are sometimes found in the footwall silicate rocks the inclusion of the sorting algorithm in addition to that of chromite allows these to be recovered to concentrate. For Platreef and Merensky ores the PGMs are typically associated with and in proximity to the base metal sulphides, again making these ore types a good candidate for sorting test work.

The underlying assumption made through the use of a surface measurement is that the whole particle is similar to the surface being presented to the sorter. For large particles this is often not the case, where valuable particles are attached to or even enclosed in waste. As particles are crushed finer and finer the fracture lines tend to take place along the grain boundaries, thereby splitting the larger composites into discrete high and low grade particles. The size at which this takes place is regarded as the point of macro liberation.

Such composite particles proved to be the most challenging for DMS applications, as the density does not vary significantly from that of a pure waste particle. During XRF sorting, however, the sorter only requires a brief peak in measurements from an x-ray deflecting off the barely visible high grade portion of a particle to determine if the particle will be rejected. Where that particle would have a very slim chance of recovery with DMS, it now has >70% probability of being detected with XRF.

The feed size specification is largely influenced by the size at which macro liberation is observed. The resulting trade-off is between throughput (larger single particles = higher t/h) and selectivity (effective liberation).

MINTEK TEST WORK

Samples from the majority of AAP operations were evaluated to assess their amenability to sorting. An ore body is considered amenable to sorting if the discrete particles have different properties (i.e. separate desired and undesired particles), and there is a way of accurately and reliably assessing the difference between them. For PGM ore bodies the difference between particles can be measured by measuring the base metals (Cu, Ni and Cr). However, the sorting will only be successful if there is a positive, proven correlation between the base metal content and the probable PGM content of a given particle.

A full scale sorter was imported as a complete unit from Russia and installed at Mintek, where it was set up to run in batch mode with a feed batch size of several hundred kilograms. For more details on the capability of the Mintek installation, please refer to Fickling (2011).

Sorter Feed Preparation

The typical experimental procedure was to crush and screen each sample to yield four size fractions: <30mm, 30-50mm, 50-100mm and 100-150mm. Individual particles were selected from the 50-100mm fractions to represent the different minerals identified in each sample and analyzed individually to assess the effect of mineralogy on sorting as well. Each rock was analyzed using the Rados sorter, and then submitted for chemical analysis to compare the correlation between the two. The pulverized residue from some of these rocks was then made into briquettes for sorter calibration purposes, because their exact chemical compositions were already known.

Only the <30mm size fraction was assayed, while the other 3 fractions were sorted at different algorithm thresholds as illustrated in Figure 3 to yield grade-recovery response curves.

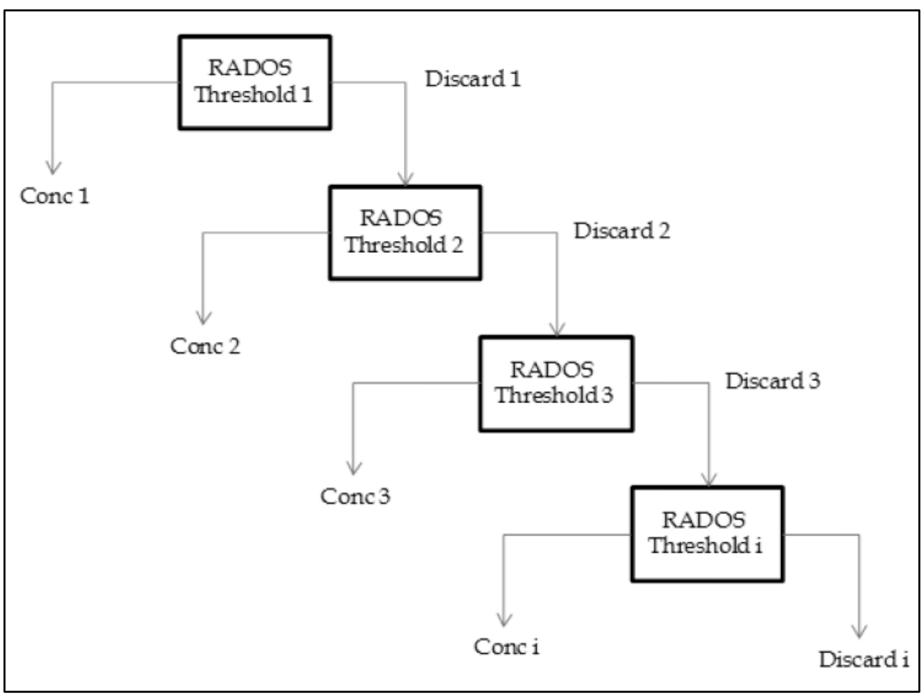

Figure 3 - Process flow for grade-recovery testwork at different sorter thresholds

