LBMA

Alchemist

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Silver's Sunlit Uplands – Lucainena de las Torres, Almeria, one of many solar energy parks using photovoltaic panels. Michael DiRienzo highlights some key industrial uses for silver on page 23.

Analysis and standards are vital however the price moves: Jonathan J Jodry shares the process of analysing LBMA Certified Reference Materials at Metalor on page 3.

The Fourth LBMA Assaying and Refining Seminar

was held at Armourers' Hall on 7-8 MARCH, 2011. More than 120 delegates attended, enjoying both presentations building on the work of previous seminars and those on new topics. Two highlights are printed in this publication: Jonathan J Jodry's description of work on certified silver reference materials is on the facing page and Dr Ian Severn's explanation of mass measurement in the UK begins on page seven. All presentations and transcripts from the seminar can be found in the Members' area of the LBMA website.

Silver

From analysis of Reference Materials to a new ISO Standard

By Jonathan J Jodry, Head, Trace Analysis Laboratory, Metalor Technologies SA

The following is an edited version of a presentation made at the Fourth LBMA Assaying and Refining Seminar.

I shall focus specifically on the LBMA certified silver reference materials. When we started our analyses, I was expecting it to be a pretty straightforward process. We believed that we knew how to analyse silver, but discovered in the process that the analysis was much more difficult than expected. We had to change our methods so much that we are now proposing a change to the international standard for the analysis of silver.

General Approach

Normally two techniques are used. First, there is analysis as a solid, which is typically done by spark OES spectrometry, a very fast method with several problems. The calibration is complex, you can only analyse a limited number of elements and it is only appropriate for specific shapes. The second technique is to analyse material as a solution. This is a precise, versatile method – at least it can be precise. The only problem is that you need to dissolve the material quantitatively.

For gold, platinum and palladium, the process is quite straightforward: aqua regia will eventually dissolve the material. Sometimes you have to use heat, sometimes you have to use pressure, but it will eventually dissolve. And this is not new chemistry; aqua regia has been known since the 11th century.

For silver, however, the same procedure will produce a solid (silver chloride) and a supernatant solution. You can analyse the solution; or you can use an alternative acid, such as dilute nitric acid, to produce a limpid solution and analyse that instead.

The Steering Committee selected 10 laboratories and asked them to analyse the new silver reference materials using whichever method they deemed acceptable. Two main methods were used, as I have just explained: either the nitric solution approach, where the material was dissolved in nitric acid and directly analysed; or the aqua regia approach, which is also the ISO 15096 (2008 version) standard, where the material was dissolved in nitric acid and then hydrochloric acid was added to precipitate AgCl and the supernatant was analysed.

Silver RMs Analysis – Representative Problems

Let me show you which results were obtained. Figure 1 focuses on magnesium analysed in silver for RM1 and RM2. Each triangle is a result given by a laboratory. There are more than 10 of them because, as I said, laboratories were allowed to use several methods. The results were collated depending on the method used for the preparation – using nitric acid, aqua regia or any alternative method. The results in blue were those that were accepted. The results in red were those that were rejected. Results were rejected either because the technique was deemed afterwards to be inappropriate or because they were outliers following certain statistical tests that we performed.

If we take magnesium, for example, we see that the results obtained from nitric acid are pretty coherent, with all measurements very close to the average value. The same goes for higher levels of magnesium. However, if we check the results from aqua regia, we see that dispersion is much higher and the absolute value is also lower. This is explained by the fact that magnesium will adsorb in silver chloride and obviously will lead to a lower absolute value.

If we take another trace element, platinum, we see the opposite trend. We have a good result in aqua regia and a larger dispersion, more outliers and results that give lower values in nitric acid. Again, this is not surprising. It is well known that platinum dissolves pretty well in aqua regia and not that easily in nitric acid.

Which Method to Use?

When we saw those results, the first question was: could we just use the nitric acid results for some elements and the aqua regia results for other elements? The short answer is, unfortunately, no. In nitric acid, we have some elements that are perfectly stable. Take copper: the sample is prepared at time zero, and since it usually takes two to three hours before analysis is performed, the first concentration is obtained after three hours. The solution is analysed again after 18 hours, after 36 hours, and this continues for four days, showing results that are completely consistent and do not change over time. The same goes for certain elements such as bismuth, antimony, zinc and so on.

However, if we take other elements, we see that they are not as stable as we had hoped. Nickel, for example: starting with a value of 72 ppm after three hours, it dropped to 60 ppm after a day and half. The same trend occurs with several elements; indeed gold and rhodium will completely disappear after a day and a half. The problem is that even if you measure that solution even after only two, three or four hours, there is obviously a decrease, so you cannot be sure that the concentration you are measuring is the real concentration. Let us be honest, in daily work in the laboratory, if you lose one ppm of one of the trace elements, it is not such an issue, but for a reference material – something we want to be certified – this is obviously unacceptable.

Therefore, the conclusion for this first part is that, in nitric acid, we not only have a solubility problem, we also have some kinetic issues to consider.

ISO 15096 Standard

We then tried the method ISO standard 15096, the latest 2008 version. As it is an ISO standard method, we expected this to work very well. The standard is intended for jewellery analysis of silver with purity higher than 999‰, but obviously it can be used for any silver alloy of sufficient purity. The procedure is straightforward: weigh a certain amount of the test sample, dissolve it in nitric acid, heat it and then add HCl to precipitate silver chloride. After filtration and washing of this precipitate, and addition of extra HCl, the liquid phase is analysed by ICP-OES.

We used this procedure on the silver reference materials and several silver standards that we had made ourselves. Figure 2 shows the recovery rate. Basically, if the method

works, the result should be 100% for each element. The first thing we see is that this method absolutely does not work for four elements: cadmium, lead, bismuth and rhodium have less than 10% recovery. This is a clear sign that those four elements cannot be measured with this ISO standard. In fact, not only those four, but most of the elements (15 out of 20), give results that are not really useable. If we take iron, for example, we have a 70% recovery rate, which means a 30% error. This shows that this approach is not applicable for the analysis of our silver standards.

What we found in the end was that some elements could neither be determined in nitric acid nor in aqua regia. This was the case for rhodium, which is an extremely difficult element to measure in silver. Therefore, what you see here is that basically most of the results are completely out of range. But if you look at the third part of the graphic called 'other methods', it seems that this time, results are more coherent.

A New Approach for the Analysis of Silver

During the course of this project, which lasted over more than a year, we had to develop a new method that would allow us to measure all the elements quantitatively.

We started with a partial dissolution in nitric acid. Looking at the sample tubes, it appeared that the solutions could contain some suspensions, which can be isolated by centrifugation. This is more effective than filtration as there is no risk of contamination and it produces a liquid phase that can be analysed immediately. Then we dissolved the solid residue in aqua regia and analysed that solution, too. For each element, the exact value is the sum of both analyses.

What results did we find? Gold is found exclusively in the solid residue. Rhodium is found mostly in the solid residue, at about 80%. Many elements were found in both solutions, which means that they are present both in the nitric acid solution and in the residue. Other elements were found almost exclusively in the nitric solution. While this also depends on their relative concentration, it still gives a good idea of where elements can be found.

This method has three main advantages. There is no precipitate in the solution being analysed. Thus there is no problem with the cloaking of the ICP instruments and the solution is significantly more stable over time: if there is no suspension, the solution being analysed will remain reasonably stable for a couple of hours.

