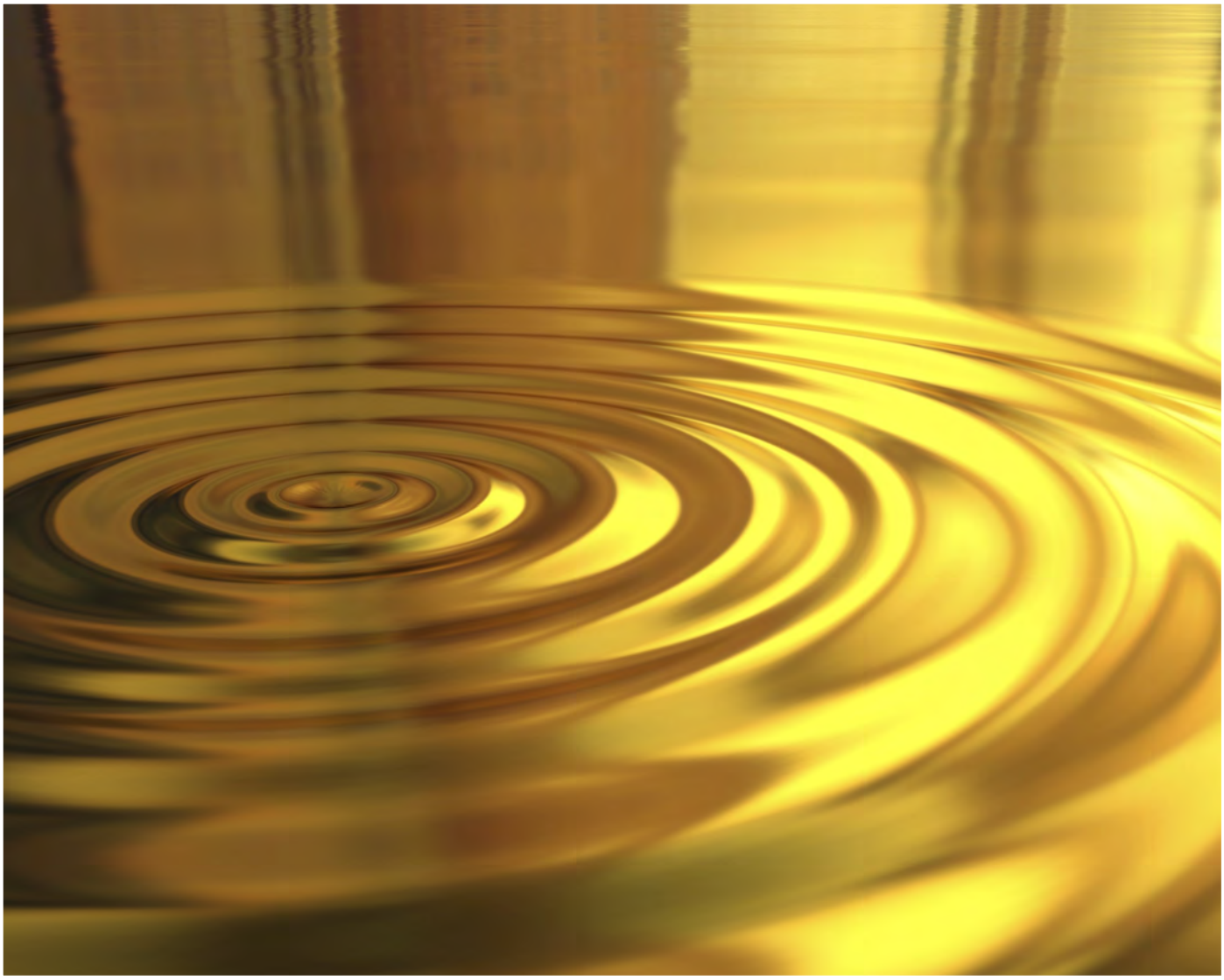


Gold

The value of gold and other metals

Mining sector report, February 2015

Published by Edison Investment Research

EDISON

The value of gold and other metals

The alchemy of finance: Turning yellow metal into yellow cake (and vice versa)

Metals & mining

5 February 2015

'The meek shall inherit the earth, but not its mineral rights.'

John Paul Getty (attrib)

Smartly targeted exploration investment critical…

Investors should be careful what they wish for however, given that, in the last year, the average value of an in-situ gold ounce has fallen by almost half, to US$10.06/oz. As a result, the business of converting cash into in-situ resources will, on average, return 14% to investors currently compared to an estimated 1,773% at the height of the cycle, with only the upgrading of Inferred resources to Indicated typically being value adding (albeit this is market dependent). Overall, exploration is similarly value destroying in the uranium sector, although (unusually) upgrading Indicated to Measured status is value adding, whereas upgrading Inferred to Indicated status is not. Of the markets for which we have calculated or imputed costs of discovery (gold, uranium and PGMs), only exploration for platinum group metals was shown to be value adding across both the Indicated and Measured resource categories. By contrast, upgrading gold resources to reserve status and then exploiting them at a good margin is still capable of generating extraordinary returns up to 3,540% on incremental investment (see page 18).

…but opportunities abound

While implied in-situ values only selectively encourage blue-sky exploration however, they imply exceptional fundamental value among junior exploration stocks, with fully 65% of the gold explorers sampled trading below the global average cost of discovery of their resources, 63% of uranium companies sampled trading below the unique cost of discovery of their resources and 33% of PGM companies sampled trading below the imputed global average cost of discovery of their resources – by any standards, a fundamental measure of value for any company looking to make acquisitions in order to expand their resources in a low-risk and cost-efficient manner. While this may suggest limited downside to share prices, a return to more normal market conditions offers the prospect of returns to investors in exploration companies of up to 1,000% across all metals and minerals (see pages 7-9), while specific merger activity can provide returns in excess of 1,000% (often significantly discounting subsequent exploitation and development). More immediately, investors in at least two sectors (uranium and iron ore) appear to accept valuations that already discount future exploration success, thereby allowing companies with small resources but good exploration potential to trade at significant resource multiple premiums to their more mature peers.

Gold price forecasts

In the meantime, the gold price continues to trade towards the bottom of a potentially wide range – apparently discounting a 78% probability of a return to a positive real interest rate environment in the US. In this case, Edison is forecasting a gold price of US$1,537/oz in 2020. However, this rises to US$1,899/oz in the event that negative real interest rates prevail over the same timeframe (thereby offering investors a nominal return of 8.2% per annum cf 3.7%).

Analysts

Charles Gibson	+44(0)20 3077 5724
Tom Hayes	+44 (0)20 3077 5725
Andrey Litvin	+44 (0)20 3077 5755

mining@edisongroup.com

Contents

Investment summary

In past publications, Edison has derived differentiated values for Measured, Indicated and Inferred gold resource ounces listed in London, Canada and Australia. This report updates these numbers and extends the methodology to other metals and minerals. In addition (and in collaboration with BDO), it calculates unit costs of discovery for uranium resources on both a differentiated and an un-differentiated basis. This analysis is performed on pages 29-85 of this report.

Results for gold explorers, including the variance in calculated values from the previous year is given below. Results for the whole suite of metals and minerals analysed is given in Exhibit 2 on page 4, overleaf.

Exhibit 1: Global average value of in-situ explorers' gold resources, by listing

	August 2014				August 2013				Change (%)			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
London market	24.07	16.38	12.60	15.55	83.74	43.14	(3.54)	23.23	(71.3)	(62.0)	N/A	(33.0)
Canadian market	48.08	(0.80)	3.35	9.78	37.39	16.46	2.17	16.37	28.6	N/A	54.4	(40.2)
Australian market	(88.18)	75.24	8.99	4.50	(11.80)	76.01	3.67	29.46	N/A	(1.0)	144.8	(84.7)
Arithmetic mean	**(5.34)**	**30.27**	**8.31**	**9.94**	**36.44**	**45.20**	**0.77**	**23.02**	**(114.7)**	**(33.0)**	**984.3**	**(56.8)**
Geometric mean	**(11.32)**	**19.83**	**4.51**	**10.06**	**(8.74)**	**37.68**	**2.04**	**19.07**	**N/A**	**(47.4)**	**121.1**	**(47.2)**

Source: Edison Investment Research

A number of features of the results are immediately apparent with respect to gold explorers:

- The overall decline in the value of global average explorers' ounces by about half, to c US$10/oz
- That the London market confers the highest average valuations on explorers on an average ounce basis, followed by Canada and then Australia, despite the latter's offering premium valuations in the Indicated and Inferred categories of resources
- The large declines in the average values of Measured and Indicated ounces, but an increase (albeit from a low base) in the average value of Inferred ounces, not only in aggregate terms, but also across all three markets surveyed (contrary to expectations)
- The discount in the average value of Measured resources compared to the average value of Indicated resources, in particular (note that this was originally considered to be an anomaly; however, this pattern is exhibited by a number of other metals and minerals, as well, see Exhibit 2, below).
- Apart from the increase in value of Inferred ounces in all three markets, the only other category to register an increase was that of Measured ounces in Canada.

Note that the coal industry did not readily yield itself to a differentiated analysis of resource categories (see pages 82-85). Hence, results have been presented on an average basis only.

Exhibit 2: Selected metals' and minerals' in-situ values, costs of discovery etc

Resource multiple	AIM gold	Canada gold	Australia gold	Global gold (geometric)	Global gold (arithmetic)	Silver	Uranium	Iron Ore	Copper	Nickel	PtE	Coal (Thermal)	Coal (Metallurgical)	Zinc	Vanadium	Tungsten (Explorers)
Measured	**24.07**	**48.08**	**-88.18**	**-11.32**	-5.34	-0.98	4.04	-0.096	141.95	-39.14	33.53			-7.88	1677.73	931.24
Indicated	**16.38**	**-0.80**	**75.24**	**19.83**	30.27	1.12	0.13	0.231	23.08	36.49	8.82			20.86	71.97	329.59
Inferred	**12.60**	**3.35**	**8.99**	**4.51**	8.31	0.04	0.08	0.005	39.82	10.40	0.70			6.71	33.03	54.76
Total/Average	**15.55**	**9.78**	**4.50**	**10.06**	9.94	0.85	0.25	0.055	42.01	14.25	4.71	0.007	0.142	9.22	466.64	244.84
Spot Price	1,313.94	1,313.94	1,313.94	1,313.94	1,313.94	20.94	28.30	95.75	7,150.00	19,400.00	1,491.13	72.00	110.00	2,387.50	12,213.61	35,000
Unit	**$/oz**	**$/oz**	**$/oz**	**$/oz**	**$/oz**	**$/oz**	**$/lb**	**$/t**	**$/t**	**$/t**	**$/oz**	**$/t**	**$/t**	**$/t**	**$/t**	**$/t**

Percentages of spot	AIM gold	Canada gold	Australia gold	Global gold (geometric)	Global gold (arithmetic)	Silver	Uranium	Iron Ore	Copper	Nickel	PtE	Coal (Thermal)	Coal (Metallurgical)	Zinc	Vanadium	Tungsten (Explorers)
Measured	1.83%	3.66%	-6.71%	-0.86%	-0.41%	-4.67%	14.26%	-0.10%	1.99%	-0.20%	2.25%	0.00%	0.00%	-0.33%	13.74%	2.66%
Indicated	1.25%	-0.06%	5.73%	1.51%	2.30%	5.33%	0.45%	0.24%	0.32%	0.19%	0.59%	0.00%	0.00%	0.87%	0.59%	0.94%
Inferred	0.96%	0.26%	0.68%	0.34%	0.63%	0.18%	0.30%	0.01%	0.56%	0.05%	0.05%	0.00%	0.00%	0.28%	0.27%	0.16%
Total/Average	1.18%	0.74%	0.34%	0.77%	0.76%	4.06%	0.88%	0.06%	0.59%	0.07%	0.32%	0.01%	0.13%	0.39%	3.82%	0.70%

Costs of discovery	AIM gold	Canada gold	Australia gold	Global gold (geometric)	Global gold (arithmetic)	Silver	Uranium	Iron Ore	Copper	Nickel	PtE	Coal (Thermal)	Coal (Metallurgical)	Zinc	Vanadium	Tungsten (Explorers)
Measured	36.82	36.82	36.82	36.82	36.82		1.37				4.18					
Indicated	10.5	10.5	10.5	10.5	10.5		0.92				1.26					
Inferred	7.16	7.16	7.16	7.16	7.16		0.09				0.9					
Total/Average	8.81	8.81	8.81	8.81	8.81		1.02				0.9					
Percentages	**0.67%**	**0.67%**	**0.67%**	**0.67%**	**0.67%**		**3.60%**				**0.06%**					

Return on upgrade	AIM gold	Canada gold	Australia gold	Global gold (geometric)	Global gold (arithmetic)	Silver	Uranium	Iron Ore	Copper	Nickel	PtE	Coal (Thermal)	Coal (Metallurgical)	Zinc	Vanadium	Tungsten (Explorers)
Measured	-70.8	85.7	-720.9	-218.4	-235.3		768.5				746.1					
Indicated	13.1	-224.2	1,883.7	358.5	557.5		-94.8				2,156.6					
Inferred	76.0	-53.2	25.5	-37.0	16.1		-6.1				-22.2					

	AIM gold	Canada gold	Australia gold	Global gold (geometric)	Global gold (arithmetic)	Silver	Uranium	Iron Ore	Copper	Nickel	PtE	Coal (Thermal)	Coal (Metallurgical)	Zinc	Vanadium	Tungsten (Explorers)
Number of Companies	19	19	14	52	52	12	29	21	15	9	7	6	3	4	3	5

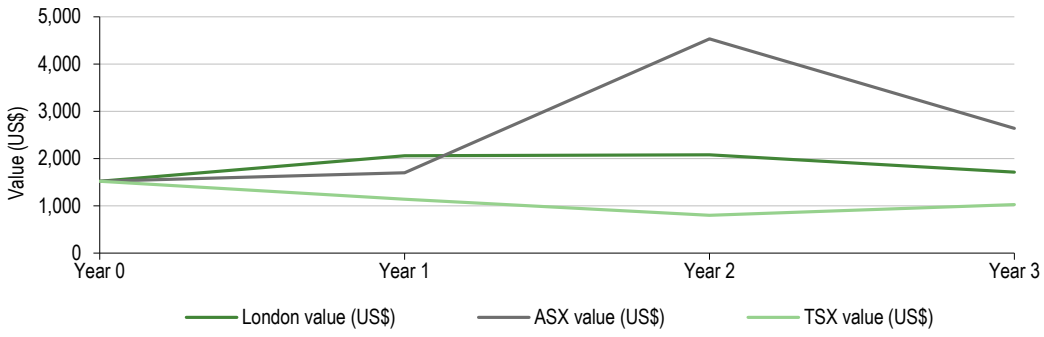
Source: Edison Investment Research. Note: PtE costs of discovery derived from Witwatersrand gold cost of discovery. August 2014.

Conclusions

Differentiated analyses

Apparent from the detailed analysis is the fact that the aggregate discount of Measured ounces with respect to Indicated ounces can be attributed solely to valuations in the Australian market – the Canadian and London markets displaying a more 'logical' valuation profile. Far from being localised however, this pattern is exhibited in at least four other junior exploration markets, namely silver, nickel, iron ore, and zinc. Those that exhibit 'logical' characteristics, whereby Measured resources trade at a premium to Indicated ones, include uranium, copper, platinum group metals and vanadium. While counter-intuitive when considering individual ounces however, the discounting of Measured ounces appears less illogical when considered in the context whole ore-bodies. In the case in which a company develops a gold ore-body in line with global average proportions of Measured, Indicated and Inferred resources and at global average unit costs of discovery, its valuation profile develops as shown in Exhibit 3 (assuming that it is afforded average values for its resources by investors), depending on whether it is listed in London, Canada or Australia:

Exhibit 3: Theoretical value profiles of companies delineating 100oz resources (3 markets)



Source: Edison Investment Research

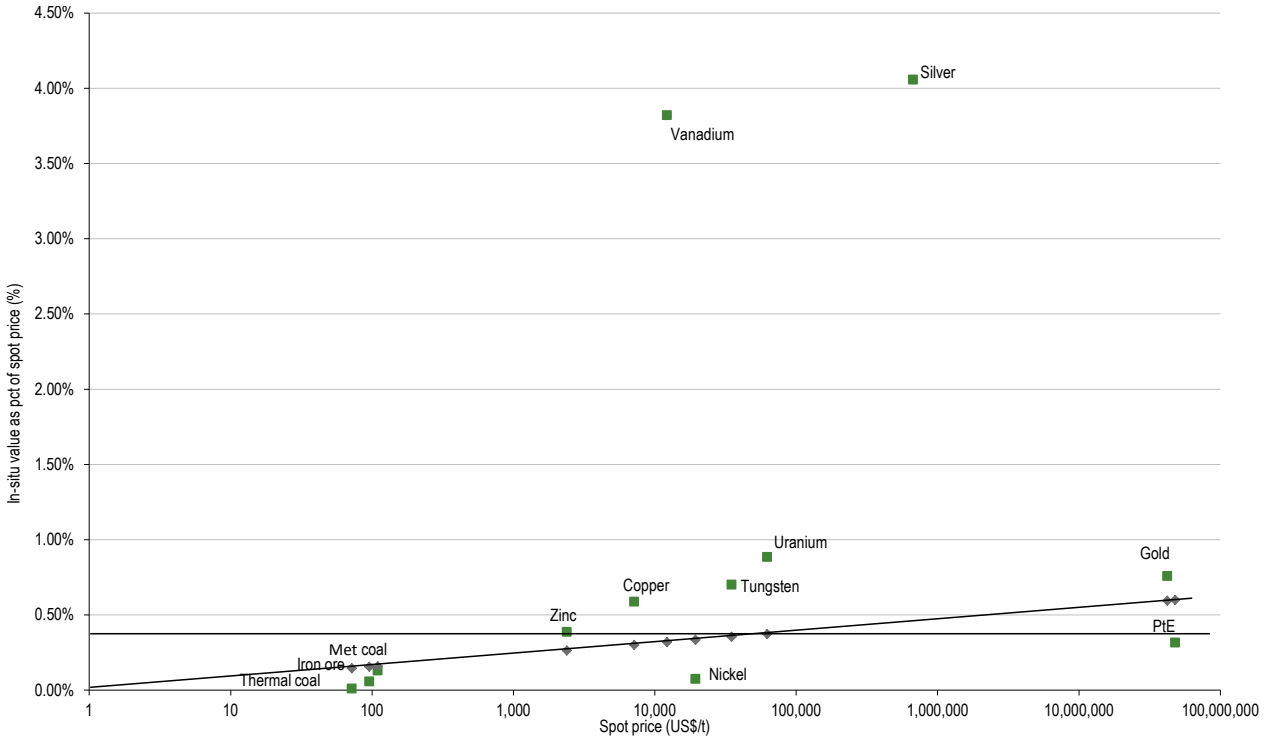
In this case, both the London and Australian market exhibit value destruction in the promotion of Indicated resources into the Measured category since the cost of doing so is greater than the value added. The only difference between the two is the extent of the value destruction which, in part, only reflects an unwinding of the earlier premium Australian valuation when the company upgraded resources into the Indicated category in the first place. As such, discounted Measured resources do not appear to be incorrect, but merely indicative of market sentiment in certain markets with respect to ongoing exploration work. Stated alternatively, Australian gold investors appear to become excited about a new prospect earlier and more easily than their counterparts in London and Canada. However, this 'goodwill' is rapidly dissipated if exploration work continues beyond a certain point and no definite proposals for the development of a mine are presented to the market.

Undifferentiated analysis

In addition to its differentiated analysis, Edison has also performed undifferentiated analyses on 12 metals and minerals. In this case, the analysis has been performed with respect to the spot price of the relevant metal or mineral at the time of the analysis. For example, the average in-situ gold ounce at the time of the differentiated analysis was US$10.06/oz (geometric average), which equated to 0.77% of the price of gold at the time that the analysis was performed. That is to say, the value of an in-situ ounce was 0.77% of the value of a refined ounce. When performed for the other

13 metals and minerals covered in this report as well, the chart produced is as shown below. Note that all metal prices have been converted in US$ per tonne in order that they may be shown on the same scale (for example, gold at the time was US$1,314/oz, or US$42,244,152/t). As such, the price can then be considered a proxy for crustal abundance (or, at least, crustal abundance with respect to economic utility).

Exhibit 4: In-situ resource values vs spot prices, selected metals and minerals



Source: Edison Investment Research

From the analysis, it is immediately apparent that silver and vanadium resources trade at a notable premium to other metals and minerals, but that the other 12 trade within a relatively narrow range. Note that the analysis is performed using a log scale on the x-axis. This is to allow all metals and minerals to be shown. Nevertheless, excluding silver and vanadium, it is possible to discern a trend within the data (line shown), although the empirical cause of the trend is not immediately apparent nor why it should express itself on a log, rather than linear scale. As such, three immediate conclusions are possible:

1. That, across the entire suite of metals and minerals profiled, from bulk commodities to precious metals, in-situ resources trade at an average 0.39% of spot price (line shown). In this case, all of the bulk commodities plus nickel can be seen to be cheap.
2. That two distinct groups of companies exist – one (bulk commodities) in which in-situ resources trade at an average 0.07% of spot price and the other (base and precious metals), in which in-situ resources trade at 0.53% of spot price. In this case, among bulk commodities, thermal coal can be seen to be cheap, while, among base and precious metals, nickel, platinum group elements and zinc can be seen to be cheap.
3. That there is a valid trend (whether or not there is a fundamental causal effect), whereby more expensive (and therefore, presumably, rarer) metals and minerals trade at larger percentages of spot value. Note that there is an obvious qualitative causal effect in that rarer metals and minerals logically require greater investment and denser drilling; however, it is difficult to rationalise the observed trend-line with simple assumptions about the likely relative costs of

discovery of the different metals and minerals in question. In this case, all of the bulk commodities plus nickel and platinum group elements appear cheap.

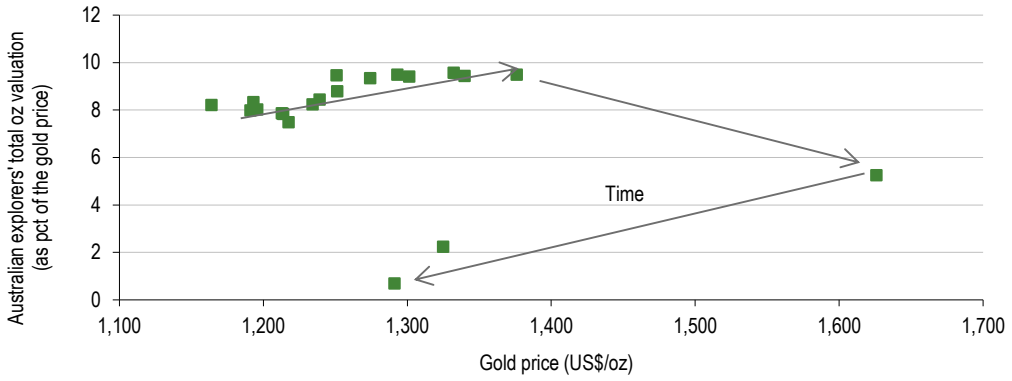
Historical context

Gold

During the 1990s legendary mining fund manager, Julian Baring, often stated that in-situ resources (gold in particular) should ordinarily trade at 10% of spot price, but should be sold if the resource multiple approached 30% of spot. At the time, it was orthodox wisdom that in-situ gold cost US$35/oz to discover and, at the time (c 1989-97), gold was trading at US$369/oz (±US$26/oz) – hence 10% of the spot price represented approximately the assumed cost of discovery.

In recent history however, these limits appear to have changed with time. Since Edison has been following the value of explorers' in-situ resources, the Australian market has exhibited the greatest range of values and, in particular, higher highs in late 2010. If these are plotted as a percentage of the gold price, then the following pattern is apparent:

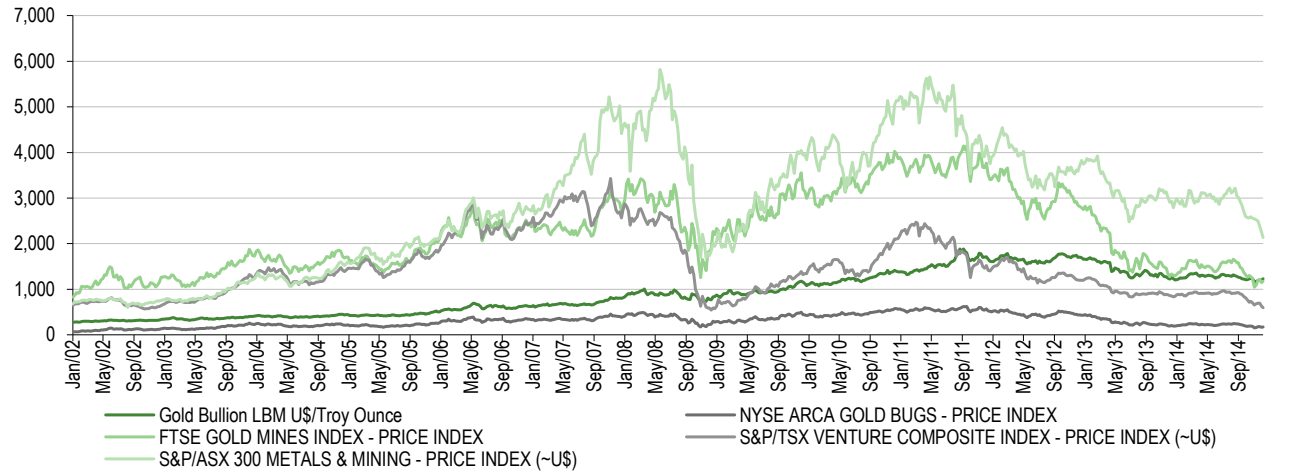
Exhibit 5: Australian in-situ resource multiples (pct of gold price) vs gold price



Source: Edison Investment Research

Of note is the fact that the value of in-situ resources (on this graph) peaked at 9.6% of the price of gold in October 2010. In fact however, the Australian metals and mining market continued to rise for another six months, before reaching a localised peak 28.9% higher than its October 2010 level in April 2011, as measured by the S&P/ASX 300 Metals & Mining index in US dollar terms (see chart, below). Over the same period, the price of gold increased by 12.0%, to US$1,500/oz from US$1,339/oz. All other things (ie resources) being equal over the same period therefore, the value of in-situ resources would have peaked at 11.0% of the spot price of gold in April 2011.

Exhibit 6: Selected gold mining indices' (US dollars) and gold (US$/oz), 2002-present



Source: Thomson/Datastream

Since April 2011, the value of in-situ resources as a percentage of the gold price has fallen to 0.7% of the spot price – representing a decline of 93.6%.

Gold acquisitions

Two recent acquisitions serve to further put these valuations into context. The first was the acquisition of Fronteer Gold by Newmont, announced in February 2011. Consideration for the transaction was C$2.3bn in cash, fully diluted, (US$2.3bn at the time) to acquire Fronteer's 4.4Moz of attributable gold resources (4.8Moz gold equivalent) – implying an in-situ resource multiple of US$475/oz Au (US$433/oz AuE) at a time when the gold price was c US$1,350/oz (ie 32-35% of the spot price). Note that this calculation ignores the simultaneous spin-out of Pilot Gold from Newmont/Fronteer.

More recently, in May 2014, B2Gold announced a merger with Papillon Resources that valued the latter at US$174/oz at a time when the gold price was US$1,287/oz – ie 14% of the spot price.

Iron ore

At the same time as it was following in-situ gold valuations, Edison was also tracking similar valuations for iron ore companies. The analysis was complicated by the observation as long ago as 2012 that the market frequently discounted the future delineation of existing resources (see page 62). Nevertheless, as recently as March 2012, the average value of explorers' in-situ iron ore resources with insubstantial exploration upside was calculated to be US$1.01/t – at a time when the iron ore price was c US$145/t (ie it was c 0.7% of the spot price. At the same time (January 2012), Exxaro announced its offer for African Iron at a price equivalent to a resource multiple of US$5.70/t (3.9% of the spot price), albeit falling to US$0.85/t (0.6% of the spot price) based on African Iron's exploration target (ie almost fully discounting future exploration success).

Conclusion

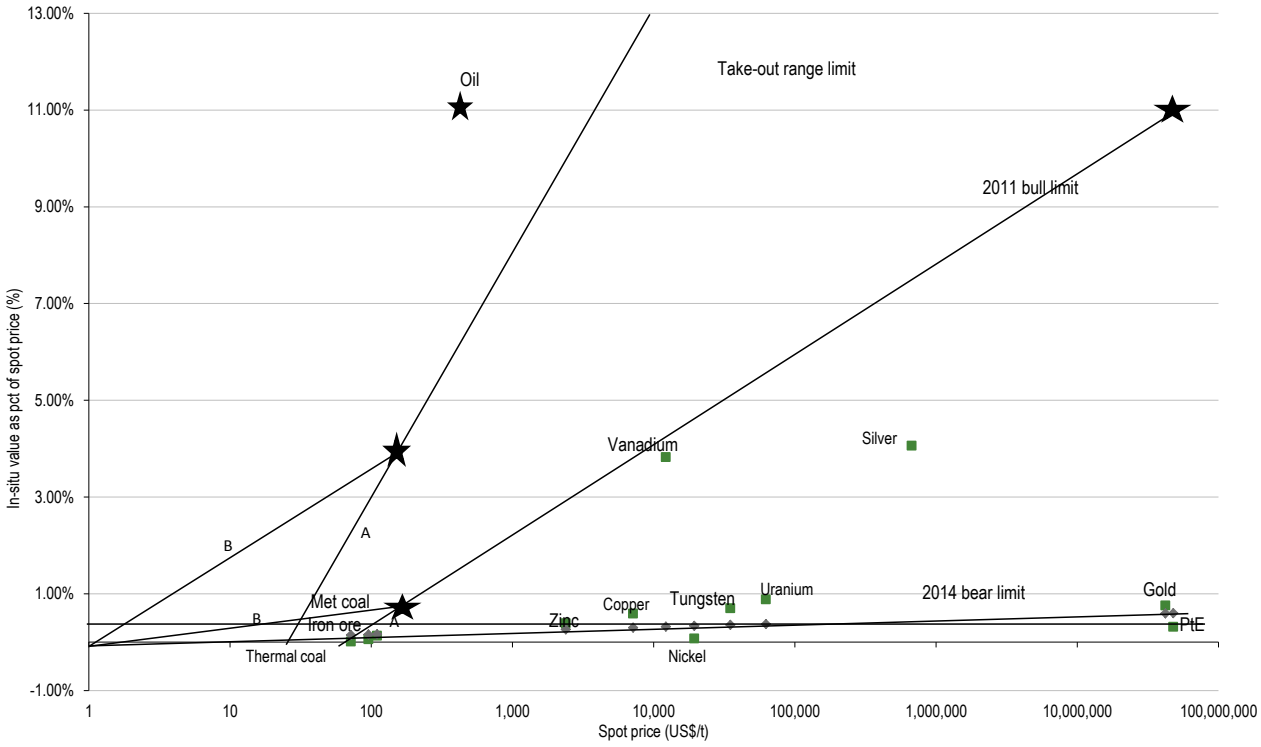
Of the metals for which cost of discovery data is known or imputed (PtE):

- 34 out of 52 (65%) gold companies are trading below the global average cost of discovery of their resources
- 19 out of 30 (63%) uranium companies are trading below the specific costs of discovery of their resources

- 2 out of 6 (33%) platinum companies are trading below the assumed global average cost of discovery of their resources

On the assumption that costs of discovery should represent a measure of fundamental value for companies, it is possible to assert that the current trend-line should represent a floor (or certainly very near floor) to explorers' stock prices and company values, generally. At the same time, within the current cycle, analysis would suggest an ordinary upper limit of 11.0% of the spot price for gold and c 0.7% for iron ore. Even so, among corporate transactions, in-situ values as high as 35% of the spot price are possible for gold and up to 3.9% for iron ore. These boundaries may be represented graphically as follows:

Exhibit 7: In-situ resource values vs spot prices, selected metals and minerals, historic limits



Source: Edison Investment Research

Several aspects of the graph bear consideration:

- The current '2014 bear limit' line appears to intersect the axes at or close to the 'origin' of the logarithmic scale (ie point [1,0]), suggesting that a metal or mineral with a price of US$1/t would have no in-situ value. In an economically rational world, it might be argued that this point should be the true origin (ie point [0,0]). If this is the case, then the '2014 bear limit' line will tend to resolve itself towards the flat 0.39% line (conclusion 1 on page 6). However, the fact that two other trend-lines apparently exist in the form of the '2011 bull limit' and 'take-out range' limit militates against this.
- By contrast, the extension of the other two lines (marked 'A' on Exhibit 7 above) intersect the x-axis, in particular, at prices between US$10/t and US95/t – implying that metals and minerals with prices below these limits have no in-situ value. There is some anecdotal evidence for this. An alternative treatment however, would be to assume that the trend-lines drawn are not straight, but deviate towards either the true origin or the log 'origin' (ie point [1,0]) at prices below c US$120/t (±US$25/t). These lines are marked 'B' on the above graph.
- For reference, a point has been added to the graph to show the current position of the oil industry. The point has been added after consultation with Edison's oil & gas team and is based

upon an oil price of US$330/t (US$45/bbl) and typical in-ground valuations (IGVs) of US$5/bbl. Immediately apparent is the fact that oil companies trade at exceptional in-situ valuations with respect to mining companies – albeit some of this may be attributable to their relatively higher unit costs of discovery (again, arguing in favour of the trend-lines in the above graph, rather than the flat 0.39% line) and their relatively lower unit costs of development. NB It might also explain some early tentative forays by mining companies into oil & gas exploration as well.

