Reconciliation: importance of good sampling and data QA-QC

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Abstract
Consider the following statements (Harry and Schroeder, 2000):

- *You don't know what you don't know*
- *You don't measure what you don't value*
- *You can't value what you don't measure*
- *If you can't measure it you can't control it*
- *If you can't control it you can't improve it*

These comments about business and operational control are very applicable to mine reconciliation, and particularly the input sampling estimates and measurements. Understanding, quantifying, controlling and correctly reporting these results is an integral part of successfully monitoring the performance of the mining operation.

Introduction
Mining reconciliation is the comparison of estimated tonnage, grade and metal with actual measurements. The aims are to measure the performance of the operation, support the calculation of the mineral asset, validate the Mineral Resource and Ore Reserve estimates, and provide key performance indicators for short and long-term control (Morley, 2003). On-going, regular and efficient reconciliation should also highlight improvement opportunities and allow for proactive short-term forecasting by providing reliable calibrations to critical estimates. The concept is that of "measure, control and improve".

Meaningful reconciliation
Many operations have a reconciliation process in place, although most function on (or are only reliable) on a long-term basis – often because of the time and effort to collate and report the data from disparate databases across multiple function areas. The aim should be to minimize multiple handling of the data, with a centralised reporting platform, an example of which is outlined in Figure 1. Operators often overlook the 'volume-variance' effect – namely that the larger the tonnage or time increment that is examined the less variable the results will be. The time period over which the reconciliation is reported is important to ensure that the results are meaningful and have the desired level of associated confidence.

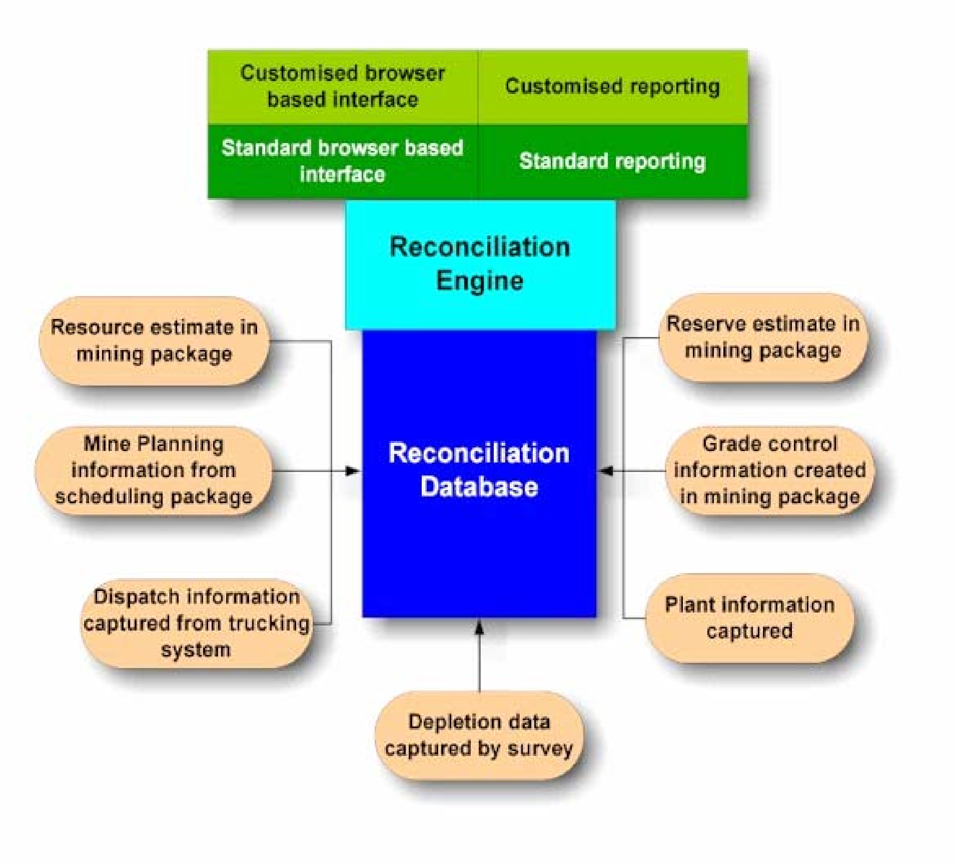

Figure 1 Schematic illustration of a reconciliation system (after Morley, 2003)

The usefulness of the reconciliation data, however, remains dependent on the quality and reliability of the input data, namely the estimates and the measurements. The resource and reserve estimates are themselves dependent on the underlying sample data and the processes used to generate the resource and reserve estimates (including short-term grade control estimates). The mining and processing measurements include survey, belt samples, on-line analysers, weightometers and flow-meters. All of these measurements have some degree of associated error or confidence level. The key elements of a reconciliation process are summarized in Figure 1, whilst some of the variables that affect the reliability of reconciliation results are presented in Table 1.