Figure 1 - A representative problem in silver RM analysis

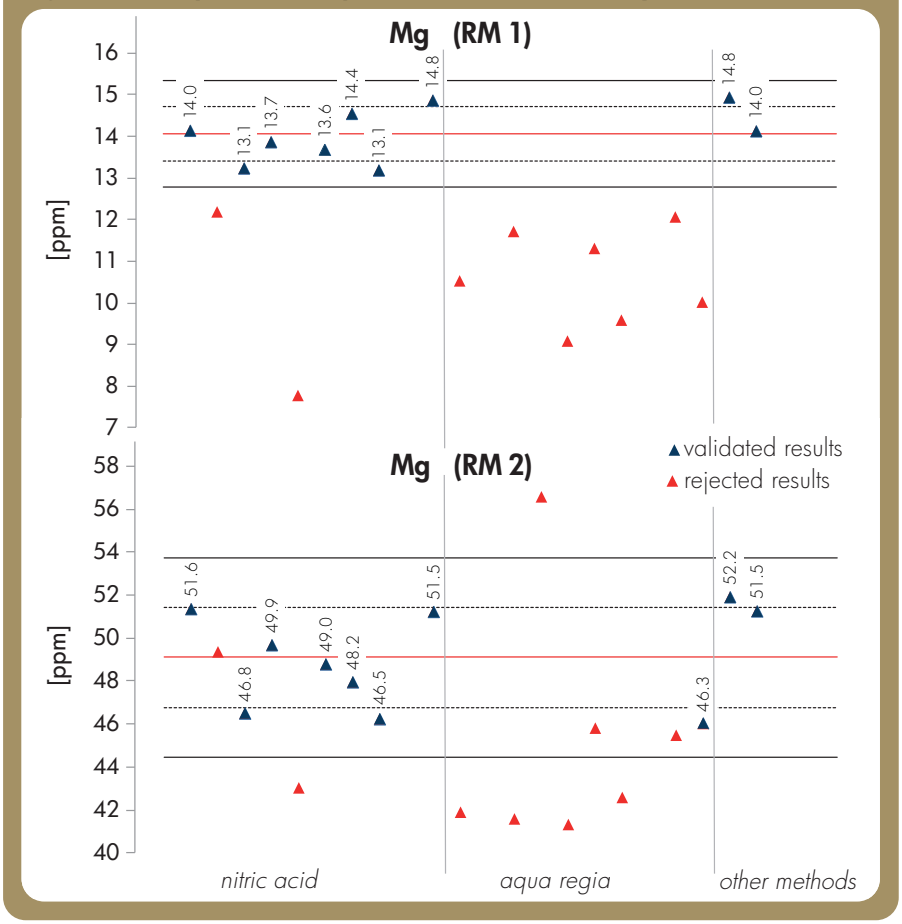
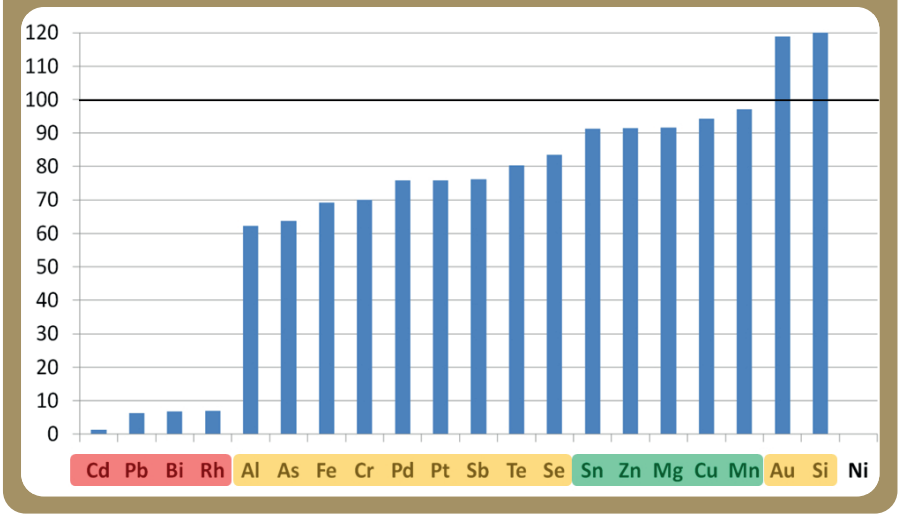


Figure 2 - ISO 15096 Standard Recovery Rate



The dissolution of the solid residue can be performed under pressure. This is mandatory for quantitative measurement of rhodium. If you do not use pressure, you will not dissolve most of the rhodium.

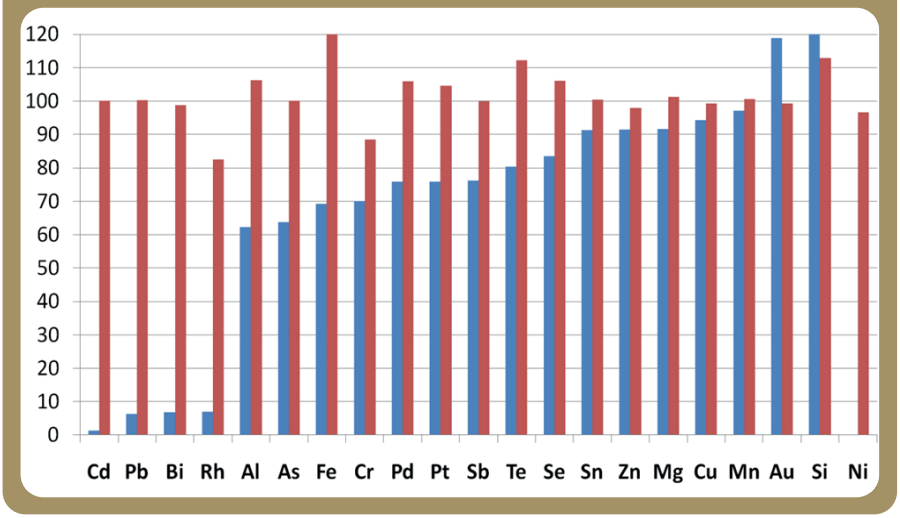
This method is valid for elements that are only partially dissolved, which was the big issue with the two previously used methods.

Recovery Rates

Figure 3 (ISO standard in blue as in Figure 2) shows the results we obtained following the ISO standard, compared with the results we obtained with this new method. You can see that we went from 15 out of 20 elements that were not of acceptable accuracy, to 16 out of 20 giving results of plus or minus 7% relative to the target concentration. We have even improved the method further recently: iron was a little high due to contamination from the pressure vessel, but we have now found alternatives to prevent that.

This method is precise, and most of the results we obtained for the reference materials were accurate with this approach. Of course, this is one technique we developed at Metalor. We have shared it with other members of the Steering Committee, some of them use it, others use their own technique, so it is not necessarily the best technique around, but we have found it effective and relatively straightforward to conduct.

Figure 3 - Recovery Rate using new method vs ISO method



Conclusion

In conclusion, the silver reference materials are important in themselves as the first silver reference materials ever made. However, I think it is even more important that we learned a great deal about the analysis of silver, improving our techniques in the process. Now we have an approach to silver analysis that is completely different and, we believe, much more effective.

The main point is that you can only get good, validated results if you use a combination of two methods. Of course, it takes a little bit more time. You do not need to use this approach for daily analysis, but if you want precise results, this is the way to go.
At the ISO level, we have seen that the ISO 15096 standard (2008 version) is simply not applicable for complex silver samples. In fact, it is basically not applicable for any silver samples. Therefore, we are now working with the technical committee handling the standard and we expect to approve a new standard using the method I have described today.

Jonathan J Jodry
got his PhD at the University of Geneva in 2000 in organic and supramolecular chemistry; he moved then to Japan to the Tokyo Institute of Technology as a JSPS post-doctoral fellowship in the field of catalysis and ionic liquids, before joining Central Glass, a Japanese company that specialises in fluorine chemistry, where he was responsible for development, scale-up and analysis of organic materials used by the semi-conductor industry. He finally came back to Switzerland and, in 2009, joined Metalor Technologies at Neuchâtel, where he is now head of the trace analysis laboratory.

Acknowledgements

I would like to finish with some acknowledgements. First, Dr Paul Bagnoud – I think many of you know him. He retired from Metalor last year, but he initiated this project and his contribution here was tremendous.

I would like also to thank my team, especially Quentin Bochud, our new engineer, who spent three months working exclusively on silver analysis from morning to evening. We have these results because of his work. The other team members, Cyril, Annik and Estelle, also did a great deal of analysis out of working hours to help us to advance.

I would like to thank all members of the silver Steering Committee, especially Mike Hinds. It was extremely interesting to work together at a scientific level, even if some of the companies are competitors. We were able to share detailed scientific knowledge and I think that we all improved our analysis techniques in the process, and will continue to do so. Finally, I would like to thank the LBMA for organising the project and this seminar. ■

LBMA GOLD AND SILVER REFENCE MATERIALS

Contact the Executive for further details and ordering information. For gold, there will be a difference of at least 10 ppm between the concentrations in RM1 and RM2.

Gold Reference Materials

Element	Au-RM1	Au-RM2
Ag	20±10	100±50
Al	10±5	30±15
As	12±6	40±20
Bi	30±15	10±5
Ca	10±5	30±15
Cr	10±5	30±15
Cu	10±5	30±15
Fe	10±5	30±15
Mg	30±15	10±5
Mn	10±5	30±15
Ni	10±5	30±15
Pb	10±5	30±15
Pd	10±5	30±15
Pt	10±5	30±15
Rh	10±5	30±15
Sb	30±15	10±5
Se	12±6	40±20
Si	10±5	30±15
Sn	10±5	30±15
Te	40±20	12±6
Ti	10±5	30±15
Zn	10±5	30±15

Silver Reference Materials

Element	Ag-RM1	Ag-RM2
Al	5-10	20-40
As	20-40	5-10
Au	5-10	20-40
Bi	10	50
Cd	5-10	20-40
Cr	5-10	20-40
Cu	20	100
Fe	5-10	20-40
Mg	20-40	5-10
Mn	5-10	20-40
Ni	5-10	20-40
Pb	50	10
Pd	5-10	20-40
Pt	5-10	20-40
Rh	5-10	20-40
Sb	5-10	20-40
Se	20-40	5-10
Si	5-10	20-40
Sn	20-40	5-10
Te	5-10	20-40
Zn	20-40	5-10

Mass Measurements in the UK

What's in a kilogram?