Silver and Vanadium

Within the context of the metals and minerals analysis, a note on the apparently anomalous valuations of the silver and vanadium industries is probably merited.

Vanadium

In the case of vanadium, the premium valuation may be ascribed to the development of vanadium-redox batteries. The product of over 25 years of research and development, these exploit the ability of vanadium to exist in solution in four different oxidation states and thereby hold out the prospect of developing a battery that has just one electroactive element instead of the usual two. The main advantages of the vanadium redox battery are:

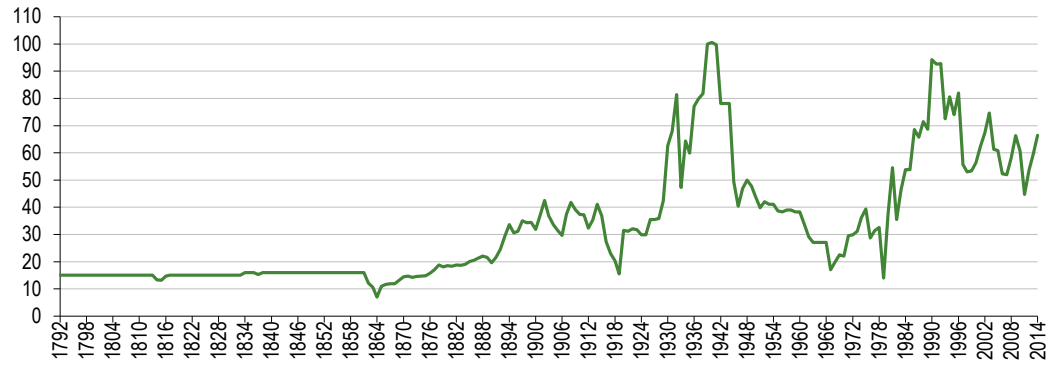
- That it can offer almost unlimited capacity simply by using larger storage tanks
- It can be left completely discharged for long periods with no ill-effects and it can be recharged simply by replacing the electrolyte if no power source is available to recharge it
- It will suffer no permanent damage in the event that the electrolytes are accidentally mixed.

The extremely large capacities possible from vanadium redox batteries make them well suited to use in large power storage facilities in order to average out electricity generation from variable sources (eg wind and solar power) and helping generators to cope with large surges in demand. At the same time, their limited self-discharge characteristics make them useful in applications in which batteries must be stored for long periods of time with little maintenance in a state of permanent readiness. Finally, their rapid response times also make them well suited to situations in which an uninterrupted power supply is necessary, even to the point at which they can replace spinning diesel generators. Also the fast response time makes them well-suited for frequency regulation.

Silver

The in-situ valuation of silver presents a more interesting case. Often seen as a proxy for gold, the industry's implied in-situ valuations is at a notable premium to its cousin. Arguably however, this can be seen as a function of the silver price, rather than the average in-situ value of silver resources. At the time of writing, the price of gold is approximately 71 times the price of silver (63x at the time of the analysis), which is almost without precedent since 1792 (see graph, below).

Exhibit 8: Silver-gold price ratio, 1792-2014, annually



Source: Source: Edison Investment Research, Kitco, South African Chamber of Mines

Within the context of resources, this ratio should arguably be considered within the context of silver's being approximately 40x more plentiful than gold in the earth's crust when measured by the number of atoms present, or approximately 20x more plentiful when measured by weight (given that the atomic mass of gold is approximately twice that of silver). As such, silver's average in-situ resource valuation could be interpreted as discounting a silver price 5.2x higher than that at the time of the analysis, which would thereby reduce the gold-silver ratio to 12.1x – slightly overvaluing silver within the context of its crustal abundance, but by less than the 5.2x implied by its current in-situ resource multiple. Alternatively, if the 'correct' price of silver were to be asserted to be one twentieth of that of gold (in line with its historical monetary ratio and its abundance in the Earth's crust relative to gold, by weight), then its in-situ resource multiple would fall to 1.3% of the spot price – still slightly expensive, but much closer to the range of the other metals and minerals analysed and within the implied error of estimation of the '2014 bear limit' trend-lines in Exhibits 7 and 4 (assuming a linear analogue).

Unit costs of discovery

Gold

In the past, Edison has used a similar methodology to its differentiated value analysis to determine average unit costs of discovery for Measured, Indicated and Inferred gold ounces. In brief, these were US$36.82/oz, US$10.50/oz and US$7.16/oz, respectively. These compare to equivalent (geometric) average values of minus US$11.32/oz for Measured ounces, US$19.83/oz for Indicated ounces and US$4.51/oz for Inferred ounces and equivalent (arithmetic) average values of minus US$5.34/oz for Measured ounces, US$30.27/oz for Indicated ounces and US$8.31/oz for Inferred ounces. As before, a deposit of 100oz, drilled in proportion to the global average ratio of companies with all three categories of resources, of 21:57:23 Measured:Indicated:Inferred (Exhibit 9), would cost US$1,519 to delineate.

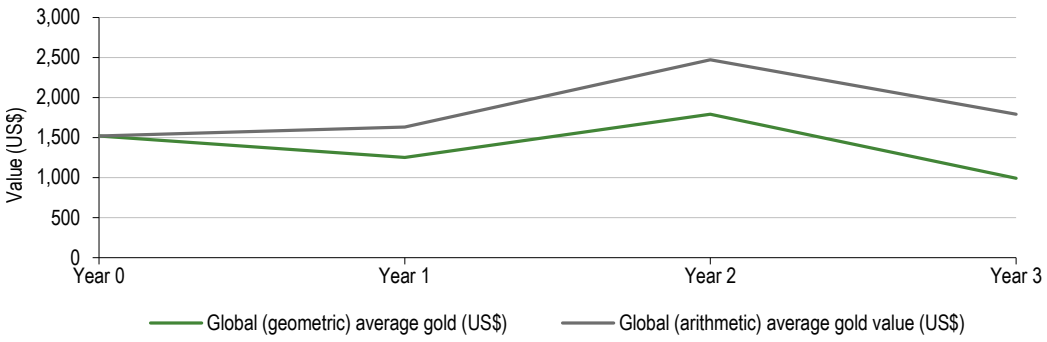
Exhibit 9: Theoretical gold explorer's resource evolution by year (oz)

Resource category	Year 0	Year 1	Year 2	Year 3
Measured	0	0	0	21
Indicated	0	0	45	57
Inferred	0	100	55	23
Total	**0**	**100**	**100**	**100**

Source: Edison Investment Research. Note: Totals may not add up owing to rounding.

As cash is converted into resources (upgrading at the rate of one category per year), the value profile of a junior explorer embarking on such a campaign can be represented graphically as follows (assuming that it is afforded global average ratings for its resources):

Exhibit 10: Theoretical value profiles of companies delineating 100oz gold resource (global averages)



Source: Edison Investment Research

Note that this is the equivalent graph to Exhibit 3, but presented on a global average basis, rather than by market.

Over the whole period, the financial return of the drilling campaign is minus 34.8% based on global (geometric) average values and plus 17.9% based on global (arithmetic) average values. While investment returns from adding Inferred ounces to its portfolio are questionable (ranging from plus 7.6% on an arithmetic basis to minus 17.4% on a geometric basis) and returns from adding Measured ounces are negative however, returns from adding Indicated ounces remain unequivocally positive (ranging from 43.0% in the geometric case to 51.3% in the arithmetic case), albeit by less than they were a year ago.

Uranium

In a similar vein, Edison (in collaboration with BDO) has now generated similar average unit costs of discovery for the uranium market (see pages 53-57). In this case, these were calculated to be US$1.37/lb for Measured resources, US$0.92/lb for Indicated resources and US$0.09/lb for Inferred resources.

Proportions of resources in each category for uranium explorers are slightly different than for gold explorers, as shown in Exhibit 11, below.

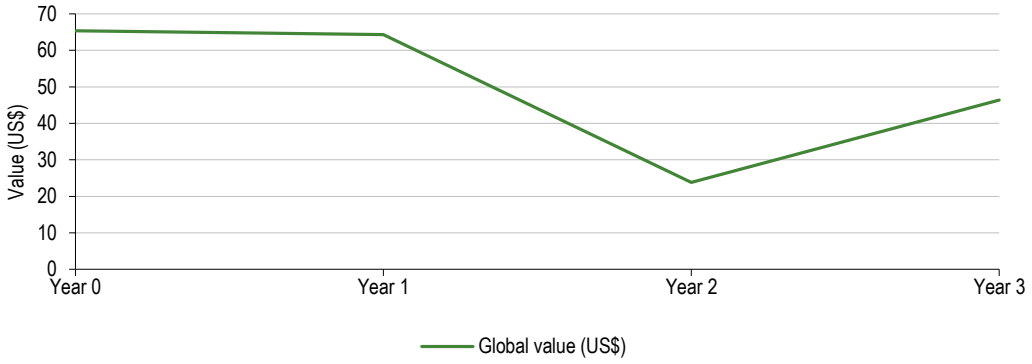
Exhibit 11: Theoretical uranium explorer's resource evolution by year (lb)

Resource category	Year 0	Year 1	Year 2	Year 3
Measured	0	0	0	8
Indicated	0	0	40	57
Inferred	0	100	60	35
Total	**0**	**100**	**100**	**100**

Source: Edison Investment Research. Note: Totals may not add up owing to rounding.

The total cost to delineate such a (100lb) resource, at global average unit costs, is US$66.55. Applying global (geometric) average values to the resources delineated, a value profile for junior uranium explorers is then as follows:

Exhibit 12: Valuation of junior uranium explorer developing 100lb resource, by year (US$)



Source: Edison Investment Research, BDO

Over the whole period, the financial return from the campaign is minus 36.1%. In incremental terms, delineating Inferred resources results in an investment return of minus 1.5%, delineating Indicated resources from Inferred resources results in an investment return of minus 47.6% and it is only at the final stage, delineating Measured resources, that investment returns become positive (+23.8%). However, note that this analysis is conditional upon the market being presented with blue-sky exploration success that it had not previously anticipated. For markets in which blue-sky exploration success is anticipated, see the section entitled 'Discounting blue-sky exploration success' on page 15.

Platinum Group Metals (PGMs)

Finally, this report is the first by Edison in which differentiated values have been derived for platinum group metals (PGMs). On account of the existence of palladium, rhodium and gold as by-products, resources have been converted into platinum equivalent ounces (PtE). Thus converted, average in-situ values were found to be US$33.53/oz PtE for Measured ounces, US$8.82/oz for Indicated ounces and US$0.70/oz for Inferred ounces (see pages 70-71).

Edison has never performed a specific analysis on the unit cost of discovery of platinum equivalent ounces. However, as part of its previous work on the unit costs of discovery of gold ounces, it did perform a discrete analysis on the cost of discovery of gold ounces in the Witwatersrand basin. While self-evidently not perfect geological analogues, the platinum reefs in the Bushveld Igneous Complex do share certain overarching characteristics with gold reefs in the Witwatersrand, including (in broad terms) depth, dip and continuity, as evidenced by the fact that narrow reef, breast stoping methods are used to mine both, virtually uniquely in the world. For the purposes of the following analysis therefore, Edison posits that the average unit cost of discovery of platinum equivalent ounces in the Bushveld Igneous Complex is the same as the average unit cost of discovery of gold in the Witwatersrand basin, namely US$4.18/oz for Measured resources, US$1.26/oz for Indicated resources and US$0.90/oz for Inferred resources (see *Gold – Valuation benchmarks are obsolete*, published by Edison in January 2010). On this basis, a deposit of 100oz, drilled in proportion to the global average ratio of such resources (see Exhibit 13), would cost US$125.50 to delineate. Note that this is much lower than the equivalent for the (non-Witwatersrand) gold deposits considered previously, which cost US$1,519 to delineate, reflecting *inter alia* the accepted continuity of Witwatersrand and Bushveld reefs. However, since they are typically deeper than non-Wits/Bushveld deposits, they also attract a lower valuation (US$4.71/oz on average compared to US$10.06/oz for non-Wits gold). In addition, the depth of the deposits limits the density of drilling achieved owing to financial constraints, which results in the definition of lower-confidence resource categories (Exhibit 13, below).

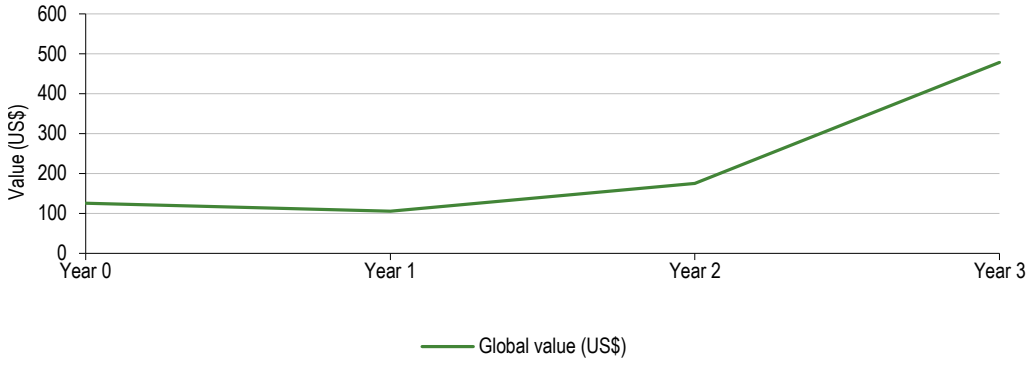
Exhibit 13: Theoretical PGM explorer's resource evolution by year (oz PtE)

Resource category	Year 0	Year 1	Year 2	Year 3
Measured	0	0	0	10
Indicated	0	0	9	10
Inferred	0	100	91	79
Total	**0**	**100**	**100**	**100**

Source: Edison Investment Research. Note: Totals may not add up owing to rounding.

Applying global (geometric) average values to the resources delineated, the value profile for junior PGM explorers is then as follows:

Exhibit 14: Valuation of junior PGM explorer developing 100oz resource, by year (US$)

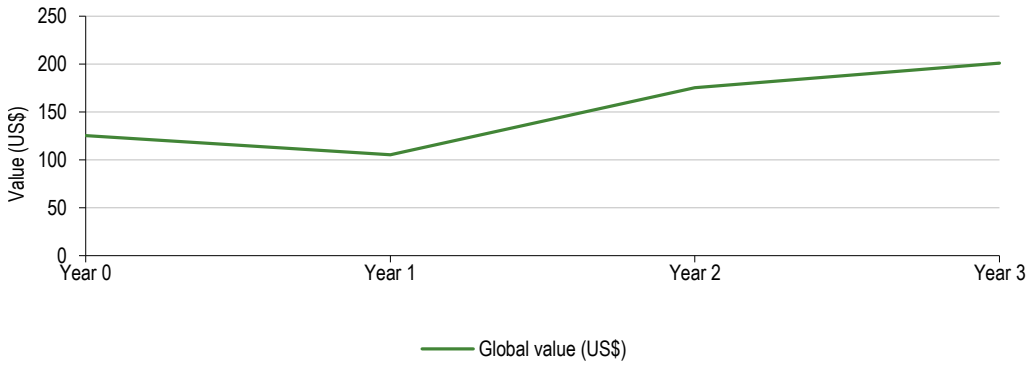


Source: Edison Investment Research, BDO

With the exception of the initial phase of exploration, when Inferred resources are delineated (which results in a negative financial return, of minus 15.9%), the following two phases, in which Indicated and Measured ounces are delineated, generate strongly positive financial returns, of plus 66.2% and plus 173.1%, respectively. The return over the whole period is plus 281.5% - in notable contrast to returns from conventional gold and uranium exploration.

Note that this analysis has been performed using the averages derived from a sample including Platinum Group Metals, which is a clear statistical outlier to the upside (see pages 71-72). Excluding this company reduces the average value of Measured ounces to US$6.64/oz, in which case the value profile for the junior PGM explorer in question would be as follows:

Exhibit 15: Valuation of junior PGM explorer developing 100oz resource*, by year (US$)



Source: Edison Investment Research, BDO. Note: * Derived from averages excluding Platinum Group Metals

In this case, the return on the final phase of drilling (to delineate Measured ounces) returns 14.6% to investors (cf 173.1%) and the return over the whole period is 60.2%. Note that the company thus created would have an average resource multiple of US$2.01/oz cf US$2.14/oz for Nkwe,

US$1.89/oz for Wesizwe, US$1.41/oz for Jubilee and US$0.45/oz for Platina – conferring broad credibility on the analysis.

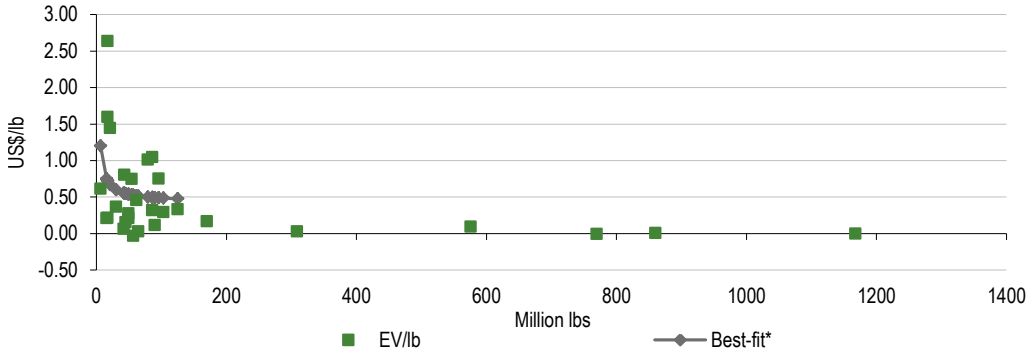
Discounting blue-sky exploration success

The previous three analyses of value evolution for global gold, uranium and PGM explorers assume a static or backward looking market mentality – that is to say, the market will confer value for resources discovered, once they are discovered, but not before. That is not uncommon. However, at least two markets analysed by Edison demonstrate a notable discounting effect – that is to say, the market conferring value for exploration success before it has been officially confirmed. The two markets in question are uranium and iron ore.

Uranium

In the case of uranium, the sample of explorers analysed by Edison demonstrated a notable inverse relationship between rating and resource size:

Exhibit 16: Plot of resource size (Mlbs) vs resource multiple (US$/lb) for uranium



Source: Edison Investment Research. Note: * Determined by a linear regression of the inverse

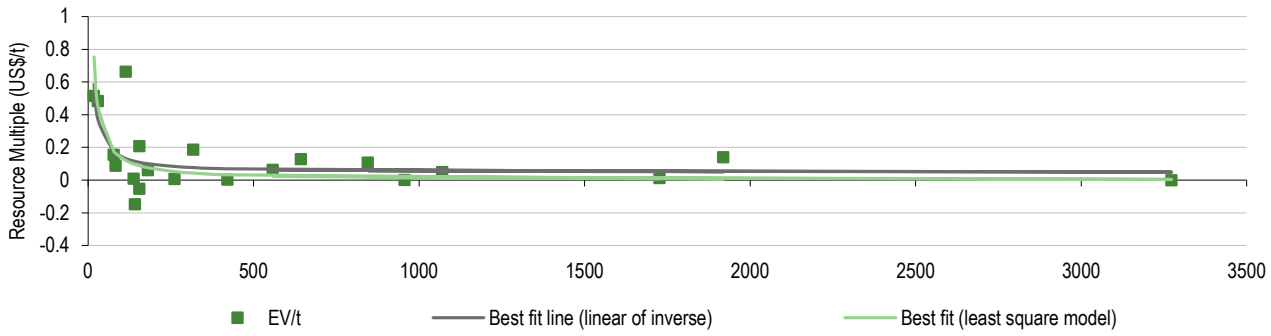
The weighted average value of an in-situ uranium lb is US$0.25/lb (see Exhibit 90 on page 58) However, the above graph could be interpreted as being representative of two markets. In the first, the market appears either to assume that there is no further blue-sky exploration potential (the bottom left of the graph) or that the resource has been largely drilled out (or that a size has been delineated which, for the purposes of the project, does not need to be increased) – towards the bottom right. The average value of these resources (the bottom 14 resource multiples) is 8.9c/lb.

By contrast, there exist companies to the top left of the graph that achieve ratings that are consistent with the ultimate delineation of up to c 125Mlbs contained uranium at a rating of 48c/lb (as indicated by the Best-fit line). Beyond that size, additional resources appear to add little or no value to companies that host them and will therefore, in all probability, be value destructive to expand further (at least at the current time). In the interim however, they enjoy valuations that are ultimately 4-5x of those companies perceived to have little or no blue-sky exploration potential and frequently higher.

Iron ore

In exactly the same way, the weighted average value of an in-situ iron ore tonne is 5.5c. Once again however, the sector demonstrates evidence of an inverse relationship between resource size and resource multiple for certain stocks:

Exhibit 17: Iron ore sector relationship between resource multiple (y-axis) and resource size (Mt, x-axis)



Source: Edison Investment Research

Note that two best-fit lines have been calculated – the one being derived from a linear regression of the inverse plot and the other being a least square method solved by Gaussian elimination in Matlab software.

For deposits larger than 1,000Mt in-situ iron, the (un-weighted) average value per tonne of in-situ iron is 4.8c – which accords closely with the 5.5c/t calculated above. However, the linear regression of the inverse methodology, in particular, implies a 'constant' premium applied to resource tonnes of in-situ iron of 4.6c/t (arguably related to the cost of discovery). Used in conjunction with the Matlab gradient, this implies that the average resource multiple of 5.5c/t is achieved at a resource size of 1,453Mt – which seems plausible within the context of the graph. The terminal resource multiple of 4.8c/t is achieved at a resource size of 3,324Mt.

Financial returns from in-fill drilling

In conducting this analysis, Edison has reprised NonSuch Gold, which is the idealised junior gold explorer that it invoked in its report *Gold – New benchmarks for old*, published in November 2012. The characteristics of this company are supposed to approximate the characteristics to which most junior miners aspire, including:

- The delineation of a resource of 1.276Moz, of which 1.0Moz will be converted into reserves and mined at a rate of 100koz per year for 10 years. It will be deemed to be listed in London and there will be three rounds of equity funding in Year 0 (initial capital for exploration), Year 4 (to complete scoping, pre-feasibility and bankable feasibility studies) and Year 7 (for development).
- The company raises equity funds in Year 0 for exploration purposes. It delineates an Inferred resource in Year 1, an Indicated & Inferred resource in Year 2 (in the ratio 45:55 Indicated: Inferred) and a Measured, Indicated & Inferred resource in Year 3 (in the ratio 21:57:23 Measured:Indicated:Inferred). It then raises additional equity funds and commissions a scoping study, a pre-feasibility study and a bankable feasibility study in Years 4, 5 and 6, respectively. In Year 7 it completes a final round of equity funding in addition to debt funding, such that its peak leverage (debt/(debt+equity)) peaks at 50%, and embarks on the first of three years of capital expenditure. Production ramp-up begins in Year 8 and full production is achieved in Year 9. Full production is maintained from Year 9 to Year 18 inclusive (ie 10 years). Working capital is released in Year 19 when the company reverts to being an exploration entity with cash and an Inferred resource.
- In Years 0 to 3, the company is valued according to a combination of its resource (at the appropriate categorisations, assuming a London listing) plus cash. Note that the London-listed assumption affects only Years 1 to 3; Canadian- and Australian-listed explorers would have the profiles shown in Exhibit 3 on page 5. In Years 4 to 18, NonSuch Gold Ltd is valued according

to the discounted dividend flow method at the mean discount rates (as interpreted by Edison) defined and set out in its report *Gold – US$2070 by 2020* plus the (undiscounted) value of the residual Inferred resource. Working capital is released in Year 19, such that the company reverts to being an exploration entity with cash and an Inferred resource only.

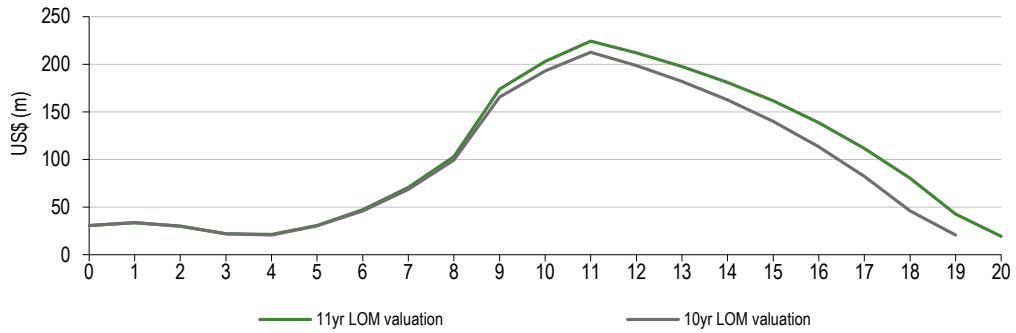
- Unit costs of discovery are those calculated by BDO and Edison and set out previously, namely US$7.16 per Inferred ounce, US$10.50 per Indicated ounce and US$36.82 per Measured ounce.
- Of the company's 1.276Moz resource, 1.0Moz are in the Measured and Indicated categories, which are assumed to have a 100% conversion ratio into reserves.
- Study costs are estimated at 1.5% of capex (ie US$1.5m in total) and are deemed to be cumulative, ie scoping study costs contribute towards PFS costs and PFS costs towards BFS costs etc.
- Central, general and administrative costs amount to US$4m per year until the company enters production, when they increase to US$7.5m per year.
- Equity fundings are conducted at the implied value of the equity, given the state of advancement of the project, ie no discount to the prevailing share price is assumed.
- Capex amounts to US$100 per annual ounce of production, ie US$100m, or US$100 per reserve ounce.
- Debt peaks at the end of Year 8 (ie the year before full production is achieved), when gearing (ie debt/equity) reaches 100% and leverage (debt/(debt+equity)) reaches 50%.
- The cost of debt is set at 11%; return on cash deposits at 0.5%.
- A gross cash profit margin of US$725/oz has been assumed during the mine's producing phase, which may be rationalised in terms of the current gold price of US$1,280/oz and total cash costs of US$555/oz.
- Profits are taxed at 28% (after depreciation); there is no write-off for past exploration expenses.

On the basis of the assumptions set out above, the undiscounted value of the dividends paid out to shareholders is US$410.7m, comprising cash flow from operations (US$459.8m), minus total life-of-mine capex (US$120.1m), plus total equity funding (US$88.2m) minus terminal cash balances (US$17.2m). Full financials for the company are provided on page 42 of *Gold – US$2070 by 2020*, published in November 2013.

For the purposes of the analysis of the financial returns of in-fill drilling, Edison increased the length of NonSuch Gold's mine life by one year, from ten to 11 years by upgrading 23,342oz of Inferred resources into the Measured category and 76,658oz of Inferred resources into the Indicated category in Year 19 (when mining would otherwise have ceased). In this case, the undiscounted value of the dividends paid out to shareholders increases to US$457.9m (ie US$47.2m greater than the ten year life of mine company) as a result of the extension, comprising cash flow from operations (US$507.0m), minus total life-of-operation capex (US$120.1m), plus total equity funding (US$88.2m) minus terminal cash balances (US$17.2m).

Exhibit 18 compares the valuations of NonSuch Gold with mining operations conducted over both 10 and 11 years:

Exhibit 18: NonSuch Gold valuation over 10 and 11yr mine lives compared



Source: Edison Investment Research. Note: LOM = Life of mine

(NB Investors should note the much smaller discontinuity in Year 4 as NonSuch Gold progresses from resource delineation to a scoping study than in previous years).

In tabular form, the value addition to NonSuch Gold as a result of the additional dividend (ie the difference between the two lines in Exhibit 18) is as shown in Exhibit 19. Note that the US$21.9m increase in Year 16 reflects the unwinding of US$17.2m in working capital in that year for the ten year mine life company, which was not previously considered as part of the valuation. The eleven year mine life company gets the same benefit in Year 20. Note that adding the value addition in Years 19 and 20 together gives an aggregate value addition for those years of US$41.3m – which is very similar to the US$40.4m that would be calculated by discounting an additional year's dividend of US$47.2m by applying a discount rate of 17% for one year.

Exhibit 19: Dividend/cash value added to NonSuch Gold as a result of additional year's mining operations (US$000s)

Year	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Dividend value added (US$000's)	386	652	1,195	2,105	3,564	8,383	9,809	11,484	13,440	15,729	18,406	21,539	25,205	29,493	34,511	21,913	19,420

Source: Edison Investment Research

Against this must be compared to the cost of the drilling undertaken in order to effect the resource upgrade (US$948k). Owing to the (high) discount rates prevailing in the sector, it can be seen that in-fill drilling in order to delineate reserves from resources is not value adding until Year 6 – ie after NonSuch Gold has completed its initial pre-feasibility study and is undertaking its bankable feasibility study.

In addition, it can be argued that NonSuch Gold should also suffer from no longer being afforded value for 100,000oz of terminal, Inferred resource (worth US$1,260k at US$12.60/oz – see pages 4 and 29). Including this as well, it can be seen that in-fill drilling in order to delineate reserves from resources is not value adding until Year 8 – ie after it has raised finance and started development of its project.

Note that, as discussed previously, the overall upgrade of 100,000oz in the Inferred category into 23,342oz in the Measured category and 76,658oz in the Indicated category is value destroying during the resource delineation phase of the company's evolution in Years 1-3 given the average costs and values currently prevailing in the London market.

An historical footnote re the performance of gold explorers

Much has been made in recent months and years of the historical underperformance of gold equities. Seen within the context of the above analysis of costs of discovery however, this could be attributed to the reduction in investment required to discover an in-situ gold ounce, from US$35/oz

in the 1990s (or c 10% of the spot price) to US$8.81/oz currently (c 0.7% of the spot price). As such, the 'underperformance' may be derived not so much from intrinsic inefficiency by explorers when they are exploring but by the fact that, in the absence of a quick development decision, the value of their in-situ assets is likely to depreciate over time as a result of new cost efficiencies and technological advances in the sector around them.

Price of gold

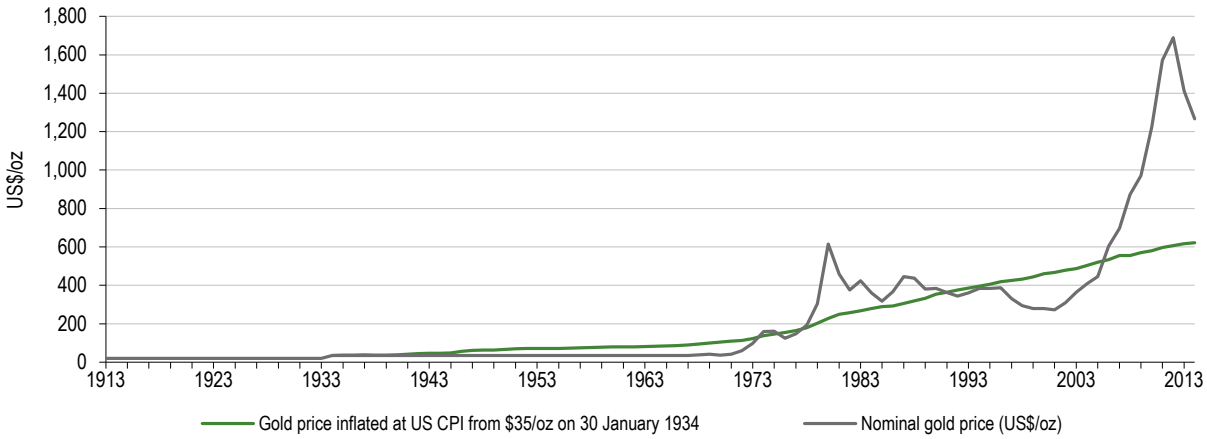
Edison's gold price forecasts remain based on its historic relationships to both inflation and the US monetary base.

Gold price relationship with US dollar inflation

Since 1945, gold can be seen to have undergone two bull and two bear markets.

- A bear market between 1945 and 1967 (a period that was characterised by inflation and positive real interest rates).
- A bull market between 1968 and 1980 (a period of negative real interest rates).
- A bear market from 1980 to 2001 (positive real interest rates).
- A bull market again from 2001 to 2012 (again characterised by negative real interest rates).

Exhibit 20: Nominal gold price (1913-2014) and indexed from US$35/oz in January 1934 (US$/oz)



Source: Edison Investment Research, South African Chamber of Mines, US Department of Labor. Note: Prices are annual averages

Between 1945 and 1971, the gold price was inextricably linked to the US dollar. Towards the end of this period, however, the US began both to run twin deficits and expand the money supply. As a result, international creditors (particularly France) began to sterilise dollar foreign exchange reserves into gold, which put upward pressure on the price of gold and downward pressure on the dollar. After a series of initiatives aimed at preserving the Bretton Woods order, President Nixon finally abandoned the link in 1971. The subsequent devaluation of the dollar had the effect, *inter alia*, of importing inflation into the United States, which jumped from a containable 3.4% in 1972 to a virtually unprecedented 8.7% in 1973. The Federal Reserve reacted conventionally by tightening monetary policy, which comprehensively burst the internal US credit bubble and started to suck markets into a debilitating debt-deflation spiral. Hence, the Dow Jones Industrials average lost 45% of its value in 1973-74, while the US economy slowed from 7.2% real GDP growth in 1972 to a 2.1% contraction in 1974. Now facing the prospect of a depression, the Fed reacted equally conventionally by reducing interest rates to the minimum possible and by expanding the US monetary base. Inevitably, this put further downward pressure on the value of the dollar and

imported price rises, leading to a second peak in inflation later in 1979, which was only brought under control after Paul Volcker's decision to raise interest rates to defend the value of the dollar in international foreign exchange markets at the expense of a further debilitating recession in the early 1980s. Positive interest rates having once again been re-imposed, international markets returned to something approaching normality, albeit with the dollar (and sterling) at permanently lower levels compared to the currencies of international creditor nations such as Germany, France and Japan.

