LBMA

Alchemist

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In this issue

The LBMA is delighted to announce that its closer working relationship with the London Precious Metals Clearing Limited (LPMCL) has recently been formalised with the signing of an SLA. As part of these new arrangements a new LPMCL website will be launched shortly. For further details and for information on other initiatives, please refer to LPMCL News on page 27 and the Editorial on page 29.

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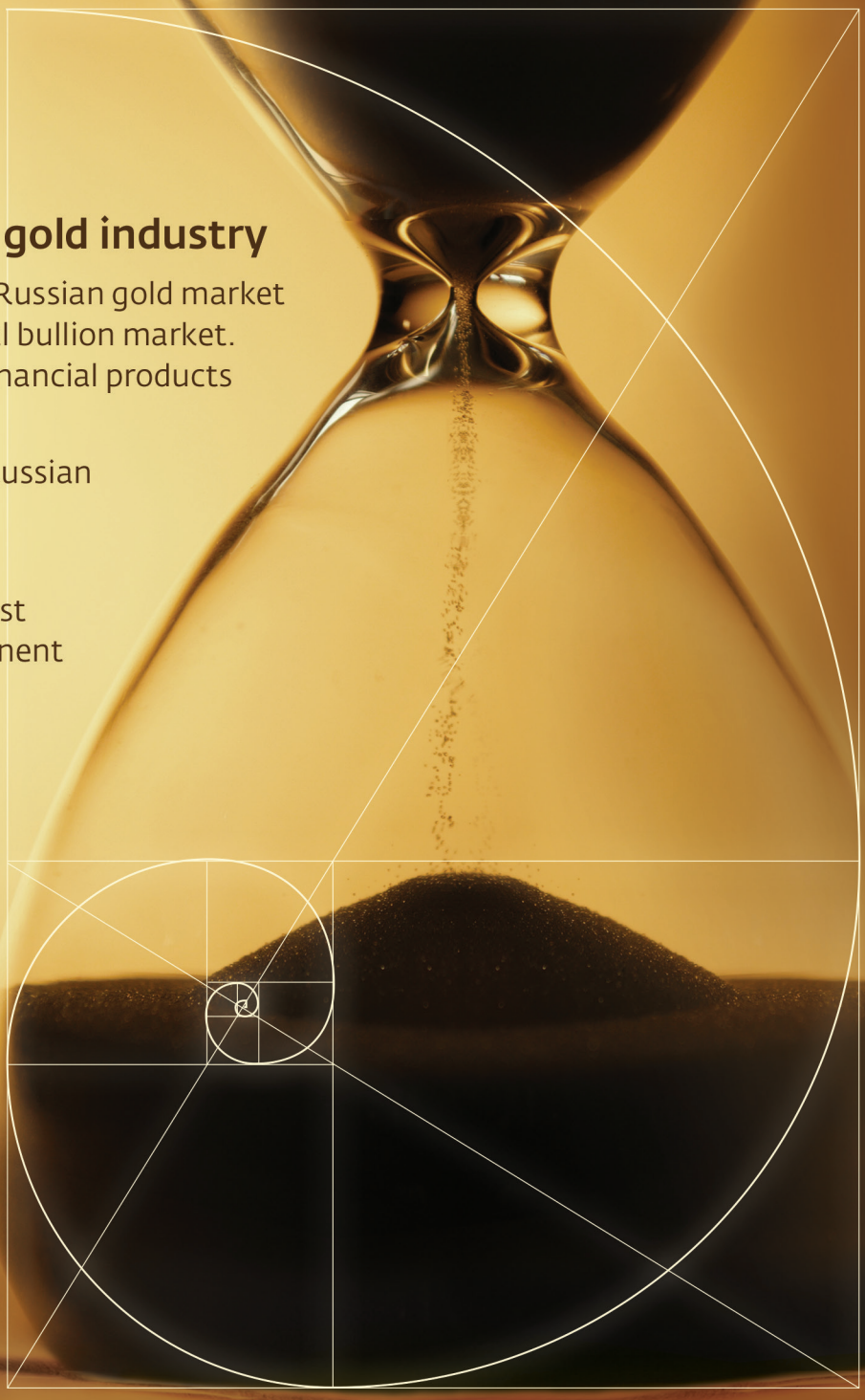

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Sampling: Theory and Practice

By Professor Kim H Esbenson, KHE Consulting, Copenhagen; adj professor Danish Geological Survey and Aalborg University

This is an abridged version of the Keynote Speech which Professor Kim Esbensen delivered at the LBMA Assaying and Refining Conference on the 20 March, 2017.

Although it feels a bit like 'mission impossible', this speech aims to provide an overview of the Theory of Sampling (TOS), including insights into the basic principles of representative sampling.

A Crucial Assumption

It is generally assumed that liquid metal is well mixed due to convection and stirring caused by the electromagnetic fields in induction furnaces. This is, of course, a crucial assumption for assaying work. But how true is it? Are all liquid metal pools in all crucibles always completely well mixed? Are impurities always completely uniformly distributed when we tap out the melt? How well can this be verified? By which approach? This is the crucial issue at the very end of the pathway from mine to product. There could easily be a heterogeneity issue involved. Were this so, any endeavour to improve on how to counteract heterogeneity could only benefit professional assaying in refining.

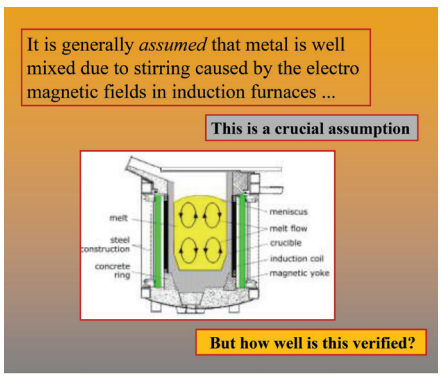

Figure 1

However, there are also many other things to talk about that come before this last analysis stage.

The AMIRA P754 project 2001 paper by Peter Gaylard noted that: "…to avoid the uncertainty related to systematic errors by a proper process concept and appropriate sampling, when inhomogeneity of the sample material can be presumed…" So heterogeneity is recognised and thus acknowledged even at this latest stage of the journey from mine to analysis. And we also know, if we go to the other end of that pathway, that all the world's precious metals most certainly were not mined out of the ground as material ready for the crucible. There is a huge and complex process going on from mining, producing a lot of broken ore, which is subjected to a massive series of mass reduction steps (which is nothing but sampling) before the crucible. There are severe order-of-magnitude differences between the mined mass and that of the analytical aliquot of at least one-to-a-million, up to one-to-a-billion [mass per mass]. This is a compound mass reduction process of staggering proportions, and all operations and stages of this process must be representative, lest the possibility of making relevant and reliable decisions based on the ultimate analytical results is impossible.

Indeed, proper sampling is nothing but a series of representative mass reduction, all of which are crucial before analysis. We need to know about this, how to do it properly and how we can work against heterogeneity at all stages in this process. This is the job of sampling competence.

We all need to know some rudimentary basics regarding this matter. So, it would be nice if we could find an international standard that tells us all about how we should conduct the critical sampling and mass reductions. Fortunately, there is now such a standard.

Sampling – 'how' instead of 'how big'

To illustrate, let us use an example from an industry sector other than precious metals – municipal waste. We need to sample this material because it is crucial to know in advance, when this type of waste is incinerated, how much dioxin we are emitting into the atmosphere – dioxin is one of the most potent toxic substances known to man. This is a terribly complex sampling job, but it is crucially important for public health. With (very) small concentrations (impurities, the concentration of which we want to characterise with the utmost accuracy and precision), we are up against heterogeneity of the most difficult kind, no matter the nature of the material. How do you take, say, a 1 kilogram sample of this material and document it is as representative? This is a tough job, but there are perfectly feasible ways to do this.

By the way, the concentration levels for the precursor chemicals that turn into dioxins in an industrial incinerator and are sent out into the atmosphere are identical to the '9999' levels within refining. While both the precious metals and dioxin analytical methods and approaches can deal with the complexities regarding analysis, the really difficult issue is the extremely irregular spatial distribution of the analyte (or the precursors to the analyte). This constitutes the key heterogeneity issue.

When faced with the demand to take a representative sample, the question always uttered is: 'How big should the primary sample be in order for it to be representative?' And after that, we have the job of mass-reducing such a primary sample down to whatever is needed for the analytical determination in the end series of steps – all of which must also be representative. It turns out that the issue is rather more complex than merely 'getting a sample'.

Sample Size and Representativeness

It is not how big the sample should be, but rather how we can make the sample representative. This is the key question. When a sample has been collected in a representative fashion, it has whatever mass is determined by the sampling process and we simply have to accept this.

Scores of standards and guiding documents start out by fixing the size of the sample without this being based on anything empirical such as a pilot heterogeneity assessment. This means that we are just following the tradition that a sample has to be as good as we can get it – so long it is of the 'required mass'. But going for the sample mass without insight as to the target heterogeneity can never lead to a representative sample. We have

to go another way around this issue. On the other hand, once we have licked heterogeneity, sampling gets simple – and we can then worry about the sample mass, etc. But not before.

Thus 'sample mass' is not the driver that will lead to representativity; however, a sample that has been collected following the rules of the Theory of Sampling will be representative. And such a sample will then be of whatever mass is needed within these specifications. The job of securing representative primary samples therefore also includes how to make sure that all primary sample masses subsequently can be mass reduced (sub-sampled) effectively and representatively.

Stages of Sampling

Representative sampling is always a multi-stage process – covering the whole pathway from primary sampling of the original lot (commodity, batch, consignment) to analysis of the final test portion, including the secondary, tertiary sub-sampling stages. Luckily, the exact same principles govern all sampling stages.

At all stages, sampling errors abound and our job is to eliminate those that can be eliminated and to reduce all others that are always with us. Thanks to the Theory of Sampling, we can go about this in a very systematic fashion.

DS 3077 – Horizontal Sampling

2013 saw the publication of the world's first universal standard for representative sampling, called the 'horizontal standard'. It describes the general principles needed to do representative sampling with regards to all types of material, at all scales and for all purposes. The horizontal nature means that the sampling specifically only focuses on the heterogeneity.

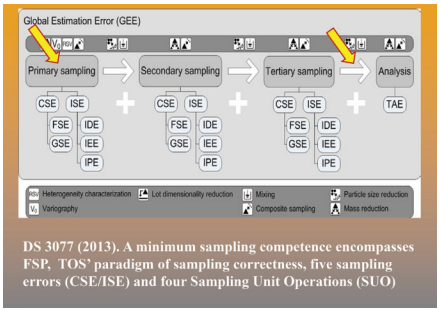

Figure 2

Here follows a sneak preview of the DS 3077 "Representative Sampling - Horizontal Standard." I had the privilege of chairing the working group responsible for producing this document. It took five years until everybody involved – industry, regulating authorities, scientists – agreed, unanimously, on this 42-page succinct standard. The illustration below manages to capture all the essentials of a proper representative sampling process – multiple stages, all with the exact same set of sampling errors, which the sampler has to suppress/eliminate, while also depicting the four Sampling Unit Operations available for this task.

Theory of Sampling (TOS)

Overview

There are 10 general elements in the Theory of Sampling and, remarkably, this is all we need to tackle any sampling objective, of any material, at any scale, for any purpose.

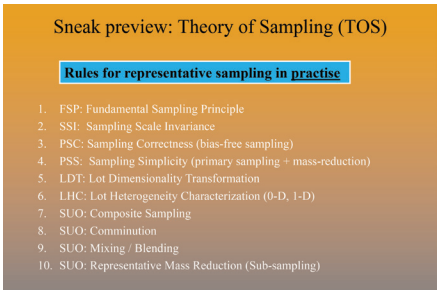

Figure 3

These elements are grouped into six Governing Principles (GP) and four Sampling Unit Operations (SUO). For example, the Principle of Sampling Simplicity (PSS) states that there is always a primary sampling and, after that, we 'only' have to perform a series of representative mass reductions until we have produced the aliquot mass needed for analysis. The entirety of this latter task is covered by Sampling Unit Operation no. 10. From a systematic point of view, these are a series of 'similar' sampling operations, but take place at smaller and smaller scales.

We should always be mindful that no analytical result is better than bracketed by the accumulating uncertainty from all these steps. Our job is to make each sampling operation representative, wherever in the lot-to-analysis pathway it takes place, i.e. no matter at what scale. Luckily, there is no interaction between any of the stages, so we can decompose all compound problems into a series of individual sampling operations governed by the same principles, using the same sampling unit operations, etc.

Heterogeneity

The arch enemy of all our sampling efforts is heterogeneity.

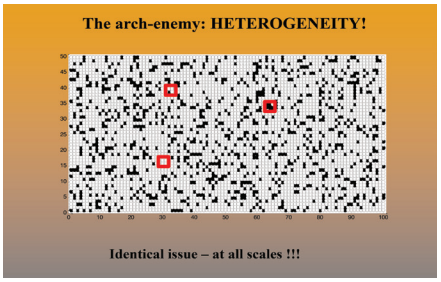

Figure 4

The above illustration is obviously a cartoon, but it shows the essence of what we are up against. The overall, average concentration of the analyte (black spheres) is 10% and the white spheres are the matrix, the filler, the gangue or whatever you want to call it.

Remember, the analyte is often 'impurities'. The key feature is its irregular spatial distribution - hetrogeneity. Let us say that we take just one sample (a 'grab sample'). It might be the one to the right. This particular sample would carry 75% of the analyte – a pretty high estimate of the total average concentration in this lot. We can clearly see something is wrong here. This is a cause for concern. Let us take another sample, but this one turns out to carry 25% (the topmost sample), which forces us to a third sample, which perplexingly turns out to carry 0% of the analyte. Obviously, we are in deep trouble – the analytical values are all over the place. In such a situation, fingers are usually pointed at the laboratory, but completely without reason. What we experience here has absolutely nothing to do with the competence of the analytical laboratory. We are simply facing what is known as the Fundamental Sampling Error (FSE), which is a sampling artefact that is always with us when dealing with low analyte concentrations. Such single samples as illustrated are simply too small to do a reasonable job; hence, the perhaps at first understandable but still futile question: 'How big… to be representative?' It is clear that a sample would have to be of the order of a very significant proportion of the whole lot before it would stand any chance of being close to being useful for estimating the overall concentration ($^1/_3$ to $^1/_2$ of the total lot mass). This is clearly not the way to go.

Solutions

But we can in fact easily sample also in the case of adverse heterogeneity – through composite sampling. This is also the main door-opener to representative sampling at the primary stage. The illustration below is generic. A sample composed of, for example, the seven individual increments shown (which make up the exact same mass as the singular grab sample also depicted) is able to 'cover the heterogeneity' of the lot in a vastly improved fashion, compared to the grab sample. The 'free parameter' of all composite sampling procedures is 'Q', the number of increments one is willing to deploy to counteract the heterogeneity encountered. Should the sampler not be satisfied with a 'too cautious' Q (in the present illustration, Q = 7), the general rule for how to increase the fit-for-purpose representativity of any composite sampling process is simply to increase the number of increments, Q (see DS 3077 (2013) and other references below).

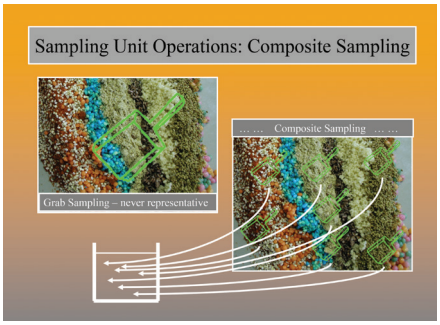

Figure 5

There are two aspects of heterogeneity: compositional and distributional, or spatial heterogeneity, and the latter is the real enemy. But a structured composite sampling procedure, patterned on the problem at hand will solve this problem. We only need to know how.

These few examples demonstrate the imperative of a pilot heterogeneity characterisation of any material for which we need a fully documented representative sampling procedure. Standard 'sampling plans', with pre-set 'sample mass' stipulations, are the very anathema to proper sampling.

Sampling in practice

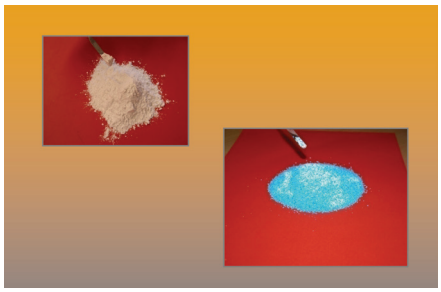

Figure 6

This is an example of what I have seen within many industry sectors. It is not always the case that you can see material heterogeneity with your own eyes, and this is indeed making the world a little more challenging and complex. But there is no problem even in this case.