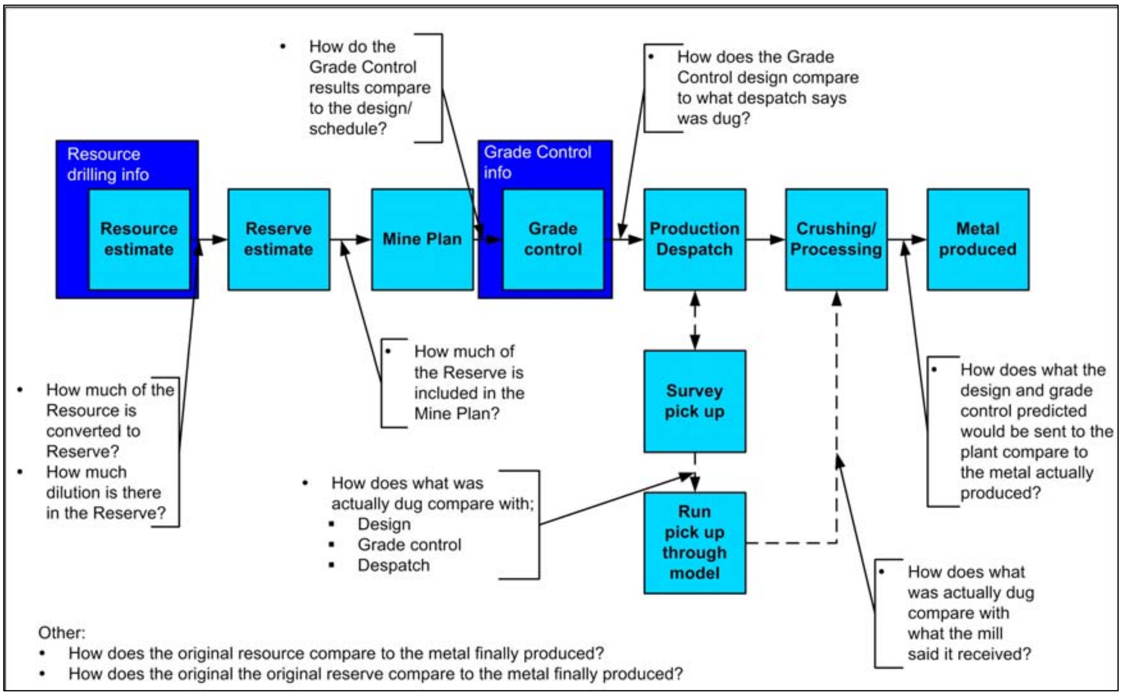

Figure 1 Schematic illustration of the mining reconciliation process and key issues for analysis (after Morley, 2003)

Geological model causes True *in situ* nugget effect Sampling and subsampling errors Analytical errors Estimation errors Excessive rejection of outliers Estimation methodology issues Ore density assumptions Definition of ore boundaries	**Mining causes** Mining model parallel to cross mineralisation in open pit Displacement of mineralization boundaries upon blasting Survey inaccuracies Truck dispatch inaccuracies Loss of fines Estimation of tonnes Dilution
Grade control causes *In situ* nugget effect Sampling and subsampling errors Analytical errors Blast holes parallel to mineralisation Averaging or Kriging methodology issues Ore grade contouring Survey inaccuracies	**Mill and flotation plant causes** Retention of metal within the Mill Analytical inaccuracy Process cycles either unknown or misunderstood Calibration of weightometers and flowmeters Poor laboratory subsampling Reconciliation calculated over too short a timeframe

Table 1 Examples of variables that affect the reliability of reconciliation results (after Pitard, 2001)

Sample Data

It is important to remember that we are making use of relatively small and infrequent samples to estimate the actual, but unknown, characteristics of the entire population, and any uncertainty in the sample data will affect our ability to draw the right conclusions.