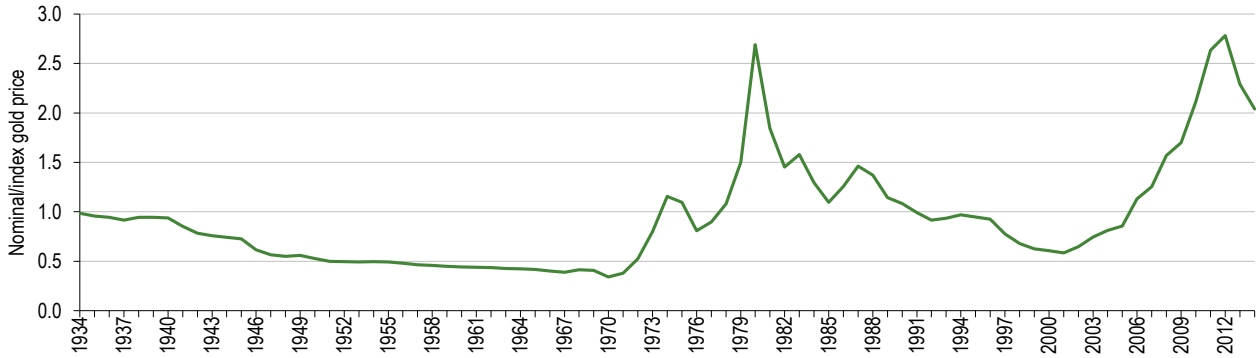
As positive real interest rates reasserted themselves in 1980, so currency markets stabilised and gold returned to a bear market phase (analogous to the period of 1945-68), which lasted until 2001. Hence, whereas the German mark appreciated by 66% against the US dollar during the 1970s, in 1999 the DEM/US$ rate was almost the same as it had been in 1980.

As the new millennium dawned, however, (and after a period of relative economic stability), the US once again began to run twin deficits as a result of a combination of the War on Terror and the rise of a new economic competitor and international creditor in the form of China, which resulted in:

1. The return of negative real interest rates in 2001
2. Inflation and a subsequent rise in interest rates in 2007
3. The bursting of the credit bubble, subsequent banking failures (Bear Stearns, Lehman Brothers etc) and the beginnings of a debt-deflation spiral in 2007-09
4. The adoption of unconventional monetary policy in the form of three rounds of quantitative easing (QE1, QE2 and QE3) from 2008 until 2014.

The two bull and two bear markets may easily be seen by comparing the actual price of gold to the price when indexed from US$35/oz in January 1934 using the US consumer price index (CPI):

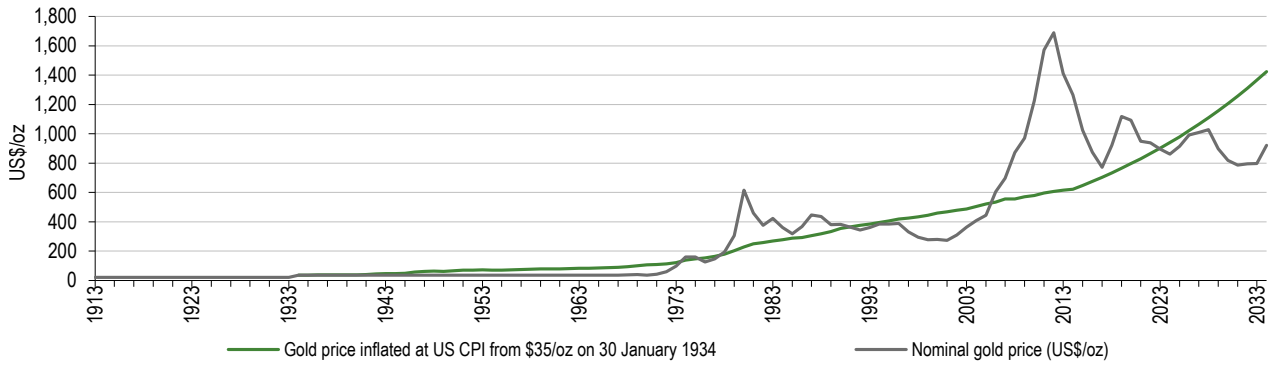
Exhibit 21: Nominal gold price divided by index gold price, 1934-2014



Source: Edison Investment Research, South African Chamber of Mines, US Department of Labor

Taken at face value, it is easy to conclude that gold's peak price in 2012 was equivalent to that in 1980 and that it has just started another 21 year bear market. In this case, projecting the indexed level of gold into the future at the same average historic rate of US CPI inflation between 1972 and 2014 and then applying the same cyclical discount or premium depicted above generates the following future price profile for gold:

Exhibit 22: Gold price, historic and forecast with respect to 1934 price (indexed), 1913-2034



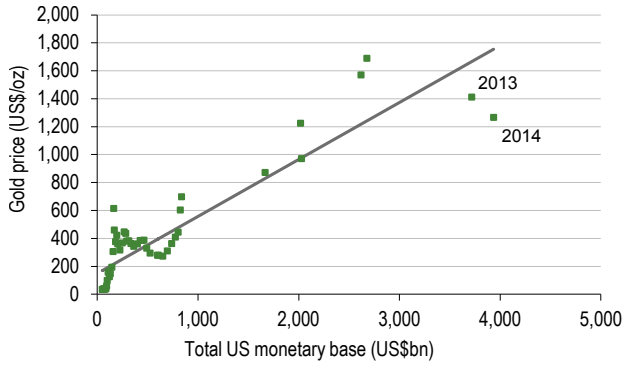
Source: Edison Investment Research and (historic) South African Chamber of Mines, US Department of Labor. Note: Prices are annual averages

That is to say, on this basis, gold will fall to US$1,023/oz in 2015, US$873/oz in 2016 and US$772/oz in 2017, before recovering to trade in the range US$945/oz (±US$173/oz) for the next 16 years.

Gold price relationship with US total monetary base

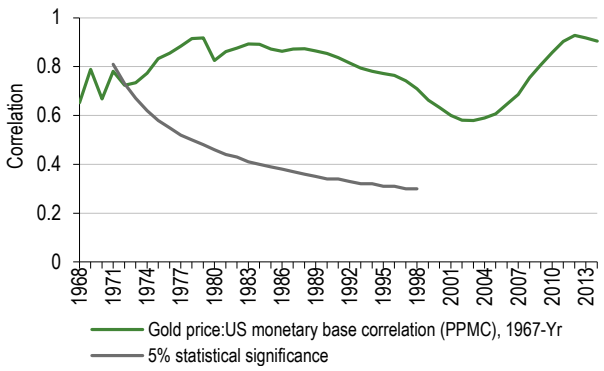
In addition to its relationship with inflation however, gold also exhibits a very close, statistically significant relationship with the US total monetary base. At the present time, the relationship between the two elicits a Pearson Product Moment Coefficient (PPMC) of 0.904 – implying that there is less than a 5% chance that the relationship occurred by chance. It also compares with a PPMC of 0.906 between the total US monetary base and the total value of US gold holdings.

Exhibit 23: Gold price vs US total monetary base, regression analysis, 1959-2014



Source: Edison Investment Research, Federal Reserve, dollardaze.org

Exhibit 24: Gold price and US total monetary base correlation, 1968-2014

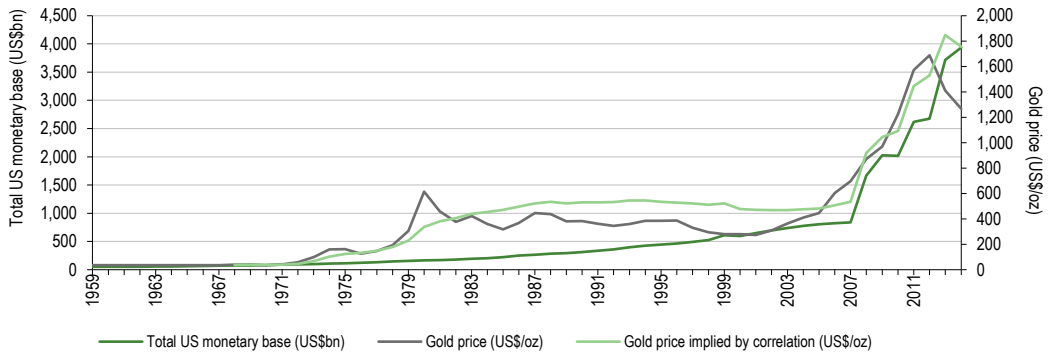


Source: Edison Investment Research and (underlying data) Federal Reserve, dollardaze.org

Since 2007, the US Federal Reserve has increased the US total monetary base by 4.7 times or US$3.1tr to US$3.9tr (NB This compares with Edison's forecast of US$3.8tr in its report, *Gold – US$2070 by 2020*, published in November 2013). It also compares to losses in the US economy at the height of the economic crisis of around US$9.0tr. However, US$4.8tr of the US$9.0tr related to retirement assets, savings and pension assets, which are closely related to the stock market. Given that the Dow Jones is now at a level comfortably above its pre-crisis level of c 14,000 in September 2007, it is not unreasonable to surmise that these losses have now broadly been recouped, at least in nominal terms. That being the case, the Federal Reserve has in fact 'printed' US$3.1tr in new money in order to cover a nationwide loss of c US$4.2tr in home equity – ie it has covered approximately 79% of the loss.

Exhibit 25 graphs the gold price and the US total monetary base since 1959. In addition, it shows what the gold price would have been, had it been predicted solely on the basis of the US total monetary base as the relationship between the two would have been perceived at the time:

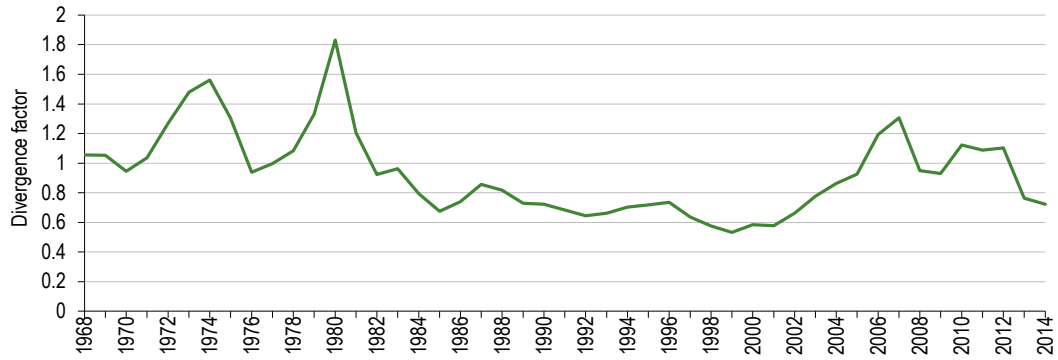
Exhibit 25: Gold price, US total monetary base and predicted gold price, 1959-2014



Source: Edison Investment Research and (underlying historic data) Federal Reserve, dollardaze.org

Statistically, the error of estimation of the regression analysis is ±US$169/oz, while the current discount of the actual price of gold compared to the predicted price is 27.8%. While that is still some way short of the maximum discount (of 46.7% in 1999, when the gold price was US$279/oz), it is nevertheless a record in nominal terms, at US$488/oz. Exhibit 26 graphs the variation of the actual gold price from the predicted one since 1968:

Exhibit 26: Variation of actual gold price from predicted, 1968-2014



Source: Edison Investment Research and (underlying data) Federal Reserve, South African Chamber of Mines, dollardaze.org

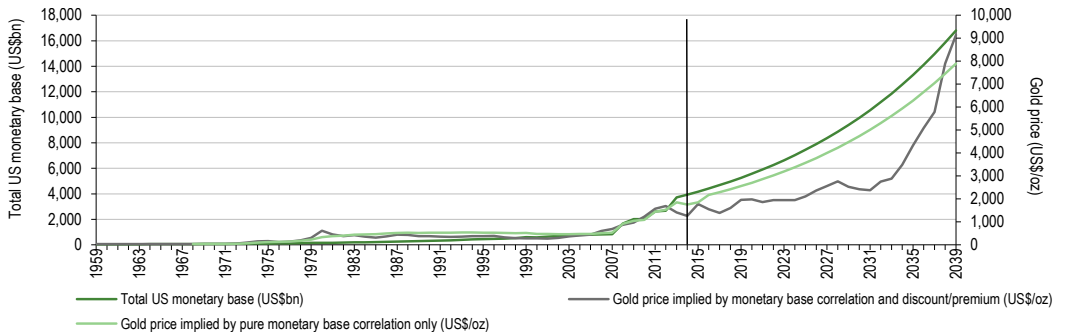
As such, the gold price can be said to have reverted from the sorts of premiums that were extant in bull market conditions (eg 1971-72) to those associated with bear market conditions (eg 2002-03 and 1994-96) within the space of two years.

Stated alternatively:

- The current gold price (US$1,280/oz at the time of writing) appears to discount a US total monetary base of US$2.8tr (cf US$2.7tr when QE3 was announced)
- The end-2014 total monetary base implies a gold price of US$1,754/oz
- The forecast end-2015 total monetary base implies a gold price of US$1,850/oz (on the basis of the historic correlation between the two)

By contrast, if the historic cycle (1980-2007) is to be repeated again in 2012-2039, with the peak in 2012 equating to the peak in 1980 and then being followed by the same discounts and premiums depicted in Exhibit 26, the gold price may be expected to evolve as follows:

Exhibit 27: Historic and forecast gold price (forecast made wrt US total monetary base)



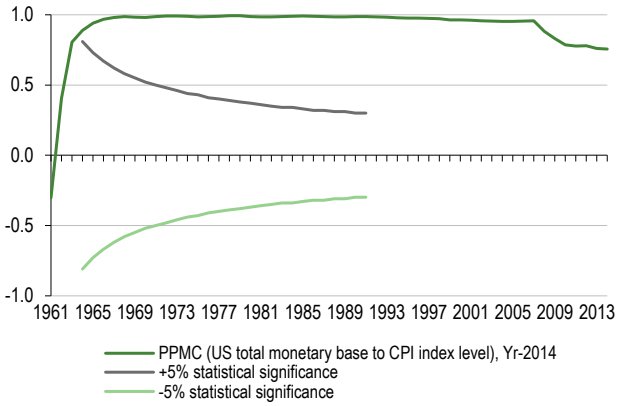
Source: Edison Investment Research and (underlying historic data) Federal Reserve, South African Chamber of Mines, dollardaze.org

Note that, from 2014 onwards, the US total monetary base is assumed to increase at its long-term historic (geometric) average rate of 6.0% per annum.

Conclusions

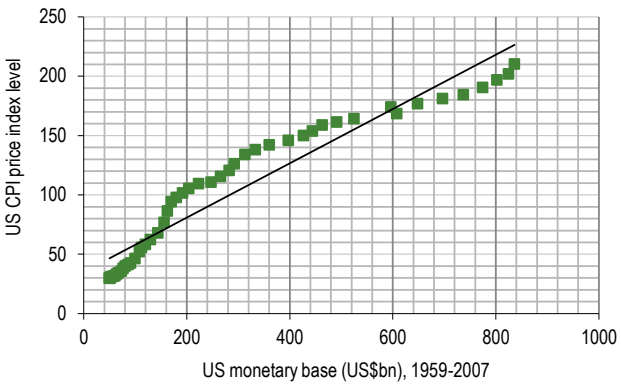
In conclusion, the gold price can be seen to be expensive with respect to indexed prices (or, stated alternatively, it has more than acquitted itself as a store of value and a hedge against inflation), however it is cheap relative to the monetary base. *Prima facie*, this appears to be a monetary paradox – especially since the historic relationship between prices in general and the total US monetary base has been extremely close (ie statistically significant at the 5% level at least) at least from 1964 until 2007:

Exhibit 28: Correlation (PPMC), total monetary base to price levels, 1961-2014



Source: Edison Investment Research, US Department of Labor, Federal Reserve, dollardaze.org

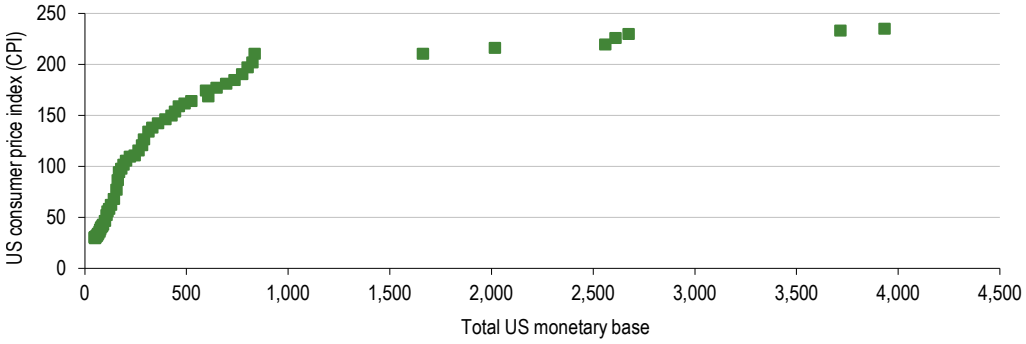
Exhibit 29: Scattergram, total monetary base vs price levels, 1959-2007



Source: Edison Investment Research, US Department of Labor, Federal Reserve, dollardaze.org

Since 2007 however, the relationship appears to have almost completely broken down, with the US total monetary base recording annual increases of 99%, 21%, 27%, 2%, 2%, 39% and 6% while (over the same timeframe) prices have increased by only 11.0% (or 1.5% per annum, on average):

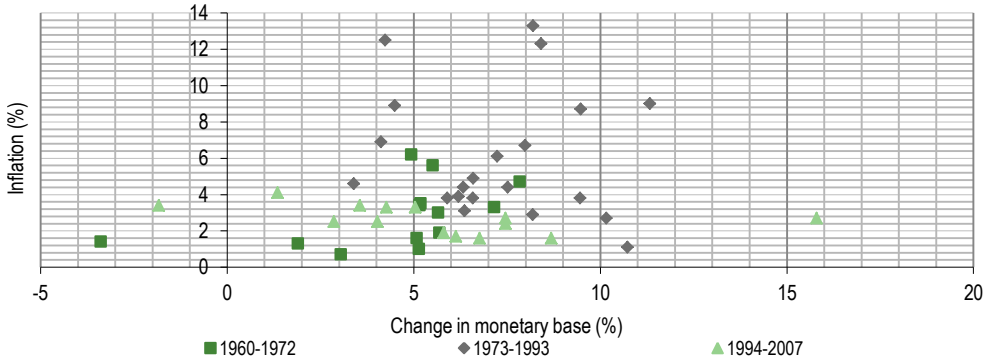
Exhibit 30: Scattergram, total monetary base vs price levels, 1959-2014



Source: Edison Investment Research, US Department of Labor, Federal Reserve, dollardaze.org

This is all the more striking when the historic relationship between inflation and changes in the monetary base is considered. Traditionally, increases in the total monetary base have been 6.0% per annum (geometric mean). Currently, the relationship between the two cannot be said to be statistically significant. However, it was between 1973 and 1992. Moreover, as Exhibit 31 demonstrates, there appears to be an increased risk of inflation in the event that the total monetary base increases by more than 4% per annum:

Exhibit 31: Scattergram, US CPI inflation vs change in total US monetary base, 1960-2007

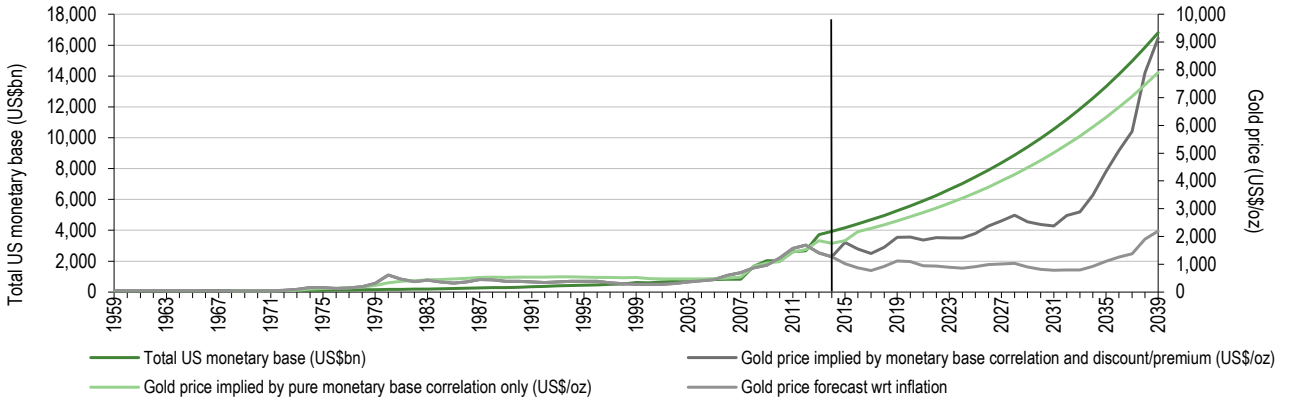


Source: Edison Investment Research, US Department of Labor, Federal Reserve, dollardaze.org

In fact, were the two to maintain their traditional relationship, given the total US monetary base now outstanding (Exhibits 23, 25 and 30), the CPI index should be almost exactly 4.0x its current level.

As such, it can be said that price rises in the general economy have not kept pace with increases in the total monetary base, given the historic relationship between the two. The gold price has risen by more than general prices in the past 15 years – arguably in part on account of increases in the total monetary base. Therefore it is now at a premium to its indexed level, but at a discount to the level implied by its total monetary base correlation. This disparity is depicted in Exhibit 32 (effectively a combination of Exhibits 22 and 27):

Exhibit 32: Historic and forecast gold price (forecast made wrt 1. US total monetary base and 2. inflation)



Source: Edison Investment Research and (underlying historic data) Federal Reserve, South African Chamber of Mines, dollardaze.org

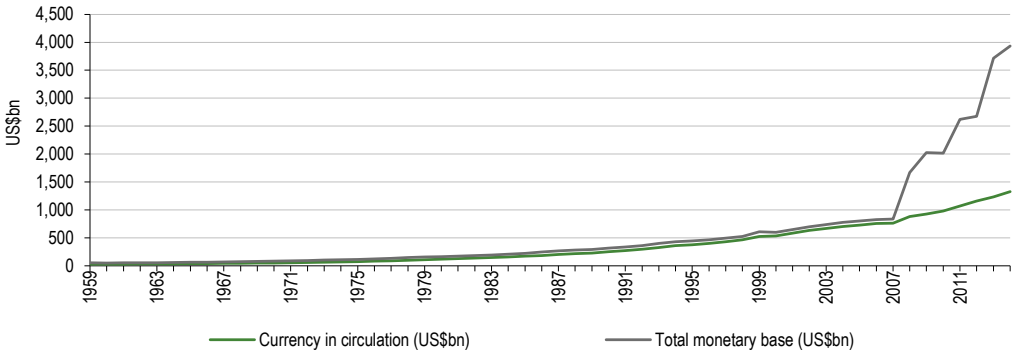
Rationalising the inflation paradox

Probably the simplest explanation for the apparent breakdown in the relationship between the US total monetary base and prices/inflation relates to the amount of currency in circulation in the US economy.

The total US monetary base is made up of two components: 1) currency in circulation and 2) total reserve balances maintained by banks and depositary institutions at the Federal Reserve (crudely, currency that could be in circulation).

Traditionally, currency in circulation has made up the majority of the total monetary base. In fact, between 1959 and 2007, it accounted for an average 74% of the total monetary base, with a maximum of 91% (in 2006) and a minimum of 57% (in 1959). During the period since the start of QE however, this proportion has reduced sharply. Arguably, the increase in the total monetary base is what was required in order to maintain growth in currency in circulation:

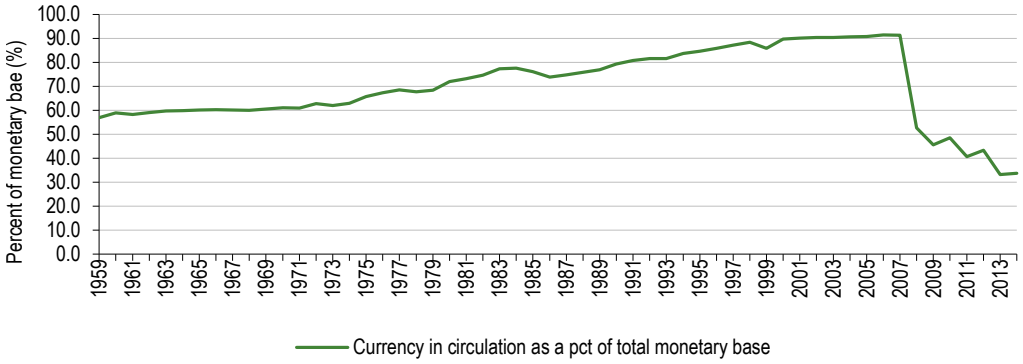
Exhibit 33: US currency in circulation vs total monetary base, 1959-2014



Source: Edison Investment Research, Federal Reserve, dollardaze.org

Nevertheless, it leaves the proportion of currency in circulation as a percentage of the US total monetary base at a post-1959 low of just 34%.

Exhibit 34: Currency in circulation as a percentage of the US total monetary base, 1959-2014

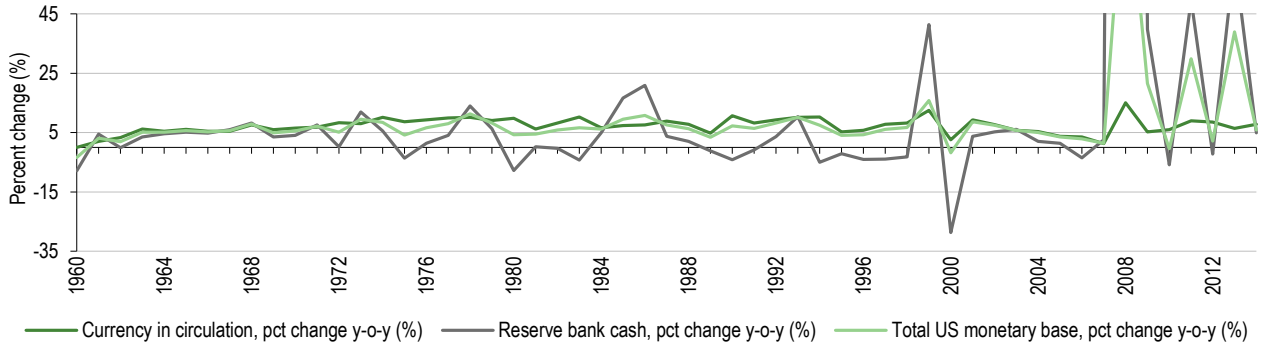


Source: Edison Investment Research, Federal Reserve, dollardaze.org

The correlation between the gold price and currency in circulation is not as strong as between the gold price and the total monetary base. In addition, the error of estimation is larger. Nevertheless, it is significant and, at the current time, US currency in circulation of US$1.3tr implies a gold price of US$1,334/oz – ie close to current levels.

Arguably, the function of manipulations to the total monetary base and reserve balances (in particular) is to maintain steady growth in currency in circulation (see graph):

Exhibit 35: Annual change in US total monetary base and its component parts, 1959-2014 (%)



Source: Edison Investment Research, Federal Reserve, dollardaze.org

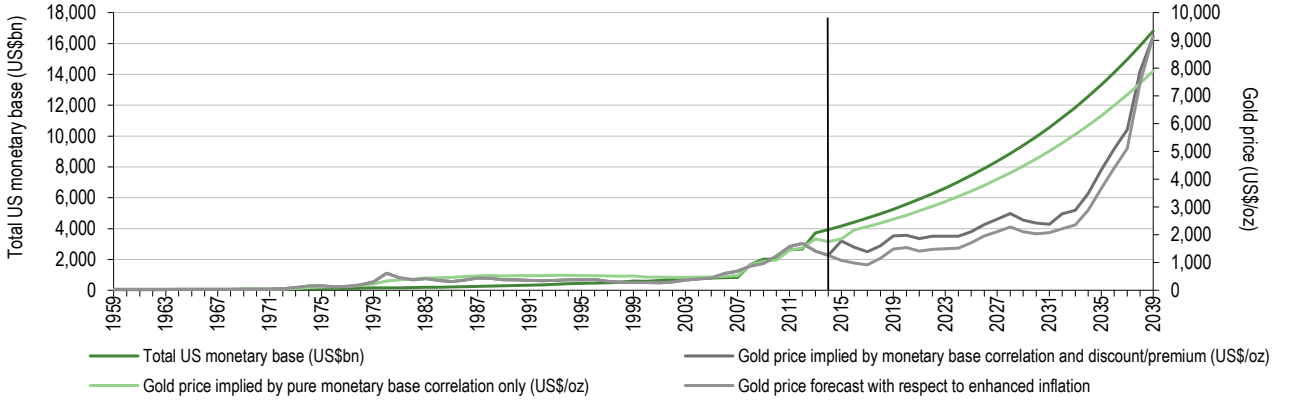
Equally however, in the 56 years since 1959, the US total monetary base has declined on only three occasions – in 1959-60, 1999-2000 and 2009-10. On the assumption that it continues its 'upward-only' trajectory, currency in circulation will have to increase from US$1.3tr currently to at least between US$2.2tr and US$3.6tr in order to revert to its traditional range of 57-91% of the total monetary base – ie an additional US$0.9-2.3tr will need to be transferred from total reserve balances into currency in circulation. This being the case, the gold price could be expected to rise (on the basis of its historic correlation) to US$2,215-3,503/oz.

Gold price forecasts

Excepting a sharp decline in the US total monetary base, almost any of the changes required to bring the United States' monetary profile into line with historic levels are non-trivial within the context of its GDP of US$17tr – implying inflation at some point in the future. Precisely when and to what extent will depend on specific monetary policy. Suffice it to say however, that in order to be able to align the two gold analyses presented above requires an inflation rate of 10.3% between

now and 2039 cf an historic average of 4.2% between 1972 and 2014 and an average rate of 0.8% in 2014. The aligned analysis is presented in Exhibit 36, below:

Exhibit 36: Historic and forecast gold price (forecast made wrt 1. US total monetary base and 2. Enhanced inflation)



Source: Edison Investment Research and (underlying historic data) Federal Reserve, South African Chamber of Mines, dollardaze.org

Note that the 'inflation' analysis permanently lags the 'monetary base' analysis until the two are finally aligned in 2039 – corroborating, to some extent, the assumption that there is a time-lagged effect between expansion in the monetary base and inflation.

A summary of Edison's gold price forecasts from 2016-2023 on the basis of the preceding four analyses is as follows:

Exhibit 37: Edison forecast gold price range, 2016-2023e (US$/oz)

	2016	2017	2018	2019	2020	2021	2022	2023
Monetary base correlation	**2,173**	**2,295**	**2,424**	**2,561**	**2,707**	**2,861**	**3,024**	**3,197**
Monetary base correlation & cycle	1,549	1,390	1,610	1,966	1,982	1,866	1,952	1,951
Top of the range	**2,173**	**2,295**	**2,424**	**2,561**	**2,707**	**2,861**	**3,024**	**3,197**
Middle of the range*	**1,523**	**1,533**	**1,673**	**1,839**	**1,899**	**1,905**	**1,981**	**2,047**
Enhanced long-term inflation	979	916	1,159	1,486	1,538	1,414	1,480	1,497
Long-term inflation (bottom of range)	**873**	**772**	**922**	**1,117**	**1,092**	**948**	**938**	**896**

Source: Edison Investment Research; Note: *Simple average of top and bottom of the range.

Note that three of four analyses effectively relate to a positive interest rate environment. Only one (the Monetary base correlation) relates to a negative interest rate one.

Otherwise, investors should be aware that the range of potential outcomes is wide. Self-evidently, to the extent that future inflation remains low (or even reverts to deflation), gold prices will tend towards the bottom of the range of forecasts – albeit, this should, to some extent, be mitigated by lower associated costs for producing mines.

In the event that there is an unequivocal reversion to positive real interest rates in the US however, Edison would discard its 'Monetary base correlation' analysis, in which case its forecast range of gold prices for 2016-2023 is as follows:

Exhibit 38: Forecast gold price range, 2016-2023e (US$/oz)**

	2016	2017	2018	2019	2020	2021	2022	2023
Monetary base correlation & cycle	**1,549**	**1,390**	**1,610**	**1,966**	**1,982**	**1,866**	**1,952**	**1,951**
Top of the range	**1,549**	**1,390**	**1,610**	**1,966**	**1,982**	**1,866**	**1,952**	**1,951**
Middle of the range*	**1,211**	**1,081**	**1,266**	**1,542**	**1,537**	**1,407**	**1,445**	**1,423**
Enhanced long-term inflation	979	916	1,159	1,486	1,538	1,414	1,480	1,497
Long-term inflation (bottom of range)	**873**	**772**	**922**	**1,117**	**1,092**	**948**	**938**	**896**

Source: Edison Investment Research; Note: *Simple average of top and bottom of the range; **Positive real interest rate environment.

As such, we estimate that the difference between a positive and negative real interest rate scenario is worth US$468/oz (±US$156/oz) to the price of gold – that is to say, that a shift from positive to negative real interest rates should increase the price of gold by c 34%, while a shift from negative to positive real interest rates will decrease it by c 25%.

