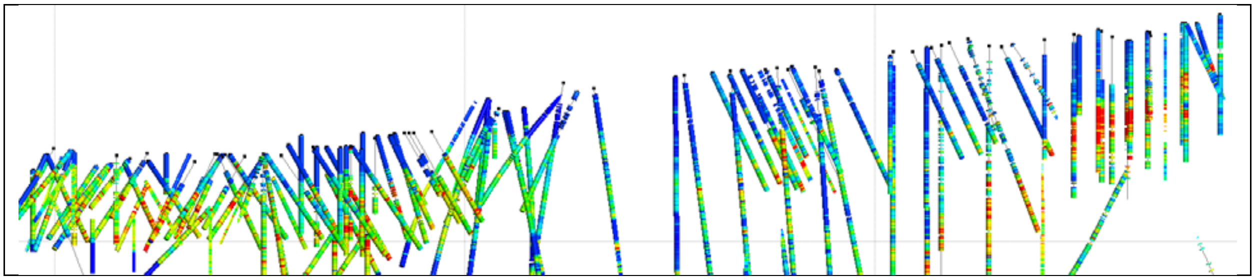


# Comparison of Precision in Assay Values

Gold is scarce in nature. Even in gold deposits with economically viable grades, the abundance of gold is a small quantity compared to the rock mass.

Mineral resource estimates are based on analytical data from drillhole samples, called assays. The units of the assay data and the precision of the values impact the resource estimation in several ways. In this article, we will illustrate these impacts, starting with the inherent difference in the precision of units.

In most of the world, the metric system is prevalent, and there is no question about the units to use for resource estimation: grams per metric ton, equivalent to parts per million. However, in the United States, mines are planned and built in length and weight units derived from the Imperial system. To add to the unit complexity, the troy ounce is the common weight unit for precious metals, and is slightly heavier than the avoirdupois (avdp) ounce, which is the common definition of "ounce" in the U.S. (i.e. one pound is 16 avdp ounces).

1 troy ounce = 1.0971428571 avdp ounces = 31.1034768 grams
1 short ton = 2,000 pounds = 907.18474 kilograms
1 troy ounce per short ton = 31.1034768 grams / (907.18474 kilograms/1,000 kilograms)
1 troy ounce per short ton = 34.285714 grams per metric ton
1 gram per metric ton = 0.0291667 troy ounces per short ton

If the sheer confusion of U.S. units is not enough reason to adopt metric units, read on.

There are 31 grams in a troy ounce. That means numeric values in troy ounces per ton are smaller than the equivalent values in parts per million, and conversion between units results in a change in precision. Effects of changes in precision, and ways to manage them, are discussed below.

*References:* https://en.wikipedia.org/wiki/Troy_weight
http://www.onlineconversion.com/weight_all.htm

*Highwall in an open pit gold mine, central Nevada.*

**Values in Metric and U.S. Units**

At the commercial labs I have worked with, gold assay measurements from current analytical methods are typically reported to 0.001 (troy) ounces per short ton (opt), if U.S. units are requested. Most laboratories offer the option to report results in either parts per million (ppm) or opt, or both. The list below has the same values with different units:

0.005 ppm = **0.000**146 opt
0.010 ppm = **0.000**292 opt
0.015 ppm = **0.000**438 opt
0.016 ppm = **0.000**467 opt
0.017 ppm = **0.000**496 opt
0.018 ppm = **0.000**525 opt
0.019 ppm = **0.000**554 opt
0.020 ppm = **0.000**583 opt
0.034 ppm = **0.000**992 opt
0.035 ppm = **0.001**021 opt
0.036 ppm = **0.001**050 opt
0.037 ppm = **0.001**079 opt
0.038 ppm = **0.001**108 opt

Notice that the converted opt values vary in the ten thousandths decimal place or beyond, while the ppm values vary in the hundredths or tenths place. The range of example values above is near the lower method detection limits, in reported ppm and opt values. Currently, for many open pit heap leach projects in Nevada, economically viable mineralization is about 0.1 to 0.2 ppm gold, equivalent to about 0.003-0.006 opt.

The converted opt values to six decimal places are statistically valid, and could be applied to resource estimation. However, the large number of decimal places can be inconvenient for data review and computation, due to the increase in file size required to store the extra digits.

