



**CHRYSOS
CORPORATION**
Assays at the speed of light

Technical Note TN-106
PhotonAssay™ Measurement
Performance for Gold
Impact of U, Th and Ba

Executive Summary

The presence of certain elements in mineral ore samples, most notably uranium (U), thorium (Th) and barium (Ba), increases the gold detection limit and decreases the measurement precision. This note summarises the quantitative impact of different concentrations of these elements. The largest impact is observed for samples with gold concentrations below 0.5 ppm.



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Introduction

The Chrysos™ PhotonAssay method assays gold by exposing mineral ore samples to high-energy X-rays. These excite short-lived changes in gold atoms in the samples; the excited atoms subsequently emit characteristic gamma-rays that can be detected and counted to determine the gold grade.

Several other naturally occurring elements also emit gamma-rays following X-ray excitation. Whilst these emissions have different energies from those of gold, their presence increases background levels and decreases the precision with which the gold signal can be measured. The consequence is a decrease in gold measurement precision and an increase in the detection limit (DL).

Figure 1 illustrates this effect, showing a portion of the gamma-ray energy spectrum measured for two different samples. Both samples are certified reference materials supplied by OREAS and have similar gold contents of approximately 1.5 ppm. The gold signal peak is visible at an energy of 279 keV. The material OREAS-209 (orange) has low uranium, thorium and barium contents (0.43, 1.75 and 73 ppm, respectively), whereas OREAS-524 (blue) contains 59 ppm uranium, 8 ppm thorium and 2.9 wt% barium and shows significantly elevated background levels, reducing the accuracy of the measurement of gold.

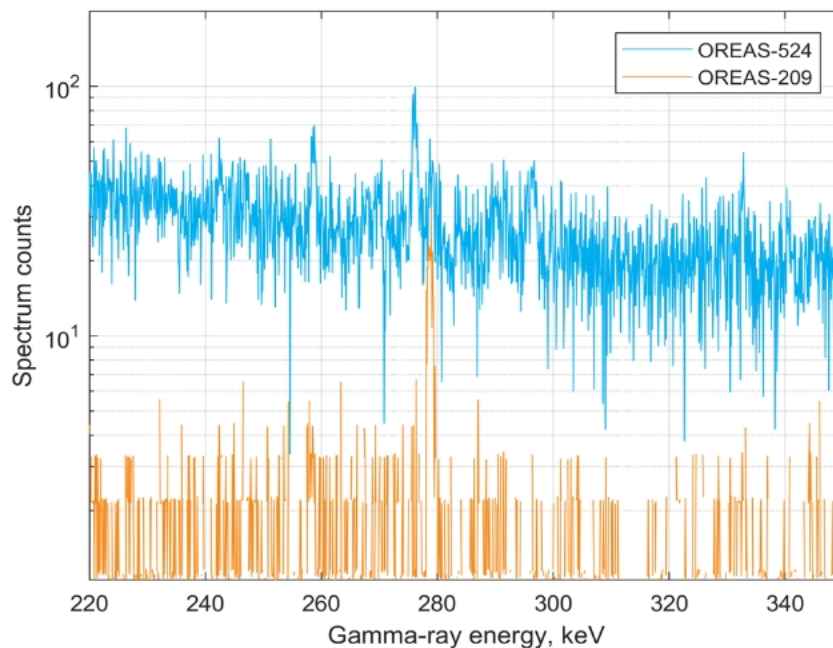


Figure 1. Comparison of gamma-ray spectra for high-background (blue) and low-background (orange) materials having similar gold contents.

This technical note highlights the impact of the background elements U, Th and Ba on the gold precision and detection limits.

Quantitative impact of U, Th and Ba

The greatest impact of U, Th and Ba on assay performance occurs at low gold concentrations. This can be observed most directly through the increase in the detection limit. Table 1 shows the effect of various concentrations of U, Th and Ba on the gold detection limit and precision at different gold grades.