London market summary

A summary of the companies, cash and assets analysed in the London market (and the changes therein over the course of the last year) is as follows:

Exhibit 39: London-listed gold explorers' sector summary with respect to resources

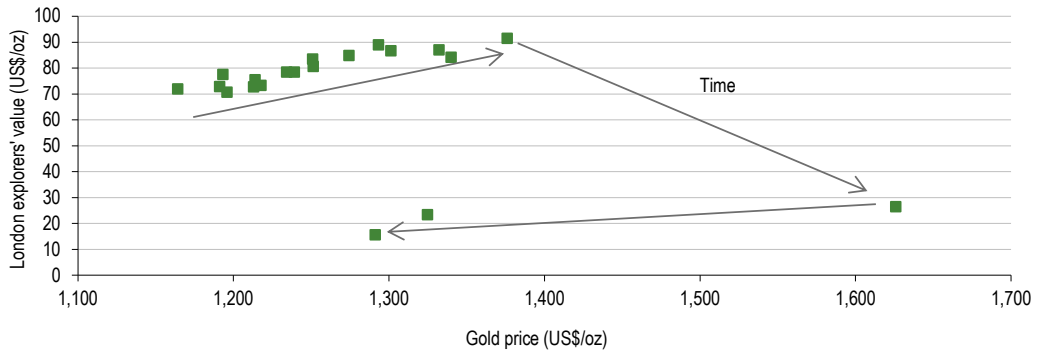
	August 2014				Percent change since August 2013			
Resource categorisation	Inferred	Indicated & Inferred	Measured, Indicated & Inferred	Total	Inf	Ind & inf	Meas, ind & inf	Total
Number of companies	2	10	7	19	-50.0	42.9	-36.4	-13.6
Percent (%)	11	53	37	100				
Market cap (US$m)	6	310	413	729	-76.9	-14.1	-7.0	-12.3
Percent (%)	1	43	57	100				
Net cash (US$m)	3	58	123	184	-90.3	52.6	459.1	100.0
Percent (%)	2	32	67	100				
Enterprise value (US$m)	2	252	290	545	-140.0	-21.7	-31.3	-26.4
Percent (%)	0	46	53	100				
Total oz (m)	0.2	17.4	17.5	35	-84.6	-0.6	34.6	10.1
Percent (%)	1	50	50	100				
Market cap per total oz (US$)	29.00	17.84	23.65	20.80	43.6	-13.5	-30.6	-20.3
EV per total oz (US$)	12.60	14.53	16.61	15.55	-455.9	-21.2	-48.7	-33.1

Source: Edison Investment Research. Note: Totals may not add up owing to rounding.

Compared to the equivalent figures in August 2013 (see *Gold – US$2070 by 2020*, published in November 2013), changes of note in August 2014 include:

- A decline in aggregate market capitalisation across the sector as a whole
- A sharp reduction in aggregate cash held by companies with Inferred resources only and an increase in cash holdings in both relative and absolute terms for companies with Indicated & Inferred and Measured, Indicated & Inferred ounces; note that London-listed companies with Inferred resources only have a higher proportion of cash relative to their market capitalisations than their counterparts in either Canada or Australia
- As a consequence of point two (above), a return to a positive enterprise value (EV) for companies with Inferred resources only and a 'normalisation' of the average value of Inferred ounces listed in London, which is once again positive
- Notwithstanding points two and three (above), a general de-rating of the sector over the course of the previous twelve months, such that the average ounce listed in London is now valued at US$15.55/oz compared to US$23.23/oz previously (see Exhibit 40, below):

Exhibit 40: Value of average oz listed in London vs gold price (US$), Jul '10-Aug '14

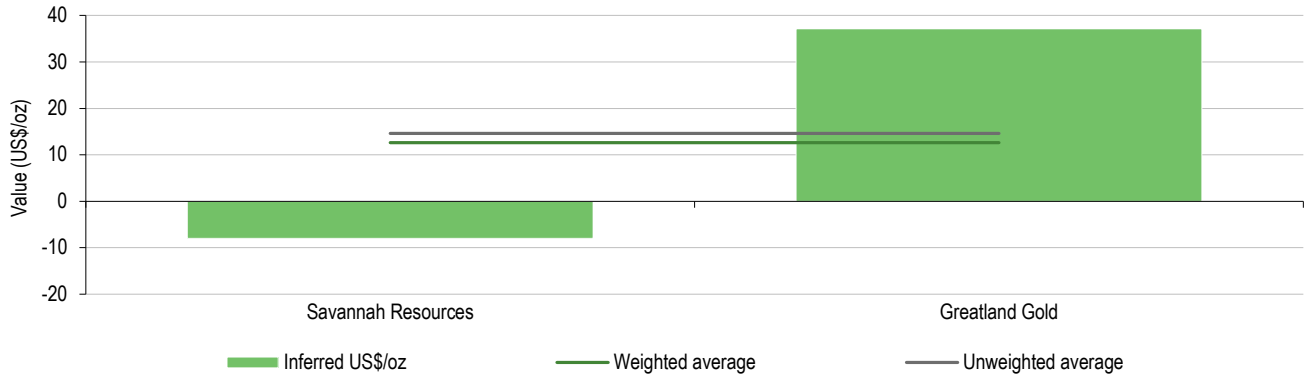


Source: Edison Investment Research

Note the similarity of the profile of the graph to those relating to the Canadian and Australian markets (see Exhibits 49 and 61).

The sample of companies with Inferred resources only in the London market has reduced markedly, with the promotion by Kefi and Ovoca of a portion of their resources into the Indicated category in particular. The weighted and un-weighted averages of the sample are closely aligned – US$12.60/oz and US$14.58/oz respectively – with a range of ±US$22.60/oz from the arithmetic mean. However, the subsequent de-rating of Greatland Gold probably now aligns it closely with the averages (cf the share price of Savannah, which has risen).

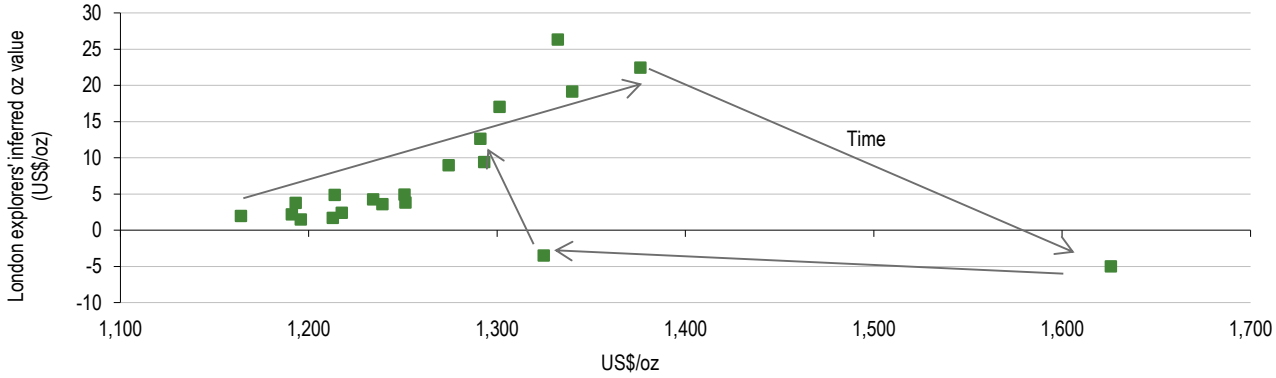
Exhibit 41: Implied value of Inferred ounces in the London market (US$), by company and averages



Source: Edison Investment Research

Notwithstanding the changes in the sample size, it is interesting to note the 're-connection' of the average value of Inferred ounces listed in London to levels which are similar to those that were extant the last time that the gold price was at similar levels in late 2010, despite the fact that gold was then in a bull market compared to a bear market currently.

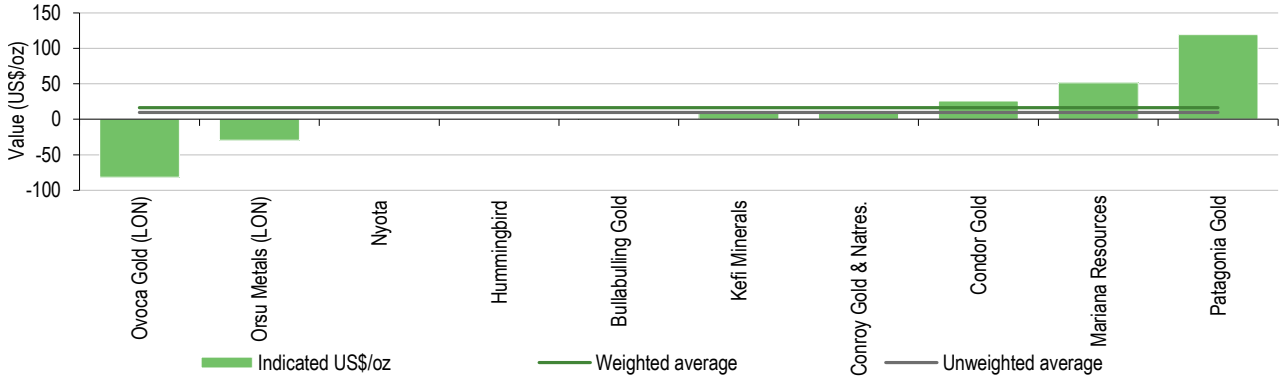
Exhibit 42: Value of London-listed Inferred oz vs gold price, 2010-14



Source: Edison Investment Research

Accepting the valuations shown above (Exhibit 41) for Inferred resources, the mean value for London-listed Indicated ounces is US$16.38/oz (weighted) or US$9.58/oz (un-weighted). Two companies at either end of the range (Patagonia and Ovoca) have values one standard deviation away from the mean. Excluding these reduces the average weighted value to US$7.64/oz and the average un-weighted value to US$7.24/oz. Given that such exclusions yield a result that is below the average value for Inferred ounces – which is counter-intuitive – the exclusion of these two companies appears unwarranted however.

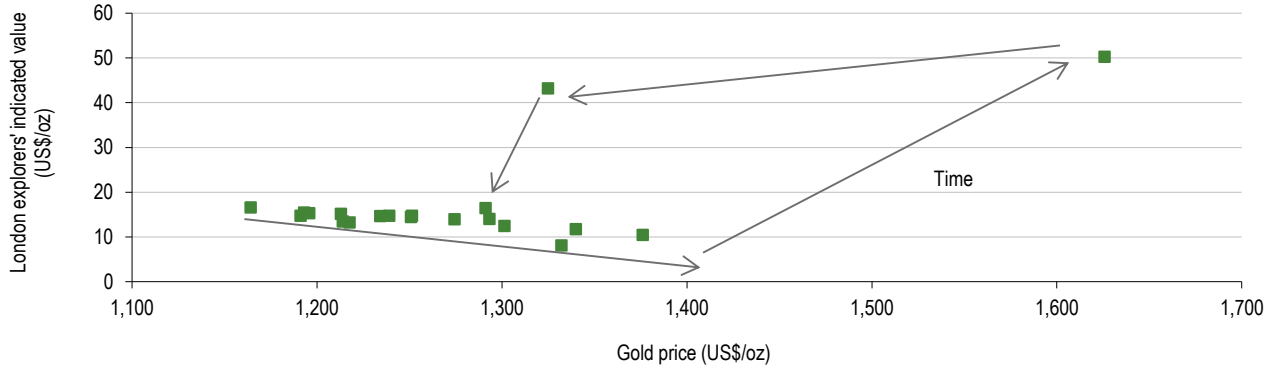
Exhibit 43: Implied value of Indicated ounces in the London market (US$), by company and averages



Source: Edison Investment Research

As with Inferred ounces, note a similar 're-connection' of the average value of Indicated ounces listed in London with those pertaining the last time that the gold price was at similar levels – reinforcing the average values calculated (including Patagonia and Ovoca).

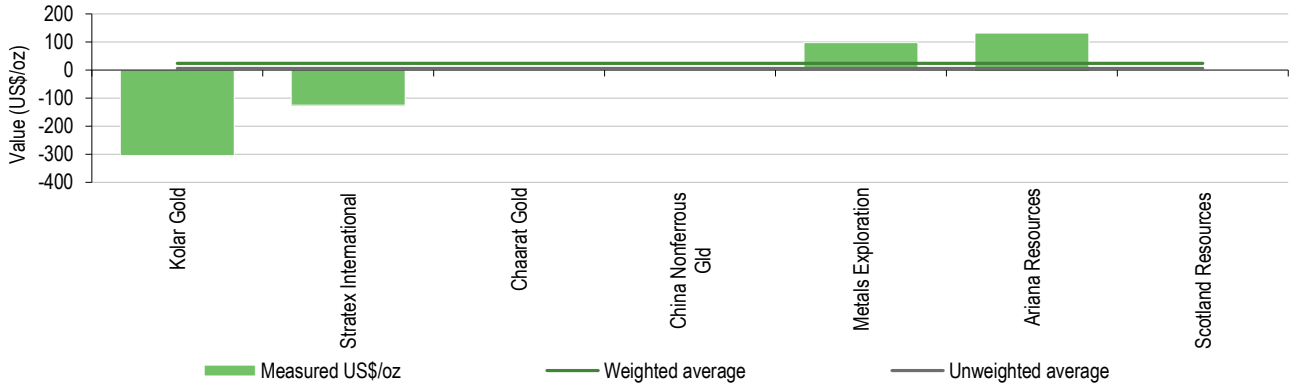
Exhibit 44: Value of London-listed Indicated oz vs gold price, 2010-14



Source: Edison Investment Research

Having established the average values of Inferred and Indicated resources of US$12.60/oz and US$16.38/oz, respectively, the average value of Measured ounces listed in the London market is US$24.07/oz (weighted) or US$10.27/oz (un-weighted). Again, two companies, at either end of the spectrum (Kolar and Scotland Resources) have values more than one standard deviation from the average. Excluding these yields a result instead of US$22.96/oz (ie close to the original on a weighted basis) or US$4.90/oz (un-weighted). Given the closeness of the weighted results in particular, excluding Kolar and Scotland Resources from the sample would again appear unwarranted.

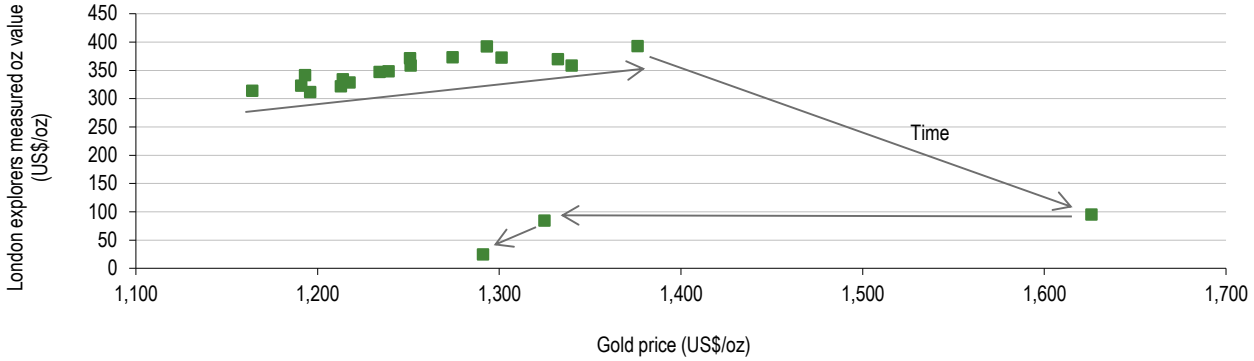
Exhibit 45: Implied value of Measured ounces in the London market (US$), by company and averages



Source: Edison Investment Research

In contrast to the evolution of value for Inferred and Indicated ounces relative to the gold price (which have 're-connected' to historical levels), the value of Measured ounces remains materially depressed. As such, one interpretation of the general de-rating of in-situ gold ounces in the London market over the past four years (see Exhibit 40) is that it has occurred disproportionately towards companies with Measured resources, compared to those in either the Indicated or Inferred categories with respect to the gold price.

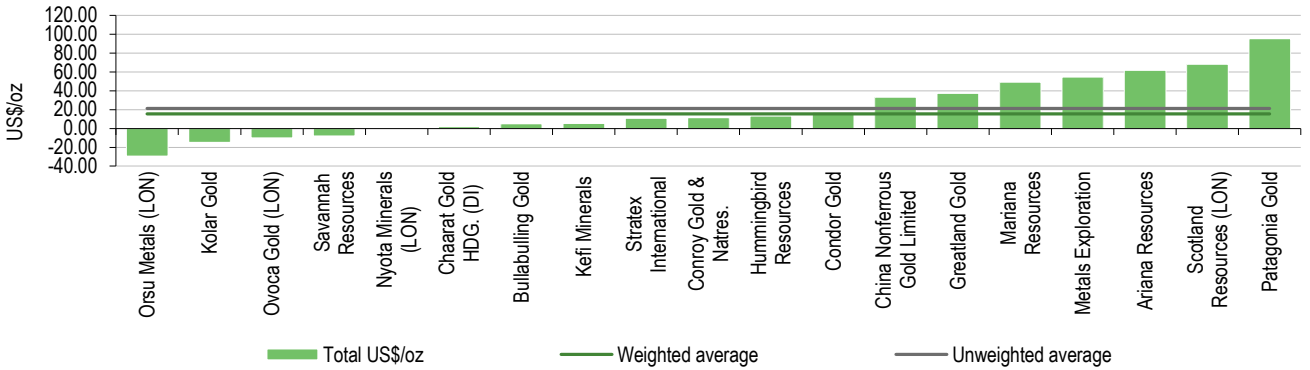
Exhibit 46: Value of London-listed Measured oz vs gold price, 2010-14



Source: Edison Investment Research

The average value of all ounces listed in the London market is US$15.55/oz on a weighted basis and US$21.12/oz on an un-weighted one with a range from US$95.21/oz (Patagonia) to less than zero. Note that the minimum market cap per ounce is US$1.31/oz for Nyota and this represents a more likely minimum value; companies on EV per ounce multiples less than this could be more plausibly interpreted as likely to exhaust their cash holdings for little or no change/expansion of their resources.

Exhibit 47: Implied mean value of average ounces in the London market (US$), by company and averages



Source: Edison Investment Research

Canadian market summary

A summary of the companies, cash and assets analysed in the Canadian market (and the changes therein over the course of the last year) is as follows:

Exhibit 48: Canadian-listed gold explorers' sector summary with respect to resources

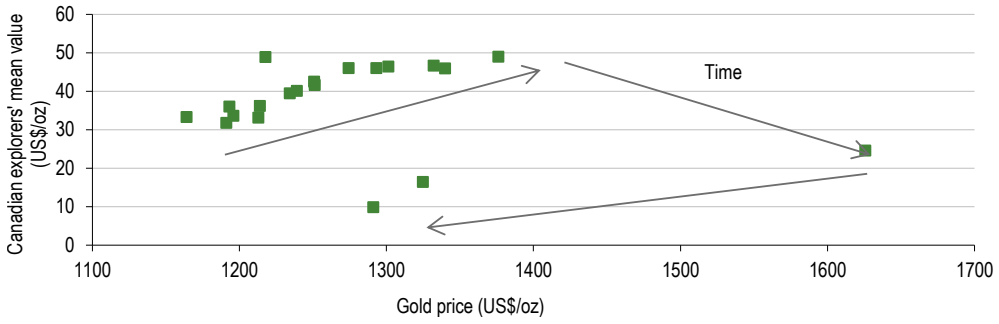
	August 2014				Percent change since August 2013			
Resource categorisation	Inferred	Indicated & Inferred	Measured, Indicated & Inferred	Total	Inf	Ind & inf	Meas, ind & inf	Total
Number of companies	5	4	10	19	25.0	-42.9	-9.1	-13.6
Percent (%)	26	21	53	100				
Market cap (US$m)	22	74	2,743	2,838	81.3	-66.7	-23.0	-25.2
Percent (%)	1	3	97	100				
Net cash (US$m)	2	42	213	257	64.0	-31.6	26.2	10.9
Percent (%)	1	16	83	100				
Enterprise value (US$m)	20	31	2,529	2,581	101.2	-80.5	-25.5	-27.6
Percent (%)	1	1	98	100				
Total oz (m)	6.0	13.6	244.3	263.9	25.0	-31.0	26.4	21.2
Percent (%)	2	5	93	100				
Market cap per total oz (US$)	3.62	5.43	11.23	10.76	46.0	-51.8	-39.1	-38.3
EV per total oz (US$)	3.35	2.31	10.36	9.78	54.5	-71.6	-41.0	-40.3

Source: Edison Investment Research. Note: Totals may not add up owing to rounding.

Notable changes since August 2013 include:

- A general reduction in aggregate market capitalisation, but an increase in net cash, resulting in a reduction in enterprise value across the sector
- An increase in aggregate resources
- A general de-rating of the value of ounces listed in Canada
- Perhaps surprisingly within the context of a general de-rating, there was an increase in the aggregate market capitalisation of companies listed in Canada with Inferred ounces only (see analysis below).
- Note that Canadian companies with Indicated & Inferred resources only have a higher proportion of cash relative to their market capitalisations than their counterparts in either London or Australia

Exhibit 49: Value of average oz listed in Canada vs gold price (US$), Jul '10-Aug '14

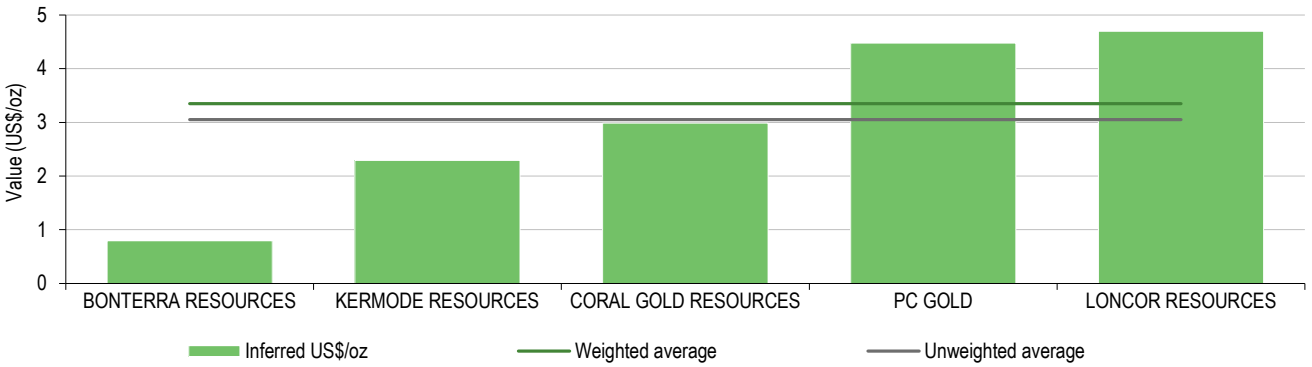


Source: Edison Investment Research

Note the similarity of the profile of the graph to those relating to the London and Australian markets (see Exhibits 40 and 61).

The weighted average value of Inferred ounces listed in Canada is US$3.35/oz and the un-weighted average is US$3.05/oz (±US$2.26/oz). The sample size of companies with Inferred resources only has increased by one since August 2013 with the inclusion of Loncor Resources. While this is the most highly rated individual company within the sample, its inclusion has a relatively small effect on the averages calculated. Excluding it instead yields averages of US$3.08/oz (weighted) and US$2.64/oz (unweighted) – still up 42% since Aug '13 on a like-for-like basis.

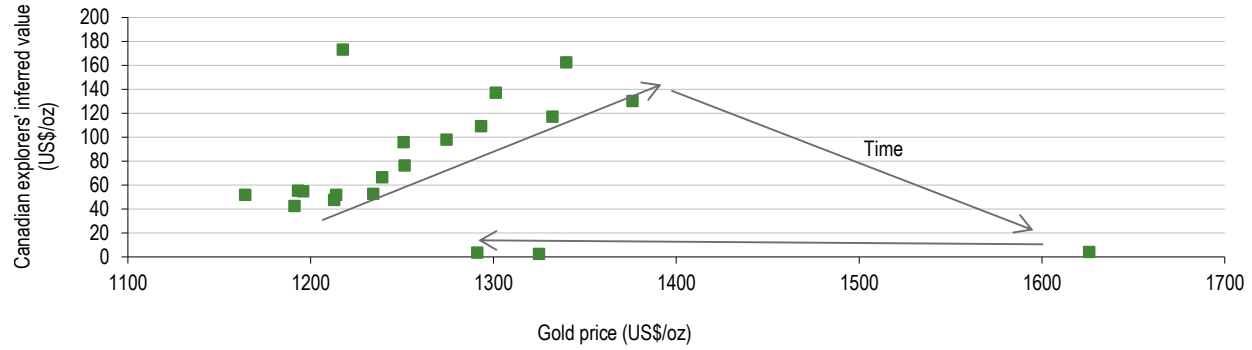
Exhibit 50: Implied value of Inferred ounces in the Canadian market (US$), by company and averages



Source: Edison Investment Research

While there has indeed been a recovery in the average value of Inferred ounces listed in Canada, that value remains substantially below those when gold was last at these levels – ie unlike the London market, there has been no 're-connection' with historical norms.

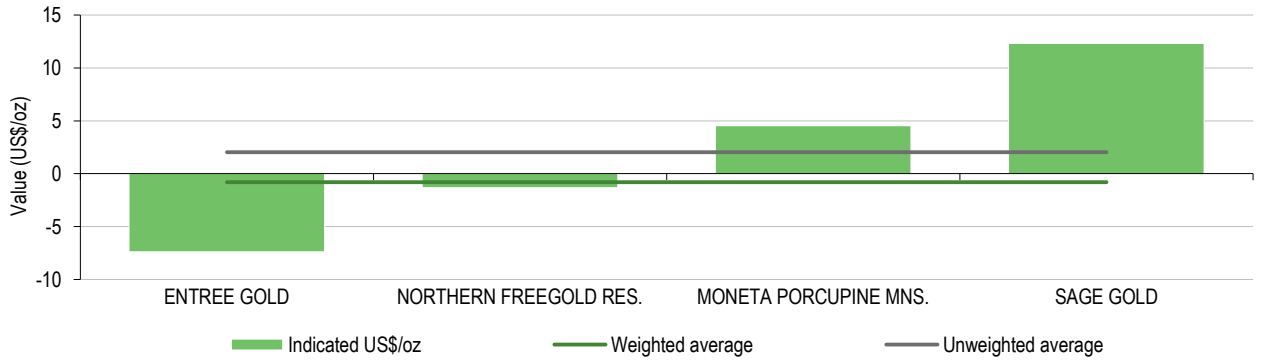
Exhibit 51: Value of Canadian listed Inferred oz vs gold price, 2010-14



Source: Edison Investment Research

Accepting the weighted average valuation above for Inferred resources, the mean value for Canadian-listed Indicated ounces is minus US$0.80/oz on a weighted basis or US$2.04/oz on an un-weighted one. The sample of Canadian-listed companies with Indicated & Inferred ounces only has been reduced by the promotion by Lupaka of a portion of its resources to the Measured category, the takeover of Oromin by Teranga and Klondex's evolution into a producer. While counter-intuitive however (since the average value of Indicated ounces listed in Canada appears less than the value of Inferred ounces), an alternative interpretation would be that the weighted average value of Indicated and Inferred ounces in Canada is US$2.63/oz when considered together.

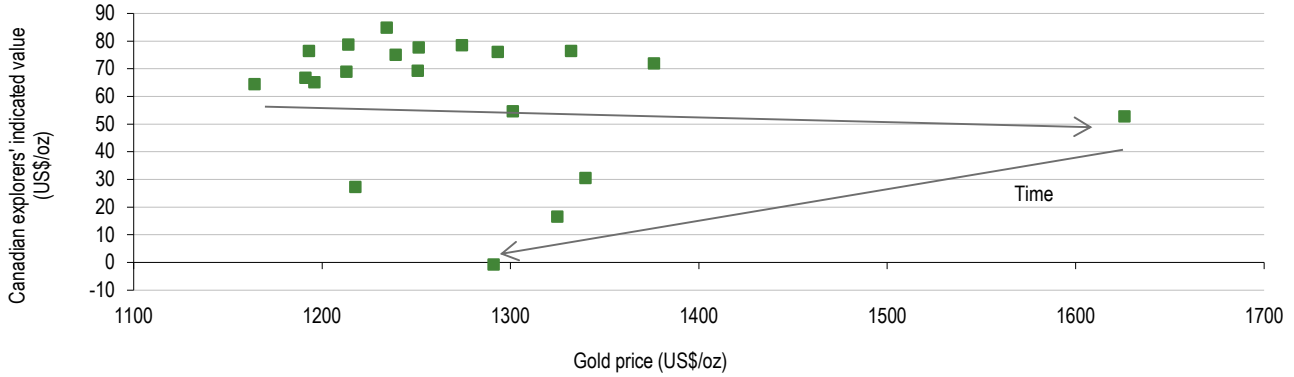
Exhibit 52: Implied value of 'indicated' ounces in the Canadian market (US$), by company and averages



Source: Edison Investment Research

Alternatively, a minimum value for Indicated ounces could be regarded as US$2.31/oz, which occurs when Inferred ounces are also worth US$2.31/oz (their maximum). Similarly, it is not possible for the average value of Indicated ounces to exceed US$11.69/oz without exceeding the value for Measured ounces (which would be similarly counter-intuitive). On any interpretation, however, the value of Indicated ounces listed in Canada is at an historical low within the context of recent times (see right).

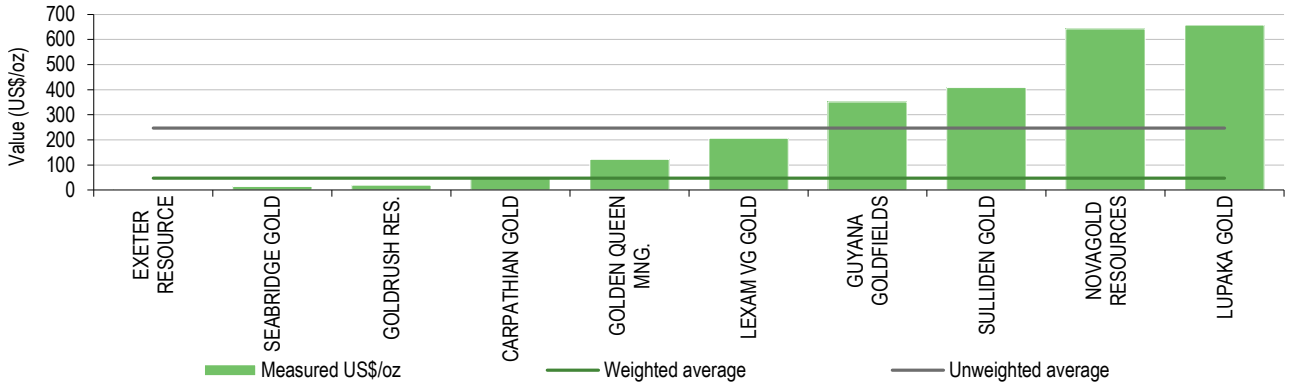
Exhibit 53: Value of Indicated ounces listed in Canada vs gold price (US$/oz), Jul 10-Aug 14



Source: Edison Investment Research

Using the calculated weighted average valuations for Indicated and Inferred resources of minus US$0.80/oz and US$3.35/oz, respectively, the mean values of Measured ounces listed in Canada are US$48.08/oz on a weighted basis and US$247.32/oz on an un-weighted basis, within a wide range, from US$2.15/oz (Exeter Resources) to US$658.82/oz (Lupaka). The result is particularly influenced by Seabridge, Exeter and Novagold which together account for 82% of the ounces considered in the Canadian market.

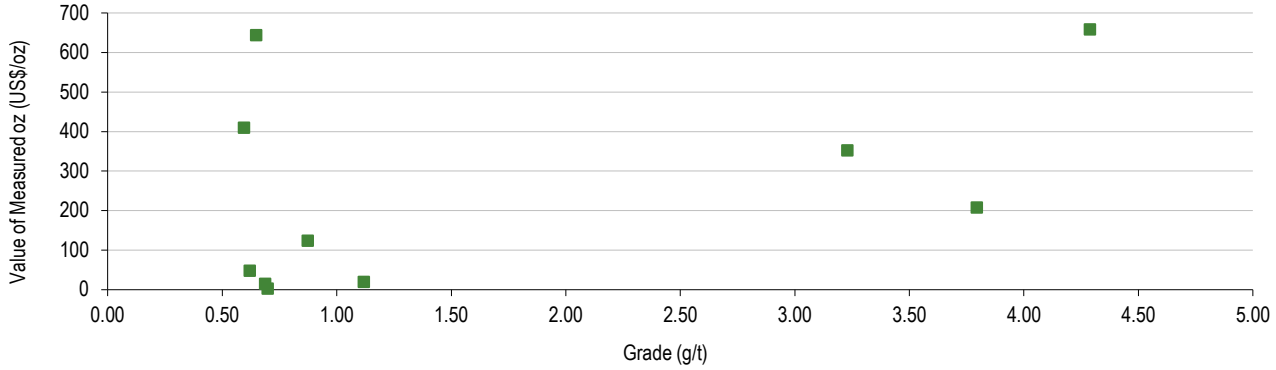
Exhibit 54: Implied value of Measured ounces in the Canadian market (US$), by company and averages



Source: Edison Investment Research

Excluding these companies yields a weighted average value of Measured ounces of US$170.90/oz and an un-weighted average of US$259.15/oz. However, given that there is no statistically significant correlation at the 5% level between the grade of a resource and its valuation within this sample (with a Pearson Product Moment Coefficient between the two of 0.43 in the Measured category – see right), excluding these three companies on the basis of the size of their resources or their grade would again appear to be unwarranted.

