Do you know if your Input Data is of High Quality ?

Dr. Ian Devereux

Qualifications: M.Sc.(Hons) in Chemistry, University of New Zealand (Otago), Ph.D. in Geochemistry, Victoria University of Wellington, New Zealand.
Memberships: FAusIMM. FNZIC, Member AEG., ANZAC Fellow (1973).
Experience: Institute of Nuclear Sciences, DSIR, New Zealand, ROCKLABS Ltd, New Zealand.
Currently: Managing Director, ROCKLABS Ltd, New Zealand.

Introduction

People involved with mine planning utilise analytical data supplied by chemists. It is extremely rare for mine planners to have any responsibility for those chemists or for the data they receive from them. However, mine planners rely on the data to produce their reports and recommendations so it is vital to know if the data is of high quality.

What can give rise to inaccuracy in analytical results ?

There are three parts to the process of producing an assay result. If any of these three parts are not carried out correctly, the final result will not be accurate. The three parts are:

A. Sampling

Sampling is the first step in the process, the collecting of the sample. The sample could be a face sample from underground, a drill core, chips from a reverse circulation drill or blast hole in an open pit. The question is, how representative of the whole is the portion that goes to the laboratory? The biggest problem occurs with chip samples. Are the fines blown away? Is the complete depth of the hole sampled equally? What weight of sample must be taken to get a representative sample?

In every step of the sampling and sample preparation process dust may be lost from the sample. In many mined deposits the fine fractions of a crushed sample will contain more or less of one mineral than the coarse fractions. Loss of dust will bias a sample low or high. Has this been checked in your mine?

B. Sample preparation

For this paper I am using the term "sample preparation" to refer to work carried out in the laboratory whereas "sampling" refers to what happens before the sample enters the laboratory.

The boundary between these two steps is changing with the growth of mechanised sampling. Some operations can be carried out in mobile facilities and only the finished sample is sent to the laboratory.

The traditional steps of sample preparation are drying, crushing, splitting and pulverising. Deficiencies in these operations can be either "operational" or "statistical". "Operational" problems include inter-sample contamination, over enthusiastic dust removal leading to biasing (as mentioned above) and sample mix-ups.

"Statistical" problems include samples being too small, crushed too coarsely, split inaccurately, pulverised inconsistently or too coarsely.

The two types of problems are inter-related by the human factor ie. if a crusher is not adjusted regularly, the product will increase in particle size - an "operational" problem leading to a "statistical" problem.

C. Analysis

Over the last ten years there has been a marked improvement in the quality of analytical work. This is part of the general movement towards better quality and consistency e.g. ISO 9000.
In laboratories there have been two main changes; increased use of LIMS Systems and increased use of standards and "round robins".

Primary rock Standards are available for many elements, from CANMET in Canada and other sources. Preparing these Standards is a long and expensive process involving many highly rated laboratories so the cost of these Standards is high. To assist laboratories with their quality control ROCKLABS is now selling secondary, "every batch", Standards. They are packaged in sachets for integrity and ease of use, one for each batch of say 50 samples.

In 1997 a laboratory should be able to demonstrate that it can produce an accurate analysis, but can it demonstrate that the sample preparation is of high quality. This is not easy to do. For example, if a lump of rock is broken in half, there is no guarantee

that one half is identical to the other. One half of a sawn core may not be the same as the opposite half. Hence, it is difficult to design a test that proves a sample preparation process is providing consistent samples, day after day.

What is wrong with sample preparation?

Sample preparation is often dusty, noisy, heavy and boring work. Most people want to keep a long way away. Mine management choose to keep well away. It is regarded as a necessary evil and ignored if possible but it is the source of many errors. Hence, it is the first area that should be critically reviewed, looking for ways to improve the quality of the final assay results.

Improving sample preparation

According to the Pierre Gy equation for the fundamental error of sampling;

$$S_{FE}^2 = Cd^3\left(\frac{1}{Ms} - \frac{1}{ML}\right)$$

S_{FE}^2	is the fundamental error expressed as a Variance
S	is the standard deviation
C	is a constant
d	is the diameter of the largest particles (D95)
Ms	is the sample mass
ML	is the total mass from which the sample was taken

If a sample is crushed finer before splitting, the error of splitting is greatly reduced because the diameter of the particles, d, is cubed. If the particle size is halved, the error is reduced eight fold. In contrast, if the sample split weight is doubled, the error is only halved. Crushing and pulverising finely is more effective than increasing sample size, but increasing sample size helps to reduce error.