There is no such thing as a homogenous material in science, technology and industry. The materials that we are dealing with are always heterogeneous to some degree. It is just a matter of to what degree. A logical and rational way to proceed is simply to treat all materials in need of sampling as if they were significantly heterogeneous. This is indeed also the simplest operational modus. Following the Theory of Sampling's principles, the professional sampler does not need to switch the type of sampling operation used when addressing a different material. There is no change of procedures when heterogeneity may differ – only Q changes. This simple, unified approach Sampling Unit Operation no.7 empowers us to tackle all sampling issues, regardless of their lot size, form or the nature of the material, by only addressing their specific heterogeneity.

Sampling Errors

I want to introduce you to Pierre Gy, a giant in science who very sadly died in November 2015, and who single-handedly developed the Theory of Sampling from 1950 to 1975. He wrote nine books and gave more than 250 speeches on the subject. He carried out a tremendous amount of R&D, but never worked at a university. He was a consultant nearly all his life – a remarkable life.

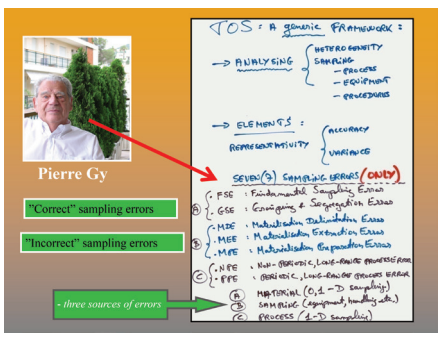

Figure 7

Pierre Gy's major breakthrough was to identify no less than seven sampling errors that cover everything that can go wrong with sampling. He then meticulously worked out how to avoid these errors and their adverse impact on the uncertainty as much as possible. It was a monumental job. Along the way, he worked for and was awarded two PhDs – one in mineral processing and one in statistics – in order to solve all the complex problems identified. There are only about 10 to 15 professionals in the world who have read his work in its entirety. Although complex, TOS can also be made more easily accessible however: These seven sampling errors originate from only three sources – the material, the sampling equipment and the sampling process – depending on whether the lot is stationary or moving when sampling takes place.

Pierre Gy's oeuvre is awe-inspiring; he is honoured in a special issue of the TOS Forum (2016).

Sampling Unit Operations

My own humble contribution to the Theory of Sampling has been to put TOS on an axiomatic footing and to develop it into the new standard now available to all of us. The whole theory can in fact be summarised as the six Governing Principles and four Sampling Unit Operations as mentioned above. The Sampling Unit Operations (SUO) are the only instruments (the only concrete procedures) that we have at our disposition when we are called upon to solve sampling problems: i) composite sampling; ii) comminution; iii) mixing/blending; and iv) mass reduction (but not just any mass reduction – only representative mass reduction will do).

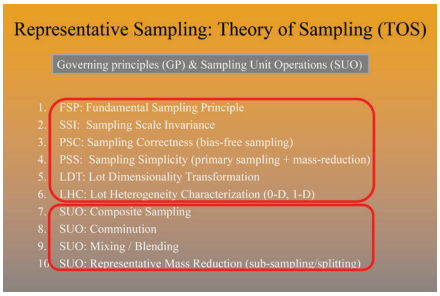

Figure 8

The above 10 elements are all we have at our disposal as professional samplers: four unit operations that we can apply in order to solve all practical problems – and guided by only six Governing Principles. This is not rocket science, but it does need structured, rational thinking. We are all familiar with crushing, mixing, blending and sub-sampling of course – but exactly how to deploy these agents when facing a specific heterogeneous material needs the full complement of GPs to succeed

Measurement Uncertainty (MU)

We all know of and work with measurement uncertainty – a characteristic of analytical methods. The fishbone diagram (in figure 9) shows how the elements of analytical methods can be structured. We can always get everything under control for any analytical method following the principles of Measurement Uncertainty (MU), i.e. we can always get a valid estimate for the total analytical Measurement Uncertainty (MU) – which we can call MU analysis.

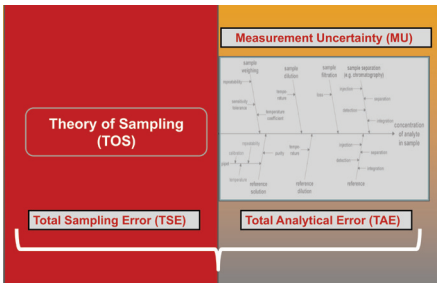

Figure 9

There is one part of the fishbone diagram that traditionally is not considered, however, and that is the sampling errors, which are simply left out. It is of course not a good idea to leave out these additional uncertainty components as they most emphatically always contribute to the effective total Measurement Uncertainty, MU sampling + analysis. This is a significant indeed often fatal problem if not properly acknowledged and rectified.

In nearly every case that I know of and in others I am sure, the sampling errors are typically many orders-of-magnitude larger than the total analytical error. In fact, it is fair to say that the Theory of Sampling constitutes the missing link in MU. The TOS deals with all the sampling issues involved and delivers the best possible representative analytical aliquot upon which to carry out the analytical determination. There are therefore always these two elements to the total measurement error, which is mandated to include the sampling errors. A recent publication deals in full detail with these issues: TOS vs. MU, Esbensen & Wagner (2014).

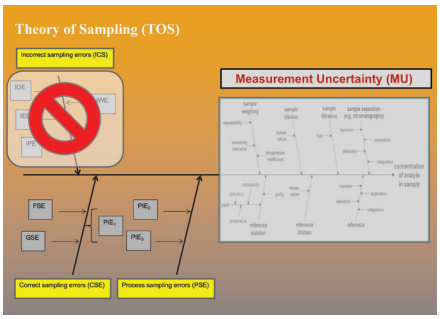

Figure 10

The above illustration is a snapshot of how this augmented systematic ties in with the analytical measurement fishbone schema. There are three types of errors 'on the sampling side of the street'. One is only involved when we are sampling moving targets and the remaining ones are: the incorrect sampling errors and the correct sampling errors. The first job of any sampling solution is to get rid of the incorrect sampling errors. They produce a detrimental sampling bias.

Analytical Processes vs. Sampling Process – a monumental difference

We all know the difference between accuracy and precision. We need both of these to qualify an analytical process, for example. In the illustration below (at bottom left) is a 'perfect' analytical process. It is unbiased and precise. We can also have a situation (illustrated bottom right) where we still have precision but there is a bias. Under the statistical assumption that this bias is constant for the analytical process investigated, it is possible to make a bias correction by subtracting the estimated bias magnitude. This is done all the time in any professional analytical laboratory.

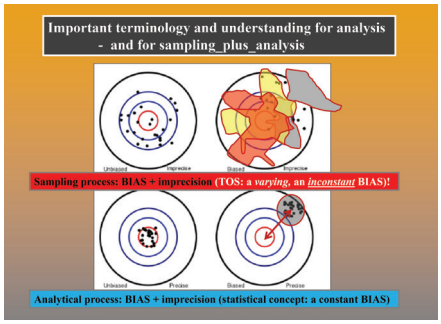

Figure 11

Let us now consider doing a replication of the whole sampling process (including the analytical determination), say 10 times, to find out where we are. If the 10 analytical results distribute themselves as shown in the upper right illustration (grey area), this is most certainly not amenable to any statistical correction. We are not really sure what is going on here. This is very surprising. We therefore try doing such a replication experiment again (yellow area) and maybe we try to get more insight from trying a third time (red area). The perplexing result is shown in the upper right illustration.

The conclusion reached by the Theory of Sampling is radical, but it also opens a door into how we can perform and document representative sampling in all events. The completely new issue is that the sampling bias is inconstant: it changes its magnitude every time we try to estimate it. This is because, for each set of replicate samples, we are taking out a little bit of the material that is significantly heterogeneous and we are definitely going to take out 10 different smaller bits the second time we try it, so we are getting our hands on different parts of significantly heterogeneous material even when we 'repeat' the sampling process in a completely identical fashion. This often causes a lot of problems for first-time observers. However perplexing this may seem, this crucial reality remains. The analytical results will never give rise to the 'same distribution' of analytical results (red, yellow, grey areas in the illustration above). Unfortunately – and here comes the crunch – this feature cannot be modelled by classical statistics, by a normal distribution; nor by any more advanced distribution.

The issue is that a significantly heterogeneous lot, because of its distributional heterogeneity, cannot be considered as a simple collection of analytical results that we can throw classical statistics at and expect a 'correction' solution from as we do with analytical uncertainties. Taking into account the heterogeneity effects, we have to work in a different way.

The Theory of Sampling's conclusion to this troubling issue is simply to demand that the sampling process must be designed so as to eliminate the incorrect sampling errors. This is the most important demand to representative sampling – eliminating all incorrect sampling errors, the 'hidden' culprits that produce the fatal inconstant sampling bias which we cannot under any circumstance control or correct for.

Theory of Sampling – the necessary and sufficient framework for practical sampling

The Theory of Sampling treats all of the issues briefly introduced above, and much more, from a strict systematic point of view. There are a few other elements to it besides what I have managed to illustrate here, but these will not alter the overview already provided. The TOS is the definitive framework for all sampling-related matters, be these procedures, equipment or performance assessment and validation of existing sampling systems and installations (auditing). At a PhD level, it takes two to three days in the auditorium to get into this curriculum (but there is a severe reading requirement), and there are many dedicated courses available for companies, industries and regulating authorities, and individuals can indulge in any level of self-studies (see references below). Getting to know all of what is needed is thus not an impossible task.

The TOS is a systematic way of thinking which has, as its main elements, material heterogeneity and how to counteract this when sampling. It is all about the sampling process. We should always be able to produce the most representative primary samples from any target lot and to mass reduce these competently in order to end up with the representative aliquot for analysis. Applied properly, the TOS allows us to forward only one aliquot to the laboratory for analytical determination. Only one is needed because the entire from-lot-to-analysis process honours the TOS's principles for representativity.

Professor Kim H Esbensen, Danish Geological Survey and Aalborg University. Kim H Esbensen, Ph D, Dr (hon), has been research professor in Geoscience Data Analysis and Sampling at GEUS, the National Geological Surveys of Denmark and Greenland (2010-2015), chemometrics/sampling professor at Aalborg University, Denmark (2001-2015), professor (Process Analytical Technologies) at Telemark Institute of Technology, Norway (1990-2000 and 2010-2015) and professeur associé, Université du Québec à Chicoutimi (2013-2016). He phased out a more than 30-year academic career for a quest as an independent consultant from 2016: www.kheconsult.com - but as he could not terminate his love for teaching completely, is also active as an international guest professor here and there.

Kim, a geologist/geochemist/data analyst of training, has been working 20+ years in the forefront of chemometrics, but since 2000 has devoted most of his scientific and R&D to the theme of representative sampling of heterogeneous materials, processes and systems (Theory of Sampling, TOS), PAT (Process Analytical Technology) and chemometrics. He is a member of five scientific societies and has published over 250 peer-reviewed papers and is the author of a widely used textbook in Multivariate Data Analysis (33,000 copies). He was chairman of the taskforce responsible for writing the world's first horizontal (matrix-independent) sampling standard (2013 and editor of the magazine TOS forum.

Kim is fond of the right breed of friends and dogs, swinging jazz, fine cuisine, contemporary art and classical music. He has been collecting science fiction novels for more decades than what he is comfortable contemplating, still, as ever... it's all in the future.

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Gold vs Trumponomics

By Jonathan Butler, Precious Metals Strategist and Business Development Manager, Mitsubishi Corporation RtM (Europe)

President Trump won last November's US presidential election, offering a bold yet vague set of economic policies including tax reform, increased infrastructure and military spending, and a protectionist approach to global trade – promises that helped establish a distinct reflation trade that is long in equities/short in bonds and other defensive assets. This article explores the challenges and opportunities for gold in this brave new world of 'Trumponomics'.

The surprise victory for Donald Trump in the US presidential election on 8 November 2016 saw gold prices rise on heightened uncertainty in the hours immediately after the election result. Bullion was soon on the defensive however, as investors piled into US equities and industrial commodities in expectation of higher growth and inflation. A move away from traditional safe-haven assets such as US government bonds saw the yield on 10-year US Treasuries (which move inversely with prices) increase to two-year highs of over 2.6%. The consequent increased cost of carry served to further tempt investors away from non-interest-bearing gold and precious metals. By mid-December, bullion had slumped to a 10-month low of $1,123 as safe-haven trades were unwound and as the dollar rose in value to the highest level since 2003 against other major currencies.

In early 2017, gold turned a corner from its oversold levels and was to remain on an uptrend for much of the first quarter, partly as investors hedged their bullish equity and pro-growth commodity trades, and remained mindful of the downside risks to growth from trade and geopolitical concerns.

Yet US equity markets remained the clear winners as 'animal spirits' were unleashed by expectations that corporate earnings would soon be boosted by tax cuts and a revived domestic economy. By March, all four major US equity indices were hitting new record highs. Inflation expectations increased to over 2% for the first time since 2014 and market expectations of US interest rate rises began to converge with the Fed's relatively hawkish rate outlook. Most significantly for gold, the yield on 10-year US Treasuries looked like breaking out of its 30-year downtrend (see chart 1) as investors continued to rotate out of bonds and send yields higher – with the implication that the inflation-adjusted real interest rate environment may be less favourable to gold in future.

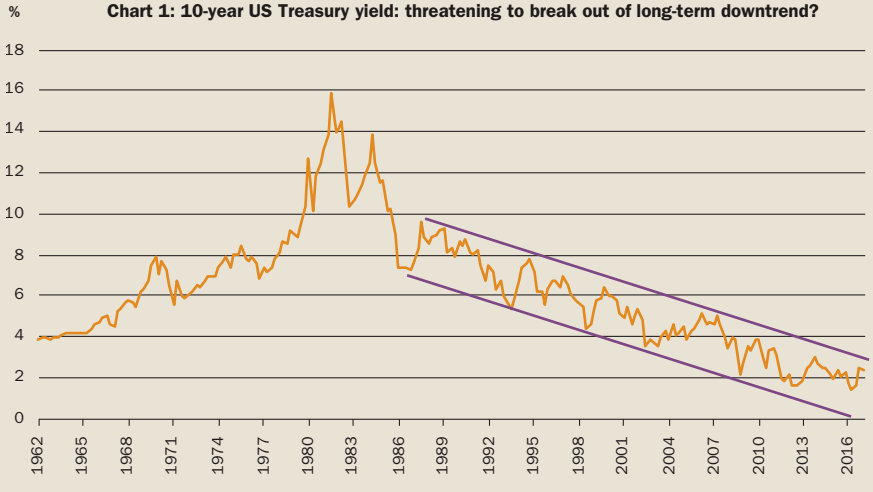
This 'reflation trade' came to a crashing halt in late March after President Trump's reforms to the Obama administration's Affordable Care Act were rejected by Congress. The failure of this high-profile campaign pledge immediately cast into doubt the ability of President Trump to push through ambitious tax cuts and infrastructure spending plans. Equities suffered a sharp drop, longer-term inflation expectations receded back below 2% and gold jumped back to levels seen just after the election, supported by ETF, physical and OTC/futures buying. That Mr Trump, the self-proclaimed 'deal-maker', singularly failed to reach an agreement on a key campaign issue, largely with those in his own Republican party, both ups the stakes for discussions on tax reform and fiscal spending, and heightens political and economic uncertainties – conditions in which gold traditionally performs well.

What therefore will Trumponomics mean in future and what are its implications for gold?

Trump's Spending

Promises of $1 trillion of additional spending on the military and infrastructure implies higher demand for everything from oil to construction materials, and also offers to create more jobs at a time when the US unemployment rate is at the lowest in a decade, at 4.5%. This is of course potentially inflationary and should be supportive of gold over the longer term as a traditional inflation hedge.

Chart 1: 10-year US Treasury yield: threatening to break out of long-term downtrend?