Many U.S. projects have older assay data reported to 0.001 opt, in addition to newer data that could have lower method detection limits, in different units. Analytical technology improved the resolution of assay results in the last two to three decades, and although legacy data may have less resolution, they are still applicable to resource estimation. Assay data in opt is the foundation of many projects, and a dataset in opt values is often all that is available for initial resource estimation. There are several ways to combine legacy and modern assay data with ppm and opt units. The impacts of each are explained below.

**Precision of Assay Values**

What happens when we truncate PPM values converted to match the precision and units of legacy data, to adopt OPT units in the database? In Case 1, values are rounded:

0.005 ppm = **0.000** opt
0.010 ppm = **0.000** opt
0.015 ppm = **0.000** opt
0.016 ppm = **0.000** opt
*0.017 ppm =* ***0.000*** *opt*
*0.018 ppm =* ***0.001*** *opt*
0.019 ppm = **0.001** opt
0.020 ppm = **0.001** opt

0.034 ppm = **0.001** opt
0.035 ppm = **0.001** opt
0.036 ppm = **0.001** opt
0.037 ppm = **0.001** opt
0.038 ppm = **0.001** opt

In Case 2, values are truncated without rounding:

0.005 ppm = **0.000** opt
0.010 ppm = **0.000** opt
0.015 ppm = **0.000** opt
0.016 ppm = **0.000** opt
0.017 ppm = **0.000** opt
0.018 ppm = **0.000** opt
0.019 ppm = **0.000** opt
0.020 ppm = **0.000** opt
*0.034 ppm = **0.000** opt*
*0.035 ppm = **0.001** opt*
0.036 ppm = **0.001** opt
0.037 ppm = **0.001** opt
0.038 ppm = **0.001** opt

Depending on the formatting applied in the source tables, values may or may not be rounded before digits are truncated. The resulting converted opt values are different, depending on rounding, if the appropriate precision is not maintained.

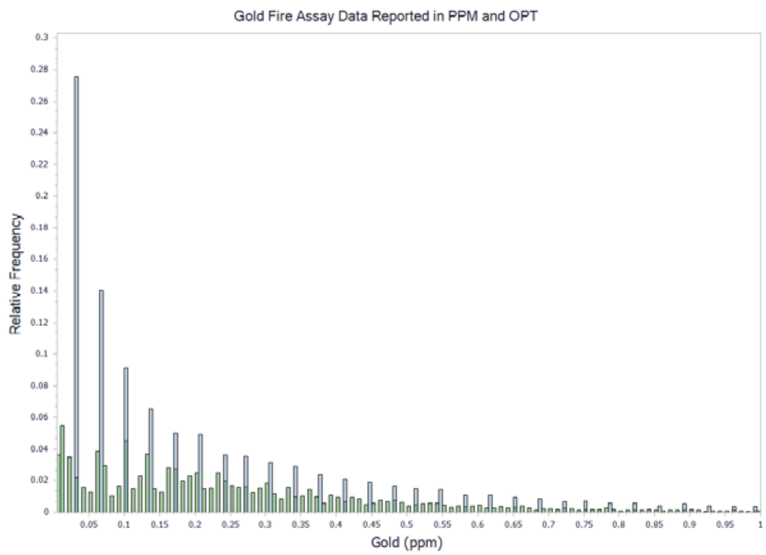
Conversely, how does the data look if we adopt higher precision values from modern sampling, and convert legacy data in opt to ppm? At values near the resource cutoff grade for typical open pit gold mines in Nevada, the effect is dramatic. In Case 3, the values represent grades of economic interest*:

0.034 ppm = 0.001 opt
0.069 ppm = 0.002 opt
*0.103 ppm = 0.003 opt*
*0.137 ppm = 0.004 opt*
*0.171 ppm = 0.005 opt*
*0.206 ppm = 0.006 opt*
0.240 ppm = 0.007 opt
0.274 ppm = 0.008 opt
0.309 ppm = 0.009 opt
0.343 ppm = 0.010 opt