Individual Particles

The comparison between single particles and briquettes made from the pulverised residue of those particles for a typical test is illustrated in Figure 4, compiled by Fickling (2011). The particles (blue diamonds) and briquettes (red squares) have almost identical linear correlation trendlines, but the particles have a much wider scatter on either side of the trend line. This is assumed to be the result of the particle surface not being representative of the whole particle.

The second useful observation from this data is that the concern over the surface being representative can be resolved by using large volumes of particle data. On average, the particles are the same as the briquettes because their trendlines, of which the y-axis intercept with the x-axis has to be at zero, are almost identical.

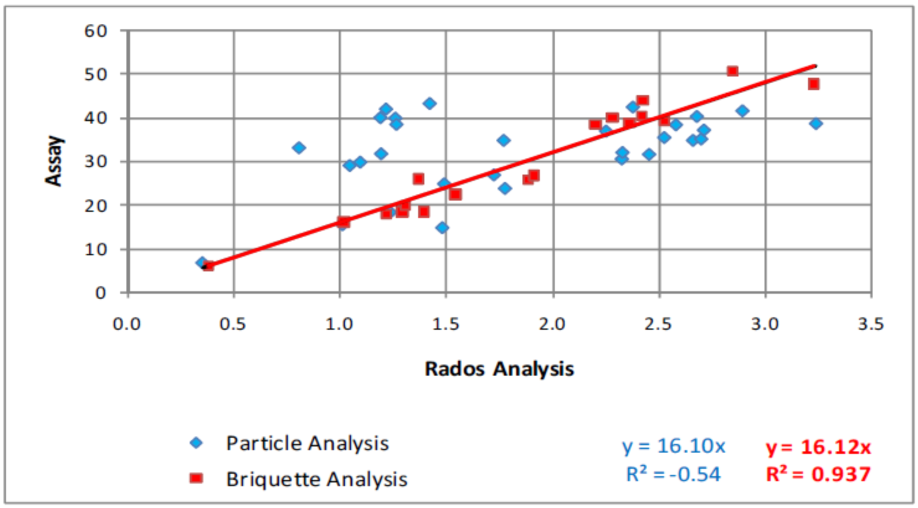

Figure 4 - Rados vs chemical analysis for particles and briquettes (Fickling, 2011)

Grade-Recovery Results

The grade-recovery response obtained for the three Platreef size fractions are shown Figure 5. The sample has a head grade of ~1.5g/t (100% Concentrate Mass), and can yield a discard grade of ~0.5g/t when rejecting 40% of its feed (60% Concentrate Mass). For this instance, the PGM recovery would be ~85% while the mass recovery is only 60%, thereby opening up capacity in the process to replenish the 15% PGMs lost. The result is 142% PGMs for the equivalent 100% mass capacity of particles.