Another part of the process that can be improved is sample splitting. In one of the few, if not the only study of sampling error in splitting, it was shown that the relative error in splitting by different methods was (Allen and Khan, 1970).

Method	Standard deviation of samples (%)
Cone & quartering	6.81
Scoop sampling	5.14
Table sampling	2.09
Riffle Splitting	1.01
Rotating splitting	**0.125**
Random variation	0.076

Because of the low cost of a riffle splitter and the speed with which it can be used, this is the preferred method in most laboratories. But its use can lead to several problems or deficiencies. It may not be used properly, it requires a lot of manipulation which could led to RSI or wrist problems and it is not particularly precise. Changing to rotary splitting removes all three problems. It operates mechanically and hence consistently, it requires no manipulation and it provides the most precise split. It costs more but should operate for many years with no maintenance.

In North America, especially in the USA rather than Canada, many gold mines are still using disc mills rather than ring mills. Hence the pulverised sample requires mixing before sub-sampling for the gold assay. This mixing step is often done by rolling the powder on a rubber mat. This step may improve homogeneity but requires a lot of manipulation. Hence it may not be done equally well by all technicians and there is a risk of RSI or wrist injuries. Once the sample is rolled on the mat it is normally split by taking several grab samples, a method described by Allen and Khan, thus "Very little confidence can be placed in any analysis where the sample has been obtained by this technique".

As a conclusion to the tests of the various methods used for splitting, Allen and Khan said (p110), "Further, the spinning riffler is so superior to all other methods that whenever possible this should be used". And again (p112) "The spinning riffler is the best technique by far and produces good results no matter what the previous history of the powder (it samples unmixed just as efficiently as mixed powders)".

If a rotary splitter is used as one step in a sequence, it may increase the time taken for the whole process.

To overcome this ROCKLABS has developed a rotary splitter that splits the output from a ROCKLABS Boyd Crusher, as it crushes, so no time is lost. This splitter is unique; it can produce any proportion of a split from 0 to 50% and the split proportion can be changed in a few seconds. The Boyd Crusher has the highest size reduction of any laboratory jaw crusher and it is patented in several countries.

What can be done to improve the situation ?

1. Change of management structure

Probably because chemistry and analysis relate more clearly to metallurgy, the laboratory often comes under the control of the "Mill Manager" rather than the "Mine Manager" (or equivalent Titles, e.g. Superintendent). With the advent of in-stream analysis and other automated control in the Mill, the number of analyses per day carried out for the Mill may be quite small. The proportion of samples being analysed for mine planning and mine geology is often away above 50%. So it seems that it may make more sense to have the laboratory report to the "Mine Manager".

2. Change of management attitude

A mine laboratory should be regarded as a Profit Centre within a mine, not as "A bottomless pit for money" or "A necessary evil". The need for the laboratory and its size should be critically reviewed. In some mines, the laboratory should be closed down if it cannot demonstrate that the cost of the results it produces is less than the money saved by using those results.

If the laboratory can justify its existence it should be supported on a rational basis. If it needs better equipment to provide better data which in turn leads to better decisions by management, then the laboratory should get the equipment, staff training, etc it needs. The attitude "Those chemists are always asking for the latest gadget", must stop.

Chemists themselves should see their role as being part of management not just a "Technical Expert" who can be easily sidelined.

3. Change to better equipment and practises

When a mine is started, someone decides what the sampling, sample preparation and analysis procedure should be. These procedures are often not critically reviewed by anyone. What someone did at their last mine may be irrelevant to the next mine!

During the life time of a mine, laboratory staff may change. Sometimes changes in procedures occur without any real testing. The mineralogy and geology of a mine may change over its lifetime for example from an oxidised zone near the surface to primary ore lower down. Laboratory procedures and hence the equipment used need to be reviewed regularly.

From a Health and Safety point of view some sample preparation facilities are in the Dark Ages. Fine dust in the air, unsafe equipment, excessive lifting, horrendous noise levels etc. These need upgrading urgently or employees could be suing management.

Mechanisation of sample preparation provides much better working conditions but also reduces labour costs and ensures consistent processing of samples.

References

Allen T. and Khan A.A. 1970. Critical Evaluation of Powder Sampling Procedures. The Chemical Engineer, May 1970, p108-112.

Pierre M Gy. Sampling of Particulate Materials: Theory and Practice. Second revised edition 1982. Elsevier Scientific Publishing.

This page deliberately left blank.