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Mining overview: Gold and other metals

Normalisation augers well for exploration

Mining sector report, October 2016

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About the author

Charles Gibson

Charlie graduated from the University of Oxford as a chemist, specialising in ligand gated ion channels (the subject of his thesis), before joining Cazenove & Co in the early 1990s. After brief stints working in pharmaceuticals and oils he settled down as Cazenove's mining analyst, spending three years in Johannesburg, among other places. He moved to T Hoare Canaccord in 1999 as a specialist mining salesman and also worked for two years as Cluff Mining's Mineral Economist, responsible for global target asset valuations. In 2003 he moved to New York, where he developed and marketed a 'black box' model for valuing large-cap equities, before returning to join Edison in 2007 as its Head of Mining. He has extensive media experience, having written for MoneyWeek, The Business, Shares, Investors Chronicle and The Evening Standard (among others), presented on LBC and been a guest on BBC One and BBC World.

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Normalisation augurs well for exploration

Silver linings: The in-situ value situation

Metals & mining

14 October 2016

"Permit me to issue and control the money of a nation, and I care not who makes its laws."

Mayer Amschel Rothschild

Financial returns from exploration positive again

Over the past two years, there has been a 67.4% recovery in the in-situ value of a global average resource ounce, from US$10.06/oz in August 2014 to US$16.84/oz currently, and a relative normalisation of the market regarding the average valuations of the three JORC resource categories. Assets remain cheap. Nevertheless, the financial return from drilling a 1Moz gold resource is now positive, on average, for the first time since August 2013 (although not necessarily for assets listed in Canada). By contrast, financial returns from both uranium and PGM exploration have deteriorated. In the meantime, exploration to delineate measured resources is likely to be a value-destructive exercise for a number of (typically) 'bulk' commodities, although these tend to be minerals that also benefit from the market's discounting of future exploration success.

Physical limitations created by financial boundaries

In this report, for the first time we expand our analysis of NonSuch Gold to calculate the physical limitations conferred on projects by the investment returns required by financial markets and conclude that companies with otherwise 'average' gold projects will find them difficult to finance in countries with a Fraser Institute Investment Attractiveness rating below Myanmar. Similarly, companies with projects in countries of roughly average Investment Attractiveness (eg the DRC, Poland, Colombia, Brazil, Madagascar) are unlikely to find equity financing easily forthcoming unless the grade of their deposits is (all things being equal) at least 1.66g/t.

Gold price forecasts

Finally, we have updated our analysis of the price of gold with respect to long-term trends in the US total monetary base and inflation. Within this context, the decline in the price of gold in 2015, coincident with a (very rare) decline in the US total monetary base, should not be a surprise. Hereafter, we estimate that the gold price should average US$1,328/oz in 2017, before rising above US$1,600/oz in 2020. It should then trade within US$50/oz of US$1,650/oz until 2023, at which point it will begin a (fairly) steady rise to reach US$2,000/oz in 2027. In the meantime, on the basis of the historic correlation between the two:

- The current gold price (US$1,320/oz at the time of writing) discounts a US total monetary base of US$3.1tn (cf US$2.7tn when QE3 was announced).
- The end-2015 total monetary base implies a gold price of US$1,597/oz.
- The forecast end-2016 total monetary base implies a gold price of US$1,682/oz.

We estimate that a rapid return to unequivocally positive real interest rates could be worth in the order of US$520/oz off the price of gold. On the other hand, monetisation of balances maintained by banks and depositary institutions at the Federal Reserve could be expected to project gold into the range US$1,860-2,093/oz.

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Executive 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 (provided overleaf).

Gold

Results for gold explorers, including the variance in calculated values from Edison's previous report on the subject (Gold: The value of gold and other metals, published in February 2015) is given in the table 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, US$/oz

	August 2016				August 2014				Change (%)			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
London market	86.74	28.39	10.51	31.17	24.07	16.38	12.60	15.55	260.4	73.3	(16.6)	100.5
Canadian market	87.52	(8.46)	6.00	12.81	48.08	(0.80)	3.35	9.78	82.0	957.5	79.1	31.0
Australian market	226.06	15.15	5.51	43.47	(88.18)	75.24	8.99	4.50	(356.4)	(79.9)	(38.7)	866.0
Arithmetic mean	**133.44**	**11.69**	**7.34**	**29.15**	**(5.34)**	**30.27**	**8.31**	**9.94**	(2,598.9)	(61.4)	(11.7)	193.3
Geometric mean	**35.66**	**15.65**	**7.61**	**16.84**	**(11.32)**	**19.83**	**4.51**	**10.06**	**(415.0)**	**(21.1)**	**68.7**	**67.4**

