The elusive fine gold problem
or the distractive power of coarse gold

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Based on real study data (slightly altered for anonymity without changing their features or conclusions), the authors intend to share an interesting situation – unfortunately encountered all too often. The observed presence of coarse gold in core samples, without any heterogeneity characterisation, often sends professionals on a path to potential disaster, almost always with dire consequences. As a remedy, the proper use of the results of heterogeneity studies is illustrated, along with the benefits.

INTRODUCTION

This paper calls attention to what distracts too often in coarse gold cases, when heterogeneity studies are not duly undertaken.

Indeed, the focus is frequently on the sometimes false assertion:

'Coarse Gold = PROBLEM'

while ignoring their actual sampling and sample preparation problems, which may at times lie elsewhere. With a clear conscience supported by the spending of small fortunes on screen fire assaying or other massive assaying methods (hoping to thus satisfy the gods of the stock exchange), they may be led to ignore this sad fact. Meantime, the bulk of their assays – in the mid- to lower-grade ranges – close to the cutoff grade, are thoroughly 'massacred'.

GOLD ORE HETEROGENEITY

It was not until one of the authors (Francois-Bongarcon , Gy, 2002) 'serendipitously' led the way by discovering that gold liberation size often increases with grade, that it was realised gold heterogeneity studies should give more attention to the gradient of that precious trend. This is the only known way to safely determine what constitutes the most challenging sampling situation throughout the full range of gold grades encountered, i.e., the worst case basis for sampling procedures and sample preparation protocol optimisation.

It was further discovered in subsequent applications that gold deposits typically come in three types:
- those for which the most challenging sampling conditions are met at the highest grades, where the gold is coarse;
- those for which the most challenging sampling conditions are met at the lowest grades of some interest (i.e., a little below cutoff grade, or COG), where the gold is generally very fine, and
- those for which the worst is in the middle.

As a result, not only heterogeneity studies are required before knowing how to collect and prepare samples, but, in gold (and more generally in free precious metals) one cannot forfeit this important study trend. This study is usually performed on duplicate samples after the overall exponent of nominal size in Gy's formula (a.k.a. alpha) has been duly calibrated.

MASSIVE ASSAY ALIQUOTS

Indeed, under the abovementioned, age-old principle (largely false in some cases, like most such principles) 'Coarse Gold = PROBLEM', methods for assaying massive aliquots have been developed; including (to mention only a few):

- bottle roll leach with catalysts
- the vortex method (Gencor)
- screen fire assays (a.k.a. metallic assays)
- PAL
- and more recently: Chrysos' PhotonAssay.

What these assaying methods all have in common is the issue of handling very coarse gold by assaying massive quantities of ore (500g-10kg). While the three first methods come with their own realm of issues and problems (and therefore should be used only as strictly needed), the last two – which have become almost standard nowadays – also have in common their potential for distracting the attention from basic sampling precautions, as will be further shown.

A TYPICAL EXAMPLE

Junior Metals (JM) is a small Vancouver mining company that has been exploring a volcanogenic massive sulphide gold deposit. They have logged the core as they progressed and very quickly discovered that visible gold (VG) could at times be observed. After two campaigns, the idea prevailed that VG was generally seen in core assaying above 2 Au ppm. The highest assay to date had a grade of 8 ppm and exhibited coarse grains of VG up to 180 microns. Occasionally, core with grade as low as 1.97 ppm would show VG, in this particular case with an estimated size of 200 microns.

Everybody agreed: JM had a coarse gold problem. Maybe there was a risk of under-reporting assayed high grades, who knows? In any case, as is usually done under such circumstances, it was decided to use screen fire assays (SFA) for the continuation, as well as on past rejects. According to the new protocol, half-core weighing 7-10kg for each interval drilled and logged was therefore entirely crushed to 75% passing 2 mm (i.e. an approximate P95 of 4 mm) then a 1kg split was pulverised to #150 and subjected to SFA. For 1 in 20 samples, a second split was taken from the crush and used as coarse duplicate SFA.
This seemed to be acceptable to everyone.

JM SAMPLING REVISITED

Fortunately, someone at JM decided a heterogeneity study would still be a good idea. After some significant time invested in convincing the directors of JM as to why it would be worth the expense, one such study was finally undertaken. Both the sample-tree and screening methods were used and they both confirmed the same result: the overall exponent of comminution size in Gy's formula was best taken at alpha = 1.6.

