DETERMINING THE APPROPRIATE SAMPLE SIZE

FOR PRECIOUS & NON-PRECIOUS METAL ORES

The definition of **a representative sample** is one that is large enough that duplicate samples of the same size, of the same material, taken at the same location, will give a statistically reproducible result and are hence truly representative of the material from which they are drawn. In general however **the coarser grained, lower grade** and **more unevenly distributed the target component** (eg gold, copper, nickel etc) is, the larger the sample must be in order to be representative and thereby reflect the same grade as the material from which it is drawn.

Most sampling problems arise when the target phase (eg gold) occurs:

- **in a relatively small number of particles**
- **these particles are relatively coarse in size**
- **are unevenly distributed**
- **and the overall grade is low.**

These factors combine to cause what is known as "**the nugget effect".**

The nugget effect and the concept of a representative sample are often difficult concepts for many people to fully understand, but they are critically important in ensuring that your numerical data is real and reproducible. If the data is not reproducible then it is not real and is in fact meaningless. **The only thing you can confidently say about assay data from samples that are not representative is that they are wrong, and can be seriously wrong, and do not reflect the composition of the material from which they are drawn.**

To help explain the concept of the nugget effect, imagine a gold deposit of one gram/tonne grade, where all the gold is in one gram size pieces and each tonne contains only one piece of gold. Imagine sampling that deposit using one kilogram samples. Nine hundred and ninety nine samples would come back with a gold grade of zero. The only sample containing any gold would register a grade of 1000 g/tonne. None of the 1000 samples gave the true grade (1 g/tonne), 99.9% gave significantly less than the true grade (zero gold), and only 0.1% of the samples recorded any gold and it was out by 1000-fold. Although this is an extreme example it illustrates the point. Taking 10 kg samples does not help, 99 samples would come back zero gold and the one sample containing any gold would come back recording a grade of 100 g/tonne. Again 100 samples all gave an incorrect result because the sample size was still far too small and unrepresentative and again the majority of samples seriously underestimate the true grade and any high results are not reproducible.

If we know that the sample size is too small to be representative, then we know that all the assay results produced are wrong. If we don't know that the sample size is too small then we don't know that the assay results are all false and this leads a serious underestimation of the true grade, (**because most unrepresentative samples underestimate the true grade**), and possibly disastrous decision making, including walking away from viable discoveries.

Question: How can you tell if your sample size is not representative?

Answer: the most obvious way is that your assay data is not reproducible.

It is imperative that you know the size of your target particles, particularly the coarser particles. Coarse particles contain a very high proportion of your target metal and are often so few in number that you may be unaware of them except though processing large samples.

How can you establish how large a representative sample is for your ore?

One way to establish how large a sample must be, to guarantee a more reliable and reproducible assay, is to determine the size of a sample large enough to contain on average about 20 larger size particles of the target mineral for the expected grade. Duplicate samples of similar size are therefore not going to have, on average, serious departures from that large number of particles (maybe a few more or a few less than the 20). A few more or a few less than 20 are not seriously going to undervalue or over value the true grade. But a few more or less would have serious consequence for the grade if the sample only contained on average say four particles. In order to determine the sample size likely to contain 20 or so larger gold particles, a graphical method has been constructed to establish the sample size required, at the 68% confidence level, knowing the target mineral particle size (see below).

The graph is used by extending the largest target mineral particle size (bottom axis), to intersect the sloping line representing the precious metal grade (in the yellow section), or the non-precious metal ore characterisation (light orange section), and extending this across to the left axis to determine the required sample size to ensure 20 large-size particles are present in the sample at least 68 percent of the time. For example if the coarsest particle size measured is around 1 mm for gold, then a sample size of 40 kg will provide 20 such particles about 68% of the time for gold grades around 1 gram per tonne. At 0.5 mm gold particle size would require a sample size of 4 kg to achieve 20 average particle 68% of the time. The finer the gold (or other relevant mineral), the smaller the sample size required. Gold at the limit of visibility (about 0.1 mm), would require only a sample of 40 grams to contain 20 such particle 68% of the time at 1 gram/tonne.