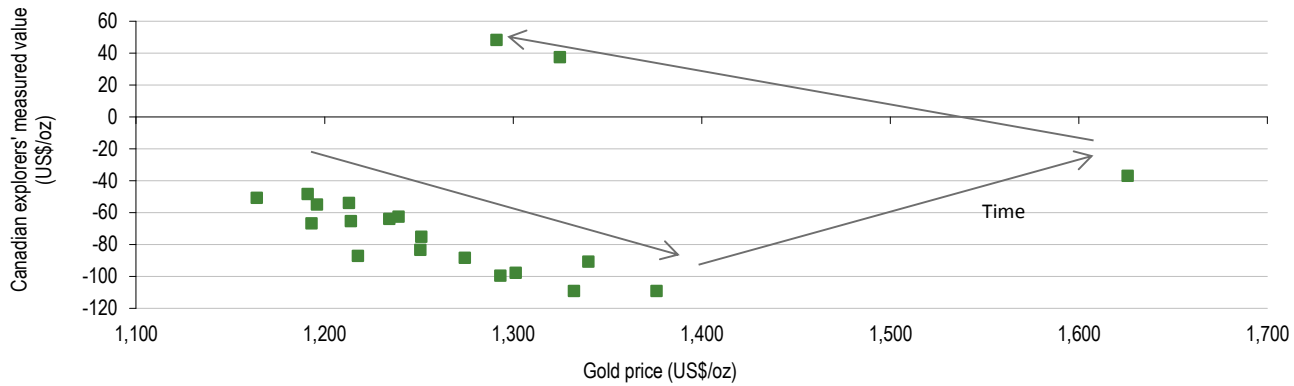
Exhibit 55: Correlation of gold grade (g/t) vs valuation (US$/oz) of Measured oz listed in Canada



Source: Edison Investment Research

In contrast to the London market, in which the average value of Inferred ounces has increased, but the average values of Measured and Indicated ounces have declined, in Canada the average value of Measured ounces has increased, while the values of Indicated and Inferred ounces have declined.

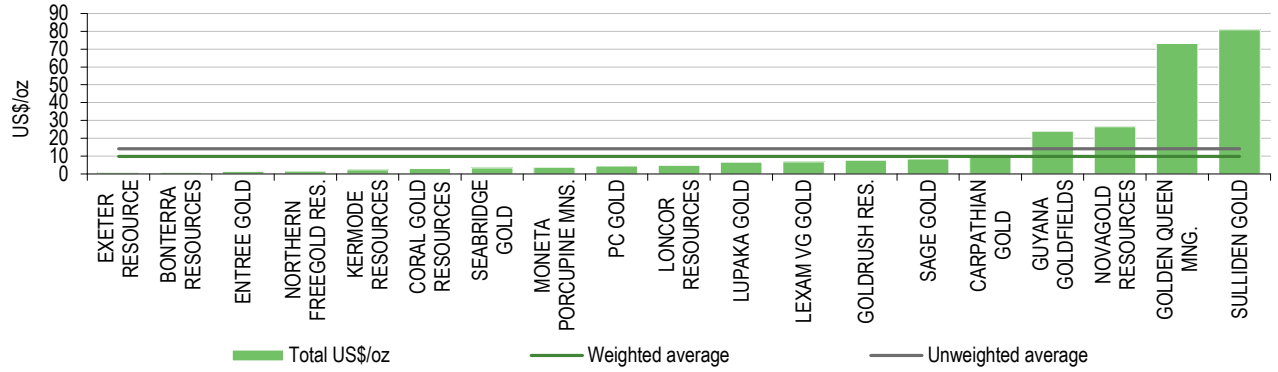
Exhibit 56: Value of Measured oz listed in Canada vs gold price (US$/oz), Jul 10-Aug 14



Source: Edison Investment Research

Considered together, the weighted average value of ounces listed in Canada is US$9.78/oz (US$14.17/oz un-weighted), within a range from zero to US$81/oz.

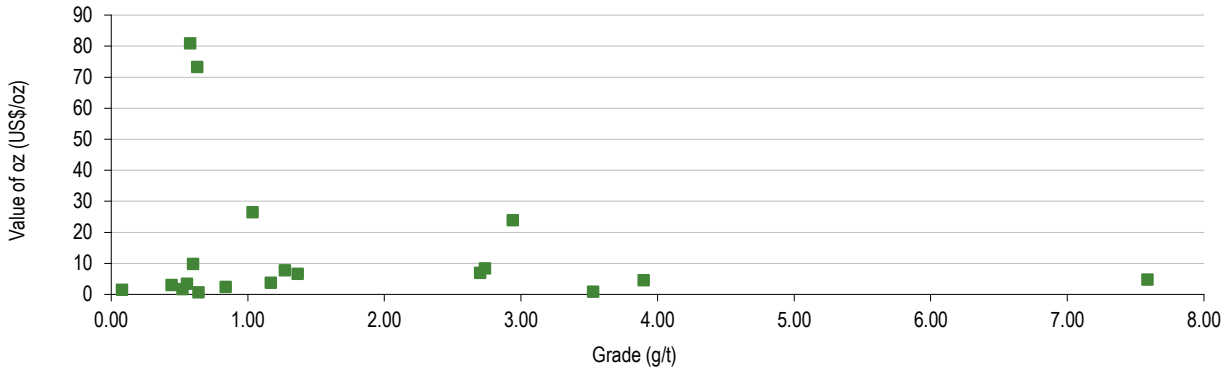
Exhibit 57: Implied mean value of average ounces listed in Canada (US$), by company and averages



Source: Edison Investment Research

Again however, there is no statistically significant correlation at the 5% level between the grade of the resources sampled and their valuation, with a Pearson Product Moment Coefficient between the two of -0.19 (see right).

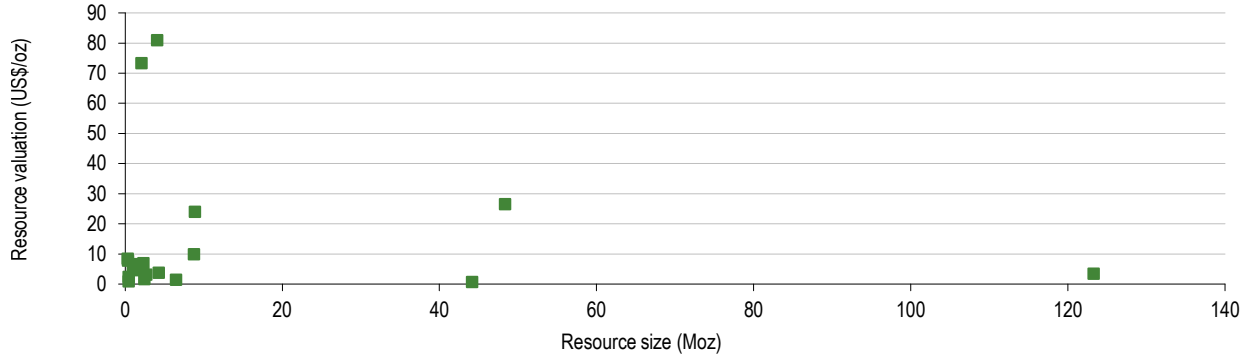
Exhibit 58: Correlation of grade (g/t) vs valuation (US$/oz) of gold oz listed in Canada



Source: Edison Investment Research

Note that there is also no statistically significant correlation (at the 5% level) between the size of a resource and its valuation, with a Pearson Product Moment Coefficient between the two of -0.09, right (ie virtually random).

Exhibit 59: Correlation of size (Moz) vs valuation (US$/oz) of gold resources listed in Canada



Source: Edison Investment Research

Australian market summary

A summary of the companies, cash and assets analysed in the Australian market (and the changes therein over the course of the last year) is as follows:

Exhibit 60: Canadian-listed gold explorers' sector summary with respect to resources

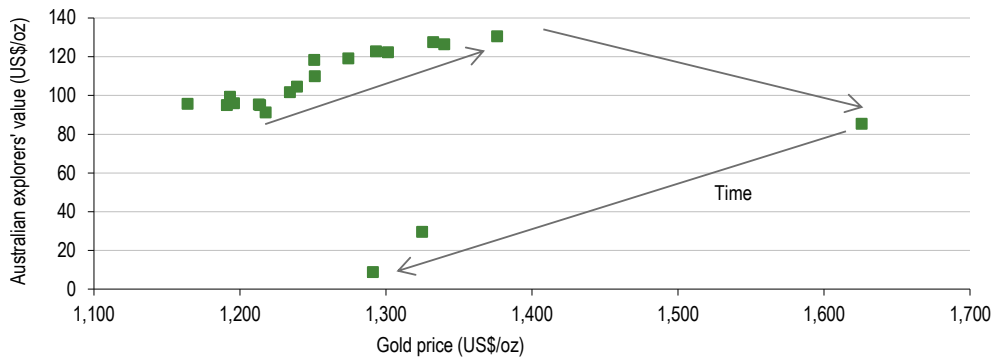
	August 2014				Percent change since August 2013			
Resource categorisation	Inferred	Indicated & Inferred	Measured, Indicated & Inferred	Total	Inf	Ind & inf	Meas, ind & inf	Total
Number of companies	3	4	7	14	-50.0	-42.9	-22.2	-36.4
Percent (%)	21	29	50	100				
Market cap (US$m)	13	77	278	368	-67.4	-82.0	-74.3	-76.2
Percent (%)	4	21	76	100				
Net cash (US$m)	3	14	254	271	-90.1	-78.8	55.9	5.8
Percent (%)	1	5	94	100				
Enterprise value (US$m)	11	63	24	97	-28.0	-82.6	-97.4	-92.5
Percent (%)	11	64	24	100				
Total oz (m)	1.2	1.8	18.6	21.6	-71.4	-80.6	-39.3	-50.8
Percent (%)	6	8	86	100				
Market cap per total oz (US$)	11.12	43.87	14.92	17.05	13.4	-7.7	-57.6	-51.7
EV per total oz (US$)	8.99	35.75	1.27	4.50	145.0	-10.7	-95.7	-84.7

Source: Edison Investment Research. Note: Totals may not add up owing to rounding

Notable changes since August 2013 include:

- A general reduction in aggregate market capitalisation across the industry (like London), but an increase in net cash, resulting in a reduction in enterprise value across the sector; note however, that the increase in cash was limited to companies with all three categories of resources. Companies without Measured resources have actually experienced sharp declines in cash holdings
- A decrease in aggregate resources
- A general de-rating of the value of ounces listed in Australia, but an increase in the value of Inferred ounces
- Note that Australian companies with Measured, Indicated & Inferred resources have a higher proportion of cash relative to their market capitalisations than their counterparts in either London or Canada

Exhibit 61: Value of average oz listed in Australia vs gold price (US$), Jul '10-Aug '14

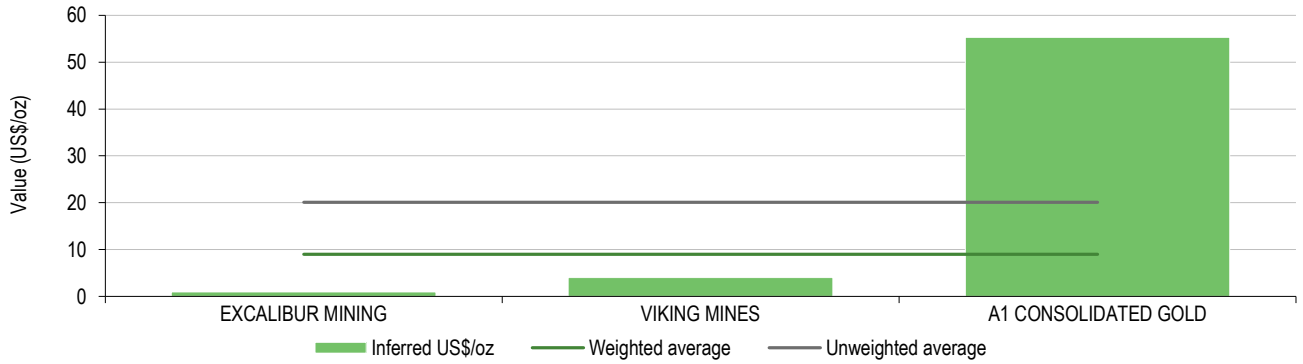


Source: Edison Investment Research

Note the similarity of the profile of the graph to those relating to the London and Canadian markets (see Exhibits 40 and 49).

The sample of companies listed in Australia with Inferred ounces only has reduced since 2013 as a result of the promotion by Chesser of a portion of its resources into the Indicated category and the acquisition by Anova of the Big Springs project in Nevada. Beyond that however, the basic profile of the sample remains broadly unchanged with A1 trading at a premium to the averages and Viking and Excalibur trading at discounts. The average value of Inferred resources on this basis is US$8.99/oz (weighted) and US$20.09/oz (un-weighted).

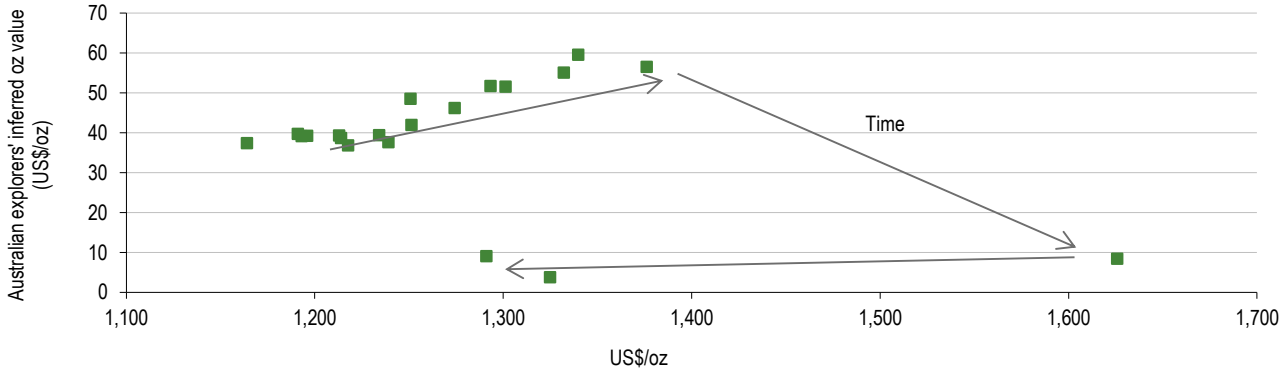
Exhibit 62: Implied value of Inferred ounces in the Australian market (US$), by company and averages



Source: Edison Investment Research

As such, the value of Inferred ounces listed in Australia has increased by 145% since August 2013 when it was US$3.67/oz – albeit the increase can be attributed to a reduction in net cash holdings acting to increase the sample's aggregate enterprise value, rather than an increase in market capitalisations.

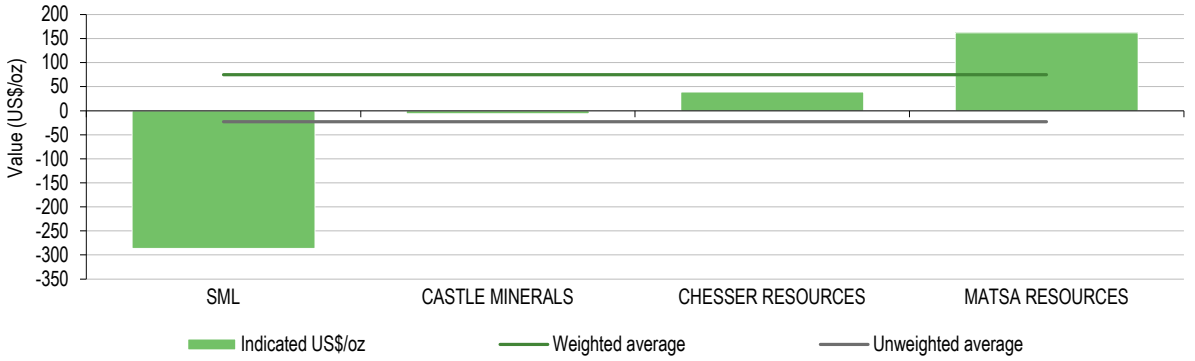
Exhibit 63: Value of Inferred oz listed in Australia vs gold price (US$/oz), Jul 10-August 14



Source: Edison Investment Research

Similarly, the sample of companies with Indicated and Inferred ounces only has been reduced by the promotion by KalNorth of a portion of its resource into the Measured category, the entry into production of Doray and the takeovers of Papillon and Ampella. This analysis was originally performed including Papillon after it had announced its merger proposals with Canada's B2Gold. As such, its shares were trading at a level reflecting the merger terms, implying a value for its Indicated resources of US$560.43/oz and increasing the value of the average for the sample to US$353.68/oz on a weighted basis.

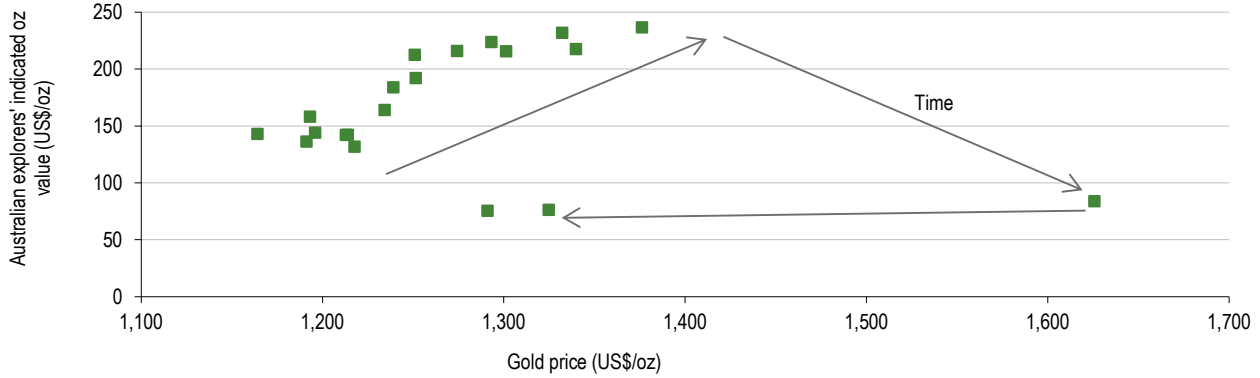
Exhibit 64: Implied value of Indicated ounces listed in Australia (US$/oz), by company and averages



Source: Edison Investment Research

In Edison's opinion however, this reflects not the actual value of Papillon's resources, but a value substantially discounting the likelihood of those ounces entering production – or, stated alternatively, what they could be worth in the future. Excluding Papillon, an average value of US$8.99/oz for Inferred ounces (see above) implies an average value of US$75.24/oz for Indicated ounces (on a weighted basis) – almost identical to 2013's valuation.

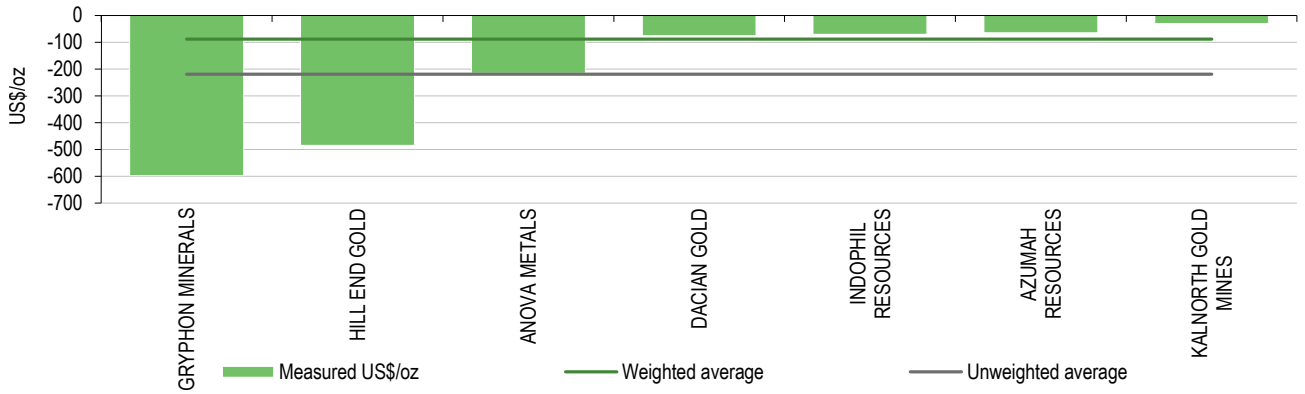
Exhibit 65: Value of Indicated oz listed in Australia vs gold price (US$/oz), Jul 10-Aug 14



Source: Edison Investment Research

Mean values of US$8.99/oz and US$75.24/oz for Inferred and Indicated ounces respectively, imply a mean value for Measured ounces of minus US$88.18/oz with every company in the sample returning a negative implied value for their Measured resources.

Exhibit 66: Implied value of Measured ounces in the Australian market (US$/oz), by company and averages

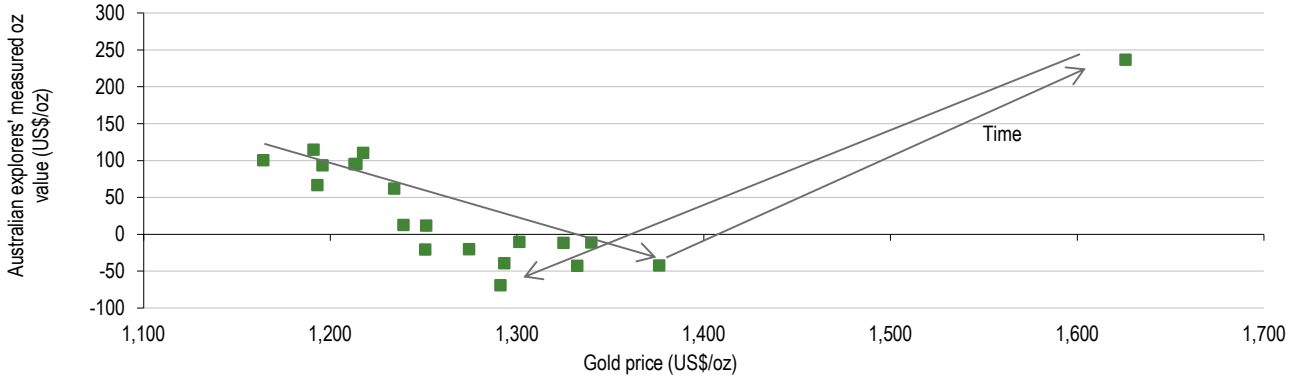


Source: Edison Investment Research

While counter-intuitive, this pattern is consistent with recent historic experience in the Australian market (see right) and also, at various times, the Canadian market (see Exhibit 56), when premium values for Indicated ounces in particular have been achieved apparently to the detriment of the implied valuation of Measured ounces.

Note that if the valuations of Indicated and Inferred ounces were reduced to zero for each, the implied value of Measured ounces in the sample would still be only US$3.53/oz.

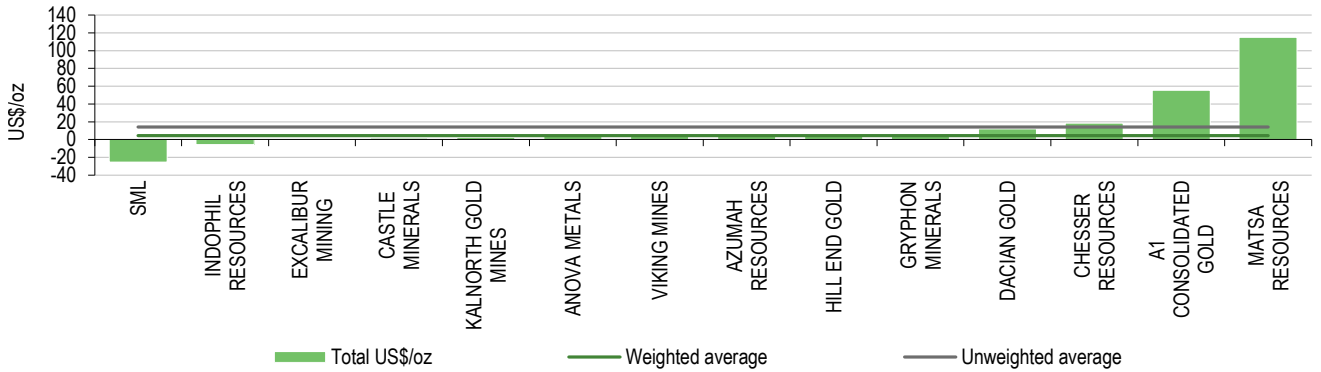
Exhibit 67: Value of Measured oz listed in Australia vs gold price (US$/oz), Jul 10-Aug 14



Source: Edison Investment Research

Alternatively, the Australian market can be analysed in terms of total resources. This implicitly confers a premium valuation on Inferred ounces and a discounted one on Measured ones. In the case of total ounces, the average in-situ value is US$4.50/oz on a weighted basis (which would represent a maximum value for Inferred ounces and a minimum value for Measured ounces) or US$14.13/oz on an un-weighted basis, within a range from US$114.94/oz for Matsa to minus US$25.46/oz for SML.

Exhibit 68: Implied mean value of average ounces listed in Australia (US$/oz), by company and averages



Source: Edison Investment Research

Silver market summary

A summary of the companies, cash and assets analysed in the global silver market is as follows:

Exhibit 69: Listed silver explorers' summary analysis

Resource categorisation	Inferred	Indicated & Inferred	Measured, Indicated & Inferred	Total
Number of companies	2	5	5	12
Percent (%)	17	42	42	100
Market cap (US$m)	2	844	517	1,362
Percent (%)	0	62	38	100
Net cash (US$m)	1	142	89	232
Percent (%)	0	61	39	100
Enterprise value (US$m)	1	702	427	1,130
Percent (%)	0	62	38	100
Total oz (m)	17.3	565.1	747.6	1,330.0
Percent (%)	1	42	56	100
Market cap per total oz (US$)	0.09	1.49	0.69	1.02
EV per total oz (US$)	0.04	1.24	0.57	0.85

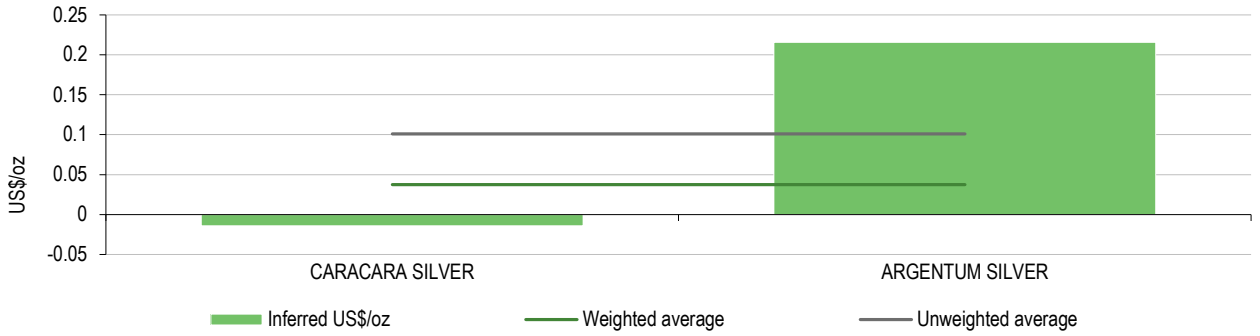
Source: Edison Investment Research. Note: Totals may not add up owing to rounding

A number of features of the industry are immediately apparent from the summary:

- The very low valuation of companies with Inferred resources only relative to those with Measured and Indicated resources as well
- Relatively high cash holdings for companies with only Inferred resources (equating to 59% of their aggregate market capitalisation cf 17% each for companies with Indicated and Measured ounces
- The fact that companies with Measured ounces trade on a mean resource multiple that is less than companies with Indicated ounces – strongly suggesting that the average value of Measured ounces is lower than that for Indicated ounces

While visually quite disparate, in fact the sample grouping for companies with Inferred resources only is reasonably close – especially when compared with the samples and averages of higher categorisations of resources. In the meantime, both companies operate in similar geographic regions (Mexico for Argentum and Peru for Caracara). Moreover, the implied weighted average value of US$0.04/oz for Inferred resources is also close to the US$0.05/oz market cap per resource ounce for Caracara (ie its EV per oz in the event that it were to exhaust its cash reserves and neither increase nor upgrade its resources), which provides additional support for the result.

Exhibit 70: Implied value of global silver Inferred ounces (US$), by company and averages

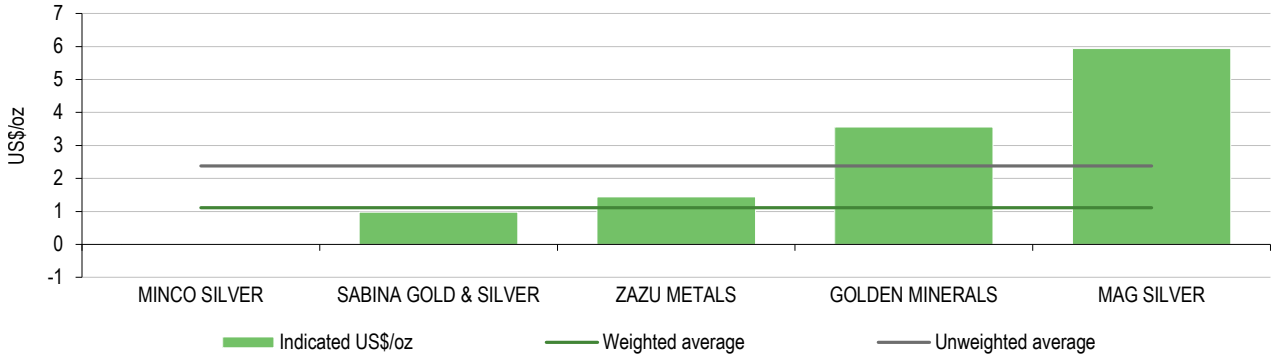


Source: Edison Investment Research

Substituting a value of US$0.04/oz for Inferred resources yields an average value of US$1.12/oz for Indicated ounces on a weighted basis or US$2.38/oz on an un-weighted basis, within a range from (effectively) zero up to US$5.93/oz (MAG Silver).

Notably the implied values for Golden Minerals and MAG Silver fall more than one standard deviation above the calculated mean – although this alone does not seem sufficient reason to exclude them from the sample.

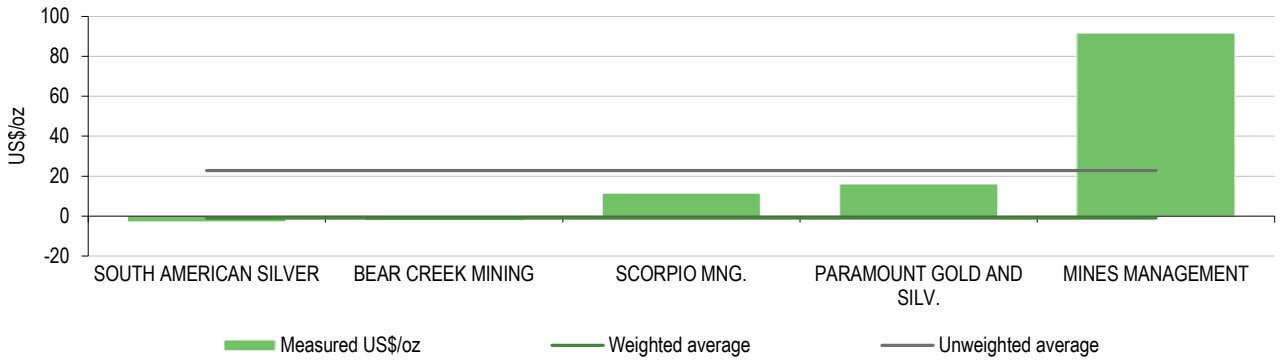
Exhibit 71: Implied value of global silver Indicated ounces (US$), by company and averages



Source: Edison Investment Research

Finally, substituting values of US$0.04/oz and US$1.12/oz for Inferred and Indicated ounces, respectively, yields a weighted average value of minus US$0.98/oz for Measured ounces, within a wide range from minus US$2.84/oz for South American Silver to US$91.69/oz for Mines Management. A number of issues affect the result, including the sample size and the fact that both South American Silver and Bear Creek Mining have experienced security of tenure issues regarding their assets. In addition, Bear Creek accounts for the majority of the Measured ounces analysed in the sample. However, excluding them results in an average value for Measured resources of US$16.97/oz – which seems equally counter-intuitive within the context of the silver price.

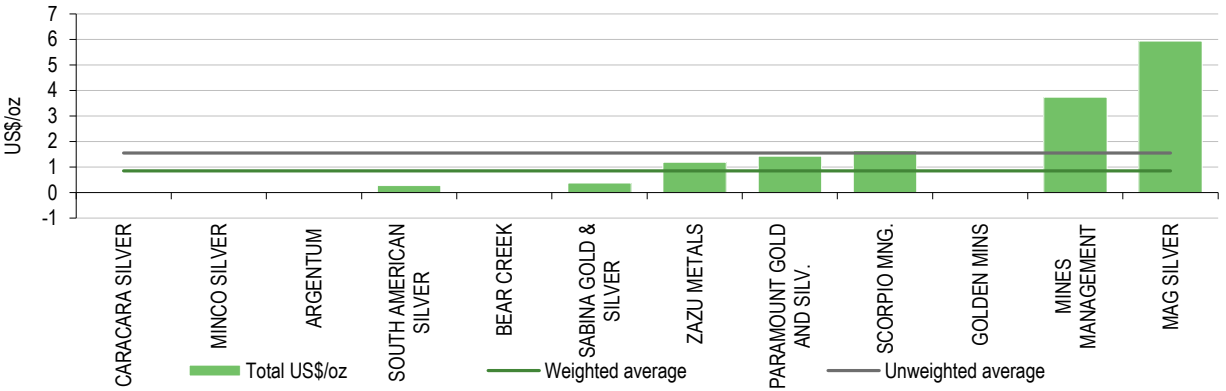
Exhibit 72: Implied value of global silver Measured ounces (US$), by company and averages



Source: Edison Investment Research

Two high level conclusions are probably appropriate for the silver explorers' analysed. The first is that the silver industry is, *prima facie*, similar to the gold industry and that upgrading resources from the Inferred to the Indicated categories is value adding (depending on cost), but that the upgrading of Indicated ounces to Measured status is of only questionable or occasional value and potentially value destroying. The second possible conclusion is that investors treat all ounces in the silver market equally and do not readily distinguish between categorisations for valuation purposes. In this case the average value of an average ounce is US$0.85/oz on a weighted basis (as shown in Exhibit 73 to the right).