Armed with this first result, the coarse rejects were processed to elicit gold liberation size as a function of grade. A visually fitted trend was used. A difficulty index, proportional to the portion of Gy's variance formula (using Francois-Bongarçon's model of liberation factor) that varied with grade, through the mineralogical factor and the liberation size, was then calculated from that visual trend. Figure 1 shows these results, along with the VG observations for which the size of the largest gold grains was also available.

Interestingly, one can see the worst sampling conditions were not at higher grades, where gold was coarse, but at the lowest grades of interest (LGI) instead, with much finer gold. Given the low COG, the LGI was deemed to be 0.25 ppm for any further applications, with a corresponding gold liberation size of 53 microns.

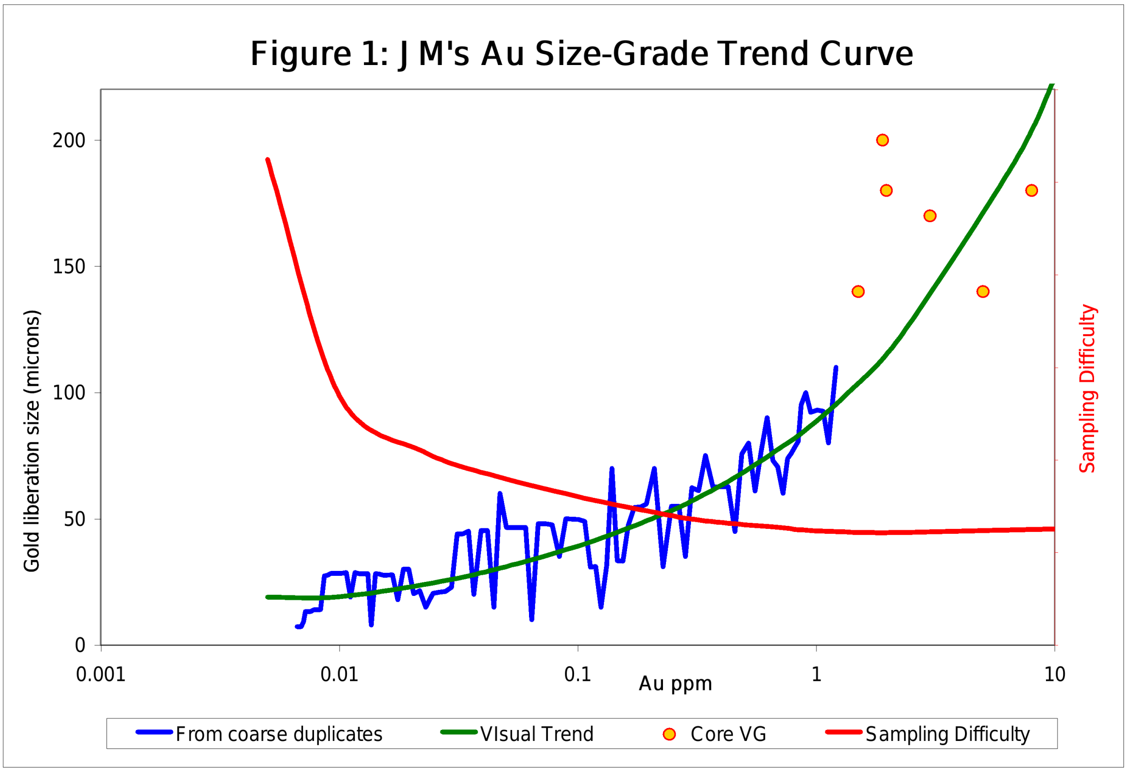

Figure 1. Gold size-grade trend curves.

JM RESULTS

The immediate application of these results was to evaluate the protocol adopted by JM. Results were a surprise to the company. Indeed, the following was discovered:

- At 10 ppm, where Figure 1 suggests gold is suspected to reach sizes of more than 200 microns, the study shows the 1 kg split from the crushed material to have a sampling relative standard deviation (RSD) (a.k.a. 'precision') of 52%. Screen fire assays (SFA) itself is probably not hurting these samples, but the split after crushing was way too small and incurred a mammoth sampling variance.
- Additionally, had a simple 30g fire assay (FA) from the pulp been assayed for these high-grade samples, it would have had a RSD of 16%; still a very acceptable figure. Two 50 g FAs would have yielded an overall RSD of 6%, showing the expensive SFAs to be totally unjustifiable at that grade level.
- At the LGI (0.25 ppm), matters deteriorated when investigated at more depth: a 30g FA would now be grossly insufficient with a RSD of 38%, and the 1 kg crushed split would yield a RDS of. 116%! (Figure 2).