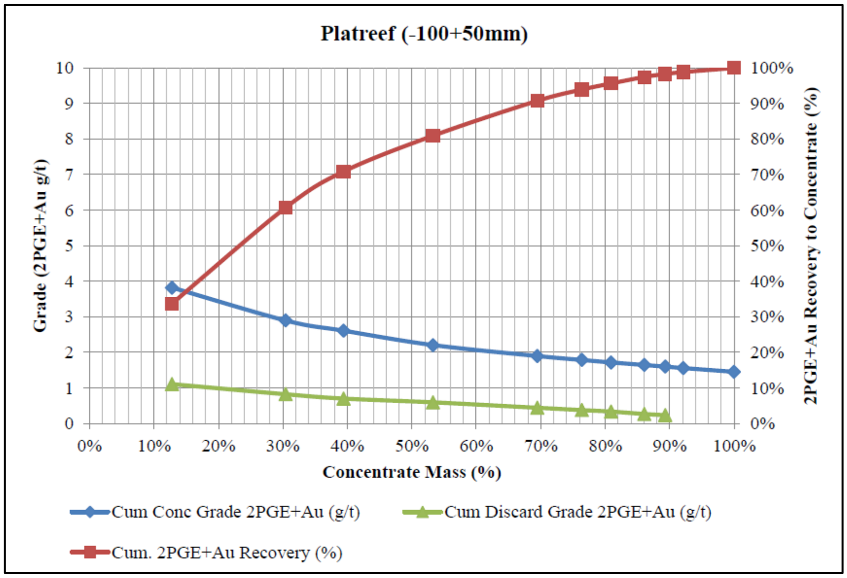

Figure 5 - Grade-recovery relationship for 50-100mm size fraction Platreef ore

There is a similar graph generated for the smaller (30-50mm) and larger (100-150mm) size fractions. From these graphs it was evident that the effectiveness of the sorter increased notably below 100mm. The feed particle size requirements of the Proof of Concept plant was accordingly set at 30-80mm.

PROOF OF CONCEPT PLANT

Objectives

This 4-sorter Proof of Concept plant is a world leader for the local PGM mining industry, being the first production scale installation outside of Russia and the former CIS. The objectives of the plant are:

- Continuously discard sufficiently barren material to significantly increase the head grade of ore for the Baobab project, resulting in improved profitability (R&D that pays for itself)
- Characterise and upgrade batches of Platreef material, thereby converting low grade stockpiles (and waste) into full grade ore, suitable as feed to a concentrator
- Mitigate the technical risk associated with new technology to acceptably low levels to justify a full scale installation
- Quantify, under operational conditions, the ore upgrade benefit previously identified through Mintek test work done on a Platreef run-of-mine sub-sample.
- Validate design parameters for future full scale ore sorting installations in the AAP group
- Serve as operational, profit generating test facility to quantify the benefit of sorting UG2, Merensky and Waste from other operations, thereby validating the suitability of the technology

Process Description and Commissioning

The Proof of Concept plant incudes everything required to operate 4 Rados sorters continuously for 24 hours per day, with the simplified process flow illustrated in Figure 6. The entire process comprises a crushing and sorting plant.

The crushing plant prepares the feed to the sorting plant, and crushes the final product(s) down to an appropriate specification. For the Proof of Concept plant the desired feed specification is larger than 30mm but smaller than 80mm, based on the Mintek testwork done.

Material is fed into the sorting plant and passed over a washing screen. The screen removes the fines in the feed, either generated through particle breakage while rehandling, or from upstream classification inefficiency, before rinsing the surface of the larger particles prior to analysis. Fines are again screened out ahead of the sorters in case breakage takes place after the washing screen. Both groupings of fines join the sorter concentrate based on the hypothesis that fines are usually higher grade because of the more breakable nature of highly mineralized ore portions.

The plant is specified to operate at 15t/h per sorter, with upside potential to 25t/h. The throughput of the plant is extremely dependent on the incoming feed particle size, because it treats particles at a unit rate instead of a mass rate. There is an operational trade-off between the selectivity achieved with macro liberated fine particles and the throughput achieved with bigger, potentially unliberated, particles.