Source: Edison Investment Research

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

- The 67.4% recovery in the value of a global average resource ounce over two years, to US$16.84/oz (geometric average), compared to US$10.06/oz in August 2014. As such, the average in-situ valuation is on a par with that witnessed in August 2013 (not shown here).
- The exceptionally strong recovery in the value of resource ounces listed in Australia, which has resulted in Australia now conferring the highest overall valuation on explorers' ounces, followed by London and then by Canada, which has exhibited the least recovery from the nadir of August 2014.
- The normalisation of valuations, such that (on average) the value of measured ounces is now greater than that of indicated ounces, which is greater than that of inferred ounces. In this respect, it is notable that the erstwhile premium paid by Australian investors for indicated ounces, in particular, appears to have dissipated.
- The one anomaly remaining in the study is the discount that Canadian investors attribute to indicated ounces, such that, on average, they attract a valuation that is less than that for inferred ounces. Alternatively, it may be interpreted as Canadian investors making no distinction between these JORC categories and paying an average US$1.92 per blended indicated-inferred ounce.
- Some areas of the market are exhibiting bull market valuation conditions (eg the valuation of inferred ounces in the London market, see Exhibit 5).
- Notwithstanding localised conditions, valuations overall remain consistent with bear market conditions, generally (see Exhibit 87).
- Nevertheless, on average, the investment return from drilling an 'average' 1Moz gold resource has returned to being positive for the first time since August 2013, although note that this is a function of valuations in the London and Australian markets only. The investment return in the Canadian market remains negative, although note that the average grade of resources listed in Canada is materially lower than those listed in London and Australia.

In-situ valuation summary

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

Resource multiple	AIM gold	Canada gold	Australia gold	Global gold (geo)	Global gold (arith)	Silver	Uranium	Iron ore	Copper	Nickel	PtE	Coal (thermal)	Coal (met.)	Potash (SOP)	(SOP Brine)	Potash (MOP)	Zinc	Vanadium	Tungsten	Lithium	Lithium (spodumene)	Graphite	Bauxite
Measured	86.74	87.52	226.06	17.83	133.44	(2.07)	3.40	(0.06)	36.97	106.62	(9.24)	0.03	5.87	(6.44)	(2.16)	(2.76)	(7.03)	135.15	1,627.68	96.47		36.10	1.78
Indicated	28.39	(8.46)	15.15	11.20	11.69	1.16	(0.64)	0.12	2.23	22.11	2.98	0.07	0.04	1.26	2.53	0.83	14.02	(6.73)	368.47	18.51	213.13	11.38	(1.13)
Inferred	10.51	6.00	5.51	7.61	7.34	0.13	0.28	(0.00)	16.59	5.87	2.98	0.01	0.01	0.30	0.45	0.11	10.85	9.64	89.59	23.17	29.30	2.01	(0.04)
Total/Average	31.17	12.81	43.47	16.84	29.15	0.59	0.15	0.03	15.94	19.43	2.31	0.01	0.10	0.54	1.24	0.02	9.45	18.01	189.60	25.72	124.91	6.42	0.39
Spot price	1,320.00	1,320.00	1,320.00	1,320.00	1,320.00	18.79	25.95	57.78	4,622.25	10,325.75	1,048.52	69.43	82.52	650.48	650.48	266.43	2,291.75	8,489.25	22,000.00	10,000.00	10,000.00	1,250.00	50.00
Unit	**$/oz**	**$/oz**	**$/oz**	**$/oz**	**$/oz**	**$/oz**	**$/lb**	**$/t**	**$/t**	**$/t**	**$/oz**	**$/t**	**$/t**	**$/t**	**$/t**	**$/t**	**$/t**	**$/t**	**$/t**	**$/t**	**$/t**	**$/t**	**$/t**
Percentages of spot																							
Measured	6.57%	6.63%	17.13%	1.35%	10.11%	(11.01%)	13.10%	(0.11%)	0.80%	1.03%	(0.88%)	0.04%	7.11%	(0.99%)	(0.33%)	(1.03%)	(0.31%)	1.59%	7.40%	0.96%	0.00%	2.89%	3.56%
Indicated	2.15%	(0.64%)	1.15%	0.85%	0.89%	6.15%	(2.47%)	0.21%	0.05%	0.21%	0.28%	0.09%	0.05%	0.19%	0.39%	0.31%	0.61%	(0.08%)	1.67%	0.19%	2.13%	0.91%	(2.26%)
Inferred	0.80%	0.45%	0.42%	0.58%	0.56%	0.69%	1.10%	(0.00%)	0.36%	0.06%	0.28%	0.01%	0.02%	0.05%	0.07%	0.04%	0.47%	0.11%	0.41%	0.23%	0.29%	0.16%	(0.07%)
Total/Average	2.36%	0.97%	3.29%	1.28%	2.21%	3.15%	0.56%	0.05%	0.34%	0.19%	0.22%	0.02%	0.12%	0.08%	0.19%	0.01%	0.41%	0.21%	0.86%	0.26%	1.25%	0.51%	0.77%
Costs of discovery																							
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%**		**3.93%**				**0.09%**												
Return on upgrade																							
Measured	121.69	264.70	701.34	(74.82)	362.58		797.88				(518.57)												
Indicated	435.29	(533.01)	188.41	7.43	30.23		(211.49)				(100.00)												
Inferred	46.77	(16.24)	(23.01)	6.29	2.51		215.73				231.59												
Number of companies	12	16	14	42	42	14	24	17	17	8	5	8	3	4	3	7	5	6	5	9	6	9	4