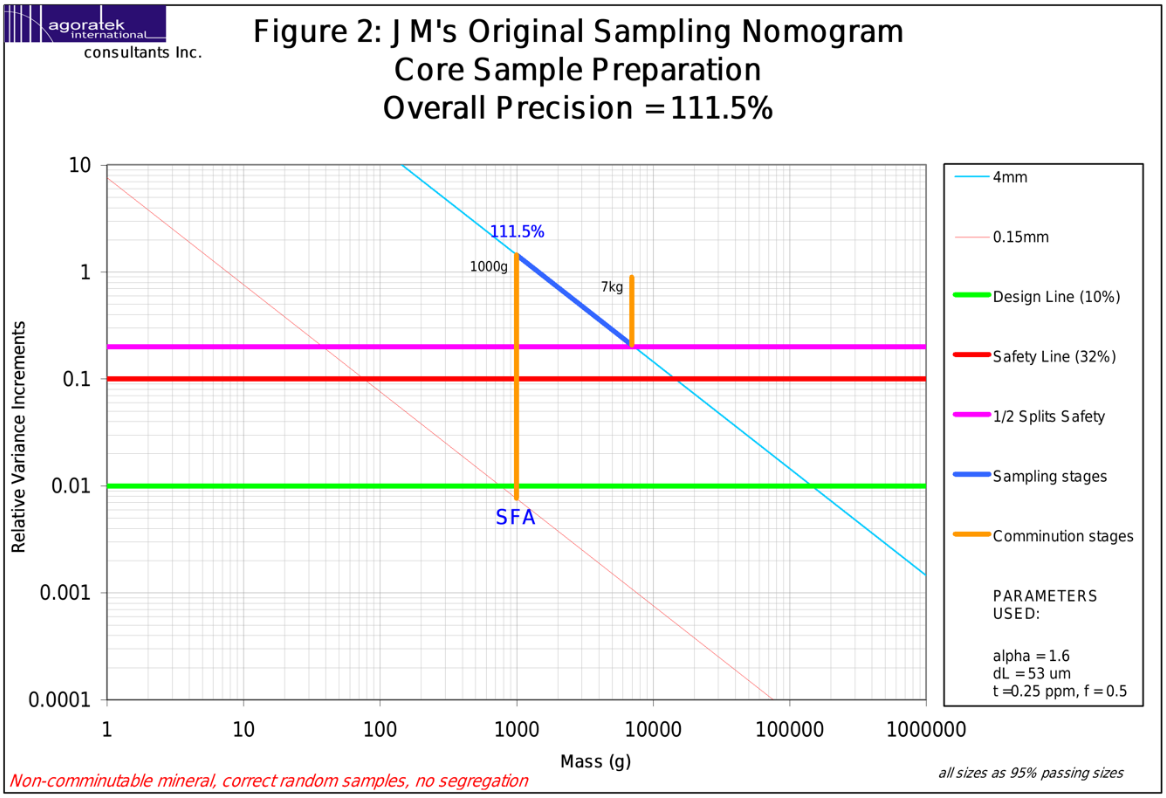

Figure 2. Initial sampling nomogram.

THE SOLUTION

The heterogeneity study has shown that an optimised protocol would be valid even for the most challenging samples of interest (i.e., at LGI). The protocol that could be proposed for this project is as follows (Figure 3):

- crush core sample (8.5 kg) to a P95 of 2 mm
- pulverise it to a P95 of 75 microns (this requires either a batch process or the use of a continuous ring mill)
- Fire assay two 50 g aliquots

This protocol can easily be shown to yield an RSD of 21% at LGI (Figure 3). Naturally, at 10 ppm, these figures are drastically improved, with an RSD of 16.4%, no SFAs necessary. The savings on assaying will pay for the massive pulverisation and the overall precision will be good enough, even in the worst case.