** Grades near resource cutoff for typical open pit heap leach gold mines in Nevada.*

The values shown in Case 3 start at the lower method detection limit (MDL) for typical “legacy” gold assays. The lower MDL value has 100% analytical uncertainty; the reported value is 0.001 opt, +/- 0.001 opt. Analytical uncertainty is a constant value, but it decreases relatively as values increase. Analytical uncertainty should be considered to apply legacy data near the lower method detection limit. In this example, values reported at 0.003 opt have analytical uncertainty of +/-0.001; the actual

value is between 0.002 and 0.004 opt, and could vary by up to 33% of the reported value. The modeler should consider this aspect of data quality for resource estimation and classification.
The histogram below shows the distribution of results reported in OPT and converted to PPM (blue) with results reported in PPM (green) on the same horizontal scale as the histogram above. Notice that the results reported in OPT fall in distinct, widely-spaced bins. These values correspond to the table above, and illustrate the difference in precision for values reported in OPT and PPM.




*Example of gold assay values reported to 0.001 opt (blue) converted to ppm, and 0.005 ppm (green).*

**Applying Assay Data**

The current gold price and processing techniques support resource cutoff grades that were barely anomalous a generation ago. Most exploration projects have assay data collected through time, with different units, precision, and method detection ranges for various drilling campaigns. In the context of low resource cutoff grades, the lower limit of valid values may differ between data sets. For some assay results with coarse data and relatively high method detection limits, the calculated resource cutoff grade may be less than the lowest valid value with acceptable uncertainty.

What are the limitations to apply assay data at low resource cutoff grades?

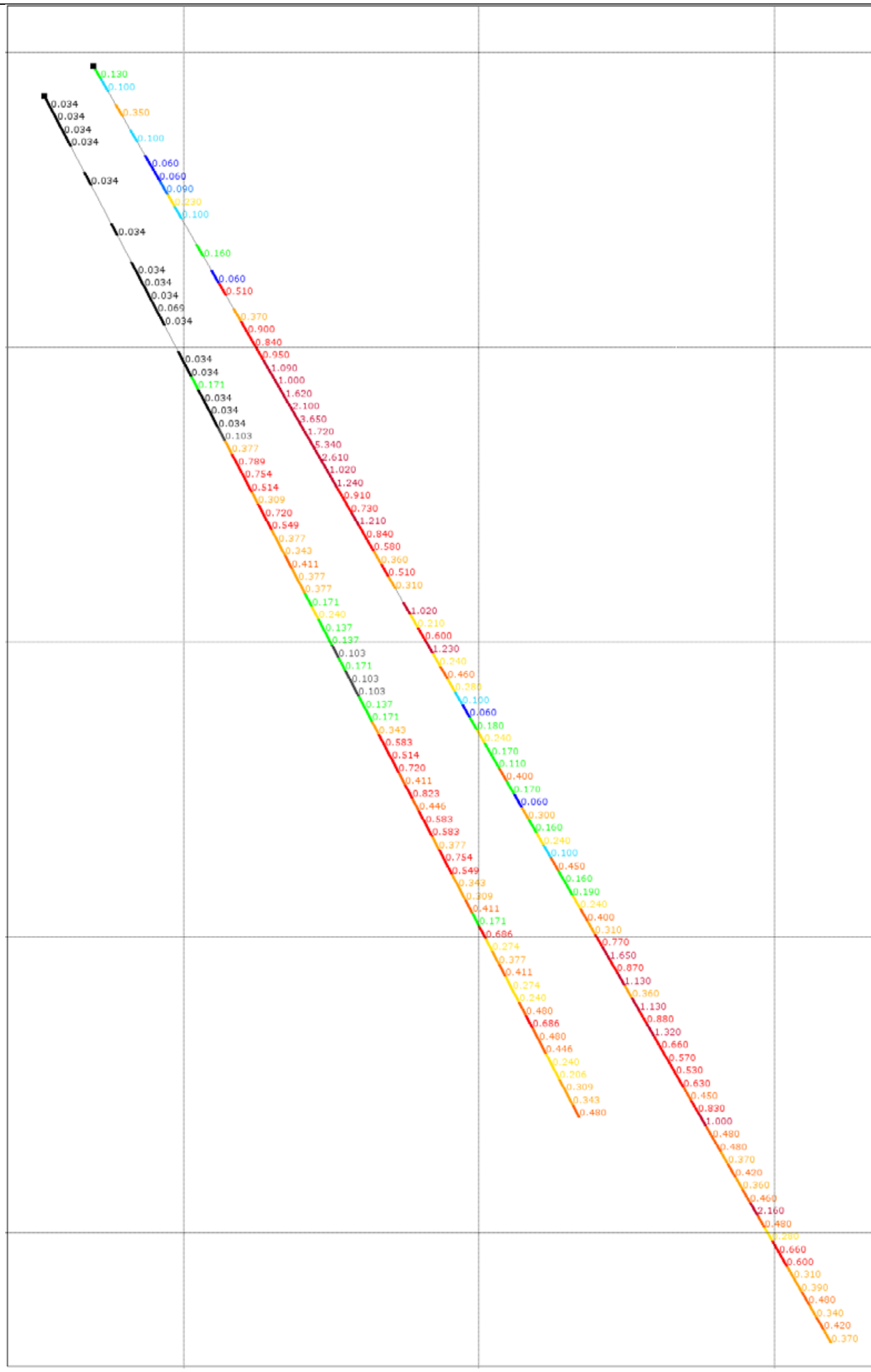
Consider the detection limit range of all data. The range may vary by drilling campaign, through time, or between laboratories. Lower and upper method detection limits are available from analytical laboratories, and should be included in the assay metadata when it is saved to the project database. The assay certificate includes the laboratory location and contact information, and the analysis codes for each method reported. Alas, many laboratories that were thriving twenty years ago, or more, no longer exist. If the laboratory information is not available, the project geologist could provide some insight on the analytical program beyond the values reported on certificates. Fortunately, many geologists who were thriving twenty years ago or more continue to do so.