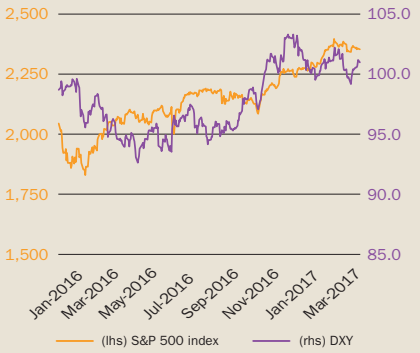
However, conservative Republicans in the House of Representatives are only likely to approve new spending where it is cost neutral. In other words, where the spending is met from savings elsewhere, so the inflationary implications of fiscal stimulus are probably much less than anticipated, and there will in effect be a reallocation of existing spending and consequently a muted net impact on job creation. Inflation outlook measures based on 5 and 10-year US Treasury breakeven rates have begun to reflect this, with inflation expectations back below 2%. Lower inflation, while not necessarily supportive of bullion, does imply that US interest rates will not be raised as quickly as the Fed might like, particularly if measured Personal Consumption Expenditure inflation remains below the Fed's target of 2%. This in turn will help keep real (inflation adjusted) yields in negative territory and therefore favourable to gold and other non-yielding assets (see chart 2).

Tax Reform

Much of the bullishness in equity markets in late 2016 and early 2017 (see chart 3) was predicated on US corporations seeing a cut to their tax rate, possibly of the order of magnitude that Candidate Trump was keen to promote, from the current headline rate of 35% to 15%. Given Congressional restrictions on increasing the budget deficit, any decrease in the tax base will have to be met with reductions in government spending – which may be politically unacceptable. This partly explains why Mr Trump as President has recently appeared more comfortable with the 20% rate. This is not far from the 20% to 28% effective corporate taxation rate after accounting for various deductions and, as such, the heady equity valuations that have resulted partly from optimism on changes to the tax code may not be justified by the political reality of few major changes to tax rates.

Gold could therefore gain as the euphoria in the equity markets fades and there is a rotation back into defensive assets.

Chart 3: Equity market (S&P500) and US dollar basket (DXY) performance



A further complication for the reflation trade comes in the shape of the differing approaches of the Trump administration and that of House of Congress Speaker Paul Ryan. While the White House is yet to publish a firm tax reform plan, Mr Ryan's approach is to replace corporate income tax with a 20% tax on businesses' domestic sales and imports, while exempting exports (the so-called border adjustment tax). Although initially hostile, Mr Trump may be warming to the idea, which fits with his overall protectionist trade stance. This and changes to the personal tax code, which together have been billed as the most ambitious set tax reforms since the Reagan administration, nonetheless look set to be mired in political wrangling for some time yet. The reflation trade may therefore wither if equity market momentum is not sustained by progress on tax reform.

Federal Budget

On the face of it, two key elements of Trumponomics – increased Federal spending together with a falling tax base due to cuts in personal and corporate rates – imply an ever larger Federal budget deficit. While this would be supportive of gold as a risk hedge, fiscal conservatives in Congress are unlikely to countenance any measure that will increase the deficit. However, discussions over the US budget deficit still loom large at the time of writing and may yet spill over, intentionally or not, into a failure of confidence in the US to repay its debts or even an outright default. The nearest parallel for this is the debt ceiling negotiations of 2011, when bitter political disputes forced the US to the brink of sovereign default and caused credit rating agencies to downgrade US debt for the first time in history. The increase in gold to all-time nominal highs of $1,921 in August-September 2011 offers a glimpse of what could happen to gold in the event of a return to this sort of political and economic impasse.

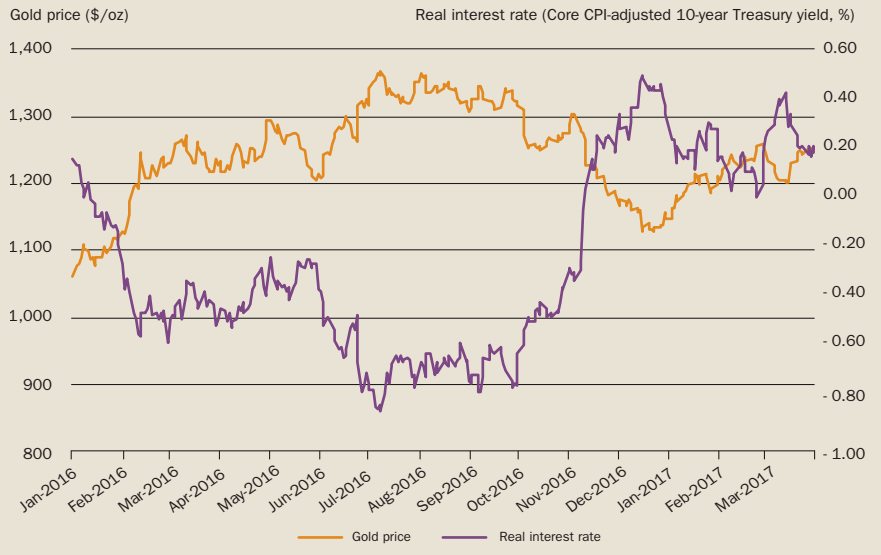
Trade Policy

Broadly speaking, a decline in global trade implies a slowdown in economic activity and a move by investors to the relative safety of gold. However, there are no modern parallels for the world's leading economy to step away from globalisation in the way that Mr Trump promised on the campaign trail, or any firm clues as to what the response of other trading nations would be. What does seem clear is that gold will remain well bid as a safe-haven for the extreme though still unlikely event that trade disputes will have a material impact on global economic growth.

> *"The most likely outcome is still that the dollar appreciates on trade protectionism and domestic US growth, but this will not necessarily be negative for bullion if a climate of uncertainty prevails."*

The Trump administration's approach to global trade also faces a conundrum in the form of the US dollar. Protectionist trade policies combined with domestic economic stimulus would ordinarily result in a high valuation of the greenback against other major currencies. This in turn would make imports into the US cheaper and increase inwards trade, while making conditions less competitive for US exporters. The voicing of support for a strong dollar by some in the administration is therefore inconsistent with the forms of protectionism currently under discussion. Any deliberate weakening of the dollar would of course threaten the sort of beggar-thy-neighbour competitive devaluations in other currencies which would be sure to boost gold both relative to a weaker US dollar and as an alternative currency in its own right. The most likely outcome is still that the dollar appreciates on trade protectionism and domestic US growth, but this will not necessarily be negative for bullion if a climate of uncertainty prevails.

Chart 2: Real interest rates and gold



The Fed – will uncertainty stay policymakers' hands?

Having raised interest rates in March 2017 for only the third time since the global financial crisis that started a decade ago, the US Federal Reserve now intends to carry out two or three further rate hikes during 2017 – each of which is likely to increase the real rate environment and could see bullion come under some short-term selling pressure. However, the pace of Fed tightening will still be the most gradual of any US rate hike cycle in history, and the risks to the Fed's outlook are still to the downside due to the uncertain US recovery and elevated debt levels. The Fed has also recently signalled that it will begin to offload some of the $4.5 trillion of government debt and mortgage-backed bonds it accumulated on its balance sheet during successive rounds of quantitative easing. While this is likely to be done in a gradual way as the Fed simply stops reinvesting the proceeds from maturing bonds, it could go a step further by selling government assets to the market. This could depress bond prices and raise yields on Treasury debt – making real interest rates less favourable to gold. However, pursuing a path of reducing its balance sheet at the same time as raising interest rates could force market dislocations that choke off economic growth and support gold.

Conclusion

After the dollar and stock market euphoria of late 2016 and early 2017, there are already signs that the Trump reflation trade may be more an expression of hopeful sentiment rather than a new paradigm of actual higher economic growth and inflation. Treasury yields, the dollar, equity valuations and inflation expectations are all reversing their previous gains, to the benefit of gold. Though it remains too early to say with any certainty, bullion may even end up benefitting further from the Trump administration's changes to the regulatory environment and the promotion of US manufacturing. As Trumponomics, in whatever form it ultimately takes, brings a new set of political, economic and trade uncertainties over the coming four years, gold should have plenty of opportunities to shine as a safe-haven asset and portfolio diversifier.

Dr Jonathan Butler is Precious Metals Strategist at Mitsubishi Corporation in London where he is responsible for business development as well as Mitsubishi's global research on the gold, silver and PGM markets. Jonathan previously worked as Publications Manager at Johnson Matthey, where he led the publications team and was responsible for producing the company's semi-annual benchmark 'Platinum' reviews. Jonathan gained his doctorate in geosciences from the University of Edinburgh and also holds MSc and MA degrees from the University of Oxford.

Ex-Morgan Stanley European Commodities Head Launches Charity in Memory of his Son

By Amrik Sandhu

"Looping the loop", Amrik on the right, with his son, Ajvir on the left.

Amrik Sandhu, with his wife and daughter, is launching a charity in memory of their son and brother, Ajvir, who passed away in an air accident in April last year. Training to be an RAF fast jet pilot, Ajvir was a phenomenally talented individual and a natural leader and mentor to his peers. The Ajvir Singh Sandhu Leadership Foundation has therefore been established in his memory to support the talented young people of today to become the leaders of tomorrow, allowing them to spread their wings and fly as high as Ajvir.

The Foundation will work with young people between 11 and 25 years of age who display impressive skills and the qualities of a future successful leader from a range of disciplines. The purpose of the Foundation is to ensure that raw talent in young people is able to reach its full potential. The ASSLF will grow to have three branches of support: offering financial aid, building a wide and experienced support network of individuals who are willing to act as mentors for young people and, in the long run, building programmes into the Foundation which focus particularly on segmented leadership development and establishing supporting accolades.

The Ajvir Singh Sandhu Leadership Foundation has worked on its first collaboration, prior to the launch, with the Northumbria University Air Squadron (NUAS), which Ajvir was a member of during his time at Durham University. The *Ajvir Singh Sandhu Leadership Foundation Trophy* went to the cadet whose demeanour, in the opinion of the Northumbrian Universities Air Squadron staff, "inspired, encouraged and supported the development of others". The Foundation will work closely with NUAS over the coming months and hopefully years, tracking the progression of award winners to determine whether there is scope to facilitate their progression further, beyond this initial recognition.

The Ajvir Singh Sandhu Leadership Foundation launched its initiative on 22 April 2017, at the Royal Airforce Museum. The Foundation desires to hold a strong connection to the military; however, in the years and months to come, the Foundation hopes to expand its influence through multiple disciplines and recognise talent in young people across the board.

Further information can be found on www.ajvirlf.com.

Press release contact: sabinder@ajvirlf.com

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Variances in Metal Accounting

By Peter Gaylard, Independent Consultant

This is an abridged version of the presentation delivered at the LBMA's Assaying and Refining Conference on 20 March, 2017.

Introduction

Development of the AMIRA Code of Practice for Metal Accounting was sponsored by a number of the world's largest mining companies, including Rio Tinto, BHP Billiton and Anglo American. It was released in 2007 and is now used in many operations around the world. That same project by AMIRA also generated a textbook called *An Introduction to Metal Balancing and Reconciliation* published by the University of Queensland, Australia, in 2008. I need to acknowledge the work of my colleagues who worked on the Code with me: Neville Randolph, who handled the sampling and analysis; Mike Wortley, who did the mass measurement; and Dr Rob Morrison of the University of Queensland, who edited the textbook.

Since the release of that Code, the team who developed it have been asked to conduct a variety of metal accounting audits based on the Code at various operations, mainly in Southern Africa but elsewhere in the world as well. We have also given a number of training workshops, initially at sponsors' operations, but more recently at various training venues, including several in-house courses, for example, at the Rand Refinery.

> *"The effects of sampling and mass measurement errors tend to be overlooked. We have also found that mass measurement is totally overlooked."*

In the work we have done in compiling the Code, in talking to people and auditing their operations, and in running workshops, we have found that the concepts of variances and accuracy and precision are still a very woolly or grey area in many people's minds in a lot of metallurgical operations.

Every figure used for metal accounting – whether it is a measurement of feed or product, which could be concentrate, matte, final metal or discard – is based on the measurement of the mass of the material concerned and the analysis of a sample of the material. That sample is obtained by sampling the bulk material. The primary sample may require splitting to give a secondary or laboratory sample. The laboratory sample will require preparation and splitting to give an analytical sample, and that preparation could involve a variety of steps, such as moisture determination, crushing or lump breaking, blending and so on. At each of these process steps, there is the possibility of error through contamination, loss of sample, sample segregation and so forth.

Generally, we have found in the operations we have audited that there seems to be, as far as metal accounting is concerned, a very strong focus on the performance of the analytical laboratories involved. The effects of sampling and mass measurement errors tend to be overlooked.

Reconciliation of Metal Accounting Figures

Reconciliation of metal accounting figures is required whenever a commercial exchange of metal-bearing material – ore, concentrate, matte or final metal – occurs, resulting in a custody transfer. The receiver has to be satisfied that he is not paying too much for the metal content, while the sender or seller has to be satisfied that he is not being underpaid. Hence, there is a risk associated with each such transaction. Reconciliation is achieved when each party agrees that the metal accounting figures recorded separately by them are both accurate and within acceptable limits of precision. This requires that the parties understand the possible sources of error in the figures being reconciled as well as their prior agreement on what those acceptable limits of precision are.

Definitions

Below are some definitions that we have found are not well understood by many people in the mining industry.

a. Accuracy

A measurement is accurate if it, or the average of a number of measurements, is close to the true value. In metallurgical operations, this true value is unknown.

b. Precision
The precision of a measurement depends on the closeness of the outcomes of a repeated measurement or test procedure. Hence, it depends only on the distribution of random errors and not on any relationship to a true value. This precision is usually expressed as a standard deviation of an estimated quantity or, alternatively, as the relative standard deviation, which is the standard deviation expressed as a percentage of the mean of the measurements of that value.

Further definitions of mean, variance and standard deviation are shown in figure 1.

Mean (of data) – The mean of a set of n items of data is the arithmetic average of the series of measurements X_i. The mean is usually designated by x with a bar above it.

$$\bar{x} = \sum_{i=1}^{n} x_i / n \qquad = (x_1 + x_2 + x_3 \cdots x_n)/n$$

Variance: the sum of the squares of the differences between each measured value and the mean of the measured values, divided by one less than the number of measurements in the data set

$$s^2 = \left[(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 \cdots (x_n - \bar{x})^2\right]/(n-1) \qquad = \frac{1}{(n-1)} \sum_{i=1}^{n} (x_i - \bar{x})^2$$

The **"standard deviation"** s or sd is then defined as the square root of the **Variance.**

Figure 1

Variances
In metal accounting, variances occur where any measurement of material is carried out or where that material is divided or sampled. Variance for mass measurement is called V_M. Moisture determination is V_{H2O}. Sampling is V_S. Sample preparation is V_{SP}. Analysis is V_A.

Of course, the sampling variance incorporates a range of different fundamental errors or sources of error in the sampling process. These variances are additive so the total metal accounting variance is:

$V_{MA} = V_M + V_{H2O} + V_S + V_{SP} + V_A$
For reference purposes, we call this Equation A.

To illustrate how this can be applied, I have used a PGM toll smelting example which I originally included in a paper presented at a Southern African Institute of Mining and Metallurgy conference, Platinum 2012. It relates to a small platinum producer producing about 120,000 oz of platinum per year from Merensky Reef. Typically, such a producer would ship 80 to 90 tonnes per day of concentrate in three 30-tonne truck loads to a smelter to be smelted. Each truck is weighed and sampled by both the shipper and receiver, and each day's receipts constitute an accounting batch.

In standard commercial toll treatment terms, the settlement is based on the receiver's mass and moisture measurements and sample. The sample is split and the same sample is analysed by both the receiver and shipper. The analytical results are exchanged on a pre-arranged date. If the results do not agree within specified limits, settlement is delayed until final metal values are agreed by negotiation or by umpire analysis.
The shipper is entitled to be present at the weighing and sampling of concentrate at the receiver's plant. The shipper obviously should also have similar sampling and mass measurement facilities to identify possible biases or errors.

Chart 1: Effect of splitting limits on daily shipments

Metal	Daily Shipment oz or t	Metal Prices $ per oz	Value Shipped $	Splitting Limits %	Risk to Each Party $
CONC., t	90				
Pt	367	1,000	367,000	6	11,010
Pd	163	760	123,880	6	3,716
Au	23	1,230	28,290	12	1,697
Rh	25	920	23,000	7	805
Ru	39	110	4,290	10	215
Ir	3	1,100	3,300	12	198
TOTAL	620		549,760		17,641

Effect of Splitting Limits on Daily Shipments
The effect of the base metals is excluded from the table in chart 1 above, but it shows a typical daily shipment. There are 90 tonnes of concentrate and a total of 620 oz of contained PGM, with platinum (367 oz) and palladium (163 oz) being the major ones. The metal prices are probably not totally current but they are not very far from being correct. The daily value shipped comes to a total of $550,000.