Exhibit 73: Implied value of average global silver ounces (US$), by company and averages



Source: Edison Investment Research

Uranium market summary

A summary of the companies, cash and assets analysed in the uranium market is as follows:

Exhibit 74: Listed uranium explorers' summary analysis

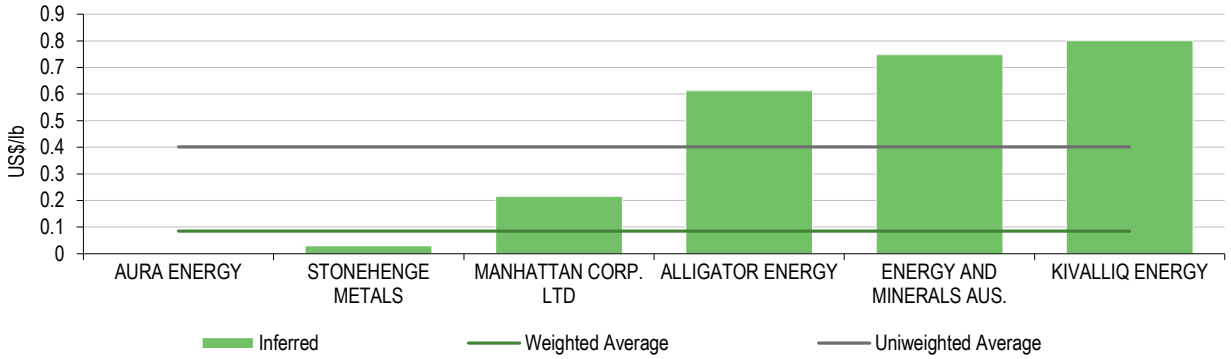
Resource categorisation	Inferred	Indicated & Inferred	Measured, Indicated & Inferred	Total
Number of companies	6	17	6	29
Percent (%)	21	59	21	100
Market cap (US$m)	75	447	259	781
Percent (%)	10	57	33	100
Net cash (US$m)	-13	95	-2	80
Percent (%)	-16	119	-2	100
Enterprise value (US$m)	88	352	260	701
Percent (%)	13	50	37	100
Total lbs (m)	1,046	3,460	606	5,112
Percent (%)	20	68	12	100
Market cap per total lb (US$)	0.07	0.13	0.43	0.15
EV per total lb (US$)	0.08	0.10	0.43	0.14

Source: Edison Investment Research. Note: Totals may not add up owing to rounding

Of particular note is the relatively low level of cash holdings of uranium explorers and, in some cases (eg Energy & Minerals Australia), evidence of the ability of these companies to raise debt as a means of funding.

The weighted average value of in-situ Inferred pounds of uranium is US$0.08/lb, while the un-weighted average is US$0.40/lb. The weighted average, in particular, is heavily influenced by Aura Energy, which contributes 82% of the resources in the sample. If Aura is excluded, the weighted average increases to US$0.46/lb. However, this generates a counter-intuitive value for Indicated lbs (see below), for which reason (and in the absence of any other reasons to exclude it) Aura has been retained. The standard deviation of the sample is US$0.33/lb and it can therefore been seen that Alligator, Energy & Minerals Australia and Kivalliq Energy all trade at ratings more than one standard deviation from the mean.

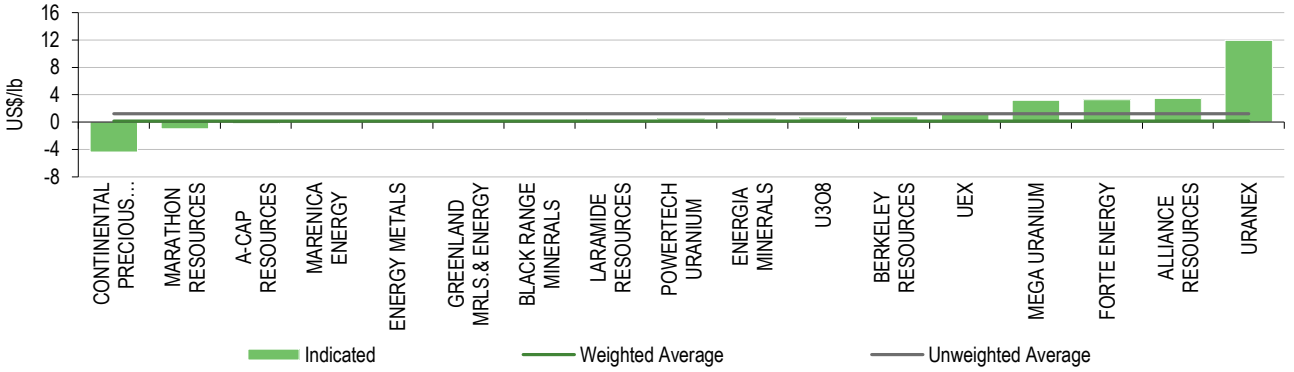
Exhibit 75: Implied value of global uranium Inferred lbs (US$), by company and averages



Source: Edison Investment Research

If an average value of US$0.08/lb is applied for Inferred resources, the average value for Indicated resources is US$0.13/lb on a weighted basis or US$1.20/lb on an un-weighted basis. The standard deviation of the sample is US$3.20/lb and therefore Uranex and Alliance Resources (on the upside) and Continental Precious Metals (on the downside) return values that are more than one standard deviation from the mean. Excluding all of these three increases the weighted average value of Indicated lbs from US$0.13/lb to US$0.16/lb – ie only marginally within the context of the uranium price at the time of the analysis.

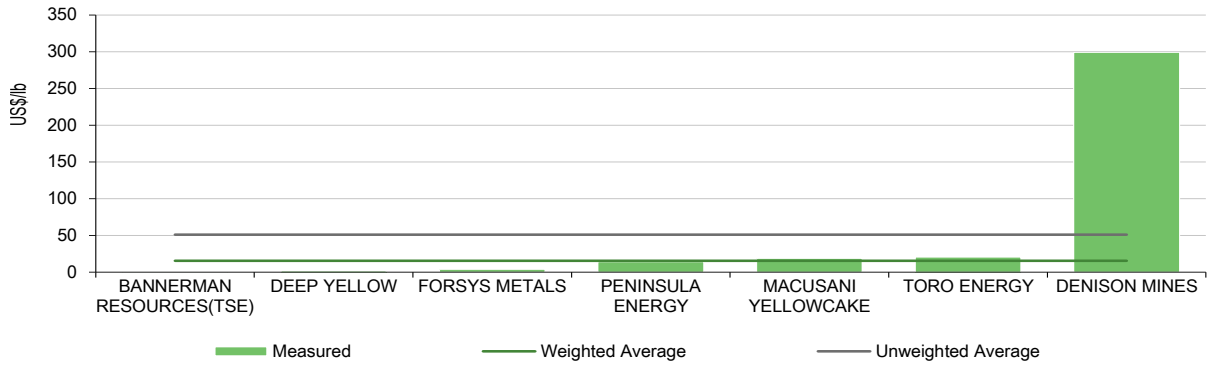
Exhibit 76: Implied value of global uranium Indicated lbs (US$), by company and averages



Source: Edison Investment Research

Prima facie, the application of values of US$0.08/lb and US$0.13/lb for Inferred and Indicated resources, respectively, implies an average value of US$15.52/lb for Measured lbs on a weighted basis and US$51.12/lb on an un-weighted basis. This is counter-intuitive within the context of the uranium price. In addition, there is a clear statistical outlier in the analysis in the form of Denison Mines with an implied value of US$298.79/lb – almost three standard deviations away from the mean.

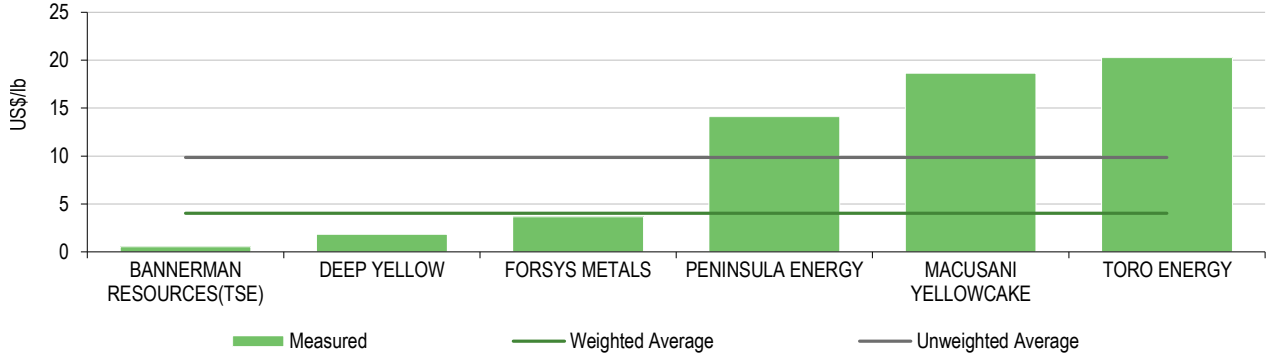
Exhibit 77: Implied value of global uranium Measured lbs (US$), by company and averages



Source: Edison Investment Research

From a business perspective, Denison Mines also represents an unusual case in that it has previously discovered and brought mines into production before selling them. As such, it is easy to posit that it is afforded a unique premium rating on account of its successful history. Excluding Denison from the sample results in a weighted average value for Measured lbs of US$4.04/lb and an un-weighted average of US$19.84/lb. The standard deviation of the sample is US$8.11/lb and therefore Peninsula, Macusani and Toro all trade at ratings more than one standard deviation from the average. However, the extent of any disparity does not appear egregious and it has therefore been decided to accept them into the sample.

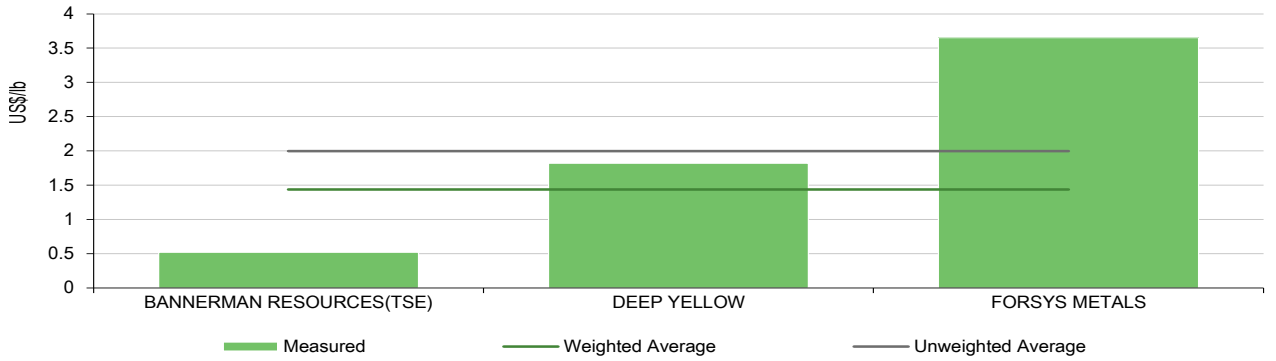
Exhibit 78: Implied value of global uranium Measured lbs (US$), by company and averages (excl Denison)



Source: Edison Investment Research

Excluding them, by contrast, would have resulted in implied average values for Measured lbs of US$1.44/lb on a weighted basis, or US$2.00/lb on an un-weighted basis.

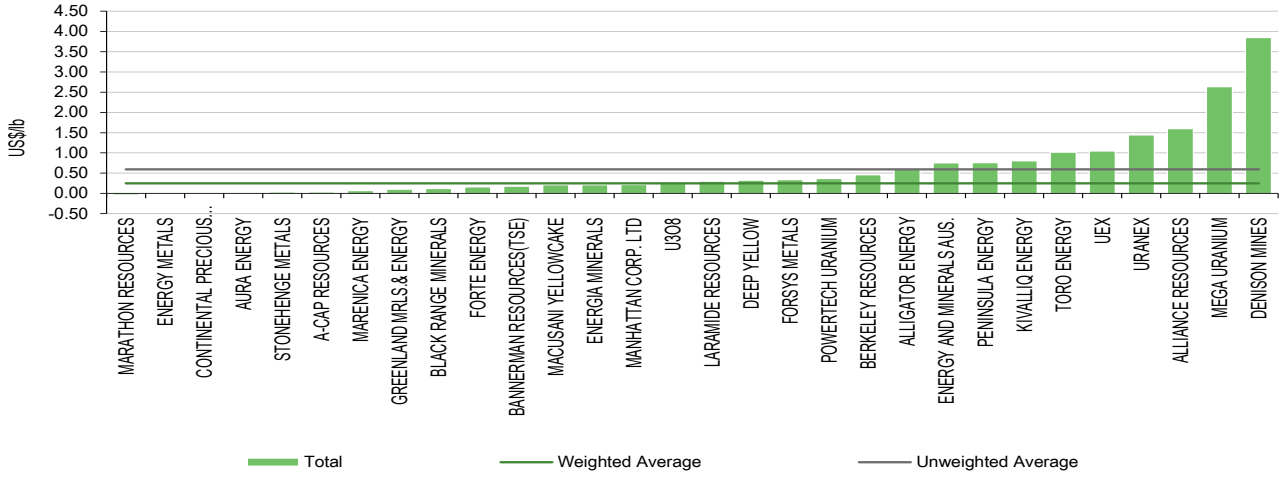
Exhibit 79: Implied value of Measured lbs, US$, (excl Denison, Peninsula, Toro and Macusani)



Source: Edison Investment Research

In contrast to the differentiated analysis (above), consideration of total in-situ resources (ie Inferred, Indicated and Measured lbs considered equally) demonstrates a notably smoother profile of value (right) – arguably implying that the markets do not readily distinguish between the categorisation of uranium lbs, even including Denison. Considered together, the weighted average value of an in-situ uranium lb is US$0.25/lb and the un-weighted value is US$0.59/lb. Excluding Denison, it is US$0.14/lb on a weighted basis.

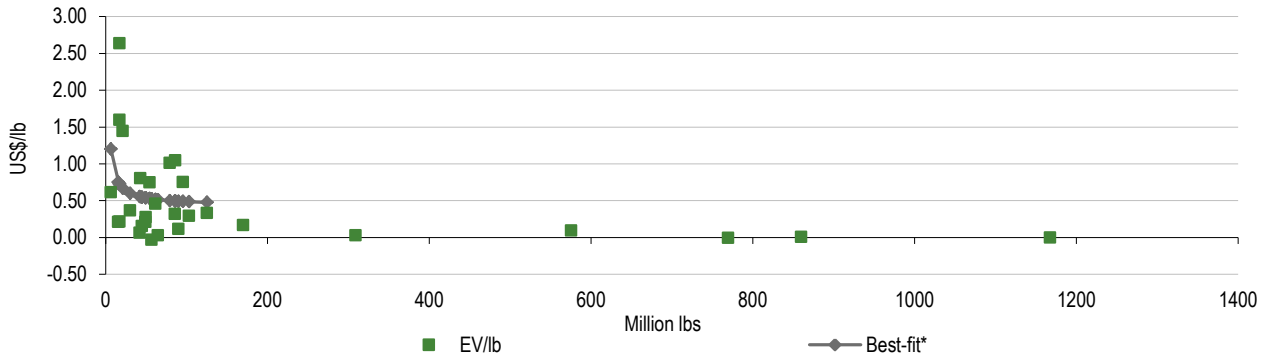
Exhibit 80: Value of average global uranium lbs (US$/lb)



Source: Edison Investment Research

In addition, the sample demonstrates a notable inverse relationship between rating and resource size (something that is also observed in iron ore, see page 62). Plotting resource size against resource multiple generates a graph that could be interpreted as demonstrating a value for average uranium lbs of 8.9c/lb (the bottom 14 resource multiples) in the event that a deposit is perceived as drilled off and without blue sky expansion potential. By contrast, deposits with blue sky expansion potential, on average, attract a rating that is approximately 4-5x the ambient up to a resource size of approximately 125Mlbs and a rating of 48c/lb. Beyond that size, additional resources appear to add little or no value to companies that host them and will therefore have been value destructive relative to the cost of their discovery (at least at the current time).

Exhibit 81: Scattergram of resource size (Mlbs) vs resource multiple (US$/lb) for uranium



Source: Edison Investment Research. Note: * Determined by a linear regression of the inverse

Uranium costs of discovery

Precisely the same methodology as was used to determine average values may be used in order to determine average costs of discovery (although the sample of companies is somewhat different – in particular, it includes producers, which highlights an interesting distinction later). In this case, accountants BDO calculated aggregate costs of discovery for individual companies, which Edison then manipulated to generate differentiated costs for Inferred, Indicated and Measured resources. A summary of the sample used is as follows:

Exhibit 82: Listed uranium explorers cost of discovery summary analysis

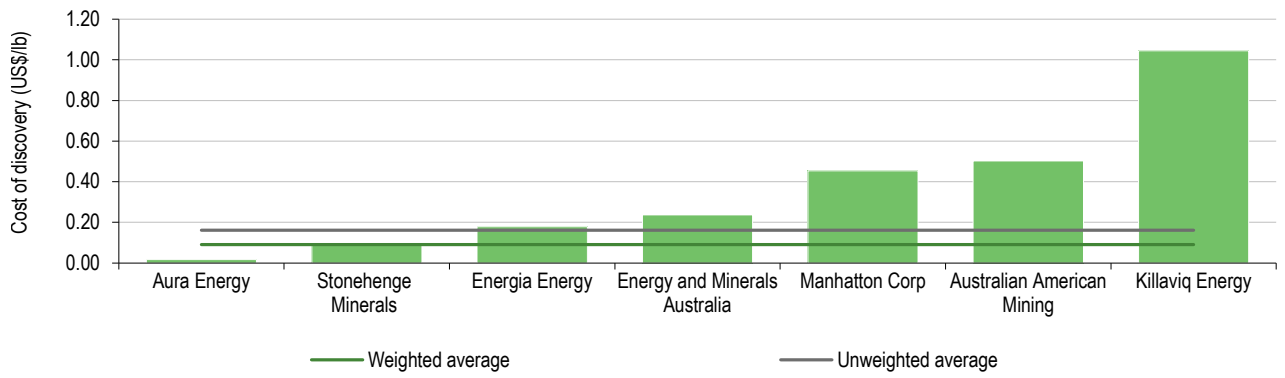
Resource categorisation	Inferred	Indicated & Inferred	Measured, Indicated & Inferred	Total
Number of companies	7	14	9	30
Percent (%)	23	47	30	100
Discovery costs (US$m)	97	630	2,830	3,557
Percent (%)	3	18	80	100
Total lbs (m)	1,072	2,189	2,521	5,782
Percent (%)	19	38	44	100
Discovery cost per total lb (US$)	0.09	0.29	1.12	0.62

Source: Edison Investment Research, BDO. Note: Totals may not add up owing to rounding

Of immediate note is the logical progression whereby companies with Measured, Indicated & Inferred resources have a higher average cost of discovery than companies with Indicated & Inferred resources only, which in turn have a higher average cost of discovery than companies with Inferred resources only – strongly implying that Measured lbs are more costly to delineate on average than Indicated lbs which are more costly than Inferred lbs (as expected).

As demonstrated in Exhibit 82 (above), the average cost of discovery of an Inferred resource lb of uranium is US$0.09/lb on a weighted basis and US$0.17/lb on an un-weighted basis, within a range US$0.02-1.05/lb.

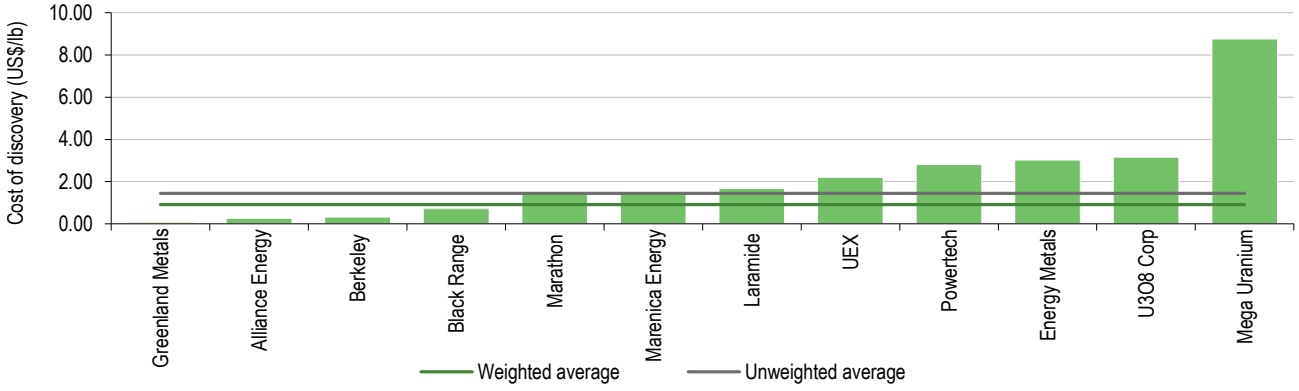
Exhibit 83: Implied cost of discovery of Inferred uranium lbs (US$), by company and averages



Source: Edison Investment Research, BDO

Using a weighted average cost of discovery of US$0.09/lb for Inferred lbs, the weighted average cost of discovery for Indicated lbs is US$0.92/lb on a weighted basis and US$1.50/lb on an un-weighted basis, within a range US$0.08-8.77/lb. Note that no companies are excluded from either the Inferred sample or the Indicated sample since (unlike enterprise values) there is no subjectivity in the cost of discovery of the resources derived from the companies' reports and accounts. Moreover, while there is some overlap between the constituents of the two samples, all figures are positive (as expected) and there are few outliers either in number or extent relative to the price of uranium – although note that both samples appear somewhat skewed by large resources, discovered cheaply (hence the weighted average for both being less than the un-weighted average).

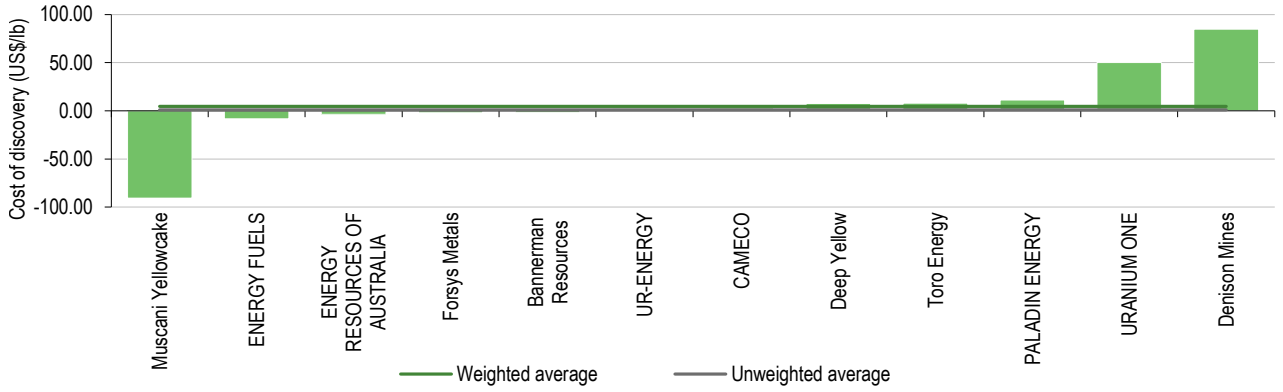
Exhibit 84: Implied cost of discovery of Indicated uranium lbs (US$), by company and averages



Source: Edison Investment Research, BDO

By contrast, the sample for Measured lbs indicates three clear statistical outliers in the forms of Macusani (to the downside) and Denison and Uranium One (to the upside). In the case of Macusani, this must indicate that costs to discover its Inferred and/or Indicated resources are below average. In the case of Denison and Uranium One, given the extent to which they are outliers, it is highly probable that their costs to discover Inferred and/or Indicated resources are higher than average. Including Macusani, Denison and Uranium One, the average cost of discovery of Measured lbs is US$9.27/lb on a weighted basis and US$5.03/lb on an un-weighted basis.

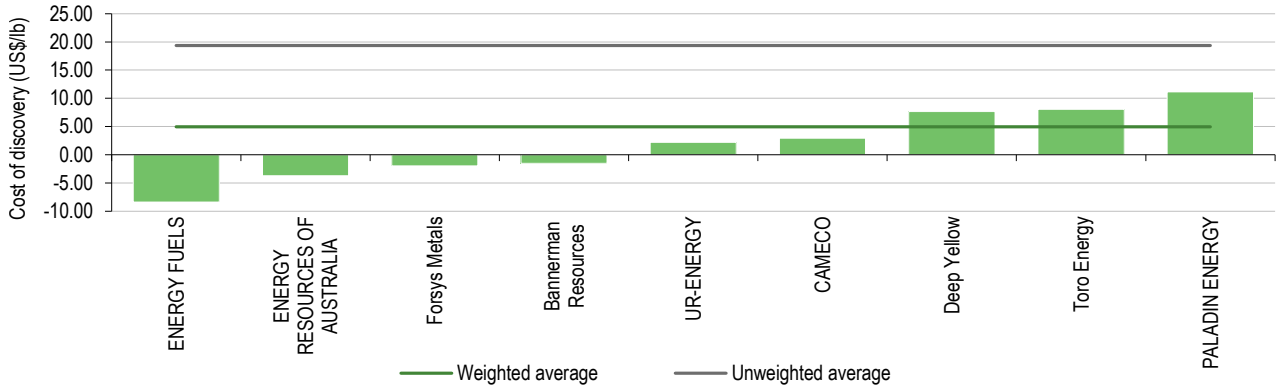
Exhibit 85: Implied cost of discovery of Measured uranium lbs (US$), by company and averages



Source: Edison Investment Research, BDO

Excluding them, the average is US$3.86/lb on a weighted basis and US$1.81/lb on an un-weighted basis. However, one further analysis bears highlighting, which is that there is a marked difference between the averages for producers (denoted by capital letters) and explorers (in lower case). For producers, the weighted average cost of discovery of Measured lbs is US$9.82/lb (including Uranium One), but US$4.17/lb excluding it. For explorers, the average is US$4.55/lb (including Macusani and Denison) and US$1.37/lb excluding them.

Exhibit 86: Implied cost of discovery of Measured uranium lbs (US$), by selected companies and averages



Source: Edison Investment Research, BDO

In each instance therefore, the cost of discovery for producers is higher than the equivalent cost for explorers. On the one hand, this could reflect the unique characteristics of the ore-bodies being drilled. On the other, it could indicate a slightly less intense focus on exploration costs by producers compared to explorers. On balance, Edison's preference is to accept the weighted average cost for explorers excluding Denison and Macusani (which appear to be atypical) and it therefore concludes that the global average cost of discovering Measured lbs (for a typical explorer) is US$1.37/lb.

Within the universe of uranium explorers therefore, the average costs of discovery of Inferred, Indicated and Measured lbs are US$0.09/lb, US$0.92/lb and US$1.37/lb, respectively, while the average values afforded those same resources by the market are US$0.08/lb, US$0.13/lb and US$4.04/lb, respectively. Hence the return on investment of delineating an Inferred uranium lb is minus 6.1%, while the return on upgrading it to an Indicated lb is minus 94.8% of incremental expenditure and a positive return is only realised once it is upgraded once again, to Measured status, at which point the return is 768.5% on incremental expenditure, or 194.9% over the total investment.

Uranium companies with Inferred resources only have 100% of their resources within the Inferred category (obviously). For companies with Indicated & Inferred resources, on average, 40% of the resource is contained within the Indicated category, while the remaining 60% is contained within the Inferred category. For companies with all three categories of resources, on average, 35% is contained within the Inferred category, 57% is contained within the Indicated category and 8% is contained within the Measured category. Assuming that each upgrade is achieved in one year periods, the resource evolution of an average explorer may be graphically depicted as follows:

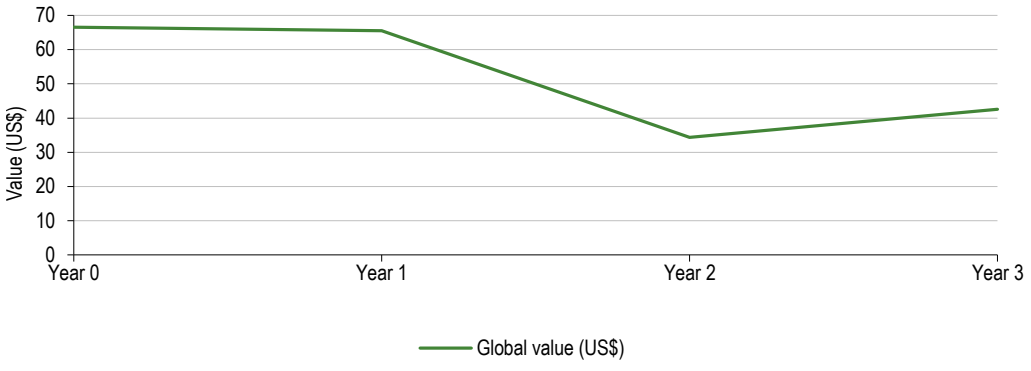
Exhibit 87: Average explorer's resource development by year (percentages)

Resource category	Year 0	Year 1	Year 2	Year 3
Measured	0	0	0	8
Indicated	0	0	40	57
Inferred	0	100	60	35
Total	**0**	**100**	**100**	**100**

Source: Edison Investment Research

At average costs of discovery a (theoretical) 100lb resource would cost US$66.55 to delineate. In that case, the evolution of value of a junior uranium explorer converting US$66.55 in cash into a 100lb resource delineated 8:57:35 in the Measured:Indicated:Inferred categories, respectively, over time would be as follows:

Exhibit 88: Valuation of junior uranium explorer developing 100lb resource, by year (US$)



Source: Edison Investment Research, BDO

By the end of the exploration phase, 76% of the value of the company/project/prospect would be in the Measured category of resources, 17% would be in the Indicated category and 7% would be in the Inferred category. Nevertheless, note the overall -36.1% return on investment over the period (albeit this could be improved by upgrading further Indicated lbs into the Measured category).

Fundamental value among uranium explorers

Of the 30 uranium explorers (including Denison) ultimately sampled by Edison in order to derive differentiated values for Measured, Indicated and Inferred lbs, costs were calculated by BDO for all but four. This allows us to directly compare the enterprise value of each company with the investment made historically in order to delineate its resource base. The following is a list of those companies sampled that are currently trading at a discount or a premium to the cost of discovery of their resources:

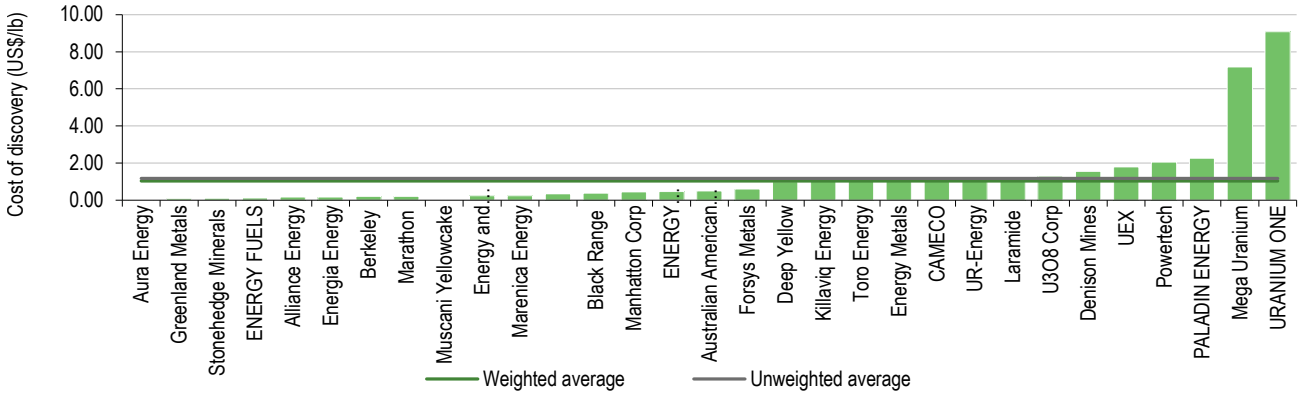
Exhibit 89: Companies trading at premiums or discounts to unique costs of discovery

Companies trading at a discount to the cost of discovery of their resources	Companies trading at a premium to the cost of discovery of their resources
Bannerman Resources	Berkeley Resources
Forsys Metals	Denison Mines
Macusani Yellowcake	Alliance Resources
Deep Yellow	Greenland Minerals & Energy
Toro Energy	Uranex
Black Range Minerals	Energy & Minerals Australia
Continental Precious Metals	Energia Minerals
Energy Metals	
Laramide Resources	
UEX	
Mega Uranium	
Marenica Energy	
Marathon Resources	
Powertech Uranium	
U3O8	
Aura Energy	
Manhattan Corp	
Stonehenge Metals	
Kivalliq Energy	

Source: Edison Investment Research, BDO

On an undifferentiated basis, the average cost of discovery of an average lb of in-situ uranium is US$1.02/lb on a weighted basis or US$1.15/lb on an un-weighted basis, within a range from US$0.02/lb to US$9.08/lb. The standard deviation of the sample is US$1.31/lb and therefore only two companies within the sample (Mega Uranium and Uranium One) fall more than one standard deviation from the mean. Note that the average cost of discovery of an average lb of uranium of US$1.02/lb compares to an average value of an average lb or uranium on world markets of US$0.25/lb (see Exhibit 80) – reinforcing the previous conclusion that, in general, converting cash into uranium resources is, at the time this analysis was performed, a value destructive exercise.