Source: Edison Investment Research. Note: Platinum equivalent (PtE) costs of discovery derived from Witwatersrand gold cost of discovery. August 2016.

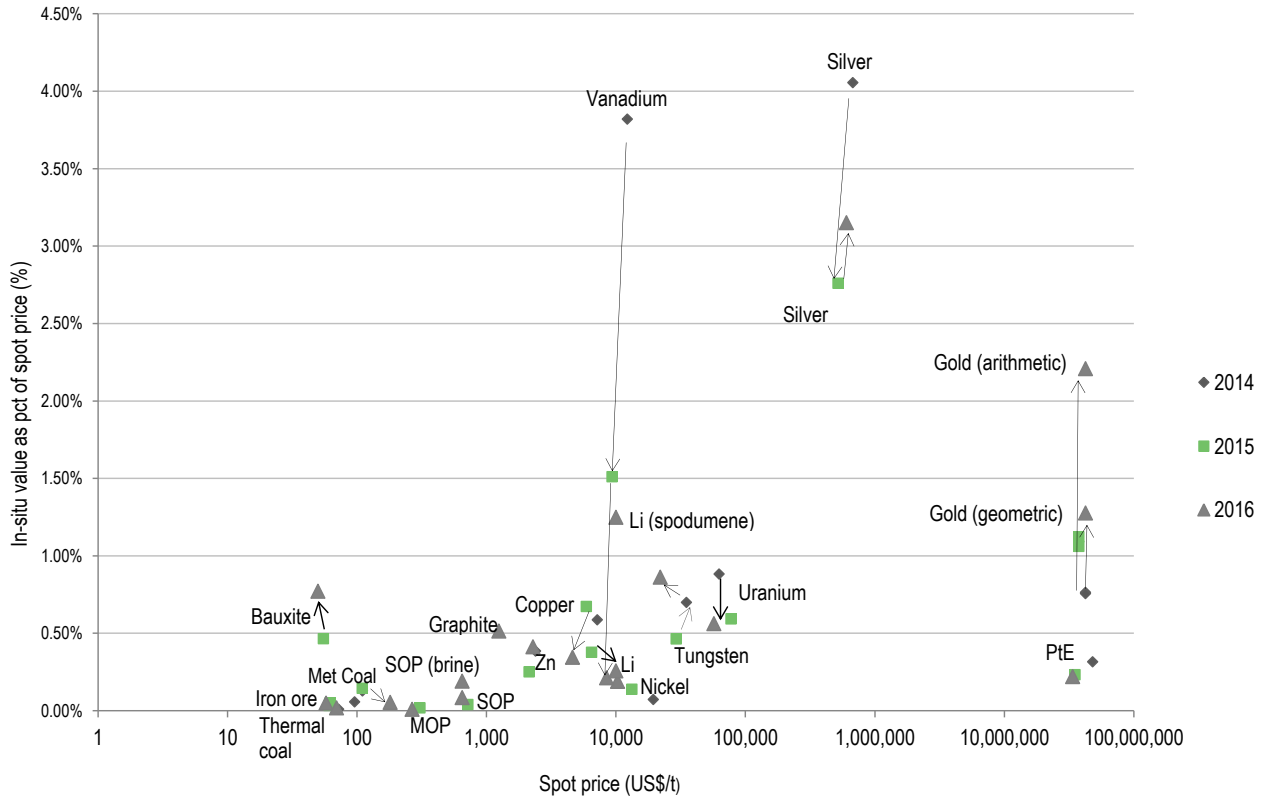
Other metals and minerals

In contrast to gold, compared to August 2014, financial returns from exploration drilling have deteriorated in both the uranium and PGM sub-sectors of the market, with declines in value in both the measured and indicated categories of resources, in particular.

Evidence of market 'normalisation'

Within the broader metals markets, the most obvious feature of the past two years has been the decline (arguably normalisation) of the in-situ value of vanadium resources relative to their spot price, from a very high rating to a relatively modest one currently. By contrast, nickel, sulphate of potash and bauxite all increased their in-situ valuations as a percentage of the spot price of their respective products, despite bear market conditions. Silver resources were notable for a recovery in their premium value rating, despite mixed market conditions. In the meantime, uranium, iron ore, PGMs, copper, metallurgical coal and thermal coal all recorded declines in in-situ value in relative terms (see Exhibits 3 and 88), albeit broadly within a context of bear market conditions.

Exhibit 3: In-situ resource values vs spot prices, selected metals and minerals, 2014-16



Source: Edison Investment Research

…but discretion required regarding categories

A number of metals and minerals exhibit a premium valuation for indicated resources. Whether or not this reflects that market's approach to the valuation of equities, it is strongly indicative of the fact that exploration to delineate measured resources is likely to be a value-destructive exercise