Table 1. Calculated impacts of U, Th and Ba on gold detection limits and precision. Concentrations of interfering elements and the gold detection limit (2-sigma) are shown in ppm. Relative measurement precisions (1-sigma) are shown in percent.

U + Th level (ppm)	Ba level (ppm)	Au DL (2 σ , ppm)	Gold precision (1 σ) at nominated grade			
			0.1 ppm	0.3 ppm	1 ppm	3 ppm
0	0	0.010	12%	6.5%	3.7%	2.5%
<1	<100	0.013	12.3%	6.6%	3.8%	2.6%
10	<100	0.025	16.1%	7.4%	3.9%	2.6%
20	<100	0.033	19.5%	8.3%	4.1%	2.7%
50	<100	0.051	27.3%	10.5%	4.5%	2.7%
<1	1000	0.019	14.1%	6.9%	3.8%	2.6%
<1	3000	0.028	17.5%	7.7%	4.0%	2.6%
<1	1 wt%	0.048	26%	10.1%	4.4%	2.7%

The presence of uranium and thorium have almost equivalent effects on the detection limit, whereas significantly higher concentrations of barium are required to have a similar impact (Table 1). The 2-sigma detection limit for a blank sample with zero concentration of these elements is 0.01 ppm. A concentration of 3000 ppm of Ba or 10 ppm of combined U plus Th have similar impact, raising the detection limit to 0.028 or 0.025 ppm respectively.

The 1-standard deviation (SD) precision or repeatability of PhotonAssay for a sample containing 0.3 ppm gold is about 0.02 ppm (6.5% relative) for materials with low levels of U, Th and Ba. A combined U + Th concentration of 20 ppm, or a concentration of 3000 ppm barium decreases the measurement precision to about 0.025 (8.3% relative) and 0.023 ppm (7.7% relative), respectively. The impact of background elements at higher gold levels is much smaller.

Samples with elevated U, Th and Ba concentrations will include a high-background (HB) status flag to enable customers to identify jars that have significantly impacted precision and detection limits. Table 2 indicates the approximate elemental concentrations at which the HB flag turns on for different gold grades.

Table 2 Minimum background element concentrations required for a HB flag status.

Gold grade (ppm)	Combined U and Th (ppm)	Ba (%)
0.1	27	0.62
0.3	45	1.02
1	105	2.4
3	278	6.4

Combined U plus Th levels above 80 ppm or Ba levels above 1.8% lead to very high gamma-ray emission rates and possible detector saturation, preventing jars from being analysed using the high sensitivity services such as PAAU02, PAAUAG02 or PAAGAU01. When concentrations of the background elements reach this level, the sample will receive a Not Suitable (NS) flag and no gold grade will be reported. The interfering element limits that result in an NS flag are currently under review. These samples can be re-measured using the high-grade service (PAAU02H) to enable a gold grade to be reported, albeit with lower precision. However, using the high-grade service on gold concentrations less than 1 ppm is not recommended.

Predictive model

A mathematical model has been constructed to predict gold detection limits and measurement precisions in samples containing various concentrations of U, Th and Ba. Please contact the ChrysoS technical services team for assistance with estimating assay performance in materials containing different concentrations of these elements.

Conclusions

For samples with combined uranium and thorium levels in the range 0-20 ppm, or barium levels in the range 0-3000 ppm, PhotonAssay can measure gold with a 2-sigma DL of 0.01-0.03 ppm, and a 1-SD precision of 6.5-8.3 % at 0.3 ppm, improving at higher gold grades. Uranium, thorium, and barium concentrations above these levels increase the DL and decrease measurement precision, with the impact being largest at low gold concentrations less than 0.5 ppm. The maximum recommended levels of interfering elements using PAAU02 are 80 ppm for the combined uranium and thorium content, or 1.8% for barium content. Measurements with higher levels of interfering elements can be performed at reduced precision using the high-range gold services.