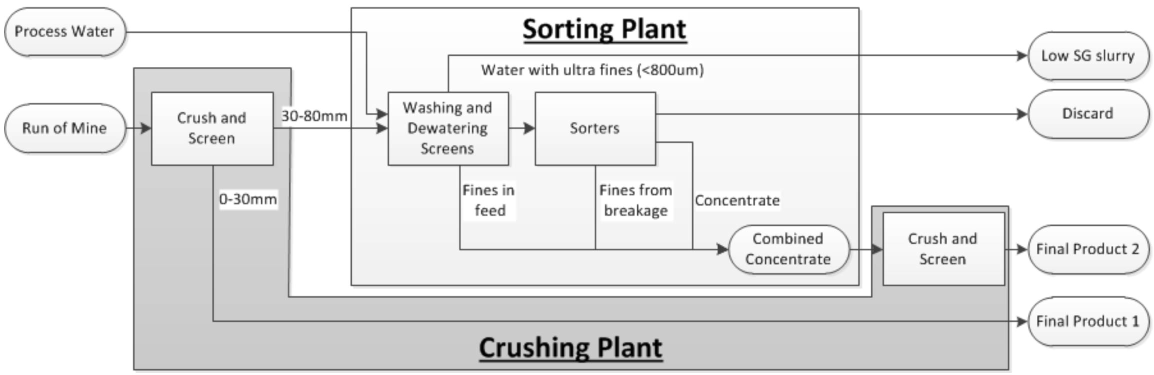

Figure 6 - Simplified process flow of the Proof of Concept plant

The sorting plant materials handling facility proved to be quite sensitive to top size and bottom size of the feed particle size distribution. The particles at the two extremes of the size range strayed the most from the desired particle trajectory when falling past the analyzer, presumably as a result of the variation in particle speed down the channel feeder. Excessive fines smaller than 30mm in the feed further proved troublesome, causing chokes and pegging in the screening area during initial commissioning.

As expected, the sorting plant has a significant information management and data processing system. When considering that each sorter can sort up to 8 rocks per second per channel, and that each rock has a recorded XRF value for 5 different metals along with its estimated size and status (concentrate or discard), it becomes clear that several stages of data processing are required to yield usable daily operational information on which to run the plant and evaluate its performance. The interfaces between different software and hardware systems require special attention during the design phase to ensure compatibility. The daily information use includes comparative data analysis between channels and between sorters over time to assess performance and to identify analyzer drift early on.

EARLY RESULTS AND FINDINGS

The complete circuit is considered here, taking the grade deportment during initial feed preparation into account. The Proof of Concept mass balance upon which the business case is based is illustrated in Figure 7. The mass recovery overall is 85.2% while the PGM recovery is 97%, attributable to the synergy between screening through upgrading and single particle sorting of screen oversize. The PGMs in the mill feed increase by 15.3%.

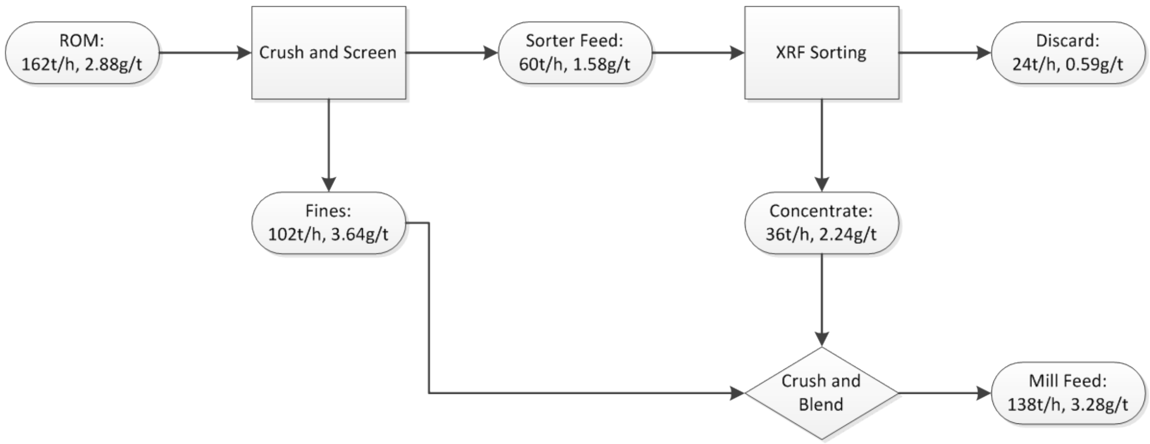

Figure 7 - Proof of Concept plant mass and metal balance used in business case

The froth flotation stage of PGM concentration will also benefit with an increase in recovery attributable to the higher feed grade. At a higher feed grade the flotation feed contains a larger proportion of mineralised material available for flotation, which will assist in stabilising the froth through higher bubble loading both in the mainstream and cleaner sections. This brings the overall PGM increase to ~17.5%.

The first measured results from the sorting plant have confirmed the initial observations from the Mintek report. The measured copper content was used to infer PGM content using the correlation displayed in Figure 8.