By Dr Ian Severn, Head, Engineering Measurement, NPL

The following is an edited version of a presentation made at the Fourth LBMA Assaying and Refining Seminar.

The National Physical Laboratory (NPL) is the UK's National Measurement Institute and has been managed on behalf of the Government by a company called Serco for 16 years. The NPL was formed in 1900 and is one of the top three such institutes in the world. A prime function for the NPL is to ensure that measurements made in the UK are equivalent to those made in the rest of the world. Every developed country has an equivalent organisation.

This manifests itself in many ways, from facilitating trade through ensuring something weighed or measured has the correct value associated with it (ie weighing a bag of sugar or trading commodities), through to things like the measurement of the temperature of the earth through satellite observation; making sure that the temperature measured by one satellite systems is equivalent to that measured by another.

Measurement is easy?

Measurement is easy, is it not? We all have a ruler, we all have scales we weigh ourselves on in the morning. If you were to go back 2,000 years, the Romans could do measurement – they were very good at it – it facilitated engineering achievements that remain impressive even by modern standards. An example of this is the water system built to take water to Nimes in France. Over a 50 km distance the height of the waterway changes by less than 17 metres, including the construction of aquaducts such as the Pont du Gard. To get the surveying right, to actually get the water to flow in the right direction over the whole course of it, remains impressive.

It is very easy to become complacent

Indeed even earlier than the Romans, the Egyptians were using measurement to great effect, for example in the construction of the pyramids. However, to underestimate the difficulty of measurement is to ask for problems. In the 20th century the Laufenburg Bridge was constructed between Germany and Switzerland, both extremely impressive, leading engineering countries. Unfortunately when the construction teams reached the middle there was a 54 cm difference in height between the two halves of the bridge. In the UK, about five years ago, a survey of blood pressure measurement was carried out in southeast London: about 30% of all the measurements were actually incorrect, and not incorrect by a subtle amount. They were incorrect by an amount that meant people were getting incorrect medication. So, it is important that people get measurement right, even in something where it looks routine. It is very easy to become complacent about whether a measurement is correct or not.

The Measurement System in the UK

The National Measurement Office, on behalf of the Department for Business, Innovation and Skills, funds four different organisations to deliver the core of the UK Measurement system, shown in Figure 1.

Mass measurement lies within the scope of physical measurement and the UK's mass scale is derived from NPL, where the national mass standard (kilogram 18) is held.

Once NPL has realised the mass scale it is disseminated throughout the UK either directly to industrial users or via accredited laboratories. The United Kingdom Accreditation Service (UKAS) is responsible for ensuring that these accredited laboratories are competent to perform measurements in an appropriate manner.

There has been a lot of investment over many years into this accreditation system, and it is, by definition, the way that all mass measurements should be traceable. Mass is also interesting as it is a base unit meaning that other units of measurement are derived from it, such as pressure, humidity and force. So, we also calibrate items to facilitate that.

The exception to the traceability route outlined above is weights used for trading purposes (legal metrology). In this case the dissemination happens from NPL via the National Measurement Office.

Users of Measurement

Who uses measurement? Industry: for example, a company like Rolls Royce, building jet engines, needs to know that the parts fit together and align correctly, and that the turbine blades are not going to melt in the engine. In medicine NPL provides traceable measurements throughout all the radiography departments in the UK, where cancer is being treated with very precise radiation doses. A further example is in Health and Safety where it is vital to know if a cable used to tether an oil rig can withstand the force that will be exerted on it.

In Europe, it is estimated that between 2% and 7% of gross domestic product is directly related to measurement. It is absolutely a key parameter, and it is essential that everybody gets it right.

Figure 1 - Measurement Organisations

Organisation	Measurement Areas
National Physical Laboratory	Physical and Biological
Laboratory of the Government Chemist	Chemical and Biological
National Engineering Laboratory	Flow
National Measurement Office	Legal Metrology

Mass Measurement

Today, the situation for dissemination of mass measurements in the UK is virtually identical to that of all the other industrialised countries in the world.

The kilogram

Figure 2 shows the International Prototype of the kilogram (a weight that is defined to weigh exactly 1 kilogram and from which the mass of all other weights in the world are derived). It is a cylinder of platinum-iridium that is kept in a vault just outside Paris under two bell jars, to protect it from atmospheric contamination. Around the world, there are about 90 copies of this kilogram. They were made somewhere between 1880 and 2000, in three or four different batches.

This definition of the kilogram dates back to the late 19th century when scientists where seeking practical ways to define the basic measurement units. Considerable thought was given to the choice of artefact in order to make it as stable as possible:

Shape – The international prototype of the kilogram is a cylinder of height equal to its diameter (about 39 mm). With the exception of a sphere, which would be difficult to handle in a safe manner, this shape represents the minimum surface area for a given volume of material. This minimises the chance of contamination on the weight.

Material – Platinum iridium was chosen as it is chemically unreactive and it is dense – so minimising the volume and hence surface area of the weight. It should also be noted that an alloy of platinum-iridium is used as this is much harder than pure platinum. This is important if the weight is to avoid being damaged in use. The material for most of these platinum-iridium kilograms was manufactured at Johnson Matthey in London.

This definition has served us well for over 100 years, but it is not as robust as the definitions of other base measurement units (such as the metre or the second) which are based on fundamental scientific constants (eg the speed of light). The definition means that any change in the mass of the international prototype of the kilogram would change the value of all of the mass scales in the world. Figure 2 shows how the mass of other copies of the kilogram have varied relative to the international prototype. There has been a 50 microgram, or 50 parts in a billion relative change. Given that these copies were made at the same time as the international prototype using the same production methods, there is no sound reason why there should be significant changes in their relative values. If you are weighing pharmaceuticals or if you are measuring very large forces, such as the sort that tether oilrigs, these uncertainties and errors extrapolate and grow. So these anomalies are important.

In the UK, we have three official copies and an unofficial copy of the kilogram, which allows us to ensure that our copy of the kilogram is not changing mass relative to the others.

Improving Definitions

There is a requirement to improve how we define mass. Our current method is good enough for industrial practice because everything is consistent. This is the whole purpose of having an organisation like the NPL. It makes sure that the measurements made in the United States are equivalent to those in Germany, the UK, France, Malaysia, wherever. However, it does not mean that it is right; it just means we all get the same answer because we use the same methods.

Figure 2 - International prototype of the kilogram

It is worth noting that we believe the UK's kilogram has been stable to within 14 micrograms – 14 parts per billion – over the last 100 years. The weight gets dirty even though we keep it in a glass bell jar with a filtered air inlet. It is just an aspect that metal gains weight, as you store it in air, because it gets contaminated. We have systems here we can use to clean this and always have a consistent answer. If you look at most of the weights that have been kept within Europe and North America, they are of a similar performance to that of the UK.

Redefining the kilogram

Within the next five to 10 years, the kilogram will be redefined, and it will be redefined in terms of a constant of nature, probably Planck's Constant. This will remove the reliance on a single artefact that could change over time. There are two ways that this can be done:

Silicon-based kilogram

One of these methods is to use a known weight such as an atom of silicon. If you have enough atoms, you can make a kilogram. So, if you can measure the volume of a sphere made from pure silicon and know all about its surface and know the spacing between the silicon atoms, you can define a kilogram in those terms. It is actually very difficult to do, and work (through an international consortium) has been in progress on this for 20 or 30 years.

An electrical kilogram

Another possibility, which we at NPL like, because we invented the method, is that you can balance the gravitational force on a weight against an electrical force. The electrical force is analogous to an electric motor. A current flows through a wire wrapped around a magnet that generates a force. We know the electrical unit of current and we can measure magnetic fields – or actually we can cancel them out – very well. So, if you can balance that electrical force with a gravitational force, you can define the kilogram in terms of that. This is likely to be the method adopted to redefine the kilogram within the next five years.

There are around five different experiments around the world looking into this. The reason it cannot be redefined at the moment is that, whilst we can achieve quite low uncertainties, they do not agree. We are pursuing experimentation to make sure that the different experiments come together and establish what the true value is. This will probably happen somewhere around 2015-18.

Concluding Remarks

The measurement procedures for precious metals are fine in terms of where they are now, and they have evolved to where they are now such that the requirements in terms of the uncertainty you can achieve in a measurement, the potential error in that measurement, are very closely linked to the technologies used in the weighing process.

The one warning I would give is that if, all of a sudden, you improve one parameter or one method in this – say, for example, you go and use improved balances (which are available) – there is a real risk that you think you are doing things with lower measurement uncertainties than you actually are. When you compare platinum-iridium with a stainless steel weight, it will depend on the density of the air at the time. In the UK, the density changes by about 10% during the year. So, you will get a different answer in the summer, when the pressure is high, than in the winter, when the air pressure is lower unless, you make appropriate corrections. The same is also true if you compare gold with stainless steel weights. As you move to better weighing technologies, you need to take into account these other effects, or you could create a problem going forward. It is just a question of being aware of that and making corrections.