The reliability of the sample results is dependent on the characteristics of the mineralization and the quality of the sampling, sample preparation and assaying. Sample reliability can be assessed through the variability in the sample grades (the precision) and the accuracy (bias) in the results. Whilst sampling concerns generally focus on grades, the importance of bulk density and moisture data for tonnage estimation should not be ignored.

The variability in the sample results can be broken down into three main sources: the "true" nugget of the mineralization (inherent heterogeneity), the sampling errors (resulting from sample selection methods and options), including sample preparation (particle size and sample size reduction); and assaying errors. It is important to understand and quantify these errors, so that the confidence of the final sample results can be reported and used in our reconciliation investigations. A classification of errors associated with a Mineral Resource estimate is summarized in Figure 2. Broken ore sample theory should be applied to control the sample preparation protocol, and can be described in a sampling nomograph (Figure 3). The nomograph plots the fundamental sample error (FSE) for various choices of sample mass and particle size for a particular operation (Sketchley, 1999).

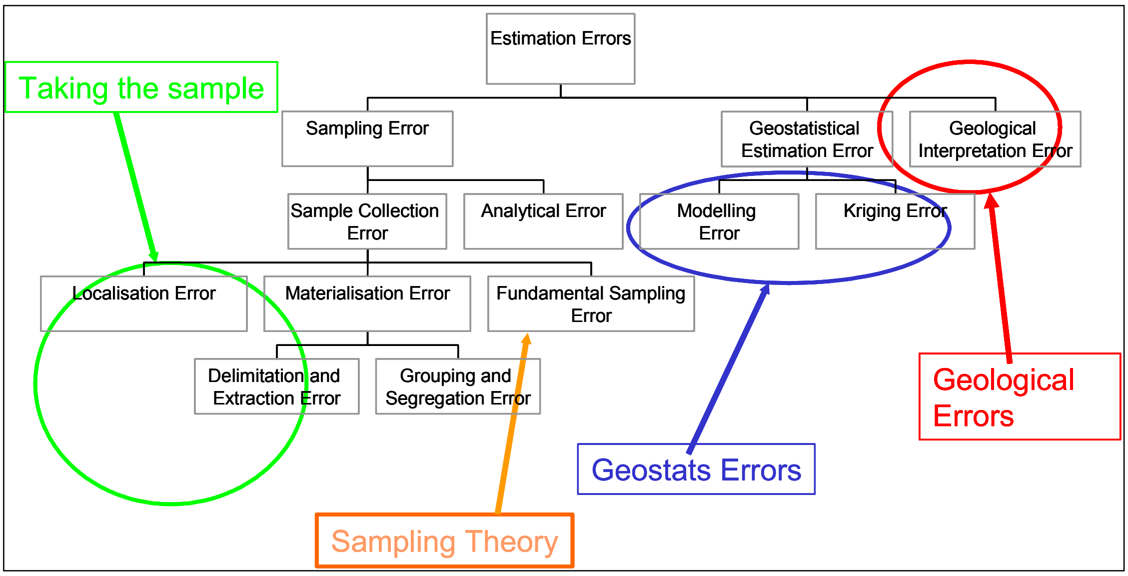

Figure 2 Sources of Mineral Resource estimation errors (after François-Bongarçon, 1995)