for the companies concerned. While these metals and minerals also tend to be 'bulk' by nature (eg iron ore and potash), two exceptions are PGMs (perhaps on account of their unique Bushveld geology) and silver. Bulk minerals also tend to demonstrate evidence of the market's discounting of the future delineation of additional resources.

Differentiated in-situ value analysis

In past publications, Edison has derived differentiated values for the measured, indicated and inferred categories of resources as well as average values for total resources. This report updates these numbers and extends the methodology to other metals and minerals.

Gold

Owing to its larger sample size, the report calculates relative values of in-situ gold ounces, differentiated by the market in which they are listed – ie separately for the world's three major centres of mining finance (London, Canada and Australia) – differentiated by JORC category.

Exhibit 4: Global average value of in-situ explorers' gold resources, by listing, US$/oz

	August 2016				June 2015				August 2014			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
London market	86.74	28.39	10.51	31.17	70.01	25.00	(2.86)	19.50	24.07	16.38	12.60	15.55
Canadian market	87.52	(8.46)	6.00	12.81	74.34	(1.87)	3.47	12.94	48.08	(0.80)	3.35	9.78
Australian market	226.06	15.15	5.51	43.47	(86.05)	58.85	4.85	4.85	(88.18)	75.24	8.99	4.50
Arithmetic mean	**133.44**	**11.69**	**7.34**	**29.15**	**19.43**	**27.33**	**1.02**	**12.43**	**(5.34)**	**30.27**	**8.31**	**9.94**
Geometric mean	**35.66**	**15.65**	**7.61**	**16.84**	**22.96**	**16.13**	**3.23**	**13.15**	**(11.32)**	**19.83**	**4.51**	**10.06**

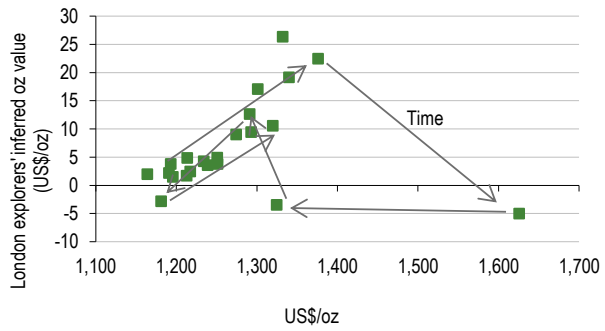
Source: Edison Investment Research, company sources, Thomson Reuters Datastream