Questions and Answers

Stewart Murray
In the bullion market, we use beam balances and we also use electronic scales. Will the effect that you mention of different air densities affect both of these equally or one more than the other?

Dr Ian Severn
Both equally. The key thing is the difference in volume or density between the standard with which the electronic balance was calibrated and the density of the item you are weighing, so in your case, gold, which is of course much more dense than steel. There is nothing wrong with the procedures at the moment. I suspect that, as with most procedures, they have evolved to a common well-defined place.

Stewart Murray
What is the difference that you could get between the highest and the lowest air pressure, weighing something like a 400 troy ounce gold bar? Are we in the eighth or ninth significant figure?

Dr Ian Severn
No, it is fewer significant figures than that. It is going to be at the fourth or fifth significant figure, potentially – perhaps fifth or sixth.

The other thing that you have to bear in mind that as you are at different altitudes, the air density changes even more between locations. For example, in the UK, the typical air density is about, ignoring the units, 1.2. In Madrid, it is typically about 1.02. So, there is a huge change: 20% or more.

Stewart Murray
When you have got an electronic scale and you take it to Madrid or Colorado, do the manufacturers correct for the altitude and the different gravity in these different places?

Dr Ian Severn
It actually does not matter in terms of the gravity and the altitude: because if you calibrate the scale using a weight in the same location, it all cancels out. So, electronic balances work well wherever; it is just about being aware of the more subtle effects like buoyancy and the air density that are the key things.

Gareth Owen-Jones (Sartorius UK)
It really becomes an issue if you move the balance from one place to another, because if you weighed something here and then took the balance to Mexico City and did not calibrate it, there would be an enormous difference.

Participant
If you weigh something in your own part of the world and then you compare the weight to the LBMA, according to their assaying and their weighing balances, would that have a difference?

Dr Ian Severn
As long as weighing is done correctly, gravity should not make any difference. Whether you are using a two-pound balance or an electronic balance, gravity is compensated for by the weighing process, as long as it is done correctly. The particularly important thing is that the electronic balance should be calibrated in the location where it is going to be used. If that is done, then there should not be a problem. ■

Ian Severn *is head of the Engineering Measurement Division at the National Physical Laboratory, the United Kingdom's national measurement institute. He started his career there 20 years ago as a mass metrology specialist and became Head of the Mass and Density Group. The area he heads includes responsibility for the realisation of the UK measurement scales associated with length, mass, temperature and optical radiation.*

The LBMA Annual Party

at Circus, Covent Garden, started on a high note and went with a swing. Acrobatic performances were enjoyed by Members and Associates and some demonstrated their own skills... More photographs can be seen in the Members' area of the LBMA website.

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Achieving more together

What do Academics Think They Know About Gold?

By Brian M Lucey, Associate Professor of Finance, School of Business Studies, Trinity College Dublin

Over the last decade, gold and other precious metals have been on a remarkable run. In February 2001, when I became interested in the properties of gold as a financial asset, gold stood at about $260 per oz, compared to its price now in the region of $1,500 – a remarkable, sustained and intriguing bull run.

The purpose of this note is to give readers an insight into what academics (think they) know about the economic and financial aspect of the gold market, and therein to perhaps set up what I hope to be a debate on how industry and academia can work together better to gain a greater understanding. There are, as we shall see, relatively few academics working on the gold market. This is puzzling, especially when we compare the torrent of papers that rightly have been published on equity, bond and currency markets. To a great extent, the research being carried out on gold is 'in house' and in what is called 'grey' literature. That does not make it any more or less higher quality than peer-reviewed academic papers, but it does beg a question as to why. One common response that I and others who do research on gold get from fellow academics is, "but why, isn't that the realm of conspiracy theorists and the extreme right". It's fair to say that the academic, and more generally the research community on gold has not managed to persuade the wider community that its work is worthy of attention.

One issue that confronts the researcher when searching bibliographic databases (the main bibliographic databases for academic economic and financial researchers would be Econlit, Scopus and SSRN) is that gold appears as a major research trend in at least three discrete areas. These are the economic and financial aspects of gold (the focus here), gold as a currency (the gold standard, bimetallism and historical uses of the metal), and the nature and impact of gold mining on the environment and on society. Focusing on the first is not to in any way downplay the importance of the other two, but merely to provide a framing for the discussion. In total, close to 700 papers have been published on these areas since 1990. Restricting this further to academic papers on the investment and economic aspects of gold, I was able to identify approximately 200 papers in the area. A full bibliography is available by email, but a number of trends emerge.

There has been a remarkable explosion in research on gold in the last number of years.

First, there has been a remarkable explosion in research on gold in the last number of years. Of the 186 papers I have collated, 26 were published in 2010 or the first quarter of 2011, with a further 40 published in 2008-2009. Given that academic papers typically take six months or more to go from idea to final publication, this indicates that, since 2008, a major research shift has taken place. The implication of this is that the time is now ripe for greater market-academic intervention in a structured manner. In this issue of the *Alchemist*, we see a potential model for this, with the announcement of the LBMA Bursary, a PhD bursary in the economics and finance of the gold market. This model, if more widely adopted, would result within three to five years in the generation of a large body of research on aspects of the market of concern to the industry, the influx into the industry of high-quality researchers trained to the highest modern standard in economics and finance, and the further mainstreaming of gold market research.

Second, there are clear trends in the author and citation patterns, with a relatively small number of authors contributing the most heavily cited and downloaded papers. Thus while there is a growth in the literature, it remains concentrated.

Third, there are a number of common trends in the literature in terms of the locus of investigation. The main areas of academic research are gold as a diversifier, as a hedge against inflation or other assets, and the efficiency of the operation of the gold market. So what do academics know (or think that they know) about these issues?

Perhaps the most studied area is the role and weighting that gold might have in a portfolio. Sherman (1982) suggested a weighting of 5% in an equity portfolio resulted in lower risk and higher return, while weighting as high as 25% has been proposed by Chua (1990), mainly down to the then low or negative correlation between gold and equities. More recent research by Hillier, Draper et al (2006) suggests weights in the small percentages for a variety of precious metals, with gold acting as the most efficient diversifier. Considering gold and oil together, Bruno and Chincarini (2010) suggest a weight of 10% for non-US based investors seeking portfolio diversification, while Scherer (2009) for sovereign wealth funds and Klement and Longchamp (2010) for high net worth individuals suggest an allocation in the range of 5% to 10% by weight to gold in an equity portfolio.

Much of the attractiveness of gold, on reading these and related papers, comes from its low correlation combined with its positive skewness, where there is a greater chance of a, say, 1% rise in one day than there is a 1% fall in any one day. Examining this and explicitly noting that this provides downside risk, Lucey, Poti et al. (2006) examine portfolio choice where the investor is concerned with such downside protection and find an optimal weight of between 6% to 25%, depending on the time period and the other (mainly equity) assets included.

The combination of low or negative correlation and high positive skewness also has begun to attract attention. An asset with low/negative correlation might well act as a natural hedge, while the skewness element might suggest safe-haven properties. However, a hedge asset may not provide safe-haven status. These have been explicitly examined in recent years, with Baur and Lucey (2010) providing the first statistical test of when gold acts as a safe haven and when as a hedge, with Baur and McDermott (2010) extending this to more countries. They find that while gold acts on average as a hedge against equities, it does not do so against bonds, but that it can and does act as a safe haven for bonds as well as stocks, extending its usefulness to investors beyond equity investors.

There is of course a long and detailed research tradition examining gold as an inflation and dollar hedge, with major contributions from Fortune (1987), Moore (1990), Taylor (1998), Ghosh, E. J. Levin et al. (2004), Worthington and Pahlavani (2007) and more recently Blose (2010) and Wang, Lee et al. (2010) on the hedging potential for gold against inflation, and by Johnson and Soenen (1997), Capie, Mills et al. (2005), Tully and Lucey (2007), Sjaastad (2008), Hammoudeh, Sari et al. (2009) and Sari, Hammoudeh et al. (2010) against the dollar. The general evidence is that while it can act as a useful diversifier, this is a long-run phenomena and comes at the cost of increased short-run volatility. There is also very significant evidence that these relationships are quite unstable over time, with slow reversion to the norm.

Much work has also been undertaken by academic researchers on a wide variety of aspects of the operation and efficiency of the gold market. Thus, from Solt and Swanson (1981) through to Diba and Grossman (1984), Ma and Sorensen (1988), Aggarwal and Soenen (1988), Lucey and Tully (2006), Aggarwal and Lucey (2007) and more recently Tully and Lucey (2007) and Lucey (2010), we find significant evidence that the gold market is not efficient, in the sense that there may be exploitable anomalous behaviour. At a more operational level, Baker and Van-Tassel (1985), Tandon and Urich (1987), Ding, Granger et al. (1993), Byers and Peel (2001), Matsushita, Da Silva et al. (2006), Tully and Lucey (2007) and Khalifa, Miao et al. (2011) find that shocks to the gold price take a very long time to dissipate.