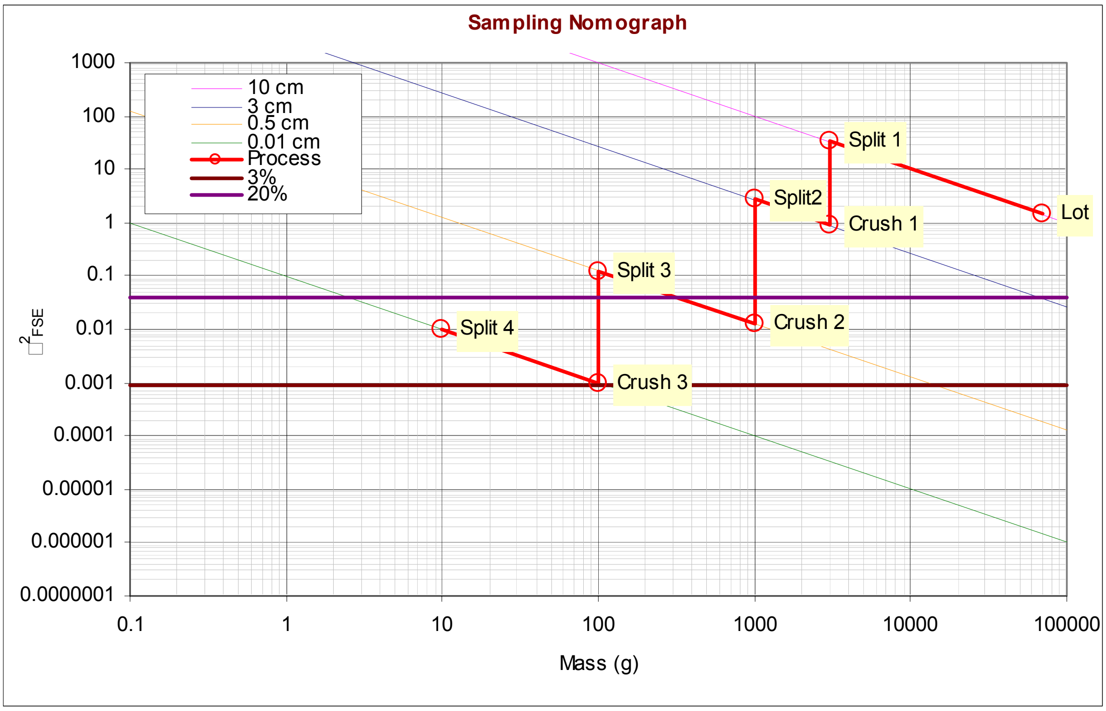

Figure 3 Example of a four-stage sample nomograph

QA-QC

Once the points of measurement in the reconciliation process are defined, the measurements (particularly in the case of sampling) should include sufficient control measurements (in the form of duplicates and standards) to monitor and report on the reliability of the data (precision and accuracy). This requires the establishment of a suitable quality assurance system and quality control procedures (QA-QC). Quality assurance deals with the establishment and documentation of systems and standards to ensure quality on macro level. Quality control is the use of statistical tools and checks to ensure the systems are in statistical control on a micro level.

A well-designed and implemented QA-QC system – like a useful reconciliation system – should not add to the workload of your already stretched technical team. The processes should be automated and be as accessible and transparent as possible so that more time can be spent on interpreting the results than on collating the data. Remember: data is not information unless it is presented in a useful way.

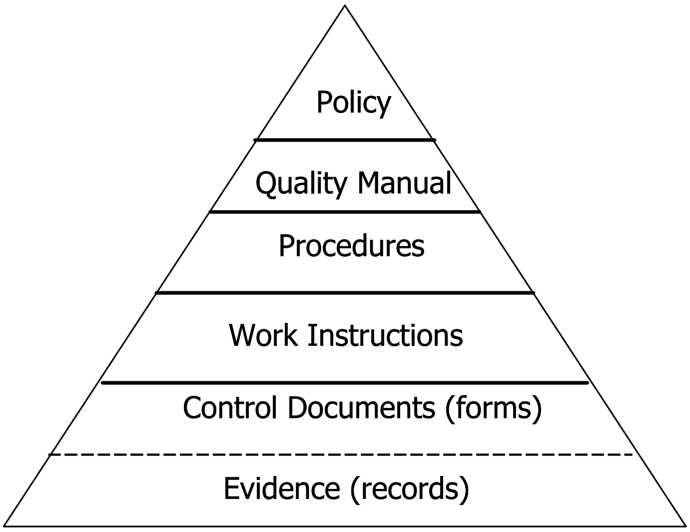

Figure 4 Elements of a quality control system

The cost of poor quality

The significant cost of poor procedures is often overlooked. If you ask someone how much money (time) is lost if something is carried out incorrectly, their first reaction will be "double the cost". However, research has shown that the total cost ranges from 8 to 14 times the original cost when something has to be done a second time (Harry and Schroeder, 2000). This is perhaps one of the most dramatic, and often unrecognised, sources of operation improvement in businesses today, and the impact on a company's profitability can be considerable. An example of this in mine reconciliation is the inappropriate reaction to the measurement results and the pursuit of meaningless and time-consuming 'witch hunts' when these are not warranted.

Conclusion

If you can't measure it, you can't control it, and if you can't control it how do you hope to improve it? The short and long-term benefits of a meaningful and efficient reconciliation system to the success of any mining operation should be obvious. The message is: don't delay, get your system up and running today!

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