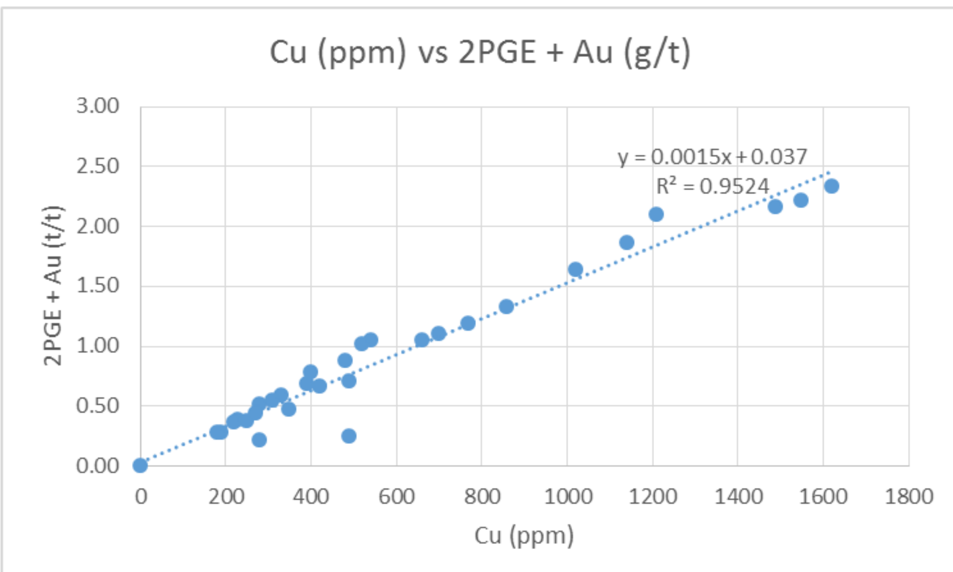

Figure 8 - Correlation between PGM and copper for PGM sample considered

The first sorter run used Sorter 1 to analyse and actuate 8 725 individual particles, with an average predicted grade of 1.28g/t 2PGE+Au. Only 1 of the rocks was misplaced (i.e. was supposed to report to concentrate but ended up in discard due to actuation), so a sorting execution accuracy of 99.93%. The mass recovery of particles is assumed equivalent to the sum of the particles in each stream. Or reworded, the realistic assumption is made that the PSD of the concentrate and discard streams are very similar. The results are summarised in Figure 9.