The relationships between the various precious metal markets have been examined by Ma (1985), Escribano and Granger (1998), Ciner (2001), Lucey and Tully (2006) and Hammoudeh, Sari et al. (2009), with the general finding being that there is no strong evidence of long-run stability in the relationship. The effect of macroeconomic information on gold has been examined by Tandon and Urich (1987), Christie-David, Chaudhry et al. (2000), Tully and Lucey (2007), Batten, Ciner et al. (2010) and Roache and Rossi (2010), who find two stylised facts: first, the dollar-gold relationship is strong; and second, there is no consistent set of macroeconomic factors that appear to influence all precious metal markets in a similar manner. The relationship between gold and oil has recently attracted attention, with Baffes (2007), Sari, Hammoudeh et al. (2007), Cheng, Su et al. (2009), and Zhang and Wei (2010) finding mixed evidence as to the influence of oil on gold and vice versa.

Overall, therefore, there is a rich and rapidly growing body of research on the gold market. The research remains small scale, compared to the work on equities or bonds or FX, which is not representative of the importance of the precious metal markets actually or prospectively. ■

See next page for references.

Brian M Lucey is a professor of finance at the School of Business at Trinity College Dublin, where he is director of the MSc Finance programme. He studied at graduate level in Canada, Ireland and Scotland, and holds a PhD from the University of Stirling. His research interests include international asset market integration and contagion; financial market efficiency, particularly as measured by calendar anomalies; and the psychology of economics.

LBMA PhD Bursary

The LBMA is delighted to congratulate Mr Fergal O'Connor, the recipient of the first LBMA PhD bursary at Trinity College Dublin.

Fergal holds an MSc in financial economics from University College Cork, where he has also lectured. His precious metals research interests include the OTC market, pricing precious metal derivatives and hedges and havens. He will undertake his research with Professor Brian Lucey at Trinity College, Dublin.

The LBMA Executive will organise a series of meetings during the summer so that he can hear more about the bullion market and the interests of LBMA Members.

Ruth Crowell, LBMA Commercial Director and Professor Lucey celebrate the award of the bursary

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Not Seeking Perfection

A confusion of aims in Good Delivery

By Stewart Murray, Chief Executive, LBMA

George Orwell, in his essay REFLECTIONS ON GANDHI, suggested that "the essence of being human is that one does not seek perfection". This also applies to Good Delivery bars.

In recent years, there has been an increasing level of interest in the physical quality of the large bars, both gold and silver, which are acceptable for storage in the vaults of the London bullion market. Some of these bars may reside in the vaults for only a short period before being sent to refineries for conversion into smaller bars (e.g. gold kilobars) or to fabricators for conversion into coins, jewellery, silverware or products for the electrical and electronic industries. However, in recent years, an increasing number of bars have been accumulating in the vaults because of the resurgent interest in precious metals on the part of investors. These investors are of various types. They include official sector participants, i.e. central banks, as well as private sector investors such as institutions, exchange traded funds and high net worth individuals. The metal purchased by many of these investors is held on an allocated basis, which means that individual bars are allocated to the investor who is then the owner of that bar. This is in contrast to the unallocated holding of precious metals where the investor merely has an entitlement to a certain number of troy ounces with the gold or silver being physically held by the bank or financial institution which is providing the account. It is perhaps this physical ownership of Good Delivery bars by investors, even though the bars are held by the various professional custodians in the London market, that has brought the question of bar quality to the fore. This was reflected in the programme for the recent LBMA Assaying and Refining Seminar in London. This included two presentations on physical quality, one from a vault perspective by Tony Evanson of Barclays and the other from a refiner's perspective by Serge Gambs (now a consultant who formerly worked for Metalor in Neuchâtel).

The LBMA's recent publication on the history of the Gold Good Delivery List back to 1750 showed how the rules on physical bar quality have evolved. It is not so much that the required standards have been raised, but rather that more and more words have been used to explain what is acceptable and what is not. The fundamental requirements for a Good Delivery bar have not changed at all and can be stated rather simply. Bars should be:

- safe to handle (i.e. no sharp edges);
- securely stackable (flat bottom surfaces, no wedge-shaped bars);
- of constant weight (e.g. no friable sharp edges which can cause a loss of metal or excessively indented marks or cavities which can cause an accumulation of dust, etc.);
- free from significant cracks, especially those that could indicate the presence of an internal cavity where water could be trapped;
- free from holes for the same reason; and free from layering (horizontal striations on the sides), though minor amounts of layering can be tolerated.

In relation to the markings, these have to:

- be clear and unambiguous;
- be durable in terms of handling in the vault; show the fineness to four significant figures (in the case of gold); and
- allow the bar to be uniquely identified (using a combination of the company's logo, the bar number and, if separate, the year.

Bars that conform to the above requirements will be accepted in the London markets as long as they have been produced by a refiner that is accredited by the LBMA and whose name and bars are included in the current version of the Good Delivery List.

The vault managers in the London system each have a responsibility to their owners to ensure that all the bars they accept for storage will meet the LBMA's physical requirements. In other words, they will reject bars that are defective. The immediate question is what is a defect (which we may define here as being a physical feature that is likely to result in a bar being rejected by a vault manager) and what is an imperfection (namely a minor deviation from what might be regarded as a totally perfect bar). Another term – 'artefact' – is also useful here. The dictionary definition of an artefact is something man-made. Some artefacts merely reflect the fact that metals are crystalline. For instance, when high-purity gold is cooled slowly, large individual crystals can often be seen on the top surface, leading some observers to conclude (wrongly) that they are some kind of defect.

Modern refiners generally take great care in the casting of their bars, but it is unfortunately a fact that some of the gold bars cast many years ago, particularly in the inter-war period in the United States, suffered from the fact that the refinery managers were under pressure to recast huge quantities of imported gold and the standards of quality control during the casting operation often suffered accordingly.

Today, many refiners take great pride in producing bars that are almost of jewellery quality – perfectly flat sides and bottom surface, with almost no discernible shrinkage on the top surface and a complete absence of the smallest imperfection. But this does not of course represent the minimum requirement that a Good Delivery bar must meet. Rather, GD bars are mass-produced articles, used as a means of storing value, and must therefore meet the basic requirements listed above. As long as the bars do satisfy these requirements, the vault managers in London will exercise pragmatism in deciding which small imperfections will be tolerated. There is no need for gold and silver bars to look as if they had been produced by Fabergé.

> ***"A perfection of means, and confusion of aims, seems to be our main problem."***
>
> ***Albert Einstein***

The process of producing a Good Delivery bar looks deceptively simple. The metal is melted, usually in an induction furnace (which may be capable of melting enough metal to cast 10 or 20 bars) and is then poured into an open mould made of cast iron or graphite. The LBMA banned the use of gated moulds (otherwise known as closed moulds) in 2008. Gated mould systems involve casting vertically into a cast iron mould with multiple chambers, usually three, which are closed by a gate, with the metal being fed through a gating system at the top. These were formerly used by refineries, particularly in China, and they had the advantage that the bar had a perfectly flat top surface. The problem with this casting system was that it was possible for the metal to solidify in the gate before the mould chambers were completely filled. This could result in

very large internal voids that were not always easily detected after the bar was removed from the mould and the casting sprue cut off.

With open mould casting, good physical quality depends on optimising the various casting parameters: preheating of moulds to the right temperature; the temperature of the molten metal; the most appropriate mould dressing; and the pouring speed. The mould dressing, which helps protect the mould from the stream of molten metal and which facilitates the removal of the solidified bar, can be of various types ranging from proprietary suspensions of refractory chemicals to carbon black, which is applied to the mould using a smoky acetylene flame. Mould dressings which can result in residual moisture in the mould may give rise to reactions with the molten metal, leading to the production of significant amounts of internal porosity. Pouring speed is another important determinant of bar quality. If the pouring speed is too low and particularly if the moulds are insufficiently heated, layering is likely to result. If layering is pronounced, to the extent that there are deep horizontal striations which can entrap dust or dirt between them, this will be grounds for rejecting a bar. There is often a small degree of layering in some bars, which will be acceptable.

In contrast to water, which expands when it freezes, gold and silver both contract by around 12%. This has important implications for bar casting. Given that the mould temperature is well below that of molten metal, the first part of a bar to solidify will be on the bottom and sides of the mould. As the metal then shrinks on solidification, the result is a depression on the top surface – sometimes with pronounced shrinkage rings, which are formed as the solidification front advances. Preheating the moulds effectively and applying a flame to the molten surface of the metal immediately after casting can moderate the amount of shrinkage and results in only a small depression on the top surface. At the other extreme, however, if there is insufficient metal left in the final stages of solidification, a shrinkage cavity (sometimes described as a crack) can form down the middle of the top surface of the bar. Cavities like this will always result in a bar being rejected because they can contain debris or even water (the latter having potentially disastrous consequences when such bars are remelted).