Armed with the assay metadata, we can determine the validity of low assay values. That depends on a few parameters, including:

- Lower method detection limit;
- Reported value relative to the lower MDL;

- Reported units, and;
- Any conversion between units.

Minimum valid values will differ based on the characteristics above. In one assay dataset, there could be several different minimum valid values. Depending on the spatial distribution of assay data and the analysis methods, some areas may have different support, in terms of data quality and precision. The image below shows a legacy drillhole on the left and a recent drillhole on the right, with assay values. Note that many of the values in the legacy drillhole are 0.034 ppm, equivalent to 0.001 opt. These were at the lower MDL for the fire assay method used at the time. The values in the adjacent drillhole are also from a fire assay method, but were reported to 0.005 ppm. They provide better resolution for lower grade values, which show more variability than the samples reported in opt. This illustrates the inherent uncertainty in the opt values near the method detection limit. Similar material analyzed with a higher precision method shows variability that is otherwise masked.



*Drillholes with gold assays reported in opt (left) and ppm (right), shown in ppm values.*

**Impact of Data Precision on Estimated Resources**

If the assay dataset has been reviewed for accuracy, and the database matches the assay certificates, which include method detection limits and reported units, grade estimation can progress. You will need a resource cutoff grade based on mining and extraction costs and metal sale price. Lately, heap leach projects in Nevada have calculated resource cutoff grades between 0.003 and 0.006 opt. Typical legacy assay data has a lower MDL of 0.001 opt.

Do the values in the data set support the low cutoff grade determined from project economics?

Assay values near the method detection limit should be applied with care, from building grade shells to geostatistics and computation. If there is no bias in the assay data, then the reported low values should represent the material, on average. The main risks of applying low-resolution assay data to grade estimation is diluting the resource with low-grade material, by over-projecting economic assay values that are not repeatable with different analytical methods.

Beyond the numeric values in the data set, the inherent analytical uncertainty should be considered for resource classification. Portions of the model that are only informed by legacy data with coarse resolution should have a lower classification than areas with recent drilling and higher resolution assay data. The lower classification could be remedied with infill drilling and a high-quality sampling and analysis program to confirm existing data.

If PPM values are converted to OPT for consistency, the loss of precision is manageable. Maintain higher resolution during computation, and round reported values at the end. On the other hand, the case of PPM values used for estimation but OPT values needed for mine planning. The estimated block values in PPM may be converted to OPT in a separate model item, block by block. This approach also maintains the precision of PPM data, with fewer decimal places for faster computation.

*Thank you for reading this article. If you enjoyed it, please like, comment on, and share it.*

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