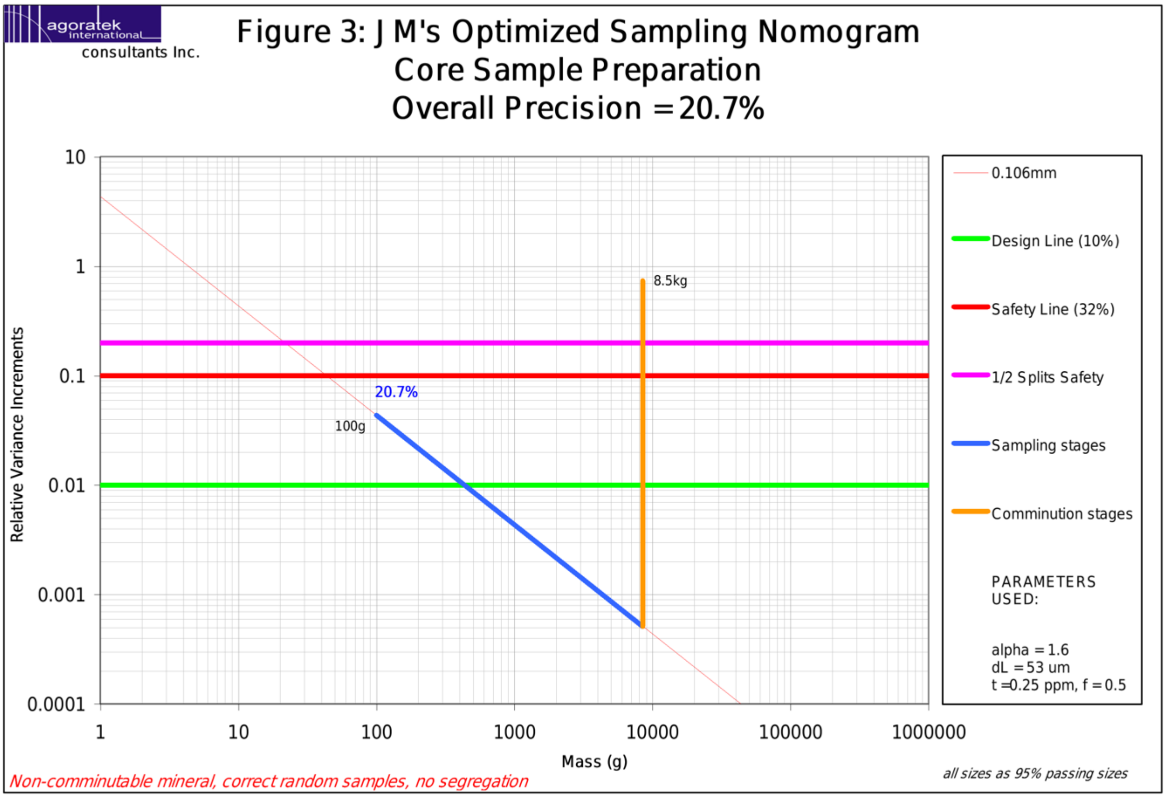

Figure 3. Optimised sampling nomogram.

THE TAKEAWAY

- During the first two campaigns, the presence of coarse gold distracted JM's staff from looking into more serious sampling problems affecting their medium-grade and low-grade assays, i.e., the bulk of their future production.

However, coarse gold was observed; further study has shown that it did not cause problems in this particular case. Going back to basics: in analysis, what ultimately makes the variance of a sample of a given size and in a given state of comminution is the average number of metal grains falling in a sample. If grains are coarse but still too numerous to account for the high grade, the variance is not necessarily high. This was the case for the JM deposit. Conversely, medium-size gold grains – if the grade is too low for their size – may be present in much smaller average numbers per sample and trigger sampling havoc, as was finally realised.

- There is no usable knowledge of the risks actually incurred without a full heterogeneity characterisation.

Had JM decided to opt for 500 g PAL or PhotonAssay, the results would have been even more catastrophic without proper grinding and re-splitting of the samples. Indeed, these two particular methods do not require the material to be pulverised, only coarsely crushed, which most companies unfortunately assume to be a licence to split only 500 g from the crushed material without pulverising first, with dire consequences in most cases (for JM, just multiply the already huge RSD by √2)!

REFERENCES

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Graduated as a mining engineer and holds a Doctorate in Mining Sciences and Techniques at the Geostatistics Center from the Paris School of Mines (Paris Tech).

More than 40 years of experience in the mining industry and work as a consultant in earth sciences for his own company.

In 1992, embarked on a career long research in Gy's theory of sampling, and worked with Pierre Gy as a consultant and on training courses. He then contributed to the onset of the WCSB cycle of conferences and in 2009, he was the recipient