Moulds do not last forever. Cast iron is a very brittle material and the thermal shock experienced on the bottom of the mould where the stream of molten metal hits the mould surface will eventually result in the formation of a crater with the mirror image of a nodule being formed on the bottom surface of the bar. Initially, such protrusions are hardly noticeable but as the crater increases in size and depth, eventually there comes a point when the nodule will be so large that the bars will not stack safely. The shrinkage depression on the top of a bar actually allows for a minor nodule to be accommodated within it without affecting the stackability of the bar.

Some Typical Defects and Imperfections

One of the most common bar imperfections is known as a 'button'. This is often found on the bottom surface of a bar and it is thought to result from the presence of a film of air between the molten metal and the mould, which then collapses into a circle before escaping as a bubble and leaving behind a discernible, approximately circular area (see Figure 1) which is however clearly innocuous and requires no further investigation during inspection. However, in some cases, the formation becomes more plug-like in appearance (see Figure 2) and even though the explanation is almost certainly the same, vault managers will not take the chance in case this

Figure 1 - "Button"

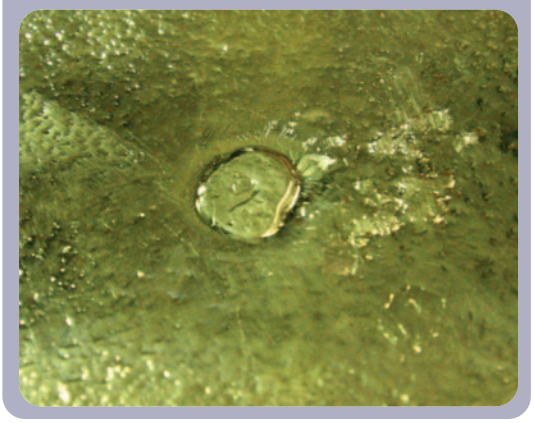


Figure 2 - Plug-like "button"

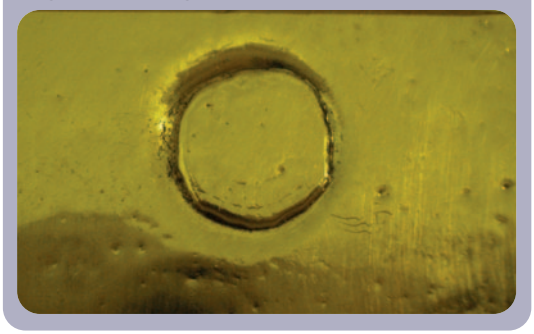
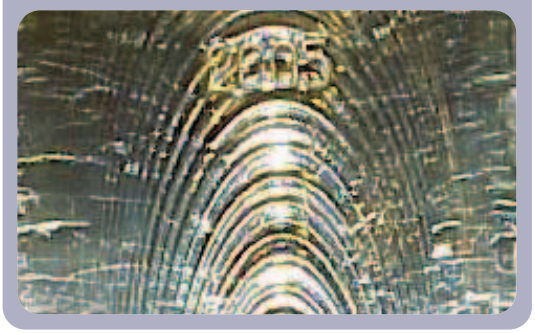


Figure 3 - Shrinkage affecting bar marks



really is a plug with some foreign body inserted in the metal underneath it. They will therefore investigate such plug-like features by means of an ultrasonic probe. Although effective, this is a time-consuming process and vault managers may exercise their discretion to reject whole batches of bars if they are found to contain a substantial number of plug-like defects.

The shrinkage depression is in itself a normal feature of a gold or silver bar cast in an open mould. However, if it is very pronounced, it can cause interference with the marks on the surface (this is particularly the case if the bar number or assay mark is positioned in the centre of the bar) and this may be grounds for rejection. The same thing applies if the shrinkage rings are very pronounced (see Figure 3) to the extent that it tends to make the bar marks difficult to read. On the other hand, vault managers will accept bars where the company stamp is partly missing as long as there is no doubt about the identity of the bar's manufacturer.

Holes of various types can be found on bars. They may result from some kind of interaction – for instance on the bottom surface due to the mould dressing, which often can be seen in the form of a honeycomb effect. On the top surface of silver bars, quite large holes may be found due to the fact that gases such as oxygen and nitrogen can dissolve in molten silver and are evolved during the final stages of solidification. Small shallow holes where there is no danger that something more profound is disguised will be acceptable, but the smallest pin hole may in fact lead to a larger internal cavity, and these will always be investigated and may therefore be grounds for rejecting a bar.

Health and safety considerations have become increasingly important in recent years and one important feature of bars that may cause a problem here is sharp edges, which may be produced for instance by grinding the top surface to improve its appearance or even sometimes by hammering. If a bar cannot be handled safely, it will be rejected. Hammering is a practice which was formerly used to remove or disguise surface defects. While reducing small asperities with a hammer may be acceptable, if its use is widespread on the surface of a bar, it is more than likely that this will be grounds for rejection.

The marks on a Good Delivery bar are obviously a vital requirement for an efficient vaulting operation. There are many ways in which marks can be inadequate to the extent that a bar will be rejected. The marks may be:

- missing (for instance an assay mark on a gold bar that only shows three digits would not be acceptable, as would a bar with a missing number or year stamp)
- shallow (which means that the mark is insufficiently durable to withstand any movement and restacking). For this reason, laser marking is not permitted and dot matrix pneumatic punching of the marks on the top surface will only be allowed if the resulting marks are at least as durable as those produced by conventional punching. On the other hand, dot matrix punching on the end surface of a bar, which is not subject to wear and abrasion in the vault, is more easily accomplished).

Tampering with any of the main marks (bar number, assay or year) will result in a bar being rejected. This includes overstamping to correct a previously applied incorrect number.

One imperfection which is tolerated is where a double image of a company logo has been produced by double stamping with the two stamps being slightly offset (as long as there is no doubt about the identity of the bar).

Future Work

At the 2009 conference, the LBMA circulated a Visual Guide to the Acceptability of Good Delivery Bars. Much of this focused on old US gold bars. Work on a second edition, which includes a wider coverage of different defects, including more silver defects, is underway. Any comments or questions on the above issues from refiners would be welcomed. ■

Regulation Update

Adding Gold to Europe's Liquidity Buffers

By Natalie Dempster, Director of Government Affairs, World Gold Council

The capital-adequacy requirements set out in the third Basel banking supervision accords, endorsed by G20 leaders in November last year, are a crucial means of preventing a repeat of the liquidity crisis that occurred in 2008.

There is, though, room for improvement in the design of the proposed rules. The rules would require banks to hold buffers of high-quality liquid assets, designed to cushion them from acute short-term funding strains. While the proposals are clearly a significant step forward in ensuring such strains are avoided, the definition of liquid assets is too limited: as they stand, the proposals only permit banks to hold cash, high-quality government bonds and high-quality non-financial corporate and covered bonds (the latter two with a 'haircut' – a discount – to reflect their higher credit risk).

In a world of hugely elevated sovereign-debt risk, there is a real danger that under the existing proposals banks would become overly dependent on government bonds for liquidity. In the last crisis, sovereign bonds were far from immune to liquidity issues, and given the current record levels of Western government debt and ongoing concerns over sovereign-debt downgrades (or even defaults), a repeat of this scenario would pose a real risk to the liquidity provisions.

This issue could be remedied with added asset diversification. The more assets eligible for inclusion in the liquidity buffers, the less distortion the new regulations will cause in any one market and the lower the concentration risk for commercial banks.

The ultimate high-quality liquid asset is generally considered to be gold. That is because gold bears no credit risk: it involves no counterparty and is no one's liability. The risks associated with it are not correlated – not related – to the risks of other financial assets, making it an effective diversifier, a characteristic underpinned by its uniquely diverse demand base. At the height of the 2007-09 liquidity crisis, it was used extensively by fund managers to raise the cash necessary to meet margin calls – to add cash to their account with their broker – and to pay redemptions in order to stay in business. To date, however, gold has not been included under Basel III's liquidity proposals.

The Institute of International Finance summarised the curious nature of gold's omission when, last April, it submitted comments on Basel III: "It is striking that gold is not recognised as having liquidity value, whereas gold is virtually always liquefiable for cash and tends to benefit from a perceived 'safe haven' status".

The bottom line is that more debate is needed, as the current standards are short-sighted. In Europe, the European Commission, under the leadership of Michel Barnier, commissioner for the internal market, has begun work on the fourth capital-requirement directive (CRD IV), which will transpose Basel III into draft law. That will be reviewed by the European Parliament rapporteur Othmar Karas and the members of the European Parliament's economic and monetary affairs committee. There is still time to amend the regulation to reflect a reality recognised by government treasuries and individual households for centuries – that in bad times, as in good times, there is a market for gold. ■

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LBMA News

By Stewart Murray, Chief Executive, LBMA

MEMBERSHIP

Members

Fortis Bank SA/NV and RBS Sempra resigned as Members effective 31 December, 2010 as their desks were taken over by BNP Paribas and JP Morgan, respectively.

