Journal Comment

Sampling and Analysis: Best Practice in African Mining

In this edition of the *Journal* a selection of the papers given at the conference 'Sampling and Analysis: Best Practice in African mining', held in Johannesburg from 4–6 June 2013, is presented.

The main objective of the conference was for the companies that are involved in the African mineral industry to present the procedures that they use for sampling and analysis, from exploration through face sampling and grade control to their processing plants and the final products that are sent to market.

The critical importance of sampling, mass measurement, and chemical analysis is explained in the paper 'From metal to money: the importance of reliable metallurgical accounting' by Dr D. Seke. These measurements are required for metallurgical accounting, and affect issues of corporate governance and compliance with codes and regulations that have been introduced to improve transparency in the reporting of financial statements of mining companies. As an example of the application of the codes, particularly of the AMIRA P754 code for metallurgical accounting, the author considers the overall metallurgical accounting process and the confidence in the measurement of inventories for a typical hypothetical platinum company. The reporting of inventories, which for the typical platinum company amount to between 10 per cent and 20 per cent of the annual throughput, is required in the financial statements of public mining companies – hence the importance of improving the confidence in their determination.

An overall summary of sampling in the South African mining industry was given in the keynote address by R.C.A. Minnitt. This review highlights two differing approaches to sampling, namely:

- The application of the Theory of Sampling, originally proposed by Pierre Gy, to sampling of precious and base metal products
- The application of ISO standards for sampling of bulk commodities, or where ISO standards are not available, procedures agreed in terms of contracts between buyers and sellers. In addition, many operations apply their own standards for sampling, mass measurement, and metallurgical accounting. Increasingly, companies are adopting the AMIRA Code of Practice, which is mentioned in the paper 'Metal accounting and corporate governance' by Gaylard *et al.*

With regard to these two approaches there are two meanings to the word 'sample'.

In Gy's definition a sample is part of a lot, often obtained by reunion of several increments or fractions of a lot. (Sampling of Particulate Materials, Elsevier 1979). In other words a sample in the Gy context is a single entity.

By contrast, in statistical terminology, a SAMPLE (in upper case to distinguish it from the single entity sample) is a set of individuals or items selected from a parent population to provide information about its distribution (Collins Dictionary of Statistics, 2005).

In the Theory of Sampling, the fundamental error (FSE) of a sample is estimated. The FSE has the dimensions of variance, but variance has no meaning for a single sample. However, after calibration against a series of statistical SAMPLES, the FSE is taken to be the variance of the SAMPLES and it models the changes in variance with grade, particle size, and mass of samples.

In terms of its financial contribution to the South African mining industry, coal is the leading mineral commodity (28 per cent of total revenues) followed by PGMs (22 per cent), gold (20 per cent), and iron ore (17 per cent).

'Sampling the coal chain' by P.E. Hand is a broad overview of the role of sampling and analysis in the coal chain, from the start of a coal project to getting the coal out of the ground, upgrading it into the correct product, and to its eventual use by a (hopefully) satisfied customer. In the design of coal mines, sampling often comes low in the priorities, and cutting out such 'fripperies' is often cited as a way to save money. However, as Hand points out in the conclusions, the costs of sampling pale into insignificance in comparison with the cost of not sampling. The coal industry is large and errors of quality or yield can very quickly translate into huge losses. The South African coal industry has been known historically for the consistency of coal production in terms of tonnage and quality, even though the absolute coal quality is not as good as other producers. The drive for proper sampling and world-class laboratory services must continue in order to keep South Africa competitive.

The comment that sampling often comes low on the list of priorities for the mining industry in general is echoed in the paper 'Mechanical sampling –a manufacturer's perspective' by Steinhaus and Minnitt.

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This paper emphasizes the need for sampling equipment manufacturers (SEMs) to apply the results and recommendations of research, and of the various ISO standards and codes, to the design of samplers in order to obtain unbiased samples. However, in some cases little provision is made for sampling and quality management at the design phase of a project. The need for this is then recognized only when a product consignment or mineral grades are out of specification or unacceptably low. At this stage, sampling equipment has to be retrofitted or the buyer's quality assessment accepted at unknown cost to the seller.

The paper 'Platinum proup metals: best practice sampling methods, assay techniques, and quality control' by K. Lomberg overviews current practice for sampling and analysis in the platinum industry from exploration to final metal production. In 'Mogalakwena Platinum Mine: a world-class PGE, Cu, Ni mine' R. Brazier describes the use of RC (reverse circulation) drilling to sample ore in a large open-pit mine. The sampling results are used for medium-term planning as well as for loading control to assign the despatch of rock to waste, plant feed, or intermediate stockpiles.

A particular challenge is the sampling of ore at the shaft head. The shaft head is the ore custody transfer point, where the ownership passes from the mining to metallurgical operations. It is important that the grade and tonnage of ore is measured there, to monitor the efficiency of underground operations and to determine the quantity of metal produced at each shaft and delivered to the processing plant.

Typically the ore is run-of-mine after a primary crushing and screening stage to a top particle size of 250 mm. In some mines, it is sampled with cross-belt samplers of various designs that have been retrofitted onto existing belts. From a theoretical point of view these samplers are not ideal because fines can be left on the belt after the cutter sweeps the increment into the sample chute and especially large particles are not included for safety reasons.

Korff, Bartlett, and Minnitt describe the application of cross-belt sampling for gold ores in their paper 'The allocation of gold production from multiple shafts feeding a common treatment plant using run-of-mine sampling of ore deliveries'. A similar cross-belt sampling technique for a platinum mining operation is described in 'Mine to metal: a practical balance for a large platinum producer' by Liebenberg and Bartlett. In both cases, the variance expected for an individual 'sample' or increment is high. However, in the course of an accounting period, which is usually a month, a large number of 'samples' are taken and the standard deviation of the mean of the statistical SAMPLE is within acceptable limits.

In both the gold and platinum mine operations, long term balances between the ore sampled by cross-belt sampling and the actual gold or platinum produced were within acceptable limits. This indicated that the potential biases of the cross-belt sampling are manageable. It is significant that there were no detectable differences between the cross-belt sampling of ore from different reef types.

For gold mines there is a lack of agreement between gold called for from underground using chip sampling and the gold accounted for using cross-belt samplers. However, as shown by Fourie and Minnitt in their paper 'The simulated chip-sample model as a method for quantifying error and bias in sampling thin carboniferous reef types', chip sampling of stope faces is an inadequate measure of gold grade because of the inherent difficulties in extracting samples from quartzite reefs interspersed with soft carbonaceous gold seams. It is significant that the mine call factor (MCF), which is a comparison between gold called for underground and gold produced, is higher for those reef types that are more homogeneous, for example the VCR or Elsbergs, as compared to reefs with carbon seams where the soft carbon is extracted preferentially in chip sampling.

My personal view is that the lessons learnt from cross-belt sampling of run-of-mine ore could be applied to in-stope sampling to obtain a better estimate of ore that is broken than that obtained with chip sampling.

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