2013-05: Quality assurance and control (QA/QC) in mineral exploration: synthesis and evaluation of current practices

A geochemical analysis provided by a laboratory is an estimate of the true value of the composition of the sampled rock mass. The quality of the estimate is affected by two types of error – precision and accuracy – incorporated into the successive stages of the chain of acquisition. The control of this parameter, i.e. the overall potential error associated with the measured value, can only be ensured by inserting control samples used in conjunction with specific validation methods. It is of major importance, if not critical, since it ultimately allows the assessment of the validity of the interpretation, both qualitative (geological models) and quantitative (resource estimates), which gives rise to the financial risk assessment associated with exploitation.

The use of a quality assurance and control program (QA/QC) has gradually become commonplace since the beginning of the early 2000s with the formalisation of certain requirements by institutions (AMF, CIM) driven by the Bre-X affair. However, the requirements remain very general and focus exclusively on the QA/QC program results, leaving complete freedom as to their nature, which is not subject of any standardisation and is established on a case-by case-basis, based on the experience of the practitioners and the recommendations of consulting specialists.

The mandate of this study is to provide an overview of current QA/QC practices, to assess the uniformity and potential limits of convergent or divergent trends, to investigate quality constancy, as well as the well-controlled aspects versus persistent shortfalls, and finally to propose some improvements if need be.

The present exercise shows that accuracy errors, or bias, in the measurement systems are always well controlled through the systematic insertion of blank samples and standards from the early stages of exploration. The rates of insertion are very variable and not modulated by field conditions. The control samples are in essence intended to monitor the proper conduct of laboratory procedures, and therefore the practiced rates indicate the level of confidence in the laboratory. Conversely, the error of precision is due to the intrinsically heterogeneous nature of the geological signal and can remain high despite good laboratory procedures. Quite alarmingly, a major flaw in the control of this inaccuracy is revealed by the fact that a considerable proportion of the examined protocols do not mention using duplicate samples, even at advanced stages of exploration. Moreover, where duplicates are inserted, interpretation methods for determining the error of precision associated with the data generally lack rigor. The results state that in most cases the practitioners do not, in fact, have any control over the precision errors associated with their data.

Nevertheless, while an accuracy control is needed, it is not sufficient. This is because we then measure samples accurately that already have errors inherited form earlier stages of sample preparation.

The error of precision was calculated for several deposits to 1) evaluate the magnitude and the need to control it and 2) document the variations depending on the metallogenic context. Results show that the total relative error is highly dependent on the metallogenic substance and style: it is enormous for vein gold deposits (in many cases >80%), average (20 à 35%) for magmatic hydrothermal gold deposits, and low (<12%) for volcanogenic gold deposits, in replacement, and for zinc and copper deposits. In conclusion, the problem is major, but mostly for non-volcanogenic gold deposits, which constitute the overwhelming majority. These results are corroborated by the Gage R&R method that measures acceptability of the measurement systems vis-à-vis the natural variability of the signal. Lastly, it is shown that most of the error of precision is inserted very early in all cases, at the primary sampling stage, whereas the downstream steps in the data acquisition stream (reject separation, pulp separation, the analysis itself) are only secondary sources of error. On average, the primary error is 82.6% of the total error for Au, 87% for Ag and 70% for Cu. An effective error reduction strategy should hence focus on primary sampling.

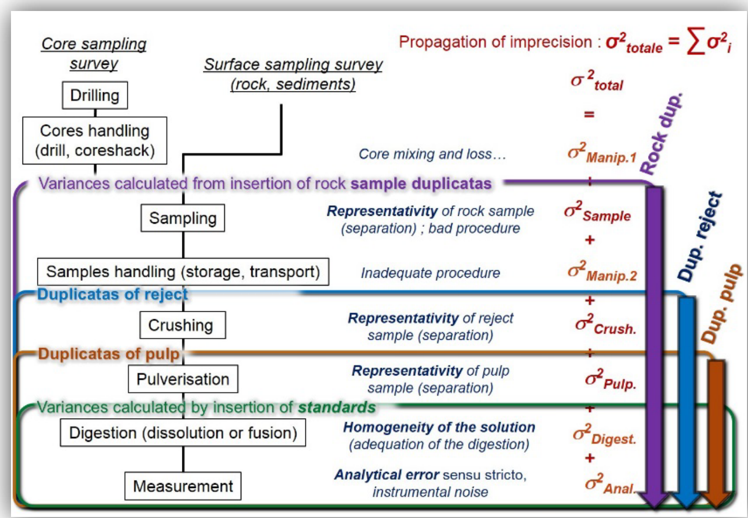

Figure 1. Source, propagation and precision control in the data acquisition stream. Coloured arrows indicate the sources of error of precision that are specifically controlled by each type of duplicate.

There are methods given for estimating the error of precision associated with measurement systems: a widespread use of them is recommended. Furthermore, more in-depth studies are recommended in order to 1) better document the precision problem by compiling more authentic cases from a range of metallogenic settings, and 2) develop a robust method for error calculation. In closing, it is essential to raise awareness among the practitioners about the impact of the precision issues and the importance of well identifying them by the systematic insertion of duplicate samples at every separation stage of the chain of acquisition.

CONSOREM
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Project 2013-05: Summary	
Objectives	• To summarise current knowledge in the field of quality assurance and quality control (QA-QC) by a comprehensive review of the literature and the recommendations of consultants. • To create an accurate picture of current QA-QC procedures carried out by practitioners in mineral exploration: review of internal procedures. • Summary and analysis: assess the effectiveness of usage, its homogeneity, convergent *vs* divergent trends, alternatives depending on the metallogenic context and exploration, and well controlled features *vs* weaknesses. • To propose improvements, evaluate the need to standardise their use.
Results and Innovations	• Creation of a relatively exhaustive inventory of current practices: review of company protocols and training documents supplied by consultants. • Observation of a convergence in practices through a very good general control of bias error by the systematic insertion of *blanks* and *standards* from the early stages of exploration on and in every metallogenic context. • Recognition of major differences and, in a general way, a significant deficiency identified regarding inaccuracies: in many cases it is not estimated, its control is very heterogeneous and low overall. The shortcomings are 1) insertion of duplicate samples is not standard and 2) inadequate methods used for error calculations from duplicate sample results. • Calculation of the size of the relative inaccuracies in several showings using rigorous methods – the results show that it is very heterogeneous and highly dependent on the type of showing: it can reach 35% in magmatic hydrothermal gold deposits and it is often critical in vein gold deposits (> 80%). • Demonstration through calculations that this error is systematically acquired very early in the data acquisition stream, suggesting error reduction strategies. • Demonstration of the need to raise awareness among the practitioners about the impact of the inaccuracy problem, the importance of identifying it, and specifying the way to control it.