If the grade was in the range of 4 gram per tonne, then a sample size of only 10 grams would be needed to contain 20 such particles.

The 68% confidence limit means that on average the assay result will be reasonably reproducible in two samples out of three.

Too small a sample size to be representative has a number of serious effects:

- very occasionally they tend to give an overly exaggerated and unrepresentative idea of the true assay grade (which is not reproducible on repeat sampling)
- More commonly (though less commonly recognised) there is an overall underestimation in the grade as there are fewer than the representative number of larger particles in the sample
- As a consequence of the above, the recoveries and therefore assay grades are not generally repeatable or reproducible in duplicate samples from the same location.

An unrepresentative sample can almost **never** give the correct grade of the material from which it has been drawn and is therefore meaningless and seriously misleading.

For many larger gold particle sizes the required sample size would be impractically large. For gold particles of 1 mm, sample sizes up to 40 kg may be required to give consistency for gold of 1 gram/tonne levels (which are profitable grades). These large samples create a problem in themselves and are impractical to assay for in bulk, and require a carefully planned series of grainsize comminution, homogenisation and sub-sampling steps (see the blue steps in the illustrated example).

XRF Sampling

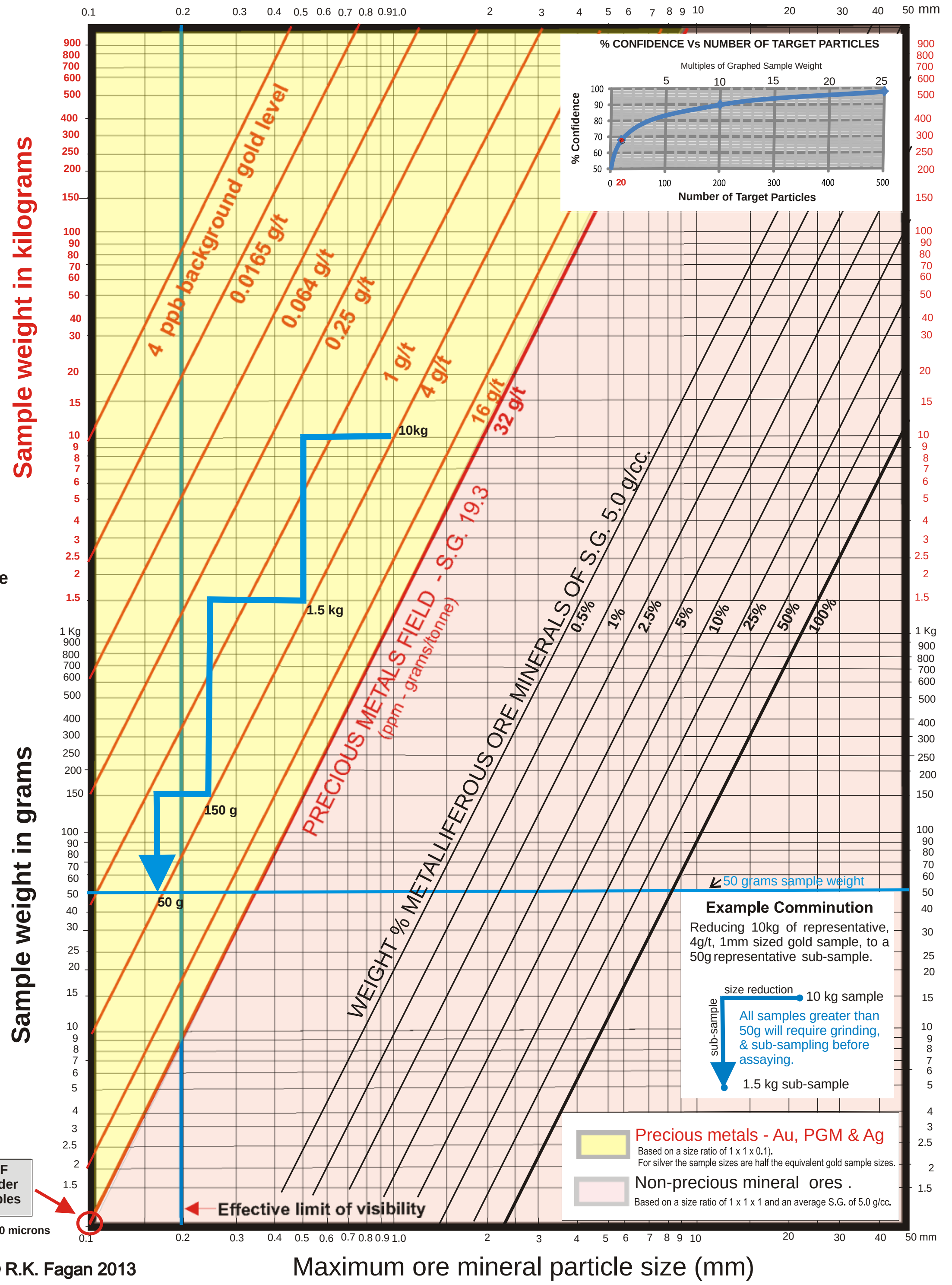
In XRF analyses, very small sample sizes are used in the analysis, a few grams to represent the parent mass. For coarse target elements, the representative sample size may be substantial. If a range of elements is involved, the representative sample size for each element may be different. In this case careful sample size selection may be required such that the assay sample size is large enough to be representative for all the elements being analysed. A careful crushing/grinding, homogenisation, and sub-sample splitting program will need to be implemented to produce a few grams of sample, at less than 100 microns (for powders), that is still representative and still contains around the 20 particles of each target phase (now considerably reduced in size) in the beam path. This last step is less of a problem for fusion beads.