Exhibit 90: Cost of discovery of average global uranium lbs (US$/lb)



Source: Edison Investment Research

Iron ore market summary

A summary of the companies, cash and assets analysed in the iron ore market is as follows:

Exhibit 91: Listed iron ore explorers' summary analysis

Resource categorisation	Inferred	Indicated & Inferred	Measured, Indicated & Inferred	Total
Number of companies	1	7	13	21
Percent (%)	5	33	62	100
Market cap (US$m)	0	504	455	960
Percent (%)	0	53	47	100
Net cash (US$m)	-1	53	192	244
Percent (%)	0	22	79	100
Enterprise value (US$m)	1	451	264	716
Percent (%)	0	63	37	100
Total tonnes (m)	262	4,199	8,638	13,100
Percent (%)	2	32	66	100
Market cap per total (c)	0.08	12.01	5.27	7.33
EV per total t (c)	0.54	10.74	3.05	5.47

Source: Edison Investment Research. Note: Totals may not add up owing to rounding.

Note the discount of the average resource multiple for companies with all three categories of resources compared to those with just Indicated & Inferred resources – strongly suggesting a discounted valuation for Measured resources compared to Indicated ones.

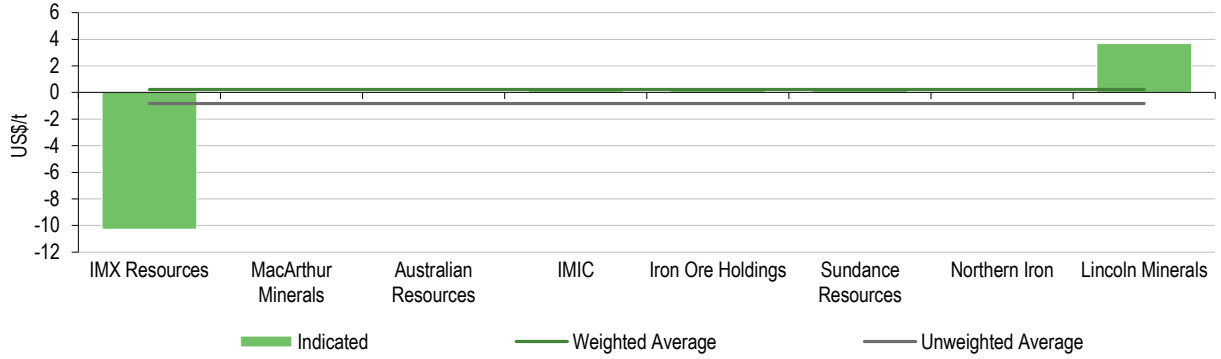
At the time of analysis, the only identifiable company within the universe of iron ore explorers with Inferred resources only was Cuervo, trading on a resource multiple of 5.4c per in-situ tonne of iron.

Exhibit 92: Implied value of Inferred iron ore tonnes (US$)

Source: Edison Investment Research

Substituting 5.4c/t as the value for Inferred tonnes results in a weighted average value for Indicated tonnes of 23.1c/t, albeit within a wide range, from US$3.68/t to minus US$10.27/t, with a standard deviation of US$4.04/t. As a result, IMX Resources falls more than one standard deviation away from the mean. However, the proportion of its resources in the Indicated category at the time of the analysis was less than 1%. Hence, excluding it makes very little difference to the result - eg 23.6c/t in the event that IMX is excluded from the sample.

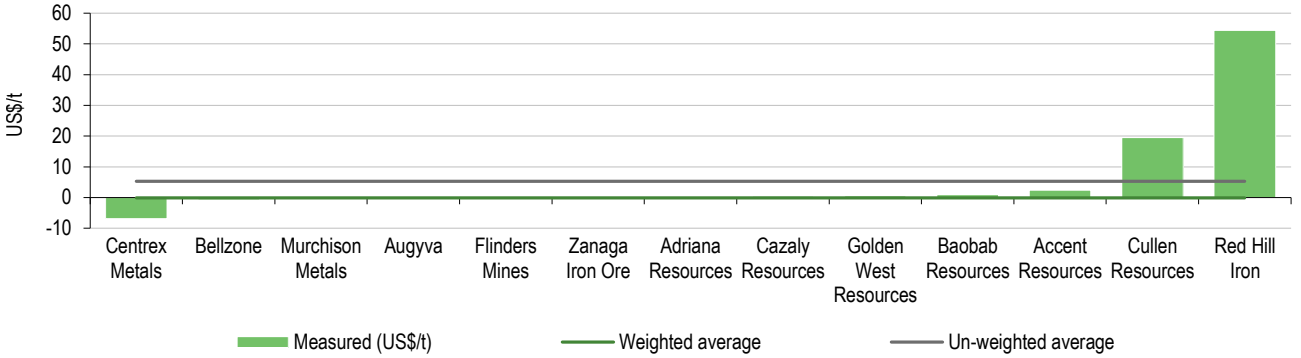
Exhibit 93: Implied value of Indicated iron ore tonnes (US$)



Source: Edison Investment Research

Substituting values of 5.4c/t and 23.1c/t for Inferred and Indicated tonnes, respectively, implies a weighted average value of minus 9.6c/t for Measured resources, albeit within a wide range, from US$54.39/t to minus US$6.84/t. Two companies (Cullen and Red Hill) have ratings more than one standard deviation from the mean. Again however, these companies only have a small proportion of their resources in the Measured category and therefore excluding them alters the weighted average value by only a small amount (to minus 12.2c/t) – and arguably in the wrong direction.

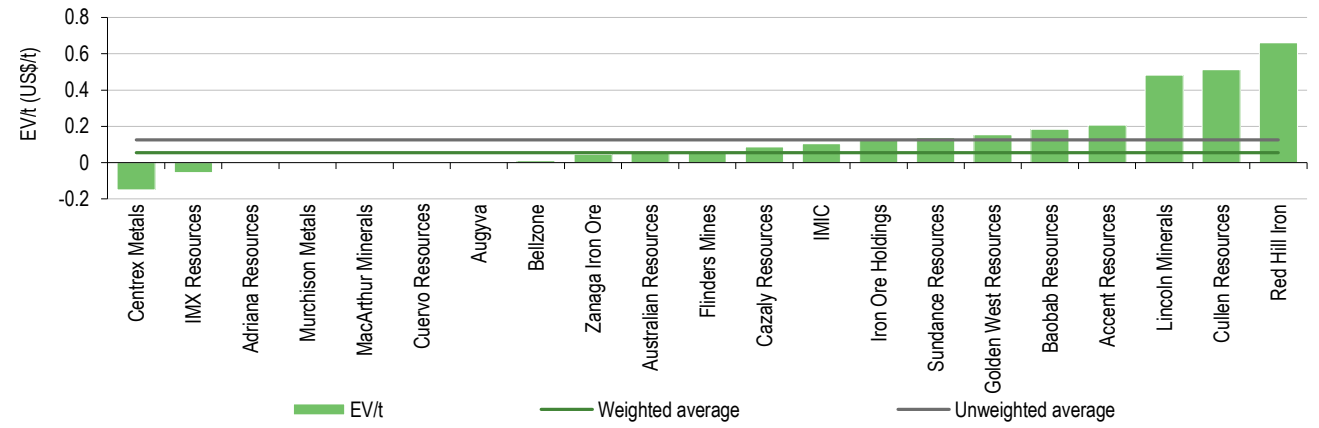
Exhibit 94: Implied value of Measured iron ore tonnes (US$)



Source: Edison Investment Research

One possible interpretation of the results is that, like other metals, the stock market affords a premium rating to Indicated resources compared to Measured ones. Alternatively, it could be argued that the market makes little distinction between Measured and Indicated and Inferred tonnes – and this appears to be borne out by a comparison of the sector based on total tonnes (right). In this case, the weighted average value of an in-situ iron tonne is 5.5c (un-weighted average 12.5c), within a range from minus 15c to 66c, with a standard deviation of 19.4c (such that only four companies – Red Hill, Cullen, Lincoln and Centrex – fall more than one standard deviation away from the mean). Note that excluding them reduces the average value only marginally to 5.0c/t.

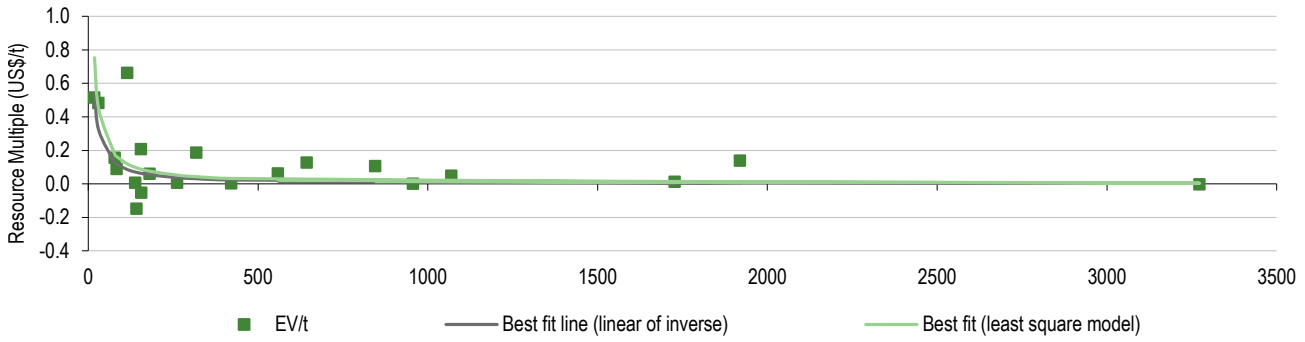
Exhibit 95: Implied value of total iron ore tonnes (US$)



Source: Edison Investment Research

Moreover, the sector demonstrates evidence of an inverse relationship between resource size and resource multiple for certain stocks. This suggests that, for smaller deposits, the market frequently discounts additional discoveries up to c 1,000Mt in-situ iron and, arguably, up to 2,000Mt in-situ iron. Note that, for deposits larger than 1,000Mt in-situ iron, the (un-weighted) average value per tonne of in-situ iron is 4.8c – which accords closely with the 5.5c/t and 5.0c/t calculated above. Note that two best-fit lines have been calculated – the one being derived from a linear regression of the inverse plot and the other being a method solved by Gaussian elimination in Matlab software.

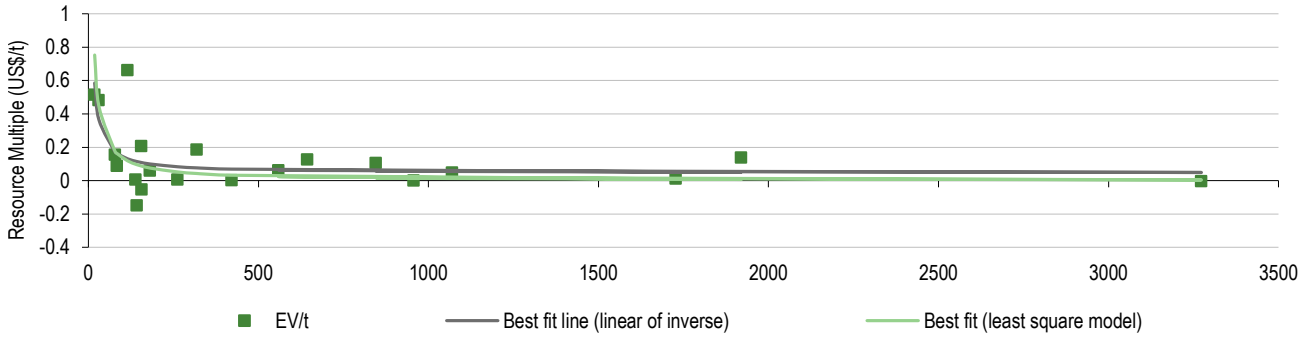
Exhibit 96: Iron ore sector relationship between resource multiple (y-axis) and resource size (Mt, x-axis)



Source: Edison Investment Research

In this case, the Matlab constant implies that the terminal resource multiple of 5.5c/t is achieved at a resource size of 252Mt in-situ iron – which appears small. In addition to the calculated gradient however, the recidivist linear regression of the inverse methodology also implies a 'constant' premium applied to resource tonnes of in-situ iron of 4.6c/t (arguably related to the cost of discovery). This alone implies that the terminal resource multiple of 5.5c/t is achieved at a resource size of 1,020Mt – which seems towards the smaller end of the scale, although plausible (see graph right). Combining the Matlab gradient with the linear constant suggests that the terminal resource multiple is achieved at a resource size of 1,453Mt (probably about right).

Exhibit 97: 'Adjusted' relationship between resource multiple (y-axis) and resource size (Mt, x-axis)



Source: Edison Investment Research

Copper market summary

A summary of the companies, cash and assets analysed in the copper market is as follows:

Exhibit 98: Listed copper explorers' summary analysis

Resource categorisation	Inferred	Indicated & Inferred	Measured, Indicated & Inferred	Total
Number of companies	3	6	6	15
Percent (%)	20	40	40	100
Market cap (US$m)	47	428	780	1,255
Percent (%)	4	34	62	100
Net cash (US$m)	8	12	-5	16
Percent (%)	54	80	-34	100
Enterprise value (US$m)	38	416	786	1,240
Percent (%)	3	34	63	100
Total tonnes (m)	1	15	13	30
Percent (%)	3	52	45	100
Market cap per total (US$)	48.58	28.08	58.66	42.53
EV per total t (US$)	39.82	27.27	59.05	42.01

Source: Edison Investment Research. Note: Totals may not add up owing to rounding

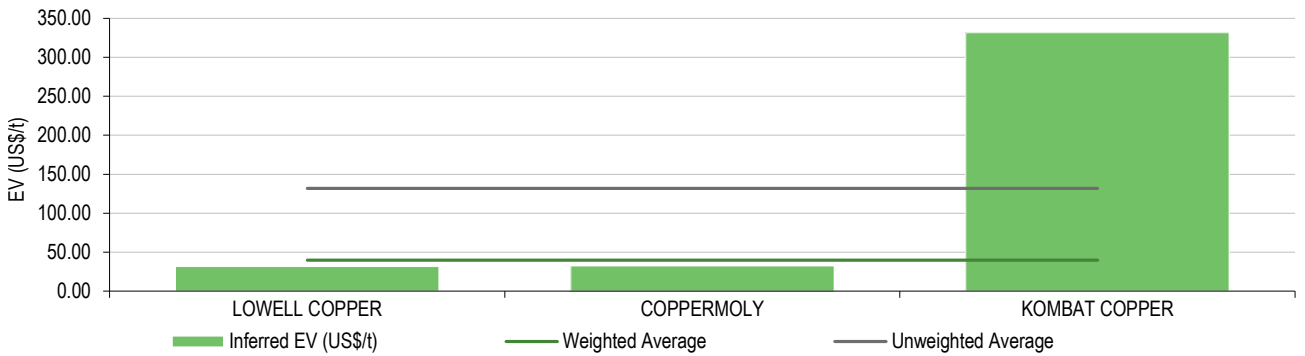
Two features of the analysis are immediately noteworthy:

- The resource multiple discount for companies with Indicated & Inferred resources compared to those with Inferred resources only (which appears to be an anomaly)
- The existence of net debt among the sample of companies with all three categories of resources.

Three copper explorers were identified with exclusively Inferred resources – with a weighted average resource multiple of US$39.82 per tonne of in-situ resource copper. One notable outlier is Kombat Copper. However, since it accounts for only 2.7% of the Inferred resources analysed in this sample, its exclusion only reduces the average to US$31.66/t.

Note that (once again) a high rating allied with a small resource could be indicative of the market's discounting future exploration success (as also evident in the uranium and iron ore markets).

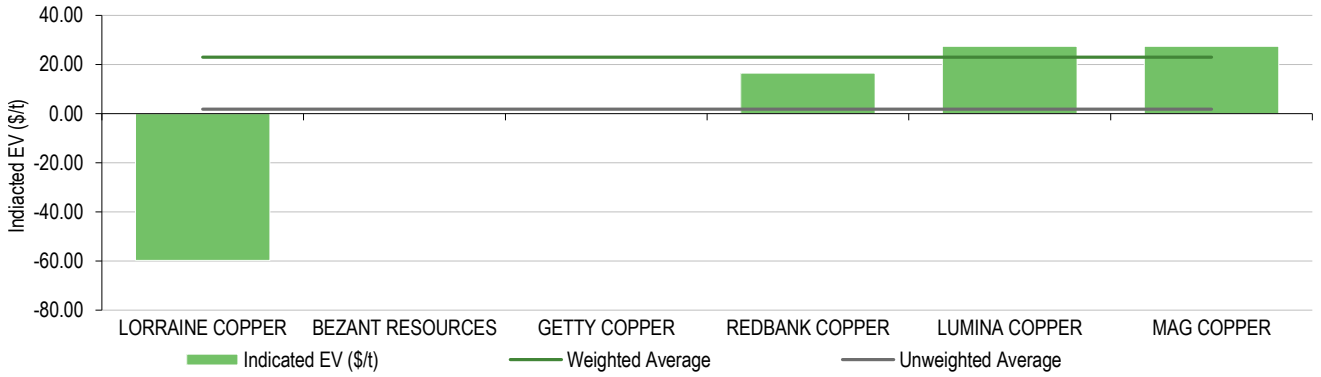
Exhibit 99: Implied value of Inferred copper tonnes (US$)



Source: Edison Investment Research

Substituting a weighted average value of USUS$39.82/t for Inferred copper tonnes in-situ then generates a weighted average for Indicated tonnes of US$23.08/t. Again, there is one obvious outlier – Lorraine. However, given that its Indicated resource makes up no more than 0.2% of the total sample analysed, its exclusion makes almost no difference to the overall result, increasing it by just 14c per tonne, to US$23.22/t.

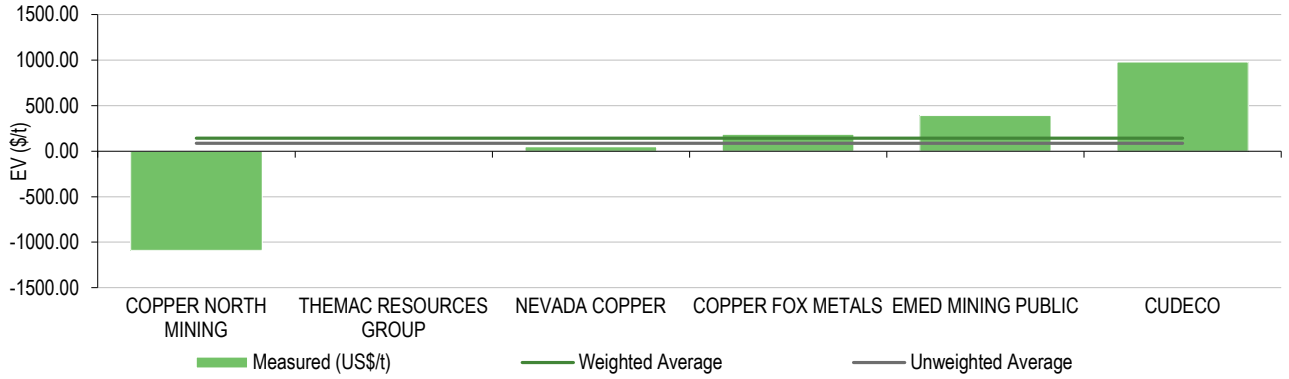
Exhibit 100: Implied value of Indicated copper tonnes (US$)



Source: Edison Investment Research

Substituting the weighted average values for Inferred and Indicated copper resources of US$39.82 and US$23.08 per tonne, respectively, generates a weighted average value for Measured resources of US$141.95/t, within a wide range (standard deviation US$617.48/t) encompassing two obvious statistical outliers (Cudeco and Copper North). Excluding these reduces the weighted average to US$83.85/t, although there seems little reason to do so apart from the values that they individually return.On the basis of their differentiated values, arguably the easiest case to make in the copper sub-sector is that Indicated and Inferred tonnes are, on average, worth approximately the same, at US$28.02/t (weighted), with Measured tonnes then rated at a premium US$166.69/t (weighted).

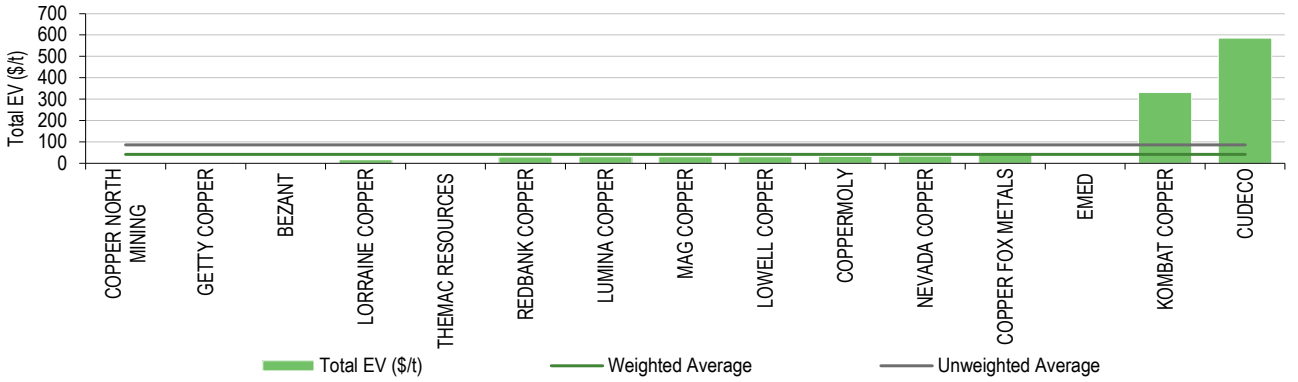
Exhibit 101: Implied value of Measured copper tonnes (US$)



Source: Edison Investment Research

Alternatively, resources may be considered in their entirety, in which case the average value of an in-situ copper tonne, globally, is US$42.01/t on a weighted basis and US$86.81/t on an un-weighted basis, within a wide range, from US$0.90/t to US$584.86/t, with a standard deviation of US$154.50/t. Within this context, it is notable that Kombat Copper (with Inferred resources only) still commands a premium rating – arguably demonstrating the discounting of additional future discoveries or that the market does indeed fail to distinguish between different categorisations of resources (or both).

Exhibit 102: Implied value of total global average copper tonnes (US$)



Source: Edison Investment Research

Nickel market summary

A summary of the companies, cash and assets analysed in the nickel market is as follows:

Exhibit 103: Listed nickel explorers' summary analysis

Resource categorisation	Inferred	Indicated & Inferred	Measured, Indicated & Inferred	Total
Number of companies	0	5	4	9
Percent (%)	0	56	44	100
Market cap (US$m)	0	111	119	230
Percent (%)	0	48	52	100
Net cash (US$m)	0	-26	6	-20
Percent (%)	0	131	-31	100
Enterprise value (US$m)	0	137	112	249
Percent (%)	0	55	45	100
Total tonnes (m)	0	7	11	18
Percent (%)	0	38	62	100
Market cap per total (US$)	N/A	16.85	10.86	13.11
EV per total t (US$)	N/A	20.80	10.30	14.25

Source: Edison Investment Research. Note: Totals may not add up owing to rounding.

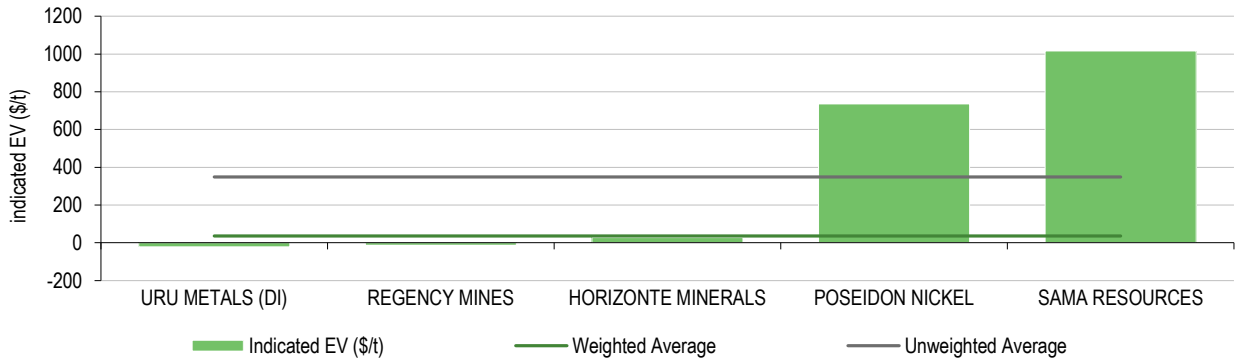
A number of features of the analysis are immediately noteworthy:

- A relatively small sample size
- The absence of a sample of companies with Inferred resources only
- The premium rating of companies with Indicated & Inferred resources only compared to those with Measured resources as well
- Relatively modest amounts of cash on the balance sheet (on average, just 6.5% of market cap).

The absence of identifiable explorers with Inferred resources only in the nickel industry, in particular, presents a problem for a differentiated analysis. However, the average value of Inferred & Indicated resources, considered as a single group, can be seen to be US$20.80/t. It can then be further assumed that Inferred resources should have a value that is at a discount to Indicated (NB this pattern is demonstrated for almost all metals and minerals considered in this report). Discounts range from nearly 100% for metals such as silver and platinum to approximately 0% for copper. Assuming a discount of 50% therefore implies a (weighted) average value for Inferred nickel resources of US$10.40/t.

Assuming an average value of US$10.40/t for Inferred nickel resources generates a (weighted) average value for Indicated resources of US$36.49/t for Indicated resources – once again, within a wide range with two statistical outliers in the form of Poseidon Nickel and Sama Resources.

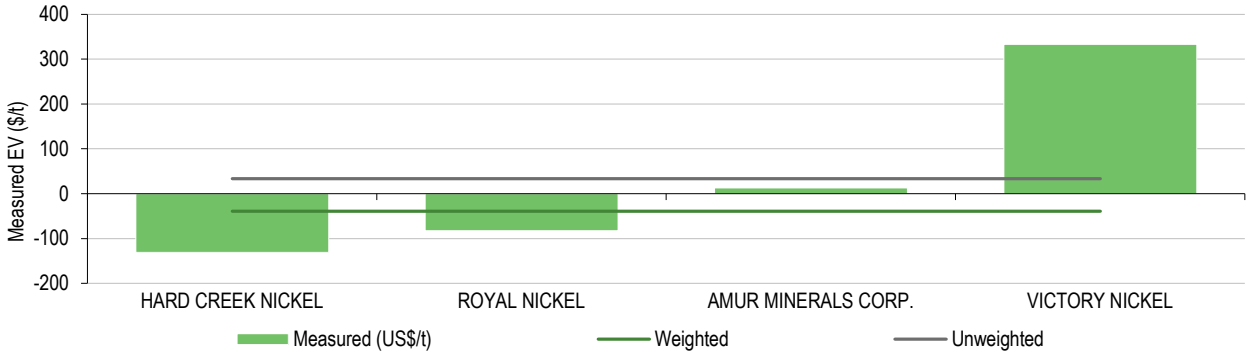
Exhibit 104: Implied value of Indicated nickel tonnes (US$)



Source: Edison Investment Research

Values of US$10.40/t and US$36.49/t for Inferred and Indicated resources, respectively, then imply a value of minus US$39.14/t for Measured in-situ nickel tonnes (with one statistical outlier in the form of Victory Nickel) – which is arguably counter-intuitive.

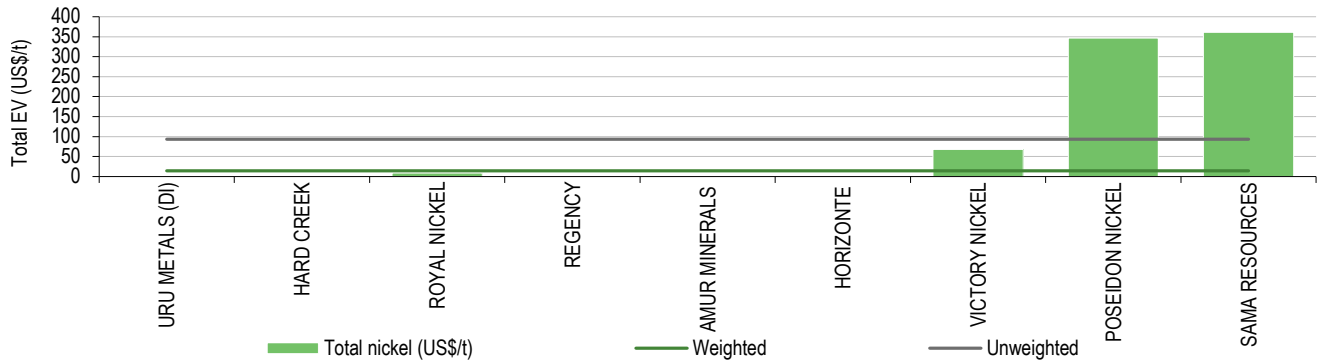
Exhibit 105: Implied value of Measured nickel tonnes (US$)



Source: Edison Investment Research

Finally, considering the nickel sector on an undifferentiated basis yields an average value for nickel resources of US$14.25/t on a weighted basis and US$93.52/t on an un-weighted basis, with two statistical outliers in the form of Poseidon and Sama – both (interestingly) without Measured resources.

Exhibit 106: Implied value of global average nickel tonnes (US$)



Source: Edison Investment Research

Since both contribute a small percentage of total Indicated resources, one possible explanation for the ratings of Poseidon and Sama is that the stock market is once again discounting future exploration success (or, possibly, value enhancing development). Note that excluding Poseidon and Sama generates values for nickel Inferred, Indicated and Measured resources of US$4.01/t, US$4.12/t and US$25.78/t, respectively.

However, an alternative interpretation would be to assert equivalence between Measured and Indicated resources, in which case the average value of a Measured/Indicated resource tonne of in-situ nickel would be US$17.29/t, compared to an average value of Inferred resources of US$10.40/t.

Finally, it is worth noting that there is a 33% difference in the average weightings of sulphide and laterite ore-bodies. Of the companies analysed, three have laterite ore-bodies (Horizonte, Regency and Royal Nickel) and six (Amur, Hard Creek, Poseidon, Sama, Uru and Victory Nickel) have sulphide ore-bodies. Whereas the average rating of sulphide ore-bodies is US$16.09/t nickel, the average rating of lateritic ore-bodies is US$12.10/t.

Platinum Group Metal (PGM) market summary

An analysis of platinum companies is inevitably complicated by the invariable co-existence of palladium and rhodium (among others) within the same ore horizons. To overcome this, palladium and rhodium ounces have been converted into platinum equivalent ounces (PtE) at the prices prevailing at the time of the analysis, namely:

Platinum: US$1,498/oz

Palladium: US$869/oz

Rhodium: US$1,075/oz

Gold: US$1,323/oz

All other by-products have been ignored.

A summary of the companies, cash and assets analysed in the PGM market is as follows:

Exhibit 107: Listed PGM explorers' summary analysis

Resource categorisation	Inferred	Indicated & Inferred	Measured, Indicated & Inferred	Total
Number of companies	0	1	4	5
Percent (%)	0	20	80	100
Market cap (US$m)	0	15	916	931
Percent (%)	0	2	98	100
Net cash (US$m)	0	-2	162	159
Percent (%)	0	-2	102	100
Enterprise value (US$m)	0	17	755	772
Percent (%)	0	2	98	100
Total oz PtE (m)	0	12	152	164
Percent (%)	0	7	93	100
Market cap per oz PtE (US$)	N/A	1.22	6.04	5.68
EV per total oz PtE (US$)	N/A	1.41	4.97	4.71

Source: Edison Investment Research. Note: Totals may not add up owing to rounding.

A number of features of the analysis are immediately noteworthy:

- Once again, a relatively small sample size
- The absence of a sample of companies with Inferred resources only
- There being only one company with Indicated & Inferred ounces only
- The premium average rating for companies with Measured resources – strongly implying a premium rating for Measured oz themselves
- The disproportionate concentration of value amongst companies with all three categories of resources
- The ability of some companies to raise debt as a means of financing.

As with nickel companies, the absence of identifiable explorers with Inferred resources only in the PGM industry presents a problem for a differentiated analysis. However, the average value of Inferred & Indicated resources, considered as a single group, can be seen to be US$1.41/oz PtE. It can then be further assumed that Inferred resources should have a value that is at a discount to Indicated resources (NB this pattern is demonstrated for almost all metals and minerals considered in this report). Discounts range from nearly 100% for metals such as silver and platinum to approximately 0% for copper. Assuming a discount of 50% therefore implies a (weighted) average value for Inferred PtE resources of US$0.70/oz.