The analytical splitting limits on each of those elements are as shown in that column: platinum, 6%; palladium, 6%; gold, 12%; rhodium, 7%; ruthenium, 10%; and iridium, 12%. The total risk is then split between the parties, so the risk to each party is $17,641, but the total combined risk is just over $35,000.

The splitting limits are defined in the toll treatment commercial terms and define the acceptable limit of analytical difference between the receiver's and the shipper's laboratory for each valuable metal. The figures shown are not atypical of actual industrial performance at the time that the paper was presented in 2012 and reflect the accepted level of error in the concentrate analyses for each reported metal. On a daily shipment, with a value of $550,000, there is a total potential error of about $35,282 or 6.4%. With these toll treatment contracts, the focus was on the analytical splitting limits and that was how the settlement was arrived at. The other risks tended to be ignored. In this particular case, both reporting laboratories analysed the same sample and the receiver's mass was used, as mentioned earlier. The precision levels shown here are, therefore, only those related to each laboratory, which incorporates splitting the laboratory sample to give the analytical aliquot and analysis of the sample itself. The precision levels related to mass measurement and sampling are not taken into account in assessing the risk to each of the parties.

The paper presented in 2012 was looking at the importance of sound metal accounting to achieve a good toll smelting contract. The effect of mass and sampling variances, and whether they are significant, was not considered.

Typical Precision Levels
From extensive experience in the industry, typical precision levels for the different components of the determination of the metal content of each shipment are as follows (see chart 2 below):
- Mass is ±0.5% – the trucks are always weighed on a road weighbridge and, if the weighbridge is well set up, it should have a precision of ±0.5%.
- Moisture determination precision is ±1%.
- Sampling and sample preparation combined is ±5%.

Chart 2: Calculation of Variance

Source of Error	Typical Precision	Error Ounces		Variance	
Mass	± 0,5%	3,10		V_M	9.61
Moisture	± 1%	6,20		V_{H2O}	38.44
Sampling	± 5%	31,00		V_S	961.00
Analysis	± 6,4%	39,68		V_A	1574.00
TOTAL	±8,2%	$\sqrt{V_{MA}}$	50,82	V_{MA}	2583.05

The analysis, as shown, is ±6.4%.
If you take those typical precision levels for mass and moisture measurement and sampling, and you apply these to the total of 620 oz of PGM in the shipment, as shown in the table in chart 2 above, you have:
- The source of error – mass, moisture, sampling and analysis.
- The typical precision levels for each of these.
- These precision levels are converted into ounces to give the error in ounces for each of the sources.
- The variance is then that error squared, giving the figures shown in the last column, so the total metal accounting variance is 2583.05.
- The standard deviation of the total is the square root of 2,583.05, which is 50.82
- This gives an overall precision of ±8.2%.

Chart 3: Determination of individual Metal Variances

Metal		Pt		Pd		Au		Rh		Ru		Ir	
Daily oz		367		163		23		25		39		3	
Source	Error %	Error Oz	Variance	Error Oz	Variance	Error Oz	Variance	Error Oz	Variance	Error Oz	Variance	Error Oz	Variance
Mass	0.5	1.835	3.367	0.815	0.664	0.115	0.0130	0.125	0.016	0.195	0.038	0.015	0.000225
Moisture	1	3.67	13.469	1.63	2.660	0.23	0.0529	0.25	0.063	0.39	0.152	0.030	0.0009
Sampling	5	18.35	336.722	8.15	66.423	1.15	1.3230	1.25	1.562	1.95	3.802	0.15	0.022500
Analysis	6			6		12		7		10		12	
Analysis		22.02	484.880	9.78	95.648	2.76	7.6180	1.75	3.060	3.9	15.210	0.36	0.130000
Total Variance, s^2			838.438		165.395		9.0069		4.701		19.202		0.152725
SD			28.955		12.787		3.001		2.168		4.382		0.391
Rel SD, %			7.9		7.8		13.04		8.7		11.2		13
													Total
Risk, $			28933		9663		3691		2001		480		429	45197
Analytical Risk, $			22020		7432		3394		1610		430		396	35282
Effect of Additional Variances, $			6913		2231		297		391		50		33	9915
Effect of Additional Variances, %			31.4		30.0		8.8		24.3		11.6		8.3	28.1

Thus, the overall error in each shipment is ±8.2%. The total value of this error is $45,000 and the risk to each party is now $22,500 and not the $17,600 as indicated from the analytical splitting limits.

Discussion

From this analysis, one might conclude that, since the overall risk has risen from 6.4% to 8.2%, there is no need to pay much attention to the mass measurement and sampling errors until the analytical errors can be reduced.

Equation A can be rewritten as: $V_{MA} = V_{M/H2O} + V_{S/SP} + V_A$.

We refer to these as the tripod of measurements, and all of them should have similar values. If one is out of line, the tripod tilts. In this case, in fact, the VM/H2O is significantly less than the VA and the VS/SP is also less than the VA, so attention should be focused on improving the analytical precision.

However, at the same time, the total risk has risen from $35,000 to $45,000 on a shipment – an increase of 28%, which is not insignificant. This whole approach was simplified for illustrative purposes, but a more rigorous approach would be to carry out the same exercise for each metal.

Full Variance Analysis

In the table in chart 3 above, the individual analytical splitting limits have been applied to each metal, using the same procedure and methodology to give a standard deviation and a new precision for each metal. Platinum has moved from 6% to 7.9%; palladium from 6% to 7.8%; gold has hardly moved from 12% to 13.04%; rhodium has moved from 7% to 8.7%; ruthenium from 10% to 11.2%; and iridium has gone from 12% to 13%. The analytical splitting limits for gold, ruthenium and iridium are relatively high, and the effect of the additional sampling and mass measurement variances is less marked. Using this approach, the risk changes slightly to give a total of $45,197, which is not very different from the figure obtained through the simplistic approach. The analytical risk was $35,282, so the change is $9,915, which is 28.1%.

The interesting figures to look at are the effect of the additional variances on the platinum, palladium and rhodium risks. Platinum has increased by 31.4%; palladium by 30%; and rhodium by 24.3%.

> *"Total risk could therefore be significantly reduced through improvement in the sampling precision in particular and in the analytical precision."*

Conclusions

The increase in the total overall risk determined by the full analysis is only $117. The simplistic approach was not wrong in itself, but the more detailed analysis highlights the effect of including the mass measurement and sampling variances on the major sources of financial risk, namely platinum, palladium and rhodium. These three metals effectively account for the overall 28% increase in the total risk. Total risk could therefore be significantly reduced through improvement in the sampling precision in particular and in the analytical precision.

In metal accounting, there tends to be a strong focus on the performance of the analytical laboratories involved, as there was in this type of toll smelting contract. The effects of sampling and mass measurement errors tend to be overlooked. Determining the variance of each source of error enables those that are excessive to be identified and, where appropriate and costs permit, enables corrective action to be taken.

Peter Gaylard, Independent Consultant. Peter worked in the Platinum Industry for approximately 30 years, where he was involved in all areas of the metallurgical extraction and refining processes, including being General Manager of Impala Platinum's Refineries and Senior Manager in charge of all of Impala's metallurgical operations, and subsequently as Senior Consulting Metallurgist to Impala. Prior to retiring, he joined the Department of Chemical Engineering at the University of Cape Town, where he worked for ten years and held the post of Adjunct Professor. While at UCT, he served as a consultant to various mining companies, mainly in the Platinum Industry, and also as Research Coordinator and, later as Research Director for AMIRA International. He was the convenor of the team that compiled the AMIRA Code of Practice for Metal Accounting. He retired to Plettenberg Bay in 2007 but continues to serve as a metallurgical consultant.

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Review of the LBMA Assaying and Refining Conference

By Aelred Connelly, LBMA PR Officer

Introduction
The LBMA Assaying and Refining Conference was held at the Royal Garden Hotel in Kensington from 19 to 22 March 2017. This was the seventh event in the series, which has been held in London every two years since 2005.

Organising Committee
The LBMA is very pleased to acknowledge the work of the Working Party, which in addition to both Neil Harby, LBMA Chief Technical Officer, and Varsha Peiris, LBMA Good Delivery List Officer, comprises representatives of the referees group:
Argor Heraeus – Alessandro Ruffoni
Metalor – Jonathan Jodry
PAMP –Daniela Manara
Rand Refinery – Madeleine Theron
Tanaka – Hitoshi Kosai.

The LBMA would also like to extend its thanks to Mike Hinds of the Royal Canadian Mint, who also chairs the Reference Materials Steering Committee, as well as Stewart Murray, LBMA Good Delivery Consultant.

Attendance
The number of registered delegates in 2017, at 206, represented a new record attendance. This is more than double the attendance of the early events in the series. Although the delegate list continues to be dominated by representatives of Good Delivery refiners, the LBMA has opened up participation in recent years and it was notable that a much wider range of organisations was represented at this year's event. As well as refiners seeking accreditation and representatives of equipment manufacturers, it was gratifying to see a greater number of banks in attendance, not only central banks but also commercial banks. The LBMA is very keen that closer ties are established between banks and producers so that they have a better understanding of the key issues which are impacting on their business models.

Programme and Presentations
The Conference proceedings began on the Sunday afternoon with a Welcome Reception which provided an excellent opportunity for delegates to network in an informal, relaxed environment. The formal Conference sessions commenced, as in all previous events, with a welcome from the Chief Executive and an update on LBMA technical activities, as well as an excellent keynote speech from Professor Kim Esbensen. An abridged version of his speech is on page 3. The rest of the day was devoted to a range of assaying and analytical techniques, and for the first time, asset management. On the second day, the morning sessions featured a second keynote speaker, Susan La Niece from the British Museum, who delivered a presentation on 'Gold in the Ancient World', as well as sessions focused on reference materials, refining and assaying. The afternoon sessions focused on standards, along with a general session which included presentations on the 'Role of the Referees'. The Conference was rounded off in fine style by Neil Harby, who summarised the key takeaways from the conference proceedings.

All the PowerPoint presentations presented at the Conference are available for download from the LBMA website: www.lbma.org.uk.

Optional Events
On the morning of Wednesday, 22 March, three optional extras were offered. These included visits to the laboratories of the Inspectorate International in Witham and the London Assay Office, as well a Workshop on Sampling, chaired by Kim Esbensen. The LBMA is most grateful to them for extending their hospitality to our delegates and, in the case of Kim Esbensen, for the huge amount of preparation that went into his workshop. It was most gratifying that the workshop and the visits to the Assay Office and Witham were so well attended and well received.

Networking
From the first event back in 2005, it has always been clear that participants find the networking opportunities at the LBMA Conferences to be particularly valuable. There is simply no other event that offers the chance for precious metals assayers and analysts to meet their peers from other companies and countries. The lunch and coffee breaks during the Conference, as well as the main dinner and optional tours on the Wednesday, all combined to provide excellent opportunities for delegates to network and share business cards and ideas. Taking into account the feedback from the last Conference, this year, drinks were organised at The Builder's Arms, a local hostelry, just a short walk from the Conference, which provided the perfect way for delegates and the Conference organisers to wind down after a hectic few days.

Sponsors and Exhibitors
The LBMA would also like to offer a word of thanks to the sponsors and exhibitors. The Conference dinner took place at the highly regarded restaurant, Quaglino's, in the heart of Mayfair. The food was particularly excellent as were the magicians who enthralled delegates with their amazing tricks. Special thanks should be extended to the LBMA's five referees who jointly sponsored the dinner. The exhibitors' stands from the following companies were located in the area used for the coffee breaks, and the LBMA would like to thank them for their support.
- Ametek – Spectro Analytical Instruments UK Ltd
- Fischer Instrumentation (GB) Ltd
- H.W. Pickardt ek
- IKOI
- Onsa Muchvherat

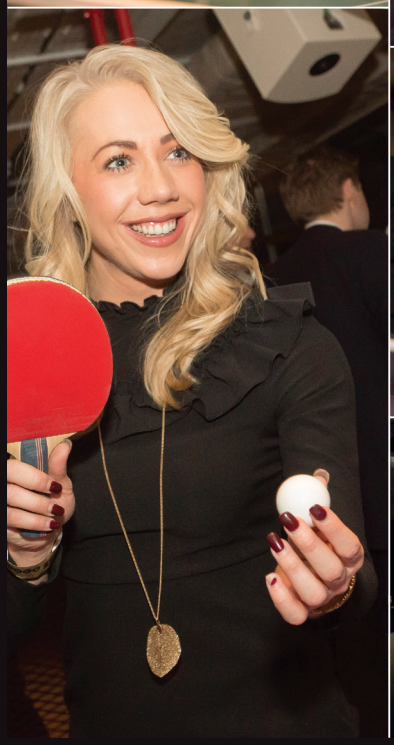
Feedback
As usual after an LBMA event, delegates were invited, via the Survey Monkey online questionnaire, to provide feedback on the Conference, including the structure of the programme, the quality of speakers, the venue and the networking opportunities. At the time of writing, we had received 58 replies (a significant improvement on the 38 replies for the last event) and the various detailed comments and suggestions will be reviewed by the Conference Committee (anonymously of course).

The feedback received so far can be summarised as follows:
- Nearly 60% of delegates rated the conference 'excellent' overall: the remainder considered it to have been 'good'.
- 79% and 77% of delegates thought that the sessions on Sampling Theory and Standards were either extremely or very important.
- 85% thought that the Informal Networking Reception was useful and 42% and 33% respectively thought that the networking opportunities could be improved by a later start in the morning and extending the conference to three days.
- Looking ahead to the next conference, more than a third of responses (38%) favoured a London location, whilst 21% preferred Edinburgh and 19% Berlin.

Next Event
The next Assaying and Refining Conference will take place in March 2019. In her closing remarks, the LBMA Chief Executive, Ruth Crowell, noted that UK locations other than London could be considered as long as they have good flight connections and facilities. The Conference Committee will shortly be meeting to discuss many aspects of the next conference. Suggestions from Alchemist readers are always welcome and should be addressed to: ruth.crowell@lbma.org.uk.

LBMA Annual Party 2017

The LBMA's Annual Party was held this year at Bounce, in Old Street, London on Thursday 2 March.



More than 250 people attended the event, with most people choosing to participate in the main theme of the evening – table tennis. Guests had the opportunity to play table tennis informally, and for those of a more competitive nature, the opportunity to enter the doubles contest. The finger food was excellent quality as was the wine and the company. All in all, it proved a great evening.

The evening began with drinks, canapés and finger food, before most of the guests took to the tables to play table tennis. The table tennis venue proved an excellent location for the party. The venue provided a team of helpers who arranged guests into pairs for the table tennis competition. Congratulations to the eventual competition winners, Oliver Heathman from Metals Focus and Michael Eubel from Landesbank, who both claimed a gold (actually plastic) trophy (see photo).

All of the photos from the event can be viewed on the Members only section of the LBMA website. We look forward to seeing as many of you as possible at the next party in 2018. And let us know if you have any interesting ideas for the theme of the party.

The Art (Science) of Bar Casting

By Ilonka Macdougall, Senior Manager - Fabrication, Quality Control, Finished Goods and Despatch, Rand Refinery Pty Ltd

This is an abridged version of the paper which was delivered at the recent LBMA A&R Conference. The purpose of this paper is to share the learnings from test work conducted at Rand Refinery to find a solution for button formation and 'plug-like' defects produced on London Good Delivery (LGD) bars. The aim of the test work was to ensure that production quality complied with the LBMA visual guidelines released in 2015. Button formation and 'plug-like' defects were a historical problem at Rand Refinery and the solution identified resulted in a 97-year practice being stopped – namely hand pouring a LGD bar.

History of Good Delivery Bars at Rand Refinery

Rand Refinery was established in 1920 in Germiston, South Africa, by the Chamber of Mines of South Africa to refine all the gold produced by South Africa's gold mines. On 27 November 1920, Rand Refinery Ltd was registered as a private company and the building of the facilities commenced in August 1920.