REPRESENTATIVE SAMPLE SIZES
PRECIOUS & NON-PRECIOUS METAL ORES

This chart calculates the sample size expected to contain 20 particles, of the nominated particle size, at the 68% confidence level. For confidence levels beyond 68% refer to inset chart.

Mineral	S.G.
Arsenopyrite	6.0
Azurite	3.8
Bornite	5.0
Cassiterite	7.0
Chalcopyrite	4.2
Chalcocite	5.6
Chromite	6.1
Galena	7.4
Goethite	4.0
Gold	19.3
Haematite	5.3
Ilmenite	4.7
Magnetite	5.2
Malachite	4.0
Molybdenite	5.0
Pentlandite	4.8
Platinum	21.4
Pyrite	5.0
Pyrolusite	5.1
Pyrrhotite	4.6
Scheelite	6.0
Silver	10.5
Sphalertite	4.0
Stibnite	4.7
Wolframite	7.5

Weighted Average S.G. ~ 5.0



For duplicate samples of irregularly distributed minerals the assumption of the presence 20 nominated particles is likely to occur within one standard deviation (68% confidence).To increase this to two standard deviations,(90% confidence level), the sample size determined from the chart should be multiplied by 10. At three standard deviations, 98% confidence level, multiply by 25 (see inset graph). For silver (S.G. 10.5), the samples sizes determined for gold should be halved.

Knowing the coarsest target mineral particle size (from observation of panned material etc), select that particle size from the graphs bottom axis, extend up to the sloping line that may be appropriate to the likely overall grade of your sample. Extend across the graph to read the representative sample size (in kilograms or grams) from the vertical axis. For non-precious metal ores, an SG of 5.0 g/cc has been chosen as an average for most common ore minerals.

NB! If the sample contains significantly less than the 20 nominated sized particles, the sample is not representative and will generally underestimate the true grade and will be incapable of giving consistent and reproducible results. If the sample contains close to 20 such particles, the sample will give a generally reliable and reproducible grade in two samples out of three. If the sample contains more than 20 such particles, the sample will also give a reliable and generally reproducible grade but be larger in size than necessary to be a representative sample.

If the presence of 100, rather than 20 nominated particles is preferred, then the sample weights determined from the above graph should be multiplied by 5.