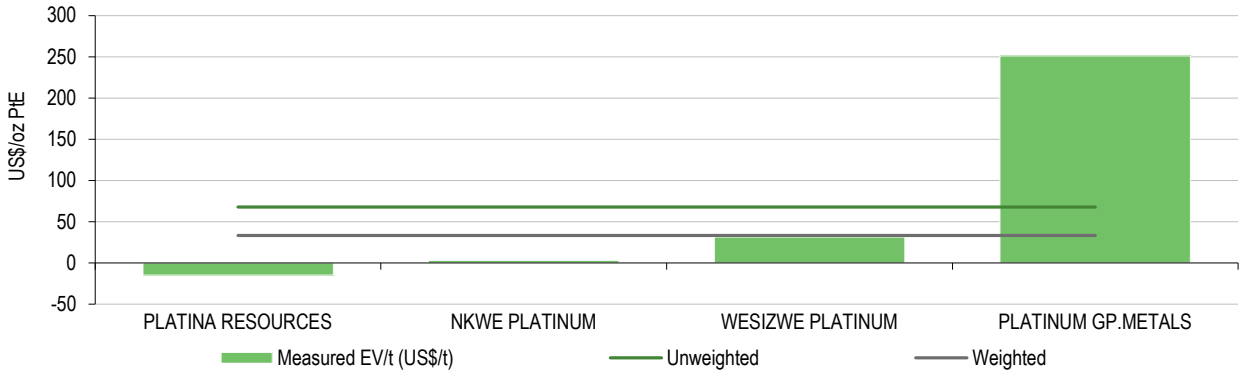
Asserting an average value of US$0.70/oz PtE for Inferred resources generates a value for Indicated resources of US$8.82/oz PtE for Indicated resources – albeit within a sample size of one (Jubilee Platinum).

Exhibit 108: Implied value of Indicated PtE ounces (US$)

Source: Edison Investment Research

Substituting values of US$0.70/oz PtE and US$8.82/oz PtE for Inferred and Indicated resources, respectively, then generates values for Measured ounces of US$33.53/oz PtE on a weighted average basis and US$67.79/oz on an un-weighted basis, within a US$266/oz range, with a standard deviation of US$110.92/oz.

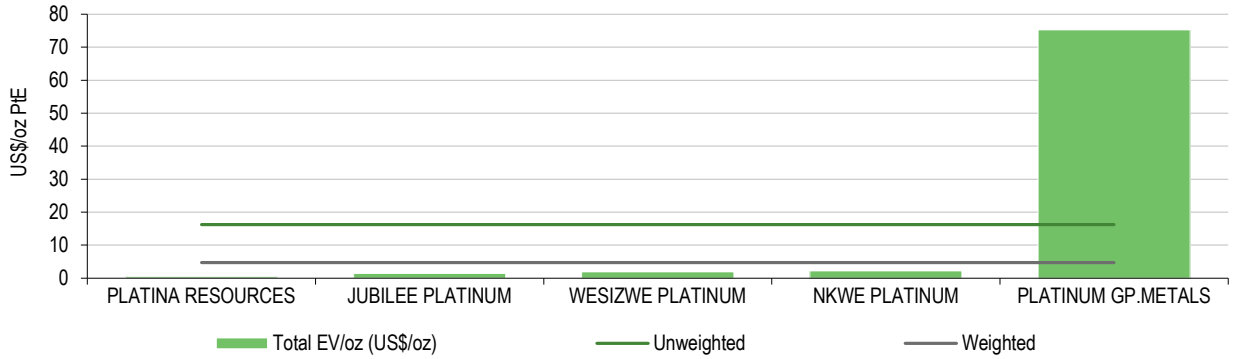
Exhibit 109: Implied value of Measured PtE ounces (US$)



Source: Edison Investment Research

By contrast, when considered together, the weighted average value of total ounces is US$4.71/oz PtE on a weighted basis and US$16.23/oz PtE on an un-weighted basis, with one obvious statistical outlier in the form of Platinum Group Metals.

Exhibit 110: Implied value of total PtE ounces (US$)

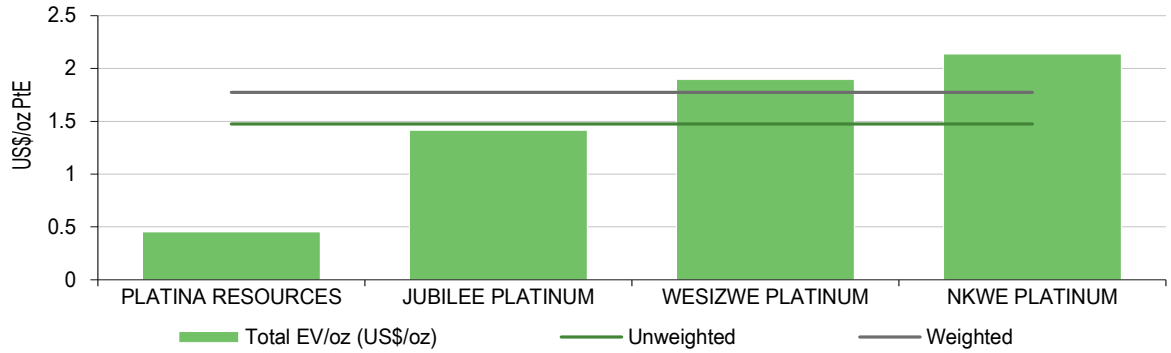


Source: Edison Investment Research

When this is removed from the sample, the averages reduce to US$1.78/oz PtE (weighted) and US$1.47/oz PtE (un-weighted).

Note that the average value of a Measured ounce, in the event that Platinum Group Metals is removed from the sample, is US$5.75/oz on a weighted basis and US$6.64/oz on an un-weighted basis.

Exhibit 111: Adjusted implied value of total PtE ounces (US$)



Source: Edison Investment Research

Zinc market summary

A summary of the companies, cash and assets analysed in the zinc market is as follows:

Exhibit 112: Listed zinc explorers' summary analysis

Resource categorisation	Inferred	Indicated & Inferred	Measured, Indicated & Inferred	Total
Number of companies	0	1	3	4
Percent (%)	0	25	75	100
Market cap (US$m)	0	48	87	135
Percent (%)	0	36	64	100
Net cash (US$m)	0	12	10	22
Percent (%)	0	55	45	100
Enterprise value (US$m)	0	36	77	113
Percent (%)	0	32	68	100
Total t (m)	0	3	10	12
Percent (%)	0	22	78	100
Market cap per t (US$)	N/A	17.84	9.08	10.99
EV per total t (US$)	N/A	13.42	8.04	9.22

Source: Edison Investment Research. Note: Totals may not add up owing to rounding.

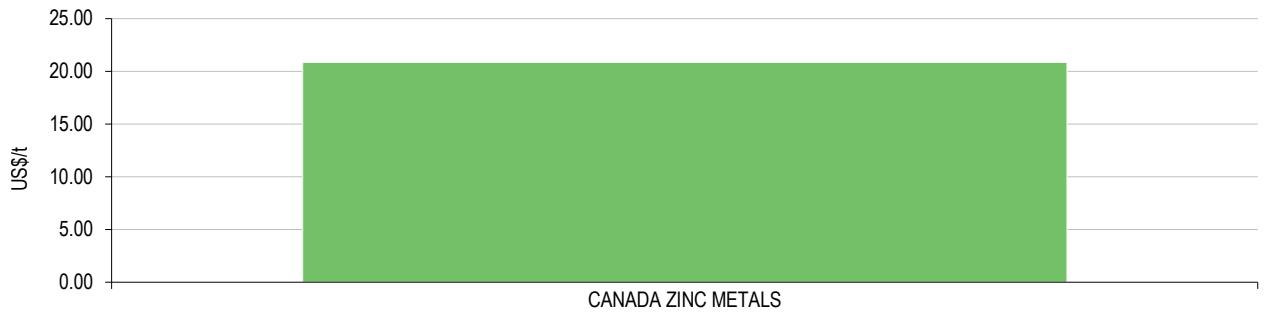
A number of features of the analysis are immediately noteworthy:

- The relatively small sample size
- The absence of a sample of companies with Inferred resources only
- The existence of only one company in the sample with Indicated & Inferred resources only
- The premium rating of companies with Indicated & Inferred resources only compared to those with Measured resources as well

As with the PGM and nickel markets, the absence of identifiable explorers with Inferred resources only in the zinc industry presents a problem for a differentiated analysis. However, the average value of Inferred & Indicated resources, considered as a single group, can be seen to be US$13.42/t. It can then be further assumed that Inferred resources should have a value that is at a discount to Indicated (NB this pattern is demonstrated for almost all metals and minerals considered in this report). Discounts range from nearly 100% for metals such as silver and platinum to approximately 0% for copper. Assuming a discount of 50% implies a (weighted) average value for Inferred zinc resources of US$6.71/t.

Asserting an average value of US$6.71/t for Inferred resources generates a value for Indicated resources of US$20.86/t for Indicated resources – albeit within a sample size of one (Canada Zinc Metals).

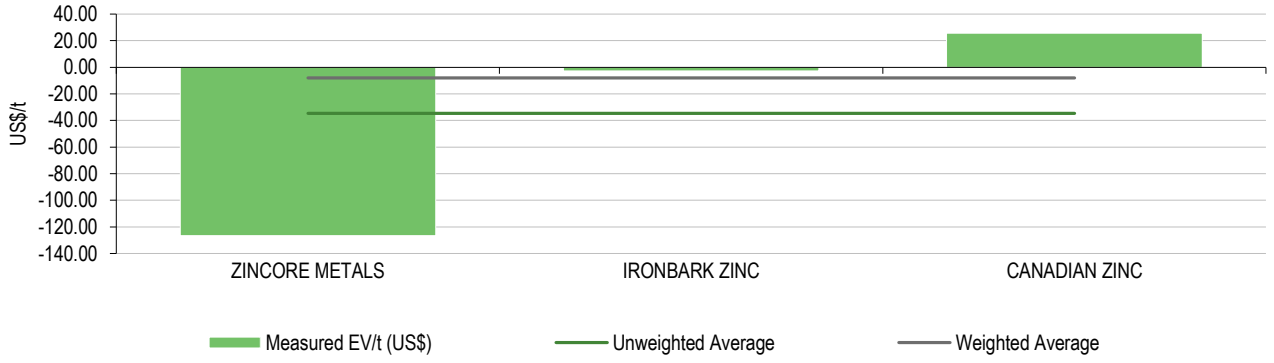
Exhibit 113: : Implied value of Indicated zinc tonnes (US$)



Source: Edison Investment Research

Substituting values for US$6.71/t and US$20.86/t for Inferred and Indicated resources, respectively, then generates a weighted average value for Measured resources of minus US$7.88/t and an un-weighted average value of minus US$34.53/t.

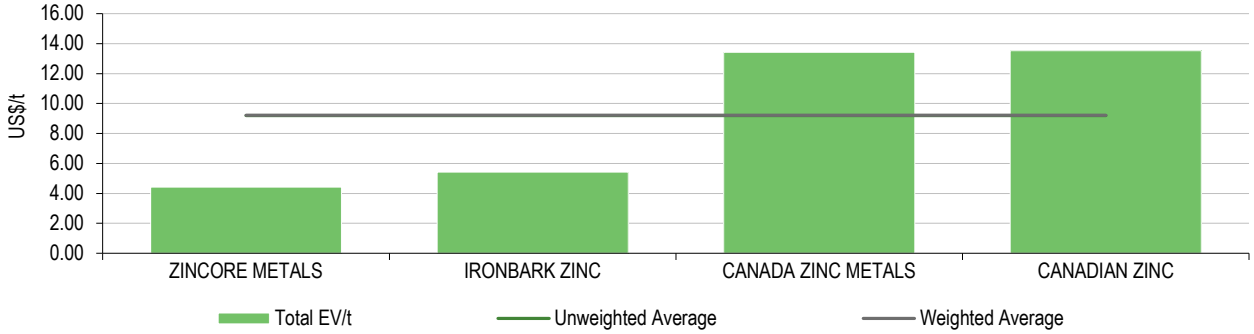
Exhibit 114: Implied value of Measured zinc tonnes (US$)



Source: Edison Investment Research

Finally, considering the zinc sector on an undifferentiated basis yields an average value for zinc resources of US$9.22/t on a weighted basis and US$9.19/t on an un-weighted basis, within a relatively narrow range (US$9.11/t) with a relatively small standard deviation (US$4.29/t).

Exhibit 115: Implied value of average in-situ zinc resource tonnes (US$)



Source: Edison Investment Research

Tungsten market summary

A summary of the companies, cash and assets analysed in the tungsten market is as follows:

Exhibit 116: Listed tungsten explorers' summary analysis

Resource categorisation	Inferred	Indicated & Inferred	Measured, Indicated & Inferred	Total
Number of companies	2	2	1	5
Percent (%)	40	40	20	100
Market cap (US$m)	6	33	30	69
Percent (%)	8	48	44	100
Net cash (US$m)	2	-4	1	0
Percent (%)	-505	904	-299	100
Enterprise value (US$m)	3	37	29	70
Percent (%)	5	53	42	100
Total t (kt)	62	29	73	164
Percent (%)	38	18	44	100
Market cap per t (US$)	92.47	1,144.72	419.18	422.80
EV per total t (US$)	54.76	1,290.40	400.11	425.63

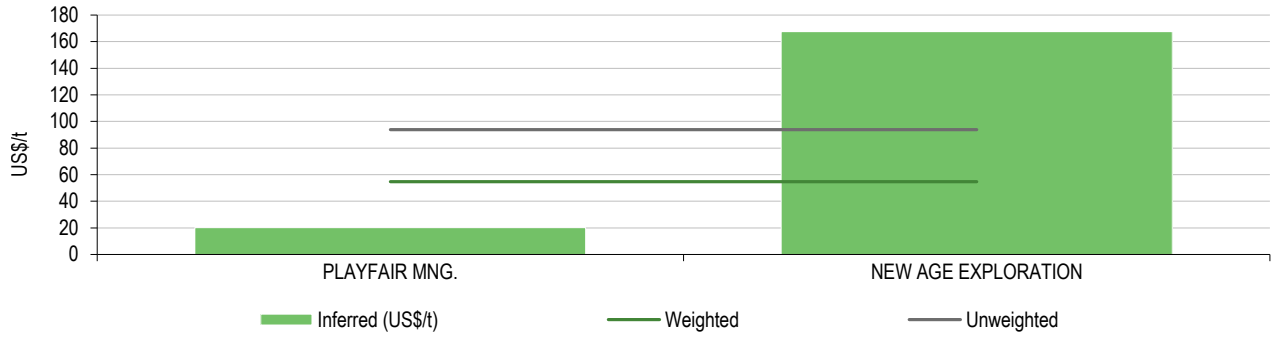
Source: Edison Investment Research. Note: Totals may not add up owing to rounding

A number of features of the analysis are immediately noteworthy:

- The relatively small sample size
- Only one company with Measured resources
- Negligible net cash in the sector, with the majority being held by companies with Inferred resources only
- The premium rating of companies with Indicated & Inferred resources only compared to those with Measured resources as well

Albeit within a sample of two, the average value of Inferred tungsten resources is US$54.76/t on a weighted basis and US$93.85/t on an un-weighted basis.

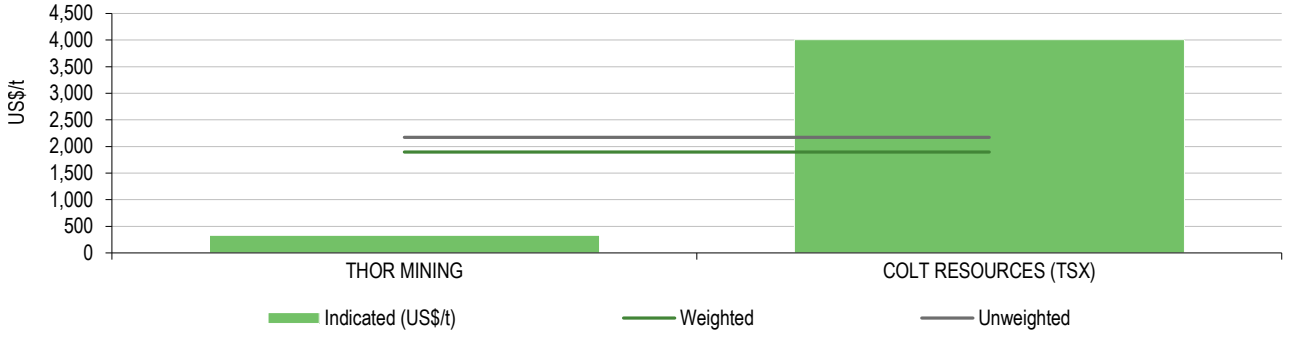
Exhibit 117: Implied value of Inferred tungsten tonnes (US$)



Source: Edison Investment Research

Substituting US$54.76/t as the value of Inferred resources generates an average value for Indicated resources of US$1,897.45/t on a weighted basis and US$2,169.70/t on an un-weighted basis. Once again, this value is generated from a sample of just two – Thor Mining (with an implied value of its Indicated resources of US$329.59/t) and Colt Resources (with an implied value of its Indicated resources of US$4,009.80/t). Note, however, that we will exclude Colt for the purposes of deriving our ultimate figures on the basis of its portfolio of non-tungsten assets.

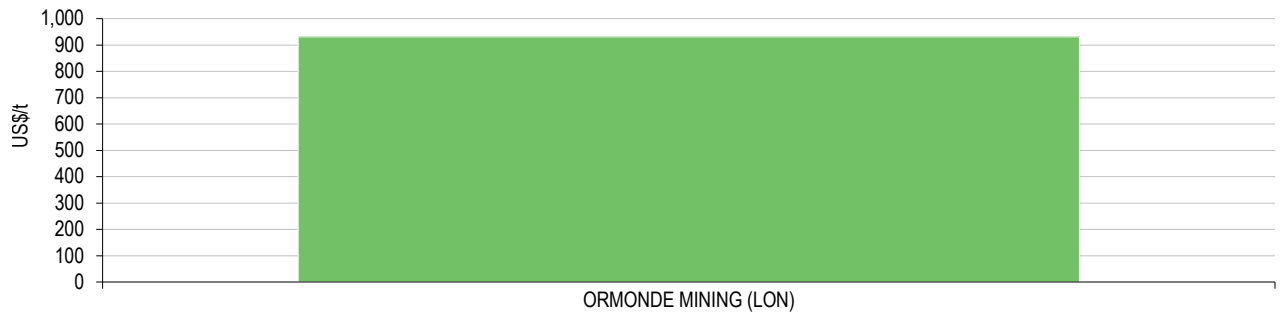
Exhibit 118: Implied value of Indicated tungsten tonnes (US$)



Source: Edison Investment Research

Substituting US$1,897.45/t as the value for Indicated resources generates an average value for Measured resources of minus US$1,771.34/t for Ormonde Mining. This value appears counter-intuitive – especially within the context of Colt's implied valuation for Indicated resources, given that Colt's project is in Portugal and Ormonde's in a proximate area, in Spain. Excluding Colt from the Indicated sample however generates a more meaningful result. In this case, the implied value of Inferred resources is US$54.76/t, the implied value for Indicated resources is US$329.59/t and the implied value for Measured resources (albeit derived from a sample of one) is US$931.24/t (right).

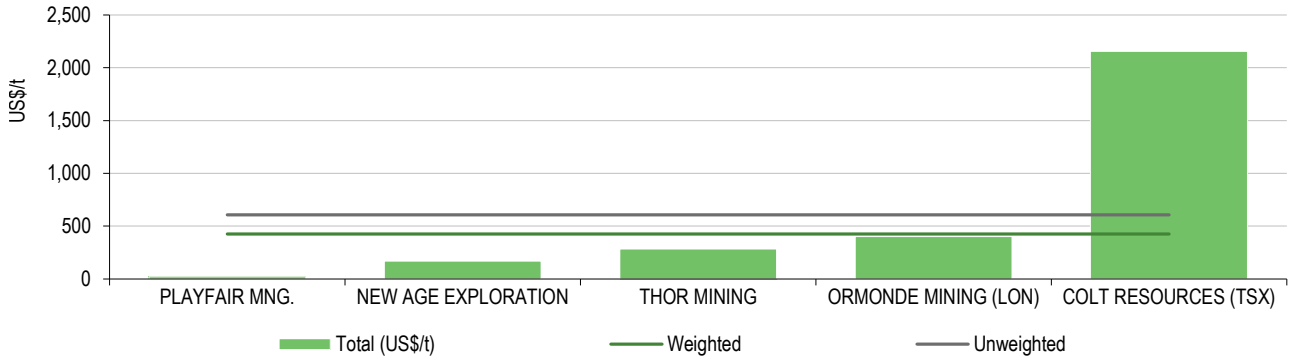
Exhibit 119: Implied value of Measured tungsten tonnes (US$)



Source: Edison Investment Research

For investors wishing to consider all categories of resource equally, the average value of total tungsten resources is US$425.63/t on a weighted basis and US$605.41/t on an un-weighted basis in a sample including Colt. Even on a total resource basis however, the extent to which Colt attracts a premium rating is evident inasmuch as the average value of its resources is more than one standard deviation above the mean (possibly because of its other, albeit early stage, gold projects). In the event that Colt is excluded from the sample, the average value of total tungsten resources is US$244.84/t on a weighted basis and US$217.86/t on an un-weighted basis.

Exhibit 120: Implied value of total tungsten tonnes (US$)



Source: Edison Investment Research

Vanadium market summary

A summary of the companies, cash and assets analysed in the vanadium market is as follows:

Exhibit 121: Listed vanadium explorers' summary analysis

Resource categorisation	Inferred	Indicated & Inferred	Measured, Indicated & Inferred	Total
Number of companies	0	1	2	3
Percent (%)	0	33	67	100
Market cap (US$m)	0	32	934	966
Percent (%)	0	3	97	100
Net cash (US$m)	0	5	38	44
Percent (%)	0	12	88	100
Enterprise value (US$m)	0	27	896	922
Percent (%)	0	3	97	100
Total t (kt)	0	404	1,572	1,977
Percent (%)	0	20	80	100
Market cap per t (US$)	N/A	79.37	594.02	488.75
EV per total t (US$)	N/A	66.07	569.65	466.64

Source: Edison Investment Research. Note: Totals may not add up owing to rounding.

A number of features of the analysis are immediately noteworthy:

- The very small sample size
- The absence of any companies with Inferred resources only
- The large premium average rating for companies with Measured resources

As with the PGM, nickel and zinc markets, the absence of identifiable explorers with Inferred resources only in the vanadium industry presents a problem for a differentiated analysis. However, the average value of Inferred & Indicated resources, considered as a single group, can be seen to be US$66.07/t. It can then be further assumed that Inferred resources should have a value that is at a discount to Indicated (NB this pattern is demonstrated for almost all metals and minerals considered in this report). Discounts range from nearly 100% for metals such as silver and platinum to approximately 0% for copper. Assuming a discount of 50% implies a (weighted) average value for Inferred vanadium resources of US$33.03/t.

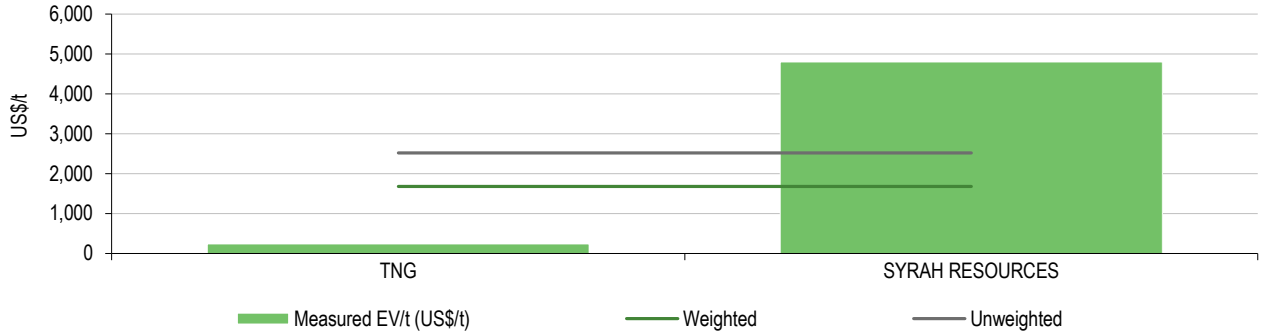
Asserting an average value of US$33.03/t for Inferred resources generates a value for Indicated resources of US$71.97/t for Indicated resources – albeit within a sample size of one (Energizer Resources).

Exhibit 122: Implied value of Indicated vanadium tonnes (US$)

Source: Edison Investment Research

Substituting values for Inferred and Indicated resources of US$33.03/t and US$71.97/t, respectively, then generates a value for Measured resources of US$1,677.73/t on a weighted basis or US$2,519.38/t on an un-weighted basis, albeit within a wide range and from a sample of just two.

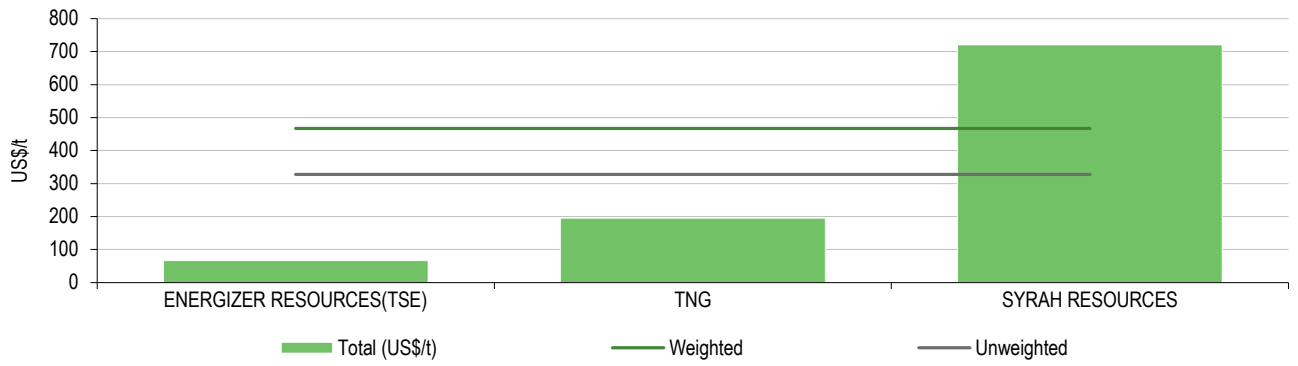
Exhibit 123: Implied value of Measured vanadium tonnes (US$)



Source: Edison Investment Research

Considering all categories equally, the average value of total resources in the vanadium sector is US$466.64/t on a weighted basis and US$327.40/t on an un-weighted basis. Note that the range is relatively wide. However, the one stock that appears to be an outlier is Energizer to the downside (rather than Syrah to the upside), which trades at a rating more than one standard deviation below the mean (arguably reflecting, at least in part, the absence of Measured resources in its portfolio).

Exhibit 124: Implied value of total vanadium tonnes (US$)



Source: Edison Investment Research

Metallurgical coal market summary

The coal market has been split into metallurgical coal and thermal coal for the purposes of the following analysis.

A summary of the cash and assets analysed for companies with metallurgical coal resources is as follows:

Exhibit 125: Listed metallurgical coal explorers' summary analysis

Resource categorisation	Inferred	Indicated & Inferred	Measured, Indicated & Inferred	Total
Number of companies	1	1	1	3
Percent (%)	33	33	33	100
Market cap (US$m)	4	13	256	273
Percent (%)	2	5	94	100
Net cash (US$m)	0	4	11	15
Percent (%)	0	27	73	100
Enterprise value (US$m)	4	9	245	258
Percent (%)	2	3	95	100
Total t (Mt)	11	239	1,567	1,817
Percent (%)	1	13	86	100
Market cap per t (US$)	0.42	0.05	0.16	0.15
EV per total t (US$)	0.42	0.04	0.16	0.14

Source: Edison Investment Research. Note: Totals may not add up owing to rounding.

A number of features of the analysis are immediately noteworthy:

- Only one company in each category
- A non-sensical value for Inferred resources within the context of the subsequent two categories.

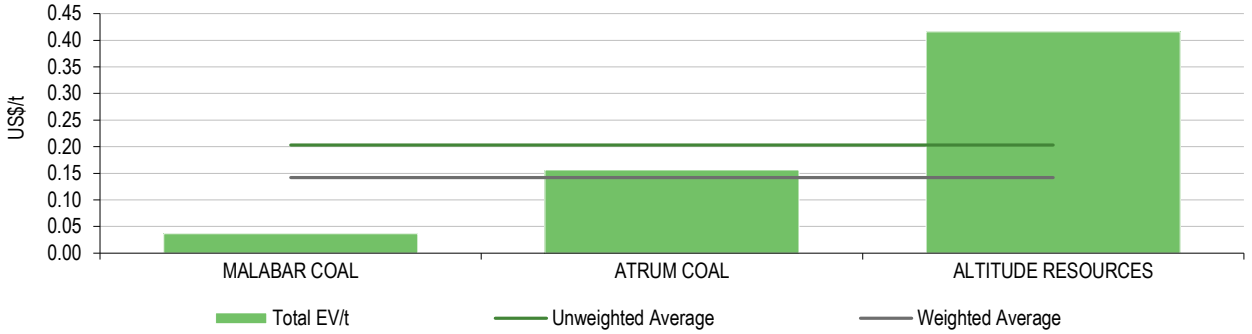
Given the limitations of the sample available, the results of the differentiated analysis have not been presented in graphical form. Nevertheless, they are as follows:

- Implied value of Inferred metallurgical coal resources: US$0.42/t
- Implied value of Indicated metallurgical coal resources: minus US$0.14/t
- Implied value of Measured metallurgical coal resources: minus US$5.64/t

Two interpretations of the data are feasible. The first is that the market considers Indicated resources to be approximately comparable to Inferred resources. In this case, the value of a combined Indicated/Inferred resource would be 5.3c/t and the average value of a Measured resource would be US$10.18/t. The second, is that the market makes no distinction between the three different resource categories in the case of metallurgical coal:

Considered together, the value of an average metallurgical coal resource is US$0.14/t on a weighted basis and US$0.20/t on an un-weighted basis. The standard deviation of the sample is US$0.16/t, indicating that Altitude Resources fall more than one standard deviation from the mean.

Exhibit 126: Implied value of total metallurgical coal tonnes (US$)



Source: Edison Investment Research

Thermal coal market summary

A summary of the cash and assets analysed for companies with thermal coal resources is as follows:

Exhibit 127: Listed thermal coal explorers' summary analysis

Resource categorisation	Inferred	Indicated & Inferred	Measured, Indicated & Inferred	Total
Number of companies	0	0	6	6
Percent (%)	0	0	100	100
Market cap (US$m)	0	0	93	93
Percent (%)	0	0	100	100
Net cash (US$m)	0	0	4	4
Percent (%)	0	0	100	100
Enterprise value (US$m)	0	0	89	89
Percent (%)	0	0	100	100
Total t (Mt)	0	0	13,326	13,326
Percent (%)	0	0	100	100
Market cap per t (US$)	N/A	N/A	0.01	0.01
EV per total t (US$)	N/A	N/A	0.01	0.01

Source: Edison Investment Research. Note: Totals may not add up owing to rounding.

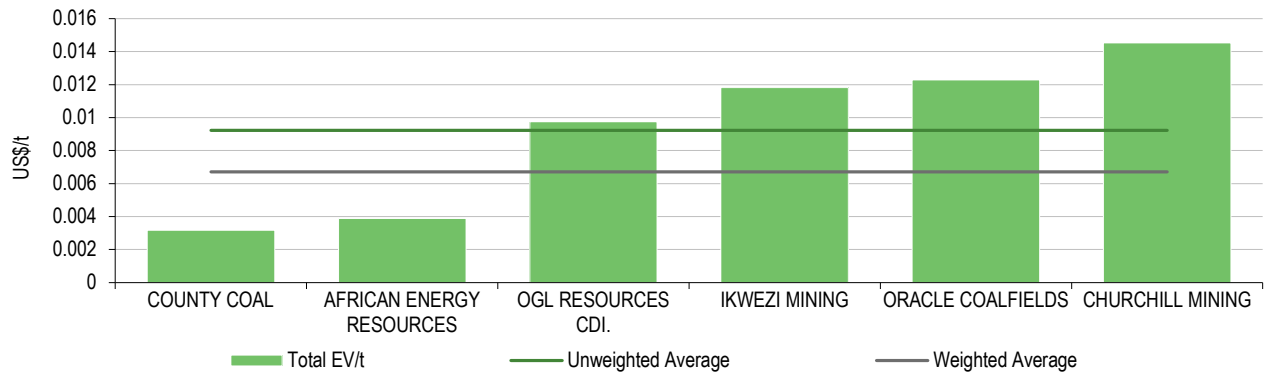
A number of features of the analysis are immediately noteworthy:

- The absence of any companies with either Inferred resources only or Indicated & Inferred resources only.

Notwithstanding the limitations of the sample, it would still be possible to analyse the thermal coal market on a differentiated basis. However, given that average resources are only worth 1c per tonne of coal and assuming that no individual category can logically have a negative value, it seems valid to presume that the market instead makes little or no distinction between categories of resources for thermal coal companies.

As already determined, the average value of a tonne of thermal coal resource is 1c. The standard deviation of the sample is 0.4c/t, indicating that Ikwezi, Oracle and Churchill all fall more than one standard deviation from the mean.

Exhibit 128: Implied value of total thermal coal tonnes (US$)



Source: Edison Investment Research

Frankfurt +49 (0)69 78 8076 960
Schumannstrasse 34b
60325 Frankfurt
Germany

London +44 (0)20 3077 5700
280 High Holborn
London, WC1V 7EE
United Kingdom

New York +1 646 653 7026
245 Park Avenue, 39th Floor
10167, New York
United States

Sydney +61 (0)2 9258 1161
Level 25, Aurora Place
88 Phillip Street, Sydney
NSW 2000, Australia

Wellington +64 (0)4 8948 555
Level 15, 171 Featherston St
Wellington 6011
New Zealand