The first LGD bars were produced in 1921 and, in the period since then, 51,000 tons of mined gold have been refined at Rand Refinery. The bulk of the products produced were in the form of LGD bars. Krugerrand production started in 1969, small cast bar production in 1995 and minted bar production in 2013. The current mined throughput is around 300 tons per annum and this is a decrease from approximately 1,000 tons per annum produced in the 1990s.

Based on annual outputs, Rand Refinery has produced approximately 3 million LGD bars through a manual pouring process which remained unchanged until December 2016. On average, 200 bars were poured a day using the manual pouring process.

Refinery and Fabrication Value Chain

The flow chart in figure 1 shows a high-level overview of the process flow of material received into Rand Refinery from various mines around Africa and the rest of the world. Feedstock can be received in the form of mine doré, mine concentrates, recycled material and smelter doré. Material evaluation is conducted in the melt house and, on finalisation of the mass and assay, the material is transferred to the Fine Gold department in the Refinery. All material is refined using the Miller Process. The charge make-up used in LGD bar production is important as South African Mines send through deposits which can contain iridium, palladium and other platinum group metals. Some of these metals are hard to detect and affect the surface finish of the bar. Material which contains iridium is not used for the direct production of LGD bars. This material is treated and poured into anodes which are then processed further in the Electrogold facility. Material is received from Electrogold in the form of 9999 granules and this is subsequently silvered down for the production of LGD bars to not less than 99.505% gold content.

Figure 2 illustrates a simple process flow for producing a LGD bar using the manual pouring process:

Mould preparation includes curing the mould, smoking the mould using a diesel flame, heating the mould to the required temperature on the gas flame table and finally placing the mould on the scale ready to receive the molten metal.

Material is received from the Fine Gold (a direct molten transfer) or the Grain Casting department (granules). The molten metal is sampled to confirm that the assay meets LBMA requirements. If the assay is greater than 99.99%, the molten charge will be silvered down. A 1 ton induction furnace is used and the molten charge mass is approximately 750 kg.

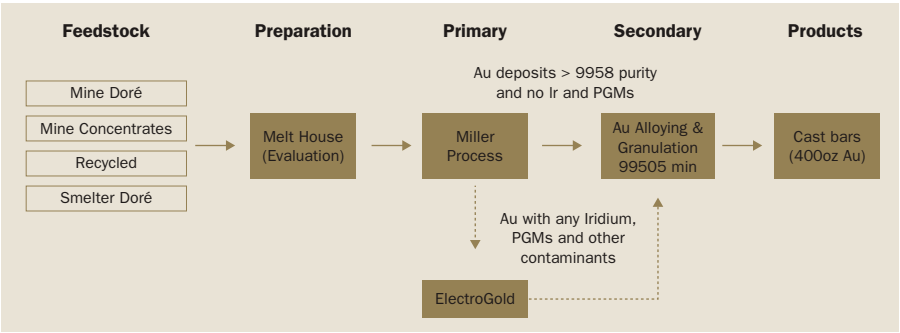


Figure 1

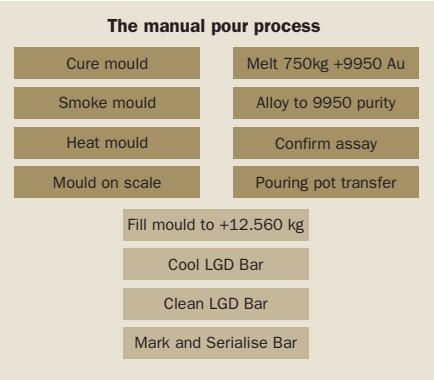


Figure 2

Molten metal is poured into a pouring pot and before being manually poured into a mould placed on a scale. Four bars are produced at a time, with a sample disc being taken after every 12 bars to verify the assay.

As soon as the molten is poured into the mould, a gas flame is used to control the cooling process until the metal has solidified. The mould is tipped into a quench tank to be cooled down, before it is serialised, cleaned, stamped with the assay and logo, weighed and then finally checked by two quality control technicians. Good bars are then transferred to the Final Storage and Despatch Department for final mass verification and preparation for shipping to the customer.

The bar casting team comprises five operators. The pouring team always work in pairs, with one person pouring and the second operator ensuring an even flow of molten metal into the mould. The other three operators are responsible for taking the moulds to the quench tank and managing the mould process.

Since this is a manual process, the ergonomics of the work space is a challenge, with the average combined mass of the mould and molten metal being approximately 25 kg.

Reasons for Investigation

In February 2016, a number of LGD bars were returned to Rand Refinery after being found to be 'non-good' delivery bars by a vault in London. The reasons for the rejections were cited as non-compliance with the visual guidelines, with the bars having buttons and plug-like defects. The visual guidelines were introduced by the LBMA in late 2015. It must be noted that buttons and plug-like defects were a historical defect at Rand Refinery, with at least 50% of all LGD bars produced showing this defect. Internally, there was also a problem with layering and this was a further challenge for which a solution was already being sought.

At the time, the order book for Rand Refinery was predominantly made up of LGD bars and the change in the visual guidelines therefore had a major negative impact on the business model. These included reputational damage, gold lock-up, increased costs due to rework, impact on the pouring team due to the high rework rate as well as the risk of missing customer orders. At least 5 tons of material needed to be converted weekly and, with a reject rate of greater than 60% due to zero tolerance of these defects, a solution had to be found as a matter of priority.

Looking after the health and safety of the team was also a challenge as the high reject rate demanded a high rework rate. Despite these challenges the bar casting team and associated support teams had the commitment and tenacity to overcome the challenges posed by the hard physical work involved and managed to meet the weekly order requirements.

The photograph in figure 3 shows an example of one of the returned bars with button and plug like defects.

Figure 3

The challenge for the business was to find a way to produce a bar with zero defects. A cross-functional team of 18 employees was established, with representation from the Quality Control, Technical Assurance, Laboratory, Asset Care and the bar casting team.

Rand Refinery was also fortunate in being able to liaise with peers around the world to learn from their experience and helps identify alternative solutions and best practice. The Royal Canadian Mint shared technical data on the mould dressing used, the Perth Mint on pouring practices and mould design, and Metalor on mould surfaces and design. The business made a decision that the acceptable reject rate would need to be < 5%. A plan had to be formulated in which each parameter was identified and then checked to ascertain whether or not there was a causal relationship with respect to button formation or the formation of plug-like defects.

Bar Casting Process

Figure 4 shows a more detailed map of the bar casting process. Each mould is smoked using diesel fumes for at least 36 seconds. A gas heating table is available for maintaining the temperature of the moulds should there be a breakdown or emergency. Forty-eight moulds make up a mould set. Four scales are used during the pouring process. This was the best fit for the pouring team and the way the line was set up. As soon as the last mould has been poured and the first mould molten has cooled down sufficiently to be transferred to the quench tank, a continuous process flow is established.

On pouring the molten metal into each mould, a flame is immediately put on the mould to slow down the cooling and improve the surface finish. Once the molten is solidified, the mould is transported to the quench tank using a specially designed trolley. This is to reduce some of the manual handling for the team. On emerging from the quench tank, the bar is numbered, cleaned, stamped with assay, date and logo, and the mass is verified using a double weighing system. Two Quality Control Technicians then inspect the bar on physical appearance, ensuring compliance to the LBMA visual guidelines

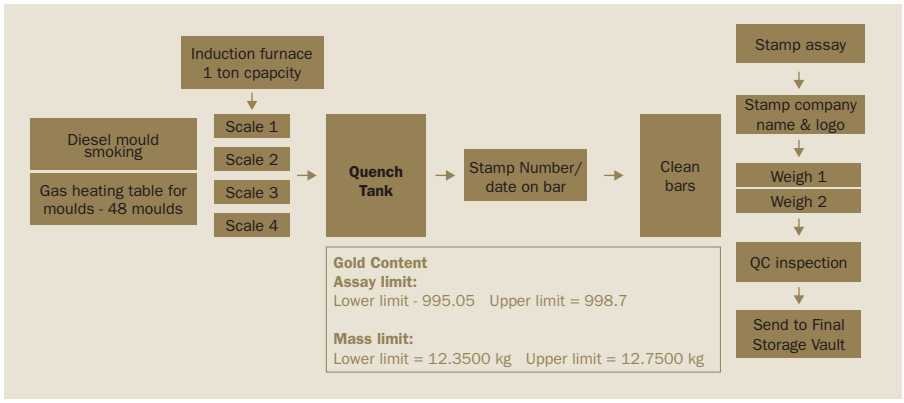


Figure 4

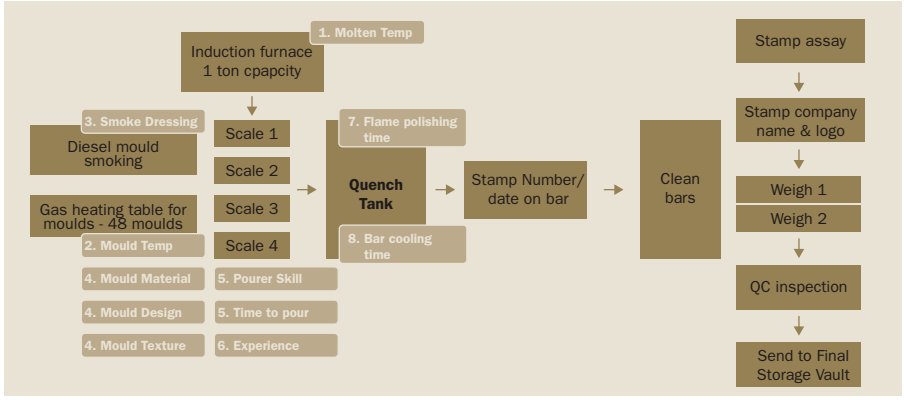


Figure 5

Process Parameters

The next step was to identify the process parameters which possibly had an effect on the formation of buttons and/or plug-like defects.

As illustrated in figure 5, the following process parameters were investigated:

- the molten metal temperature at pouring
- the mould temperature
- the mould material used and the surface texture and finish
- the hand pouring skills and experience of the operators
- time taken to pour a bar
- the experience of the operators
- the flame polishing time, and
- the time it took for the bar to cool.

It was ascertained in the early part of the investigations that the smoke dressing, flame polishing time and the bar cooling time did not have an impact on the formation of buttons or plug-like defects, and no further testing was conducted.

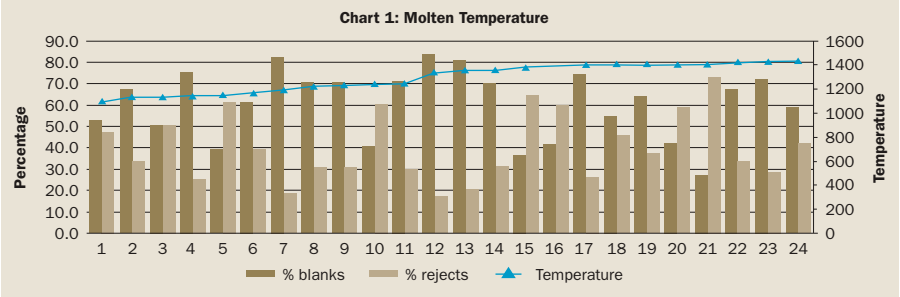
Impact of Molten Temperature

The next parameter that was investigated was the impact of the molten metal temperature just before pouring commenced relative to the percentage of bars rejected due to the formation of button and/or plug-like defects.

The molten metal temperature ranged from 1,100°C to 1,450°C. The blank bars referred to in chart 1, were bars produced with no buttons or 'plug-like' defects. As the molten metal temperature increased, it also became harder to manage from a health and safety perspective as the personal protective equipment (PPE) issued to the team had to meet higher specifications, which resulted in thicker material and additional risks with manual handling.

It can be seen from chart 1 that there is no real discernible correlation between the molten metal temperature on the production of a blank (good) bar versus the production of a bar with buttons and/or plug-like defects.

During this test work, it was observed that there seemed to be some kind of relationship between the temperature of the mould and the formation of buttons and/or plugs. This was mainly due to the fact that the moulds were heating up with each successive round poured and becoming harder and harder to cool down, and patterns were observed with button formations. It was decided to focus attention on the pouring technique of the operators. It was also observed that moulds with different surface finishes cooled down at different times.



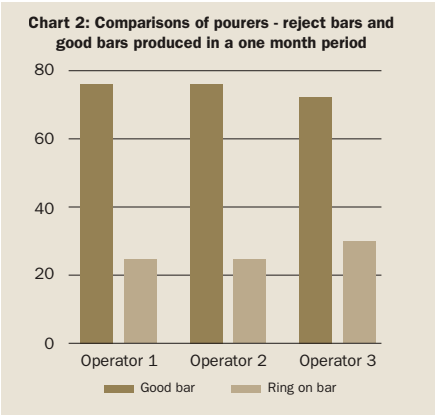
Experience of Pourers

In this exercise, data was collected over a one-month period to identify whether or not the pouring technique and experience of the pourers was a contributing factor to producing bars with buttons or plug-like defects. Three pourers with different levels of experience were monitored. The first pourer had more than ten years of experience, the second had more than three years whilst the third had less than one year.

The same mould set and consumables were used and different pouring techniques were also tried.

The percentage of good bars produced by all three operators, regardless of the pouring technique used, was between 60% and 63%. It was deemed reasonable to conclude that the experience of the pourers was not a contributing factor to the production of bars with buttons and plug-like defects.

Chart 2 illustrates the outcome of the tests.



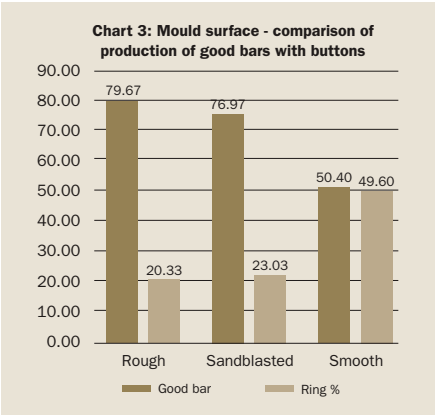
Mould Surface

In the first month of testing, it became clear that the mould surface finish was having a major impact on whether or not a bar was produced with buttons and plug-like defects. The moulds were of a mild steel composition and all moulds were purchased from the same local foundry. Historically, Rand Refinery purchased moulds with a smooth surface finish. However, due to the increase in demand, moulds with a rough surface finish had also been introduced into the mould set due to a delay on the order from the supplier. The bulk of the moulds received from the supplier for this batch were rejected due to the rough surface finish and only a handful were available on the floor for use. It was noted that all the bars produced with the rough surface finish mould had a 20% reject rate. The moulds with a smooth surface finish had an average of 50% bar production with buttons and/or plug-like defects.

Based on this data, an order was placed for a full set of moulds with a rough surface finish – the same finish as the moulds that had originally been rejected. Unfortunately, due to changes in the foundry's finishing process, moulds with the rough surface finish could no longer be replicated. The best that could be offered to the business were moulds with a sand-blasted finish – this was not as rough as what was requested, but it was approved and the order placed.

The smooth, rough and sand-blasted finish moulds were all subject to the same initial curing process using castor oil and gas flame before being introduced into the bar casting production process.

In chart 3 it can be seen that, on average, the sand-blasted finish moulds had a reject rate of 23% bar production with buttons or plug-like defects.



The next step was to identify, in more detail, what process parameters needed to be controlled to consistently produce bars at a reject rate of less than 25%, with the target being less than 10% per batch.

Temperature of the moulds during the pouring process

The graphs in chart 4 indicate test work conducted where the percentage of reject bars produced was recorded relative to the temperature of the mould at the time of pouring.

The moulds with the rough surface finish produced reject bars at less than 5% when the moulds were at room temperature. Since this mould finish could no longer be sourced, it was a moot point.

The moulds with the sand-blasted finish produced the highest rate of good bars in the range of 100°C to 200°C. The reject rate was highest between 50°C to 100°C.

The moulds with a smooth surface finish only started producing a lower reject rate at temperatures of above 300°C. Working with moulds and molten at such high temperatures had a number of challenges. These ranged from the increased risk to the bar casting team handling the moulds, pouring the molten and the PPE required to handle the very hot moulds. The thicker the PPE, the harder it became to physically handle the hot, heavy moulds – both empty and during the tipping process. It was also a challenge to heat the moulds to this temperature and heat the moulds evenly on the gas table.

A decision was made to swop out the smooth finish moulds with the sand-blasted finish moulds and find ways to control the mould temperatures in the ranges which produced the lowest number of bars with buttons and plug-like defects. The next parameter to be investigated was how the temperature of the moulds increased and could be controlled relative to the number of rounds poured in a shift.

