

Rebuttal to François-Bongarçon & Oliver

By James Tickner¹

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Dear Editor,

We read with considerable interest the recent paper by François-Bongarçon and Oliver (F-B&O) concerning the PhotonAssay™ method for gold analysis (SST, this issue). As developers of the technology, we welcome rigorous technical discussion of PhotonAssay performance and sampling behaviour. Such scrutiny is important for any analytical method achieving widespread industrial application.

However, we are concerned that readers unfamiliar with PhotonAssay™ may come away with a misleading impression regarding both the maturity of the technology, the extent of comparison testing that has been performed, and the practical significance of the positional sensitivity effects discussed by F-B&O. We therefore wish to provide some additional context and clarification.

Historical and operational background

First, PhotonAssay™ is not a newly introduced or lightly studied method. The underlying physics, instrument design, calibration methodology, and sampling behaviour were originally developed over fifteen years at the CSIRO, Australia's national applied research agency. PhotonAssay™ has subsequently been commercialised and further developed by Chrysos Corporation over the past nine years.

Approximately one hundred detailed studies have now been performed comparing PhotonAssay's performance on measuring gold in crushed and pulverised material with fire-assay, cumulatively including hundreds of thousands of samples across a very wide range of ore types, preparation protocols and operating environments. More than forty PhotonAssay units are now operating globally, collectively running more than one million samples per month, with their results supporting JORC and NI 43-101 compliant resource reporting and day-to-day mine planning and operations. Consistent with best practice, Chrysos' clients routinely run inter-laboratory round-robins and comparisons to existing methods.

Comparison of PhotonAssay™ on crushed/pulverised ore with fire-assay

The assertions of F-B&O that PhotonAssay™ measurements on coarse materials routinely underreport with respect to measurements on RC or pulverised ore, and that PhotonAssay™ generally underreports with respect to fire-assay are not consistent with our extensive experience, nor that of Chrysos' mining and laboratory clients.

In the absence of any information on the design of the studies mentioned by F-B&O (including the mining operations involved, material selection, preparation and sampling, or statistical procedures followed) we can only offer some general comments on the likely cause of the alleged effects.

Across the very large number of comparison studies performed to date, PhotonAssay™ measurements on crushed and pulverised materials are generally self-consistent and show strong agreement with conventional fire assay across a broad range of deposit types. Where statistically significant differences have been identified, they can typically be explained by ordinary sampling effects, contamination during pulverisation, recovery limitations and QC fails in comparison methods, or inappropriate statistical treatment of heterogeneous assay data.

This latter point is important. Comparison of gold assay methods is statistically non-trivial. Ore grade distributions are strongly skewed and dominated by sampling variance. The uncritical use of standard metrics such as comparison of mean values, t-scores, simple regression etc can produce misleading conclusions when applied without appropriate treatment of multiplicative errors and heteroscedasticity. Considerable work has already been published on this topic, including by our group.

The Chrysos technical team has performed or contributed to many comparison and validation studies since 2017 across a broad range of deposit types, ore characteristics and preparation workflows.

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In our experience, where apparent discrepancies between analytical methods are observed, careful collaborative review of the sampling protocol, preparation methodology, statistical treatment, underlying ore characteristics and QC performance is usually sufficient to identify the dominant contributing factors.

We therefore actively encourage independent evaluation of PhotonAssay™ performance and are always willing to work constructively with laboratories, consultants and mining companies seeking to better understand the technique or investigate unexpected results. This includes detailed review of comparison datasets, experimental design and statistical interpretation.

In the present case, while several studies and observations are referenced by F-B&O, the underlying datasets and supporting details have not been made available to us for technical review. We would welcome the opportunity to examine such results collaboratively and in detail. Our experience has consistently been that open technical engagement and transparent data review provide the most effective path to resolving apparent discrepancies and improving collective understanding of assay behaviour.

Positional sensitivity

One of the central questions raised by F-B&O – namely positional sensitivity within the sample volume, effects of material presentation, and interactions between sampling heterogeneity and instrumental response – is not new. These effects are well understood, have been explicitly modelled during instrument development, and have been extensively explored experimentally. Indeed, samples determined to have a significantly heterogeneous gold distribution are automatically flagged ‘HET’ in a standard PhotonAssay™ report.

As with any bulk radiation-based measurement system, PhotonAssay™ does not exhibit perfectly uniform sensitivity throughout the sample volume. This is a straightforward consequence of radiation transport physics. The relevant question, however, is not whether positional variations exist in principle, but whether they materially affect assay accuracy and operational performance in practice. Our experience, supported by extensive experimental data, is that they do not.

The recent F-B&O paper places considerable emphasis on experiments involving highly artificial distributions of gold within sample containers.

While such experiments can illustrate underlying physics, they do not by themselves establish that analytical bias will occur in practice under normal operating conditions.

For example, in Section 2.4 of Part 1, F-B&O describe repeat measurements performed on individual weighed gold fragments placed within jars of barren material. The reported variations of approximately 3–4% RSD are broadly consistent with the expected instrumental precision combined with limited movement of the fragments between measurements. Importantly, these experiments primarily illustrate local spatial response variations under highly controlled conditions and do not, by themselves, demonstrate the existence of significant operational assay bias.

In real ore systems, the dominant contributor to uncertainty is almost always the Fundamental Sampling Error associated with the heterogeneous distribution of gold itself. Indeed, the principal advantage of PhotonAssay™ – namely the use of sample masses approximately an order of magnitude larger than conventional fire assay – is precisely that it substantially reduces these sampling effects.

A key point is that positional sensitivity contributes only a small increment to the overall uncertainty when considered alongside ordinary ore heterogeneity and sampling variance. In operational terms, the effect is modest. Our modelling and experimental work indicate that the contribution of positional sensitivity to the overall uncertainty is comparatively small, typically increasing the effective relative sampling error by only a few percent under realistic operating conditions. Moreover, unless gold particles become grossly and systematically segregated within the sample volume, then positional sensitivity does not result in a reporting bias. This results theoretically from the design of the PhotonAssay™ irradiation and measurement systems, and is evidenced empirically by an absence of bias seen in our experimental studies.

Concluding comments

To present our arguments in greater detail, we have prepared a technical paper addressing the physical basis of PhotonAssay™ response, appropriate comparison methodology for heterogeneous ores, large-scale empirical comparison studies, and quantitative evaluation of positional sensitivity effects within the broader uncertainty framework of gold sampling and assay. We refer the interested reader to this paper, which appears in this issue of SST.

Our intention here is not to dismiss continued investigation of PhotonAssay™ performance – indeed, we strongly encourage it – but rather to ensure that discussion remains appropriately balanced and grounded in both the theoretical and empirical body of work that already exists.

PhotonAssay™ represents a fundamentally different approach to gold analysis from traditional small-charge chemical assays. Like all analytical methods, it has limitations and operating constraints that must be properly understood.

However, after extensive testing and commercial deployment, the evidence overwhelmingly indicates that the method provides robust, accurate and operationally valuable measurements across a wide range of ore types, mining and metallurgy applications.

Yours sincerely,
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