ABN AMRO N.V. also resigned effective 31 December, 2010 as they closed their bullion desk.

Associates

On 21 March, Aster Commodities DMCC was admitted as an Associate.

On 28 March, World Gold Trust Services was admitted as an Associate.

Most recently on 6 April, Kuveyt Türk Katilim Bankasi A.Ş. was admitted as on Associate.

SGS Group resigned their Associate status as they would be unable to provide renewed sponsorship for their upcoming Associate review. The LBMA requires Associates to renew their sponsorship every three years, either through the original sponsoring companies or, if the Associate is no longer doing business with them, with new sponsors. Korea Zinc resigned their Associate status effective 31 December.

These changes brought the membership list at 6 April to a total of 123 companies, comprised of 59 Associates, 4 Affiliates and 60 Members.

GOOD DELIVERY LIST

The silver refinery of the Royal Canadian Mint, was added to the Silver List on 14 April, 2011. The company's gold refinery was listed in approximately 1919.

COMMITTEES

Management

The Management Committee met twice in the first quarter of 2011. As usual, the Committee's work largely consists of reviewing the reports from the Sub Committees and making decisions based on their recommendations.

Recognising the important role played by Ordinary Members in the work of the LBMA and in the market more generally, the Committee proposed to create an additional place on the Management Committee for a representative from an Ordinary Member. This would create a nine-person LBMA Management Committee consisting of five Market Makers, four Ordinary Members and the LBMA Chief Executive. The Committee also proposed that terms for Management Committee members be extended to two years instead of one, to ensure continuity in the membership of the Committee. These proposals were discussed and approved by an Extraordinary General Meeting of LBMA Members held on 12 April. All Committee members will step down at the AGM in June 2011 and the two year term for the Market Maker representatives will begin with effect from the election at that meeting. The Ordinary Members elected at the 2011 AGM will have a term of only one year. Thereafter, the two groups will stand down after alternating two-year periods.

The Committee approved the PAC's recommendation to donate to the British Red Cross – Japan Tsunami Appeal. The funds used for the donation derive from the fines which the Executive levies on Market Makers which fail to contribute to the daily GOFO and SIFO figures.

The Committee also approved the PAC's recommendation to provide a Bursary to Fergal O'Connor, a PhD student at Trinity College, Dublin. For further information, please see the announcement on page 13.

Regulatory Affairs

In response to the growing number of regulatory issues facing the bullion market, the Management Committee has set up a new standing committee of the LBMA, the Regulatory Affairs Committee. This Committee is chaired by Ed Wells of HSBC, with representation from the Bank of Nova Scotia – ScotiaMocatta, Barclays Capital, Deutsche Bank, Goldman Sachs, JPMorgan, Metalor and UBS. The Management Committee will be represented on the new Committee by Simon Churchill. Barbara Ridpath of the International Centre for Financial Regulation also accepted an invitation to join the Committee.

The Committee's primary tasks are to discuss and disseminate to the membership information on regulatory issues facing the bullion market as well as to recommend a response from the Association where appropriate. The Committee has met twice in the first quarter of 2011. The first meeting focused on responding to the US Securities & Exchange Commission (SEC) consultation paper on conflict gold regulation.

The Committee also discussed possible EU & US regulation of OTC derivatives. For more on regulation issues facing the precious metals market see the regulation update on page 18.

Physical

The Committee met three times in the first quarter of this year. In spite of the substantial number of companies achieving GD accreditation last year, there are still many gold and silver refiners which are hoping to achieve GD status. The Committee has spent some time discussing vault procedures as well treatment of button defects or "imperfections". This topic, among other, will be discussed at a meeting of vault managers in mid-May. For more on the assessment of bar imperfections in London, please see the article on page 15. This topic was also discussed at the 2011 Assaying & Refining Seminar (page 2). Another important topic relates to the levels of impurities in GD bars that are considered to be deleterious. The Committee has asked the Referees group to look into the question of whether these levels can be quantified for the guidance of GD refiners.

Charitable Giving 2011

As noted above, the LBMA Management Committee approved a donation to the Red Cross - Japan Tsunami Appeal.

Japan's important role in the international bullion market, from technical expertise to retail, is widely known. 10 gold and 13 silver Good Delivery listings are evidence of this. Many Members will remember the 2008 LBMA Conference in Kyoto. Our thoughts remain with our many friends living and working in Japan as they rebuild. In his editorial over the page, Bob Takai describes the atmosphere in Tokyo after the tsunami and the effects on the market.

Suggestions of charitable funds are welcome from all members of the market.

Public Affairs

The PAC has met four times in the first quarter of 2011. The primary focus of the first two meetings was on speaker selection for the LBMA Bullion Market Forum: Shanghai on 26 May. This Forum focuses on issues in the bullion market in China of interest to market participants both in China and in countries that trade with China. For more information, please see the announcement on page 18.

Most recently, the Committee has worked on the speaker programme for the LBMA's annual precious metals Conference, which is to be held this year in Montreal, Canada during the period 18-20 September. The LBMA is delighted to be working with the LPPM again in the arrangement for this premier industry event. The LBMA will also be working with the LPPM during the London Precious Metals session at the IPMI Conference in June.

Membership

The Committee met once during the past quarter when it discussed a new sponsorship regime for Member and Associate applications. The new system follows the Associate Review system by putting the onus on the applicant to ensure that letters of support are provided in good time by its sponsors. The Committee's main activity is of course vetting applications for membership and making recommendations to the Management Committee. As is implied by the list of new Associates above, this work is carried out mainly by email.

Finance

The Committee met in January to review the three-year forecast for income and expenditure. It also met in March to discuss the results of the annual audited accounts for 2010, which showed a substantial surplus mainly due to the success of the 2010 Conference in Berlin.

LBMA Annual General Meeting - 5.30pm on 22nd June

Armourers' Hall, London

The twenty-third AGM will take place at Armourers' Hall, Coleman Street in the City of London at 5:30 pm on 22nd June. All Members and Associates are cordially invited to attend. This will be an ideal opportunity to find out about the activities of the LBMA in the past year as well as to meet other Members during the drinks reception following the meeting.

The formal papers for the meeting (including nomination forms for the Management Committee) will be circulated in May to the LBMA contact at each Member and Associate company. All members of the Committee stand down at this AGM but may be re-elected.

Data Commercialisation

The LBMA's eight Forward Market Makers have committed to creating a Silver Forward Curve. The Market Makers will contribute their forward prices for silver at the close of business each day, consisting of 10 data points covering the period from one week to three years forward. The Market Makers have also committed to the creation of a Gold IRS Curve. The Market Makers will contribute their gold IRS prices at the close of business each day, consisting of 10 data points covering the period from one to 10 years forward. The data will submitted to the LME system as with the existing gold forward curve. The LME system will remove the high and low contributions for each of the 10 tenors and calculate the mean of the rest, which are the figures that will be published on Bloomberg, Thomson Reuters and others. Both the Silver Forward Curve and the Gold IRS Curve will be available in May 2011. ■

DIARY OF EVENTS

MAY

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LBMA Bullion Market Forum
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F: +44 (0)20 1196 2112
varsha.peiris@lbma.org.uk
www.lbma.org.uk

JUNE

11-14

IPMI 35th Annual Conference
San Antonio
T: +1 850 476-1156
mail@ipmi.org
www.ipmi.org

22

LBMA AGM
Armourers' Hall, London
T: +44 (0)20 1196 3067
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varsha.peiris@lbma.org.uk
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SEPTEMBER

18-20

LBMA Precious Metals Conference 2011
In association with the LPPM
Montreal
T: +44 (0)20 1196 3067
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Editorial

Editorial Comment by Bob Takai, General Manager, Energy Division, Sumitomo Corporation

At 2:46 pm on 11th March…

…I was at Sumitomo Metal Mining's office in Shinbashi, Tokyo to say greetings and to announce my change of assignment from 1st April. I was with James (Iwanaga) who was just about to ring upstairs from the ground floor lobby to say that we had arrived at reception.

Suddenly the earth shook rather strongly, in a way that I hadn't experienced before. I shouted to James, "James, an earthquake. Big one." He shouted back to me, "Bob, the phone is dead. This must be a very big one. We've got to run."

We dashed out of the building into the street. The tremor got bigger and bigger. I could see people getting out from the nearby buildings, all with scared faces, and all saying to each other that this earthquake is clearly different from the usual ones.

In the Shinbashi business district, there are many "pencil buildings", less than 10 stories high, built side-by-side on very small patches of land. Those buildings were shaking like trees being blown by a strong wind. The earth beneath my feet trembled even more strongly – I could hardly stand without holding onto the trees on the street. I felt like I was in a film in which Godzilla was walking down the street making the ground shake with each step.

After the initial tremor, which lasted for about a minute or two, we finished our scheduled meeting swiftly and started to walk towards the JR Shinbashi Station. We soon realised that our cell phones were dead. Almost everyone on the street was holding their phone in their hands, mumbling that it didn't work.