An interesting pattern emerged in the investigation into the mould temperatures related to pouring. As identified in chart 5, rough finish moulds had a less than 5% reject rate at room temperature; however, the rough finish moulds were in the minority and a plan had to be formulated on how to manage the mould set where – for at least three to four months – the majority of the moulds would be moulds with a smooth finish. There was a three-to five-month lead time to get a full set of moulds with a sand-blasted finish from the foundry. The foundry agreed to sand-blast the

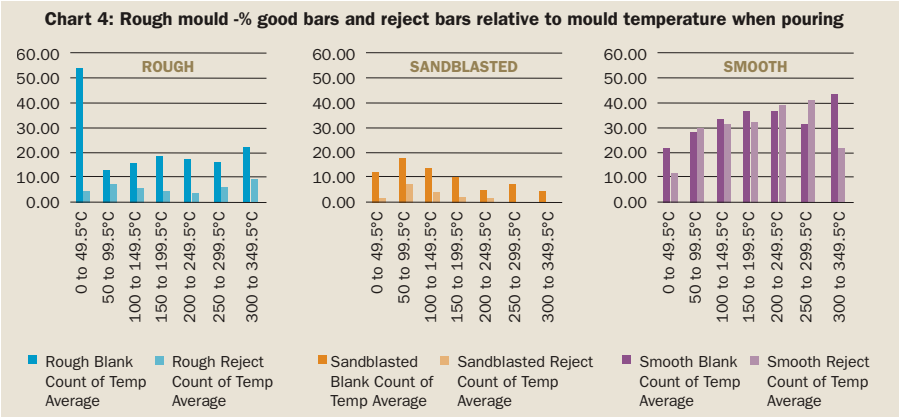
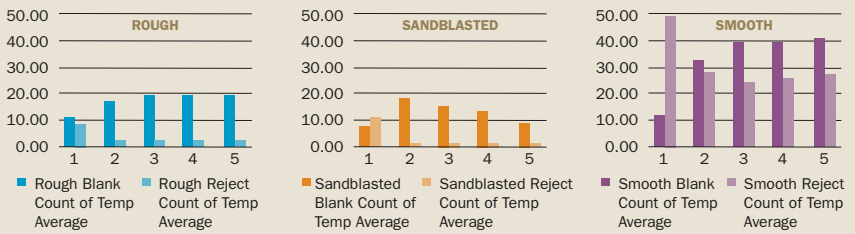


Chart 5: Reject rate of moulds vs rounds poured



smooth finish moulds that Rand Refinery had in stock and these were received over a period of three months.

In an attempt to get the lowest reject rate from the smooth finish moulds while waiting for the sand-blasted finish moulds to come on site, the mould set was heated up using the gas heating table. It can be seen that there was always a high reject rate in the first round. It was assumed that the mould heating table was heating the moulds unevenly. A decision was made whereby the first round poured would be used to heat the moulds up as this was the most efficient way to get the uniform heating required. The bars produced in the first round were always discarded and the bars produced from the second round onwards were counted and went through the normal process. It can be seen from the graphs in chart 5 that, with each successive round poured, the moulds became hotter and the reject rate stabilised. The number sand-blasted finish moulds tapered off on rounds four and five as the moulds would become too hot and were removed from the process. Rough finish moulds produced a consistently low reject rate with respect to button and plug formations regardless of the number of rounds poured in one shift.

Reject Rate Improvement

Based on the findings, it was obvious that the smooth finish moulds had to be removed from the process. Chart 6 indicates the change in the reject rates as the smooth finish moulds were removed from the process and the sand-blasted finish moulds were added in.

It should be noted that that a 'blank' bar is a bar free of buttons and/or plug-like defects and was considered to be a good bar.

The photographs in figure 6 show the change in the surface finish on the underside of the bars from the smooth finish moulds (upper photo) and the sand-blasted finish mould (lower photo). It can be seen that the reject rates were still too high and the business had to make a decision to find a new solution.

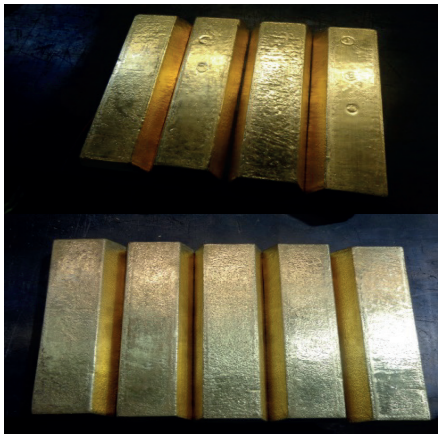
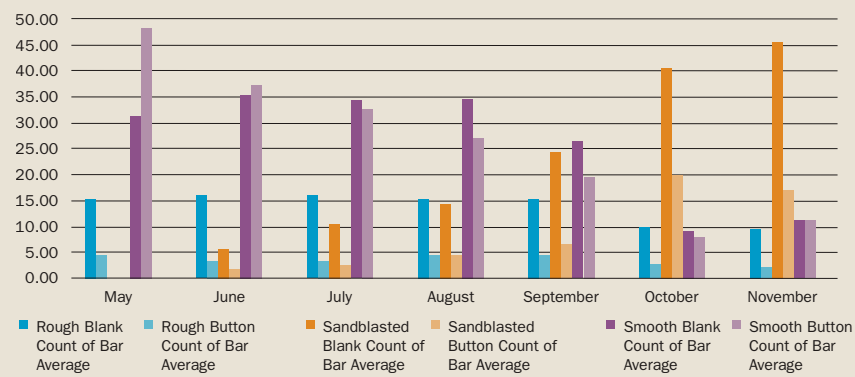


Figure 6

Continuous Induction Furnace (CIF)
A solution had to be found to make a low-cost, repeatable, zero-defect London Good Delivery bar using a continuous induction furnace. The brief was to find a solution to produce 100 LGD bars in six hours from granule feedstock. The target reject rate of blank bars after production was less than 5%. Preferably, the surface treatment of the bar produced must be minimised.

A decision was made to go back to the technology used in the continuous induction furnace for the production of kilo cast bars and to see if there was a possibility of developing an in-house solution using this technology. In 1999 to 2002, Rand Refinery and IECO developed a CIF to produce kilo cast bars. A decommissioned kilo bar CIF was rebuilt on-site between April and September 2016. Testing work commenced and, by December 2016, the modified CIF was ready to go into production. On 2 December 2016, Rand Refinery stopped a 97-year process of hand-pouring LGD bars and moved over to production of LGD bars in a CIF.

Chart 6: Reject rate of improvement with introduction of sandblasted mould finish



Operation
The cost to rebuild the furnace was less than €50,000, with cycle time of 170 seconds and an average reject rate of less than 3%.

The kW setting of the inverter is below 150 kW. The temperature of the mould after the furnace is at approximately 1,250°C when it passes from the furnace to the cooling zone.

Improvement on Surface Quality
The quality challenges no longer relate to button and plug-like defects. The new challenges primarily relate to the top surface blemishes which can be traced back to specific impurities in the feedstock used to produce the bars. An example would be iridium in the granules which affect the surface finish of the bar.

Conclusion

A solution to reduce the formation of buttons and plug-like defects at a cost-effective and in a timely fashion was not found. Since the LGD bar is produced at a zero profit to refineries, LGD bar production is avoided and production is completely dependent on market conditions. Investing €500,000 to find a technical solution was not feasible.

Rand Refinery is fortunate to have highly skilled and knowledgeable individuals. These individuals were able to find a solution involving a small investment which has changed the way this team operates, improving both the health and safety of the team and the quality of London Good Delivery bars produced.

Acknowledgements: Peter Bouwer, Chris Horsley and Willem Schoombee

Ilonka Macdougall joined Rand Refinery in late 2013. She is responsible for the production of cast bars, minted bars, coin blanks, product quality control, finished goods and despatch, mass metrology. She also manages the asset maintenance team dedicated to the fabrication Business Unit.

Prior to joining Rand Refinery she spent 20 years in the pharmaceutical industry. Her experience encompassed the areas of research and development, regulatory compliance, new business development, marketing, supply chain, project management and validation. She studied Analytical Chemistry at Technikon Witwatersrand (now the University of Johannesburg) and has a BCom degree in supply chain management and Total Quality Management from the University of South Africa.

LBMA Events in 2017 – Save The Date

Asia Pacific Precious Metals Conference 4 - 6 June, 2017 Grand Copthorne Waterfront Hotel, Singapore

The LBMA is sponsoring the Dinner on Monday 5 June as well as speaking at the Asia Pacific Precious Metals Conference (APPMC).

The APPMC is a key platform through which SBMA and International Enterprise (IE) Singapore will work towards developing and strengthening a unified body in Southeast Asia for the bullion market.

SBMA and IE Singapore would like to welcome the entire bullion fraternity to attend the inaugural APPMC here in Singapore and to share their views, inputs and suggestions to enhance the region's role in the global bullion market. See http://www.asiapacificpmc.com/ for further details and to register for the event.

LPPM/LBMA Cocktail Reception 14 September, 2017 New York

In association with the LPPM, the LBMA is co-hosting a cocktail reception for Members only during NY Platinum Week at the Lotte New York Palace hotel. If you would like to attend, please email: admin@lppm.com.

LBMA AGM 6 July, 2017 Glaziers Hall

The LBMA Annual General Meeting will take place from 16:30 at Glaziers Hall, 9 Montague Close, London Bridge, London SE1 9DD. This is a Member only event. Further details will be published on the LBMA website nearer to the event.

14th India International Gold Convention 11 - 13 August, 2017 Grand Hyatt, Goa, India

The LBMA will be speaking at the Convention. Organised by Foretell Business Solutions, the three day event provides an apt platform for the entire Indian bullion industry to deliberate on various challenges facing the industry, articulate the possible solutions and set an agenda for the development of the industry.

LBMA Executive Outreach

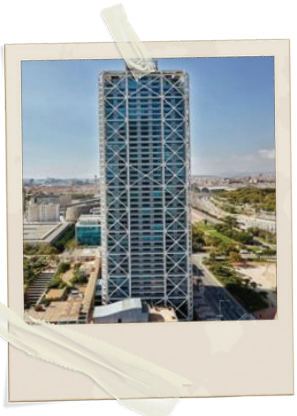
The LBMA executive will be attending or speaking at the following engagements:

10 - 13 June 2017:
IPMI 41st Annual Conference. See www.ipmi.org/ for further details regarding the Conference.

24 - 27 September 2017:
Denver Gold Forum. See www.denvergoldforum.org/dgf17/ for further details relating to the Forum.

LBMA/LPPM Precious Metals Conference 15 – 17 October, 2017 Hotel Arts, Barcelona

The LBMA/LPPM 2017 Precious Metals Conference will take place at the Hotel Arts in Barcelona. Open to Members and non-Members. Registration for the Conference will be opening soon, so keep an eye on the LBMA website for further details.



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‘Catch Them Young’ – The Career of Robert Stein

By Dr Michele Blagg, Research Consultant and Visiting Research Associate at the ICBH, King’s College London

At a time when the UK is undertaking divorce proceedings with the EU, we look back at the career of Robert Stein, who began his career in the early 1970s just as the UK was in the process of negotiating membership of the EEC.

Bullion trader Robert Stein unusually did not begin his career at one of the five traditional market fixing companies of the City of London. Instead, he entered the Chase Manhattan Bank in 1971 – a year that marked a new era for British economic, social, political and popular cultures. It was the year when Chancellor Anthony Barber, appointed by Edward Heath, oversaw a major liberalisation of the banking system. Showing the eagerness of the Conservative party to join the EEC, Barber gave the economy ‘a nudge in the right direction’, abolishing Purchase Tax and introducing Value Added Tax (VAT). Later that year, Geoffrey Rippon, the Cabinet’s EEC negotiator, declared that a very satisfactory deal had been reached for Britain to join the Common Market. Subsequently, a House of Commons voted 566 to 244 to back this move. Pounds, shillings and pence gave way to the new decimal currency. The media branded Education Secretary, Margaret Thatcher, the ‘Milk Snatcher’. Rolls Royce, the symbol of British engineering excellence, collapsed. Astronauts drove on the moon. Fashion revolutionary Coco Chanel died at the Ritz in Paris. Hot pants were the height of fashion. The charts included Middle of the Road’s Chirpy Chirpy Cheep Cheep, T Rex’s Get it on and Benny Hill’s Ernie (The Fastest Milkman in the West). Manchester United’s legendary forward, George Best, became the first victim of the ‘referees’ revolution’, being sent off the pitch as part of the FA’s determination to bring the conduct of players in line with their continental competitors. 1971 was also the year that the Bank of England applied Competition and Control Credit,

Robert Guy, former Chairman of the LBMA, featured on the left, with Robert Stein.

replacing controls on borrowing and competition for credit by means of interest rates. The intention was the breaking down of functional barriers between the clearing banks’ cartel and other finance companies in order to create a uniform credit market allowing market forces free rein.[1] Generally speaking, the reshaping of the City had begun as protected markets started to open up to the new possibilities appearing with the prospect of ‘cross-border’ lending and international funds seeping into London from American and foreign banks.

Robert joined Chase Manhattan Bank in April, much to the despair of his parents – both were doctors and wanted him to pursue an academic career. He had announced on leaving school at 18 that his preference was to pursue a career in the City, rather than follow the preferred destination of many of his contemporaries who attended University. Robert did not fully turn his back on his studies. He subsequently enrolled at the Institute of Bankers, working by day and studying by night to gain his banking qualifications. Responding to an advert placed by Chase Manhattan in one of the national papers for young, progressive, potential bankers, he was offered a job two days after his interview and, better still, on his first day at the bank was given a pay rise.

‘Catch them young’ was the recruiting policy of many of the City’s commodity firms.[2] In 1973, Robert moved to the well-known merchant bank, S.G. Warburg, and after 18 months, he moved internally, joining the trading desk at the London Metal Exchange (LME) trading company Brandeis Goldsmidt, a subsidiary of S.G. Warburg. Brandeis dealt in LME metals in addition to the rare and exotic. This global company employed approximately 150 people, principally in London and New York. Thanks to Chief Executive Walter Rothbarth, who happened to be a distant relative by marriage, Robert was recruited internally to Brandeis where he was first exposed to trading gold and silver. He had the privileged position of sitting next to Walter in the trading room. Robert recalled how one day Walter said “let’s get involved in the gold and silver business”, even though at the time the company’s principle activity wasn’t gold and silver. It was his exposure to the bullion market over the next five years that led Robert to join Derby & Co. in 1979. This was at a time when after the London bullion market closed, the American gold market extended the trading day and the emergence of the Hong Kong market led to an earlier start, thus a new trading framework for a round-the-world and round-the-clock trading day developed.[3] Gold proved an effective hedge against the weakening dollar. As the price of both gold and silver increased, more firms were eager to exploit this profitable market (in 1980, gold hit the record price of $850 an ounce). In 1979, Prime Minister Margaret Thatcher swept away the UK’s exchange controls. Thereafter,

1 Offer, A., *Banking, Real Estate, and Financial Stability in the UK* c.1870-2010 in ed., N. Dimsdale, & A. Hotson, British Financial Crisis Since 1825 (Oxford: Oxford University Press, 2014), p.166.

2 Irving, J., *The City at Work*, A guide to the institutions that make up the City of London and their roles (London: Andre Deutsch Ltd., 1981), p.174.

the London bullion market was open to the world, competition increased and foreign banks scrambled to establish London dealing rooms. Throughout much of the 1970s, there were only seven or eight dealers handling all gold and silver trading.[4] The role of the bullion dealer is learned rather than taught, so the recruitment of staff came from within the London market as the American houses came in.