A number of features of the results are immediately apparent:

- The 67.4% recovery in the average value of global explorers' ounces from c US$10/oz in 2014 to US$16.84/oz in August 2016 – approximately the same level as August 2013 (see Gold: The value of gold and other metals, published in February 2015).
- The re-establishment of a broadly logical progression in the values of ounces, by category and also by market, for the first time since at least November 2012 (ie the value of measured is greater than the value of indicated, which is greater than the value of inferred). In particular, the historical characteristic whereby the Australian market conferred a greater value on indicated resources compared to measured ones (the value of which was frequently negative, on average) has now regularised.
- Whereas the Australian market conferred the lowest average value on explorers' ounces in August 2014, it now appears to confer the highest, followed by London, followed (by some margin) by Canada, which continues to confer almost no value on early stage indicated and inferred resources.

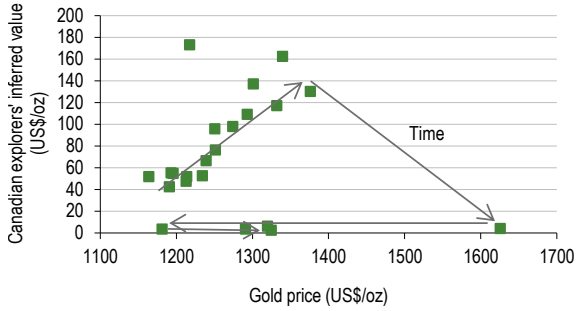
As in previous years, the analysis was complicated by a lack of companies with resources in the inferred category only. In London and Australia, for example, there was only one company in each market that met this criterion (Greatland Gold and Viking Mines, respectively). In the case of Australia, the valuation for inferred resources implied by the single company (Viking Mines) was accepted. In the case of London, it was not, as this would have resulted in a result (US$52.93/oz) that was inconsistent with both other markets, history, given market conditions (this order of magnitude valuation being consistent only with Australian and Canadian valuations in times of a strong bull market), and the effect this valuation would subsequently have had on indicated resources (ie rendered it negative). As a result, the valuation for inferred resources in the London market was taken to be half the overall valuation of resources for companies with indicated and inferred ounces only (ie half way between zero and the, logical, maximum valuation of inferred ounces, namely the valuation of indicated ounces). Nevertheless, at this valuation, the valuation of inferred ounces for each of the three markets is where it might be expected to be, according to history, given the gold price at which the analysis was conducted. Whereas the valuation in the cases of Australia and Canada is consistent with bear market conditions, however, that in London is consistent with a relatively buoyant market.

Exhibit 5: London inferred oz value vs gold price (US$/oz)



Source: Edison Investment Research

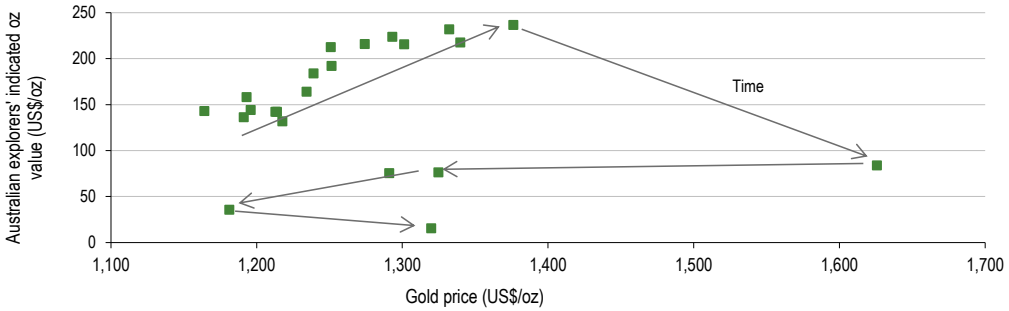
Exhibit 6: TSX inferred oz value vs gold price (US$/oz)



Source: Edison Investment Research

The value of indicated resources in Australia, by contrast, has continued to de-rate, relative to the gold price:

Exhibit 7: Australian indicated oz value vs gold price (US$/oz)