We came to a square where there is a big TV screen attached to the side of a building. On that sunny Friday afternoon around 4 pm, we saw horrifying scenes unfolding live on the screen. A flood of water was sucking in roads, bridges, cars, houses and people. I couldn't believe my eyes, thinking this must be a nightmare or some Hollywood disaster movie.

We decided to try to find somewhere where we could get more information about what was really going on, so James and I walked to the Shinbashi Daiichi Hotel, where we found the lobby full of people gathering information. Finally we found out that a mega earthquake had hit the northeast region of Japan, and a giant tsunami had swallowed the cities on the coastline. James luckily spotted a desk-top PC available for hotel guests and we finally connected to our office via email.

We found that our colleagues were stuck in the office on the 34th floor and the lifts were not working. We also discovered that all metropolitan transportation – trains, underground and buses – had stopped operating, and the streets were full of cars and taxies trying to escape from the city. Our employer soon announced that all employees should leave the office before it got too dark and cold to walk. Many of our colleagues walked down the stairs to the ground floor before marching much further back home to wherever they live.

James and I also had no other choice but to walk home. It was already around 6 o'clock on a Friday evening, the most pleasant time of the week under normal circumstances. The streets were full of people like us. They all looked so exhausted that they didn't even have the energy left to mourn their most unpleasant fate. We walked for about 4 hours, reaching home at around 10 pm, but we were the lucky ones because others who lived too far away to walk home had to spend a night in the office.

About a month and a half has passed since that tragic day. We now know that some 28,000 people are dead or missing and 4,900 people injured – mostly in the northeast region of Japan, which was hit by this magnitude 9.0 mega earthquake and the subsequent tsunami. To make matters worse, we have another crisis at the Fukushima Daiichi atomic power plant, where the vital fuel cooling system has been badly damaged by the tsunami and has leaked dangerous radioactive substances into the air and ocean. The beautiful coastline of the Fukushima Prefecture, about 240 km north from Tokyo, is facing the danger of being contaminated by nuclear substances.

Tokyo Electric Power, the owner/operator of the power plant, is now trying to contain the nuclear spill-over with the help of the Japanese government, but the severity of the incident has been raised to Level 7, which is the highest possible and as bad as the Chernobyl nuclear explosion of 1986. The battle with the radiation leakage is still going on and I do hope the whole mess will be sorted out as quickly as possible.

From the day the earthquake hit, there were outflows of money and people from Tokyo. A number of foreign companies, banks and embassies shifted their staff to cities in the western part of Japan like Nagoya, Osaka and Fukuoka or even transferred them to Hong Kong and Singapore.

Money also flooded out from Japanese Exchanges, including from commodities. TOCOM Platinum was hit by heavy selling from abroad. The price plunged from $1,790 to $1,660 within a week, and the forward premium also collapsed from $22/oz to only $2/oz. The Open Interest of TOCOM PT fell by as much as 37% from 62,000 contracts to 39,000 in just over a month. TOCOM Gold was also sold by foreigners and the Open Interest dropped by 19% from 120,000 to 97,000 by the end of March. The gold forward premium also plunged from $6/oz to $2/oz.

On the physical side, many base metals refineries were hit by the earthquake and tsunami. The domestic supply of silver, zinc and lead has been affected. The manufacturing plants of some Japanese car makers have also been damaged and some PGM supply contracts were said to have been cancelled during March.

Though we still have lots of things to do in reconstructing the damaged area, we believe this crisis could be an opportunity to change our society for the better. As the old Chinese proverb says: "Misfortune can be turned into a blessing".

Last but not least, I must tell you that in April I leave the bullion market after 31 years of involvement. My new assignment in Sumitomo is to head the Energy Division, where I will run the upstream oil and gas exploration business as well as the mid/downstream trading business. The assignment is quite challenging for me in the face of the ongoing nuclear disaster and the anticipated change in the structure of the Japanese energy market.

I would like to take this opportunity to thank all of you in the bullion market. It has been a pleasure as well as an honour for me to be part of the market for so long.

Arigato to all of you and Sayonara LBMA ! ■

Silver Industrial Demand Outlook Looks Bright

By Michael DiRienzo, Executive Director, The Silver Institute

Silver's industrial demand has greatly expanded its role in the global silver market in recent years. A number of factors have played a crucial factor in this growth, not least of which is silver's unique technical proficiency, which makes it suitable for a wide range of applications while also limiting the ability of industrial users to shift in favour of less-costly alternatives.

Silver is one of the best electrical and thermal conductors, which makes it ideal for a variety of electrical end uses, including switches, multi-layer ceramic capacitors, conductive adhesives, contacts and in silvered film in electrically heated automobile windshields. Silver is also used as a coating material for optical data-storage media, including DVDs. Silver is employed as a catalyst and used in brazing and soldering as well. It is also incorporated into health and medicinal applications given its natural antibacterial qualities.

You'll find silver in many of the electronic devices we use today, including cell phones, plasma-display panel televisions, personal computers and laptops. Silver is also incorporated into button batteries, water-purification systems, automobiles, and it is a component of the growing photo-voltaic industry, to name just a few of its applications.

Putting silver industrial demand growth into perspective (Figure 1), in 1990 it stood at 273 million troy ounces (Moz), representing a then respectable 39 percent of total fabrication demand. By 2000, the world total had grown by 100 Moz and saw its share exceed 40 percent for the first time. After the technology bubble burst in 2001, with silver industrial demand suffering a setback as a result, industrial offtake grew uninterrupted for the following six years. Although silver industrial demand declined after the global economic crises that began in 2008, by 2010 industrial demand had already recouped most of the lost output.

In fact, a healthy outlook for global silver industrial demand is forecast for the next five years according to a recent report. The report, *The Future of Silver Industrial Demand*, was produced by the precious metals consultancy, GFMS Ltd., on behalf of the Silver Institute, and it examines silver's industrial uses in detail through 2015.

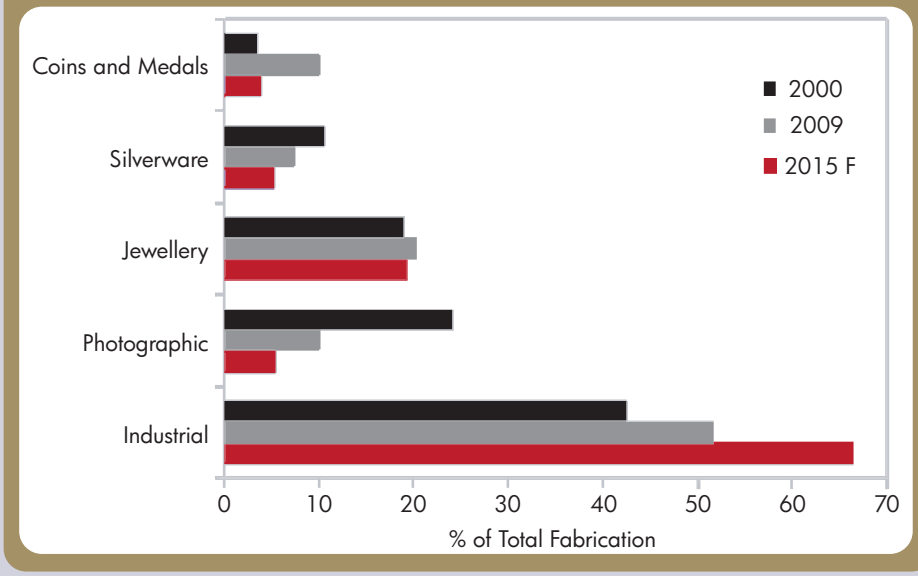
The report states that industrial uses of silver should rise sharply to 666 Moz in 2015, representing 60 percent of total fabrication demand that year – a 36 percent increase over 2010's figure of 487 Moz. The report maintains that stronger silver industrial demand in the US and Asia will be a key factor in driving growth in the global total through 2015, and healthy developing country demand especially in markets such as China and India will also be an important factor. Much of the forecast growth will come from established applications, such as silver's use in electrical contacts and in the photo-voltaic market.

The report also focuses on many new uses that rely on silver's antibacterial qualities, where the incorporation of silver makes the difference between an ordinary product and a unique one. Noteworthy in the report is the potential market impact of 11 recent applications that incorporate silver. These uses, which range from food packaging to radio-frequency identification tags to autocatalysts, taken together could exceed 40 Moz of industrial demand by 2015. Emerging end uses that benefit from silver's antibacterial properties or incorporate silver's electrical and thermal conductivity are expected to boost silver consumption through 2015.

The report demonstrates how buoyant silver industrial demand is, not only because of the lack of substitution, but also because of the wide range of established and growing new uses that make up industrial demand. ■

The Silver Institute is a non-profit international industry association headquartered in Washington, D.C. Established in 1971, the Institute serves as the industry's voice in increasing public understanding of the value and many uses of silver.

Figure 1 - Industrial Demand's Growing Importance



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