Other than the five fixing members, Derby & Co. was one of the first firms since the introduction of exchange controls in 1939 to be authorised as a dealer in gold by the British authorities. Initially owned by Engelhard, by the late 1970s, Derby & Co. had become a London subsidiary of the American firm Philipp Brothers. Guy Field, formally of Samuel Montagu, was engaged to set up the gold dealing operations on Derby & Co.'s behalf while Robert was recruited to run the silver book. Just after his joining the firm, the Bunker Hunt crisis hit the market. Hunt and his brothers had been accumulating large amounts of silver and by 1979 had nearly cornered the global market. It was estimated that they held a third of the entire world supply. Prices of silver futures contracts and silver bullion rose from $3 in early 1979 to $11 in September and to a record high of nearly $50 an ounce in January 1980. In response to this large accumulation, COMEX adopted 'Silver Rule 7', which placed heavy restrictions on the purchase of commodities on margin. Over the next two months, the silver price collapsed. It was on 27 March 1980 – 'Silver Thursday' – that the greatest single drop in the price of silver occurred. The Hunt brothers, who had borrowed heavily to fund the purchase of commodities, suffered as the price fell and they were unable to meet their obligations, causing panic in the markets.[5]

Robert was involved in liquidating Hunt's silver positions. For him, it was an interesting period and a baptism of fire, as he suddenly found himself with a huge responsibility for a very important asset which the firm had to manage. Following the collapse in the price, silver remained depressed in the main for the next 20 years.

In 1981, Philipp Brothers purchased Salomon Brothers. In a quirk of fate, between 1981 and 1985, a reverse takeover took place when Investment Banking became the dominant partner as Commodities Business went into cyclical decline. Salomon then became the dominant partner and Philipp Brothers became a division of Salomon Inc. By the early 1990s, it had almost completely closed down the metals business but retained its thriving energy business.

Robert kept one step ahead of this development, moving to Goldman Sachs

The Derby (Phibro) dealing room in Moor House in 1983. Pictured left to right are Trevor Clein, Martin Turner, Vincent Thompson, George Pajak (sadly deceased) and Jeremy East (doing a very plausible impression of George Osborne).

in 1989. He recalled that the recruitment process had been more intense than his previous appointments. While some people reported undergoing 25 interviews before being hired, Robert had a couple of interviews in New York and three or four in London. Again, he joined at an interesting time in the firm's history. There was a lot of integration going on, specifically at J. Aron, which had been gobbled up in 1981 by Goldman. When Robert joined, the division was headed up by Dennis Suskind and after his retirement by Lloyd Blankfein, the current Chairman and CEO.

In 1994, Robert moved to AIG and accepted a new challenge, spending most of his time covering central bank gold reserve management. He was involved in this business until 2006, moving internally from AIG Trading in 2003 to AIG Financial Products for his final three years in the business after internal changes at the firm had taken place. At the time when AIG decided to become the sponsor of Manchester United, it was to Robert they turned to and asked to set up the private bank in London. Although not a well-known name at that time in the UK, AIG was very well known both in the US and the Far East. Robert didn't need to be asked twice when the Chief Executive of AIG private banking in Zurich, Peter Wild (also an ex-bullion trader with Julius Baer), called him up and asked him if he "wanted the Man U job". At first, Robert thought he was missing something. "Do I have latent talent as a football manager or is Sir Alec Ferguson about to resign?" After his flippant comment, it took him 10 seconds to say "yes", turning his back on over 30 years of commodity trading. This project lasted until September 2008 when it was abandoned during the financial crisis and Robert's exciting project sadly never came to fruition.

Robert has continued in the football business since this time and works independently with a partner on financing international football transfers and accelerating broadcasting receivables for major clubs. He has now been a season ticket holder at Chelsea for 52 years and is also an MCC member, combining his love of sport with his business, Harewood Global Sports Ltd. He shared that "after all those years working for somebody else, it is now rather nice being accountable only to oneself".

Reflecting on his career in commodities, it was the periods of crisis that stand out most for Robert. The market was able to withstand the shocks and survive the Bunker Hunt crisis, the collapse of Johnson Matthey Bankers, the demise of Drexel and the Brink's-Mat robbery. However, the major event that stood out was regulation, which followed the introduction of the Financial Services Act of 1986. Whilst in many ways it was positive, it also brought new challenges that took up a lot of man hours as each firm was undressed by the authorities. The introduction of Compliance Officers was one new aspect of business, making sure firms operated in a proper manner. During his time in the bullion market, Robert sat for several years on the Board of the LBMA, for a time he was the Vice Chairman and he also chaired the Finance Committee.

Robert can be contacted at: rastein1952@gmail.com

Dr Michele Blagg (BA, MA, PhD) is an historical consultant, researcher and writer who works independently offering client services, specialising in financial and business history. She holds a PhD in History from King's College London, which was funded by The Rothschild Archive in collaboration with the Arts and Humanities Research Council. Her doctoral research focused on the Royal Mint Refinery operated by N M Rothschild & Sons between 1852 and 1968 studying how it adapted to change within the London gold market. She worked for many years in the financial services industry before pursuing her studies in Political, Economic and Social history. She received a First-class BA (Hons) from the Open University and subsequently, an MA in Contemporary British History from the Institute of Historical Research. She recently qualified in Global Risk Analysis and Crisis Management at Vesalius College, Brussels, gaining an in-depth knowledge, together with a wide range of practical tools, in identifying and analysing global security risks to advance effective responses to humanitarian, military and political 'complex crises'.

Engaged by the LBMA in 2014 she managed the oral history project 'Voices of the London Bullion Market'. Sitting as an Executive of the Business Archives Council, she promotes the preservation of business records, encouraging interest in the history of Britain. michele.blagg@kcl.ac.uk

3 Harvey, R., *Duty to the Firm and Market, The Subnational and Sociocultural Constitution of the London Gold Fixing* (The University of Chicago: PhD Thesis 2008), p.233.

4 Ibid., p.231.

5 Time Magazine, May 12, 1980, 'Bunker's Busted Silver Bubble'.

LBMA News

By Ruth Crowell, LBMA Chief Executive

Membership

On 5 April 2017, Ping An Bank Co., Ltd. was admitted as a Full Member.

These changes brought the total membership to 146 companies, comprising 13 Market Makers, 57 Full Members, 10 Affiliates and 66 Associates.

Good Delivery List
There are currently three active applications for silver, one of which is in the initial review stage and two are in Stage 2. One application for gold has been received and undergone the initial review.

There are presently 70 refiners on the gold Good Delivery List and 79 on the silver Good Delivery List.

LBMA Board
The Board has been focused on an ever full agenda in recent weeks, looking at a range of strategic issues, including initiatives in respect of Responsible Sourcing and Due Diligence, as well as trade reporting, finalising the Precious Metals Code and lobbying in respect of the Net Stable Funding Ratio (NSFR). The Board have also been involved in the recent launch of the Request for Proposal (RFP) process in relation to the LBMA Silver Price auction. This RFP is following CME Group's and Thomson Reuters' announcement that they will be stepping down as administrators of the LBMA Silver Price auction. Since then the LBMA has received a number of expressions of interest and has also consulted with market participants to prepare a RFP which was subsequently launched in mid-April. It is expected that a decision will be announced by the Summer, with implementation planned for the Autumn. During the transitional period, CME Group and Thomson Reuters have committed to the market to continue to administer the auction until a new provider is fully implemented. This is to ensure the continuity and integrity of the LBMA Silver Price during this transition.

Subcommittees

Regulatory Affairs Committee
The Committee continues to provide guidance to the LBMA in respect of a wide range of regulatory developments as well as continuing to provide support and advice to the wider LBMA membership. One of the issues that the Committee has been focused on is reviewing the comments and feedback received from the market-wide consultation on the new Precious Metals Code, which closed on 28 February. The Code will be published on 25 May 2017 at the same time as the FX Code is published by the Bank of England. Other issues which the Committee continues to be currently focused on include the RfP process to identify a new solution provider for the LBMA Silver Price auction, LBMA-i Trade Reporting initiative, NSFR, the Market Abuse Regulation regime, Margin Requirements for Non-Cleared derivatives, as well as the EU Conflict Minerals legislation. For further details, as well as other regulatory information, please refer to the Regulatory Update on page 27.

Physical Committee
The Physical Committee has been focused on an ever expanding range of issues, including the continued enhancement of the integrity of the Good Delivery Lists, processing a number of new and existing GDL applications (with more in the pipeline), and the continued development of the responsible sourcing programme to encompass the implementation later this year of Responsible Sourcing for silver.

The first round of Proactive Monitoring is due to start, based on the revised schedule and the new requirement for refiners to demonstrate the ability to cast London Good Delivery bars, if they have not recently sent large bars to London.

The latest round of proficiency testing was completed and the report was circulated to all participants. For the first time, the Proficiency Testing scheme was extended to include silver. 67 refiners participated in the scheme, with 55 of these refiners participating in silver and 60 in gold. A presentation was delivered by Jonathan Jodry at the recent LBMA Assaying and Refining Conference (A&R), which is available on the LBMA's website.

The LBMA would like to thank the A&R Working Party for its hard work in regards to the speaker programme for the Conference, which was considered the most successful one to date, with a record attendance of more than 200 delegates. A full review of the Conference can be found on page 16.

Membership Committee
The Committee's work continues to focus on the development and implementation of the Due Diligence Policy. With the pilot scheme completed, the Committee is now focused on implementing the policy, which will be executed on a staggered basis for all members.

The Committee is also processing a number of new applications for Full Member, Associate and Affiliate status as well as undertaking a review of the sponsorship process. Any companies including refiners, producers or central banks that may be interested in applying for membership are invited to contact the LBMA Executive at: mail@lbma.org.uk.

Public Affairs Committee
The Committee is focused on preparations for the annual Conference in Barcelona. As well as preparing a high-quality speaker programme, one of the other key considerations for the Committee is evaluating the feedback from last year's Conference. The Commitee will consider improvements to the format and structure of the programme as well as ways to deliver improved networking opportunities for delegates, for example, by introducing new technologies and extended breaks.

The LBMA is proposing to sponsor two PhD students to undertake research on precious metals related projects. One bursary has been advertised through Trinity College, Dublin (Dr Brian Lucey) and the other through the Institute of Materials, Minerals and Mines (Dr Graham Woodrow). In return, the successful candidates would be expected to meet with industry representatives via the LBMA, contribute occasional articles to the *Alchemist* and attend industry conferences.

Finance Committee
One of the other key areas that the Committee has been focused on is the budget and forecast out to 2019. This work will ensure that the LBMA continues to meet the growing needs of the market. The Committee has also been focused on finalising the budgets for recent events, including the Annual Party and the recent Assaying & Refining Conference.

The Committee is also monitoring the financial management integration workstream of the LBMA's new customer relationship management (CRM) project, which will be launched shortly. Look out for further member communications for updates on the CRM project.

LBMA staff
The LBMA is delighted to announce that Marta Rola has joined the LBMA as its new Financial Controller. She brings extensive experience to the role. In addition, Jade Maisey has joined as the new Office Administrator. The LBMA would like to extend a warm welcome to them both. These new joiners arrive following the sad news of two resignations, Juliet Pithers and Chloe Wright. The LBMA would like to thank them for their contribution to the work of the Association and wish them both well in the future.

Annual General Meeting
The LBMA's Annual General Meeting will take place at Glaziers Hall, 9 Montague Close, London Bridge, London SE1 9DD, on Thursday 6 July at 16:00. The AGM presents an ideal opportunity for any interested member of staff in Member and Associate companies to hear about what the LBMA has been doing over the last 12 months as well as meet representatives of the other member companies. This year, it will be the turn of the Market Maker member representatives to be elected. In line with the usual procedures, the documentation, including nomination forms for the Board election, will be circulated to the official LBMA contact in each Member firm in advance of the meeting. The AGM will be followed by refreshments in the River Room, Glaziers Hall.

LPMCL News

The LBMA is delighted to announce that its closer working relationship with the London Precious Metals Clearing Limited (LPMCL) has recently been formalised with the signing of a Service Level Agreement (SLA). The LBMA is now the registered head office for the LPMCL and will assume responsibility for the administrative and secretarial duties on behalf of the LPMCL. The Executive has been working closely with the LPMCL on upgrading and rebranding its website. It is expected that this will be launched soon. The LBMA has also been collecting clearing statistics for platinum and palladium from the LPMCL members and, following a period of quality checking, these will be published monthly at the same time as the gold and silver clearing statistics.

The LBMA and the LPMCL are also delighted to announce that from summer 2017 the LBMA will be publishing the gold and silver physical precious metals holdings of the London vaults, with the platinum and palladium holdings to be published at a later date. It is expected that the first set of numbers will be accompanied by a detailed commentary, with the data published monthly thereafter.

Regulation Update

By Sakhila Mirza, LBMA General Counsel

Responsible Gold Guidance
It has been four years since the LBMA launched its Responsible Gold Guidance (RGG). The RGG extends the OECD Gold Supplement for Refiners and builds on existing Anti-Money Laundering and Know Your Customer management systems and auditing practices. It also makes the voluntary OECD Guidance system mandatory for all LBMA Good Delivery gold refiners wishing to be accredited for the London bullion market.

Both refiners and auditors have been working diligently with the LBMA to ensure that the implementation of the RGG guidelines continues to be successful. Refiners have made excellent progress to further improve their internal processes and procedures, and to be proactive in complying with the updated RGG provisions. Failure to comply with the RGG has led to refiners being transferred to the Former List.

In February 2017, the LBMA attended the OECD Regional Workshop on Best Practices for the Sustainable Development of Artisanal Mining. Discussions on stakeholder engagement and governmental responsibility are critical for meaningful, measurable progress, and this forum enabled the LBMA to represent downstream companies' increasing expectations and demands for responsible and sustainable sourcing practices.

Responsible Silver Guidance
In May 2016, with strong support from industry stakeholders across the supply chain, the LBMA launched the initial consultation period for its Responsible Silver Guidance (RSG). Earlier this year it launched a consultation on the draft Guidance in order to ensure an implementable, beneficial set of standards that will assist refiners in demonstrating their compliance with industry best practices in responsible sourcing.

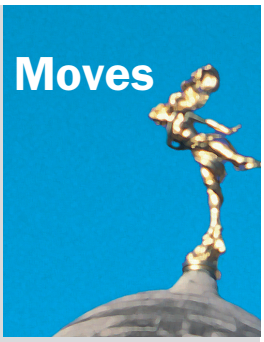
The LBMA would like to thank everyone who has submitted feedback so far. Public consultation for the proposed RSG will begin on 1 July 2017, with the final Guidance to be published in Q4 2017. Refiners will be able to submit audit documentation on a voluntary basis from 1 January 2018.

OECD Alignment Assessment
The EU Conflict Minerals legislation, due to take effect from 1 January 2021, will require EU companies to take demonstrable steps to ensure importation of "3 TGs" (tungsten, tantalum, tin and gold) from responsible sources only. The LBMA believes that industry schemes, such as the RGG, could help companies in demonstrating compliance with the requirements under the Regulation. In order to help determine which industry schemes meet the standards of the EU legislation, the OECD has undertaken a pilot Alignment Assessment of a few select industry programmes. The LBMA voluntarily took part in the pilot, which focused on: i) the alignment of industry programmes' standards and systems with the OECD Due Diligence Guidance; and ii) alignment of the industry programmes' implementation efforts with the OECD Guidance. The OECD will be sharing feedback on the Methodology Tool used during the assessment at its Responsible Minerals Forum in May 2017 and the results from the pilot in summer 2017. The LBMA continues to stay focused on further developing its programme and is working on issuing the next draft of the RGG later in 2017.

Net Stable Funding Ratio (NSFR)
The LBMA and law firm Norton Rose Fulbright have recently completed a position paper summarising the potential adverse market impact of the NSFR, as well as suggested amendments that would help the precious metals market. The next steps will be to present the paper to the European legislators and then meet with key stakeholders to explain the likely effect that the NSFR provisions would have on the end user. The potential for a fall in liquidity and higher costs continues to be a critical concern for the precious metals market.

Precious Metals Code
The LBMA will be launching the global Precious Metals Code on 25 May 2017. The new Code will apply to all precious metals market participants and will provide guidance on industry best practices. The Code will be supported by an explanatory note to help organisations understand the compliance requirements, and firms will be expected to sign a 'statement of commitment' to confirm compliance.

Market Moves



Giles Maber joins Sharps Pixley

On 13 February 2017 Giles Maber joined Sharps Pixley Ltd in London as Business Manager. Giles brings with him an excellent understanding of the metals markets coupled with extensive experience in building new client relationships, especially in the wealth management sector.