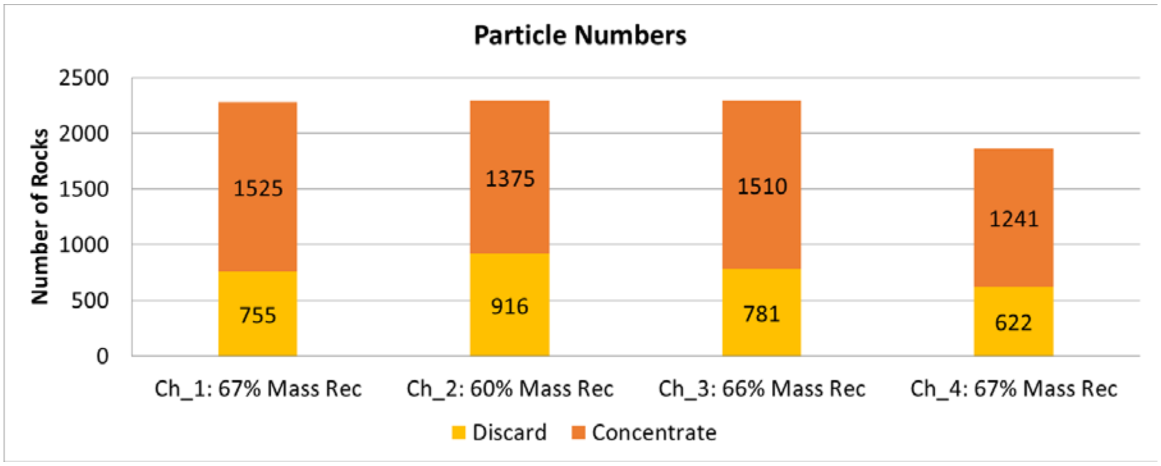

Figure 9 - First mass deportment results from the 4 channels of Sorter 1

The sorter successfully upgraded the material received from an average grade of 1.28g/t to 1.62g/t, with the comparison between the channels showing an expected but reasonable amount of variation as illustrated in Figure 10. The average % mass discard was 35% (vs planned 40%), with a grade of 0.65g/t 2PGE+Au (vs a plan of 0.59g/t 2PGE+Au). Again the sample built up head grade (BUH), albeit calculated from particle number averages instead of weight, was in the low grade ore range despite being fed from the full grade crushing operation. The conclusion: there is definitely grade deportment by screening only!

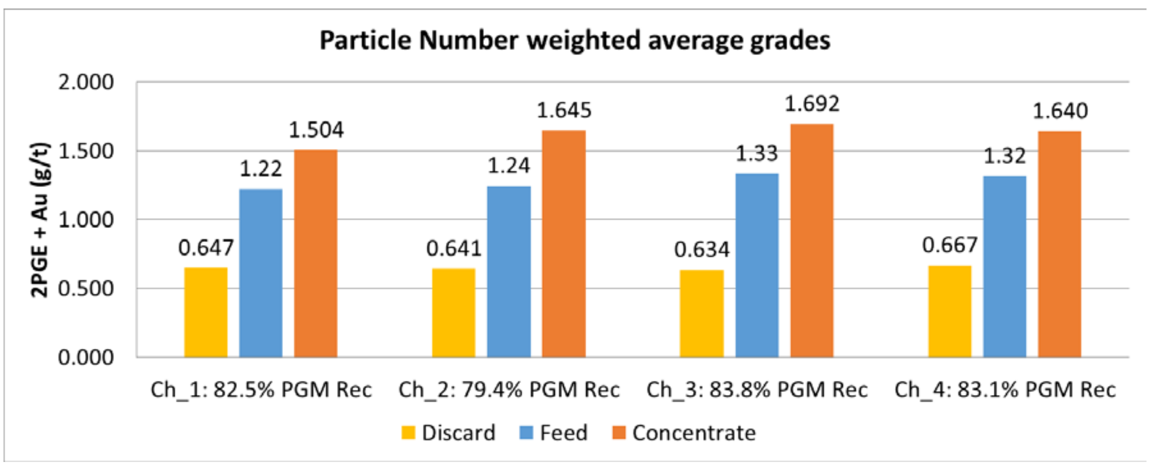

Figure 10 - First PGM deportment results from 4 channels of Sorter 1

These numbers are still from non-optimal running and the sorter operation will continue to improve going forward but the first results definitely prove beyond doubt that upgrading takes place.

CONCLUSIONS

Run of mine ore sorting promises to revolutionize the PGM beneficiation industry through upfront waste rejection to mitigate the observed downward trend of resource grades over time. Major drivers for this technology have been the attractiveness of mechanised mining and bulk mining for the PGM industry from a labour cost, productivity and safety perspective.

Over the 2012 to 2014 period, Anglo American Platinum (AAP) has been investigating the application of ore upgrading using XRF sensor technology sourced from Rados International, at Mintek South Africa. This has been in parallel with a more comprehensive sensor sorting investigation at the Anglo American Research facilities.

Arising from this in first quarter 2015, a 25,000 tonne per month, 4 sorter, proof of concept plant, has been commissioned at the Mogalakwena Mine of AAP in the Limpopo province of South Africa. This plant will be used to determine the economic cases for multi-site applications of the technology at several potential sites. The opportunity to develop and improve the operating parameters jointly with the technology suppliers is a key component of the agreement with Rados International.

Preliminary results indicate that up to 15% of the run of mine mass can be rejected while 97% of the PGMS are retained. Where the milling plant is the constraint in the business, this increases the overall PGM yield from such an operation by 17.5% at a marginal operating cost increase, thereby drastically improving the overall profitability of the mine. The mass split figures quoted can be improved upon by selective drilling and blasting and screening to enhance the economics of the process of ore upgrading. It is the intention to trial the technology on many different or types and grades over the next few years.

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