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Editorial Comment: Leadership, Integrity and Trust

By Ruth Crowell, LBMA Chief Executive

It is probably an understatement to say that there have been a lot of developments and changes in the bullion market since I became Chief Executive just over three years ago. The LBMA has had to expand its role and reach to meet the associated challenges. In a recent exercise, the LBMA Board and Executive identified Leadership, Integrity and Trust as the three key values for the LBMA. If we are doing our job well, Members, clients, regulators and other stakeholders should associate those values with the Association. Collectively, I believe they encapsulate the vision and mission of the LBMA and provide a framework for the way that the Executive conducts its work. My first editorial focused on regulation and how it was taking up an increasing amount of the Executive's time. Some things never change, but whilst regulation remains a priority, I also want to focus in this editorial on the wider raft of issues that the Executive is now faced with and how each of them align to the three key words.

Leadership

In recent weeks, the LBMA has been processing and incorporating the comments and feedback received from the market-wide consultation on the new Precious Metals Code. The Code will be issued at the same time as the FX Code, prepared by the Bank of England and scheduled for publication on 25 May 2017. The new Code will apply to all precious metals market participants and will provide guidance on best practice for market conduct. This includes principles that should be adopted by Members, including ethics, compliance, governance and risk management, as well as pre-trade, execution and post-trade business conduct. I would encourage you all to embrace the Code to ensure best practice is followed in the market.

The LBMA continues to lobby, along with other industry bodies, the European Commission to amend the proposed Net Stable Funding Ratio (NSFR) of 85% for gold. After many years of working to raise awareness, I'm delighted that so many Members and market participants have provided their support to assist us with our lobbying efforts. It is clear that such a requirement would have a serious impact on the bullion market and I would encourage all Members to continue to provide your support and assistance to the LBMA in any way that you can.

Integrity

To complement the now well-established Responsible Gold Guidance (RGG), the LBMA is proposing to extend its Responsible Sourcing initiatives to include a Responsible Silver Guidance (RSG) programme. The LBMA is currently engaged in a consultation exercise with participants in the silver market and GDL refiners, with a view to making compliance with the RSG mandatory in 2018. The new RSG will be implemented later this year and will provide refiners with a tool to demonstrate not just compliance with regulations on conflict minerals, but other responsible sourcing issues, such as those relating to anti-money laundering. The introduction of the RSG adds integrity to the Silver Good Delivery List. We are grateful to those refiners who voluntarily underwent a Responsible Sourcing audit for all four metals as part of their 2016 audit assessment. This will prove extremely practical for the consultation.

Indeed, the integrity of the Good Delivery List (GDL) remains at the heart of the work of the LBMA. Any incidents or issues that may put the credibility of the GDL and the London bullion market in doubt are treated very seriously. The LBMA has a standard procedure that enables it to handle such incidents and issues in a systematic way to maintain the credibility of the GDL generally but the RGG in particular. Under this Incident Management Process, the LBMA stands ready to take action whenever appropriate, with the ultimate sanction to move to the former lists any refiner who is in breach of the process.

The LBMA continues to maintain a close relationship with the Bank of England. There is also a range of other legislation in relation to commodities as well as recent EU regulations, including EMIR, which have focused on reporting requirements for forward markets. We still await final MIFID definitions, although it is not clear at this stage what exactly will be included. The LBMA Executive will continue to keep a close eye on regulatory developments and respond to them as and when appropriate.

Trust

The LBMA is also developing an ever closer relationship with the London Precious Metals Clearing Limited (LPMCL). The relationship was recently formalised with the signing of a Service Level Agreement (SLA). The LBMA is now the registered head office for the LPMCL and will assume responsibility for the administrative and secretarial duties on their behalf. The Executive has also been working closely with the LPMCL on upgrading and rebranding its website to align more closely with the LBMA's. It is expected that this will be launched soon. The LBMA has also been collecting clearing statistics for platinum and palladium from the LPMCL Members and, following a period of quality checking, these will be published monthly at the same time as the gold and silver clearing statistics. The LBMA and the LPMCL are also delighted to announce that from summer 2017, the LBMA will be publishing the gold and silver physical precious metals holdings of the London vaults, with the platinum and palladium holdings to be published at a later date. The data will be published monthly (three months in arrears), on an aggregated basis. In order to provide clarity around what the data represents, it is proposed that the first set of numbers will be accompanied by a detailed commentary, with the data published monthly thereafter.

Publication of physical holdings represents a further step towards improved transparency of reporting for the London precious metals market, in line with the recommendations of the Fair & Effective Markets Review. Publication of aggregate physical holdings is the first step in reporting for the London precious metals market. The next step is trade reporting. The collection of trade data will add transparency to the market and provide gross turnover for the Loco London market, which previously had been calculated from one-off surveys or estimated from the clearing statistics. The requirement will be to report for all four metals all spot, forward, options, deposits, loans and swaps, whether Loco London, Loco Zurich or other locations. Reporting will be through LBMA-i, which can be accessed through portals operated by Cinnober Boat or Autilla. Bilateral meetings have already taken place with all market makers to explain the reporting requirements and how they are required to report. Further meetings with all other participants who trade are taking place and are expected to continue over the coming weeks and months. Reporting will begin later this year in a phased approach and, following a period of quality checking the data, it is expected that it will be published in early 2018.

Last year, the LBMA introduced changes to the structure of the Board, for example, the appointment of new independent Non-Executives, including the Chairman, Paul Fisher. The structure, services and governance of the LBMA will continue to evolve to serve the market, but the fundamental role of the LBMA will not change. That role is to ensure that the London bullion market continues to serve the needs of its Members and their customers in what is truly a global business. I invite you to support the LBMA in all the initiatives described above and help us to demonstrate leadership, integrity and trust.

The Alchemist is published quarterly by the LBMA. If you would like to contribute an article to the Alchemist or if you require further information please contact Aelred Connelly, London Bullion Market Association, 1-2 Royal Exchange Buildings, Royal Exchange, London EC3V 3LF
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Obituary

Anton Dranitsyn,

By Alla Starodubtseva, Head of Precious Metals Department, Rosgosstrakh Bank and Stewart Murray, former CEO of the LBMA

The photo shows Anton holding the LBMA Associate certificate for MDM Bank in December 2010.

In the prime of his life, at the tragically early age of 42, Anton Dranitsyn died of a sudden heart attack on 23 February 2017.

Anton was born in Moscow on 1 April 1974. His father, Yevgeniy Semenovich worked for the government in the field of international economics and became a member of the USSR's Council of Ministers. His mother, Raisa Vladimirovna, worked as an engineer. Anton spent his early childhood with his family in Senegal, where his father was posted.

After graduating from the Russian Institute of Management at the age of 21, Anton then took a further degree from the Russian Federation's Financial Academy. He had a fondness for languages and, as many of his friends in the bullion market subsequently experienced, he developed a real fluency in English, German and French. Following his studies, his military service was as an artillery officer, which included a period of active service in the Caucasus. No doubt based on the knowledge of explosives and ballistics he developed in the army, he was also a part-time member of the team at Mosfilm Studios, where he arranged various pyrotechnic events.

Anton started his business career in 1996 in the precious metals department of the Russian bank SBS AGRO. In 1999, he joined MDM Bank and was soon appointed as Head of Precious Metal Operations. Here, he developed a well-deserved reputation as one of the most respected gold traders, not only in Russia but also in the world market. It was through his single-handed development of the annual Russian gold forum, commencing in 1998, that he first became known to many LBMA members. During the next 18 years, this event grew in size and stature, attracting many analysts and speakers from Western banks to experience the first snows of the Russian winter and the warmth of the welcome arranged by Anton and his Moscow colleagues. No one who attended will forget his ebullient hosting of these events and the Russian Bullion Awards which became part of them in the past 11 years.

On the LBMA side, Anton was a pathfinder: he was immensely proud of the fact that MDM became the first Russian bank to be accepted as an LBMA Associate in 2010, a path subsequently followed by other Russian banks. Starting from his attendance at the LBMA's bullion market forum in Moscow in 2004, his cheerful participation at LBMA conferences will be remembered by his many friends, and at least for one of the authors of this obituary, his late-night rendition of *Flower of Scotland* on more than one occasion will be an unforgettable memory.

In Russia, Anton will be remembered not just for the immense contribution he made to the development of the market but especially for his kindness and willingness to help colleagues and competitors. He was indeed the very life and soul of the Russian precious metals market and his presence will be sorely missed by all who knew him.

DIARY OF EVENTS FOR 2017

2017

MAY

03 - 04
New York Mines & Money
Double Tree Hilton, New York, USA
http://newyork.minesandmoney.com

03 - 05
Mining Investment Africa
Abuja, Nigeria
www.mininginvestmentafrica.com

10 - 11
121 Mining Investment London
ETC Venues, 8 Fenchurch Place, London, UK
http://www.weare121.com/121-mining/

15
WPIC Platinum Quarterly Demand and Supply Report
https://www.platinuminvestment.com/reporting-calendar

15 - 19
LPPM Platinum Week
London, UK
http://www.lppm.com/

JUN

04 - 06
Asia Pacific Precious Metals Conference 2017
Grand Copthorne Waterfront Hotel, Singapore
http://www.asiapacificpmc.com/index.html

06 - 07
121 Mining & Investment
Westin Grand Central, New York
http://www.weare121.com/121mininginvestment-new-york/

13 - 14
RBC Global Mining & Materials Conference
Boston, MA, USA
www.rbccm.com/en/about-us/conferences.page

JUL

06
2017 LBMA AGM
Glaziers Hall, London Bridge, London, SE1 9DD
www.lbma.org.uk/upcomingevents/agm-2017

AUG

11 - 13
14th India International Gold Convention
Grand Hyatt Hotel, Goa, India
www.goldconvention.in

SEP

18 - 20
2017 Precious Metals Summit Beaver Creek
Park Hyatt Beaver Creek
Colorado, USA
www.precioussummit.com/event/2017-summit-colorado/

24 - 27
Denver Gold Forum
The Broadmoor Hotel, Colorado Springs, Colorado, USA
www.denvergoldforum.org/dgf17/

29 - 30
Coinex 2017
The Ballroom, Millennium Hotel, London, UK
http://www.bnta.net/index.cfm?do=coinex

OCT

15 - 17
LBMA/LPPM Precious Metals Conference
Hotel Arts
Barcelona, Spain
www.lbma.org.uk

26 - 27
Silver Institute Conference 2017
Details to be announced
www.silverinstitute.org/site/

30/10 - 3/11
LME Week
London, UK
www.lme.com/news-and-events/events/metals-seminar/

NOV

07 - 08
2017 Precious Metals Summit Zurich
Park Hyatt Zurich, Switzerland
www.precioussummit.com/event/2017-summit-zurich/

09 - 10
2017 Precious Metals Summit London
Hyatt Regency – The Churchill, London
www.precioussummit.com/event/2017-summit-london/

facing facts

By Dante Aranda, Senior Analyst, Mine Economics, Thomson Reuters, GFMS

In light of surging silver prices and the consequent increase in margins, GFMS has sought to present silver producers' costs in a way that facilitates a clearer relationship between costs and margins than using by-product credit methodology. This has involved a reinterpretation of the data to present costs also on a co-product basis, including capital expenditure (capex). While cash costs net of by-product credits is a useful metric, it is vulnerable to swings in the pricing of silver's by-product metals, which can distort the picture.

Using By-Product Methodology

Silver Total Cash Costs (TCC) net of by-product credits fell year-on-year from -$3.75/oz to -$4.12/oz led by higher production and by-product credits from Peru. The drop was partially offset by lower base metal production from KGHM Polska Miedź and Hindustan Zinc, shifting two of the world's lowest cost producers further up the cost curve. Over 2016, both operations averaged a TCC net of by-product credits of -$32.42/oz, a sharp contrast against -$42.17/oz in 2015.

If we exclude silver production from India and Poland, TCC net of by-product credits costs continued trending lower in 2016, averaging $1.45/oz, or 59% below the same period last year. This was driven by most countries including Peru, Argentina, Australia, the United States, Russia and Mexico, where higher grades, lower fuel costs and direct mining costs expressed in US dollars led to lower costs globally. Amongst the countries in the aforementioned group, Peru posted the largest drop in TCC net of by-product credits, falling from $4.57/oz to -$3.76/oz due to higher silver and copper production at Uchucchacua and El Brocal respectively.

As metal prices remained subdued over 2016, a common theme around costs savings took shape in Peru. Lower contractor and supplier costs, coupled with falling freight costs and technical services paved the way for miners to secure lower fixed costs. The demands of local communities became more lax and, with businesses looking to rent their equipment at any price, significant savings materialised. The significant drop in cash costs followed the remarkable surge in Peruvian silver and copper production at the country level, up 7% and 38% in 2016.

Turning to the world's largest silver producer, cash costs in Mexico dropped by $0.38/oz to $1.48/oz on the back of higher by-product credits at Dolores and higher grades at Palmarejo, partially offset by lower silver production.

Using Co-Product Methodology

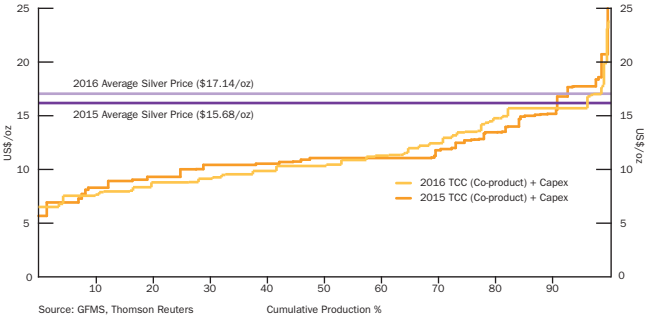
On a co-product accounting basis, TCC+capex in 2016 at the global level stood at $11.38/oz, up 5% from last year. The main driving force was a 13%, or 122 Moz, drop in silver equivalent ounces, partially offset by a 6% contraction in capital expenditure to $2 billion. KGHM Polska Miedź accounted for nearly 50% of the drop in silver equivalent ounces, while Mexico saw the largest contraction in capex, followed by the United States and Argentina. Under this cost measure, we note a change in trend following three years of downside pressure on costs.

However, if we exclude silver production from India and Poland, the falling trend comfortably extended into 2016, with costs dropping by 2% to $11.22/oz. Under this smaller sample size, capex dropped by 10% year-on-year, partially offset by a less pronounced drop in silver equivalent ounces, mostly explained by Penasquito. Contrary to this downward trend, costs at the second-largest silver-producing mine in Mexico jumped by 42% to $15.70/oz due to a 46% drop in gold production as a result of lower ore grades (-30%) and throughput (-16%). In addition, capex climbed 16% to $235mn as Penasquito's Pyrite Leach Project (PLP) gained company approval in July 2016. Goldcorp forecasts that the PLP will add approximately 5 Moz per year commencing in 2019 by increasing overall silver recoveries stemming from the treatment of zinc tailings.

A pronounced weakening of most 'producer currencies' versus the US dollar since 2014 has offered substantial cost benefit. Year-on-year, the Mexican peso, Peruvian sol, Australian dollar and Argentine peso were respectively 59%, 6%, 1% and 59% weaker. By the co-product TCC+capex measure, excluding Poland and India, 5% of the silver industry was 'underwater' against the 2016 average silver price of $17.15/oz, a 7% drop relative to 2015.

Although US-based primary silver mines did not have the same advantage of currency devaluation, as a group, they succeeded in cutting costs by 22% to $11.47/oz largely thanks to higher production and lower capex. This was particularly the case at Lucky Friday, where production rose by 0.6 Moz, while capex fell by 26%, or $14mn as the #4 Shaft, a key growth project, neared completion.

Silver Mining Costs



Source: GFMS, Thomson Reuters

Turning to costs, lower diesel prices and higher grades led to a $3.71/oz drop in costs on a TCC+capex co-product basis to $17.01/oz.

We expect global by-product costs to continue trending lower over 2017 as credits from gold and base metal operations materialise, albeit at a slower rate as grades and oil prices begin to exert upward pressure on direct mining costs. However, we believe silver costs on a co-product accounting basis will edge higher, with cost of sales and capex following in the footsteps of the silver price.

Dante Aranda, Senior Analyst, Thomson Reuters, GFMS
Dante began his career in the commodities market in 2010 when he joined Thomson Reuters in Toronto as a commodities specialist, working with a broad range of natural resources companies. Now based in London as a precious and base metals mining analyst, he is heavily involved in the team's modelling of mine production and industry costs using Matlab and VBA and is also a leading contributor to the GFMS team's technical analysis. Prior to Thomson Reuters, he worked at Banco de Credito del Peru as a Junior Trader on the FX structured products desk. He holds a BSc (Honours) in Financial Economics & Applied Statistics from the University of Toronto, and is a CFA Level III Candidate.

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