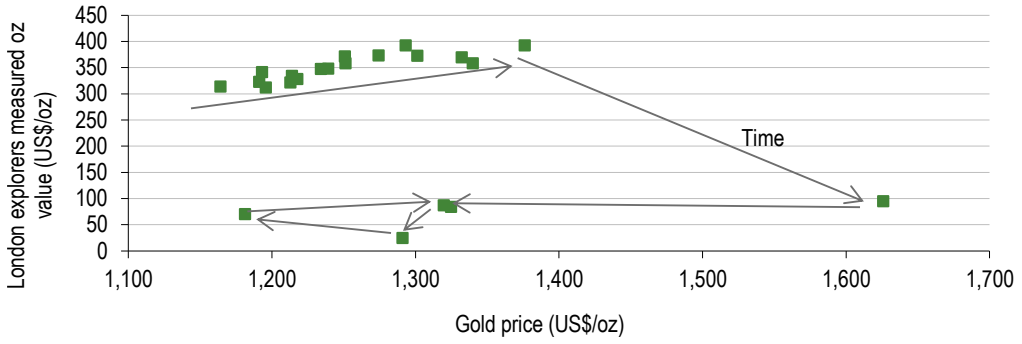
Source: Edison Investment Research

A number of factors have been responsible for this de-rating, including:

- The de-rating of SML via an increase in its cash holding coupled with a simultaneous decrease in its market capitalisation, and
- The sale by (previously, relatively highly rated) Matsa of its Mt Henry asset to Metals X and its evolution into a more diversified metals explorer, resulting in it being excluded from the gold analysis.

Notwithstanding the overall de-rating however, discrete values for indicated resources in individual companies listed in Australia can exist within a relatively large range – ie ±US$250/oz from the geometric average. Similarly, early stage resources in Canada continue to be unloved by the market. Notwithstanding the individual values for indicated and inferred ounces listed in Canada, the overall pattern is (and has been, since at least August 2014) that both are at a substantial discount compared to measured ounces and relatively close to zero. Even so, the value of a 'blended' indicated and inferred resource has continued to decline, from US$2.48/oz in June 2015 to US$1.92/oz in August 2016. As a result, the implied value of measured ounces in Canada has continued to rise. By contrast, despite the recovery in the value of indicated and inferred ounces listed there, the implied value of measured ounces listed in London has continued to rise:

Exhibit 8: London measured oz value vs gold price (US$/oz)



Source: Edison Investment Research

Nevertheless, one of the most striking features of the analysis is the re-rating of the value of Australia's measured ounces (if not its indicated ounces) to levels comparable to the last bull market:

Exhibit 9: Average value of in-situ explorers' gold resources (Australia), US$/oz

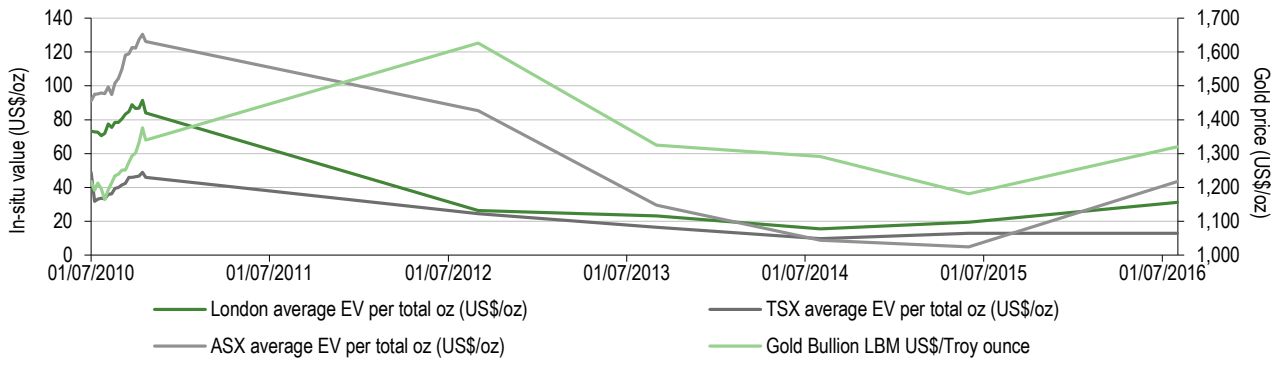
	August 2016				August 2012*			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
Australian market	226.06	15.15	5.51	43.47	236.33	83.52	8.33	86.09

Source: Edison Investment Research, company sources, Thomson Reuters Datastream. Note: *See Gold – New benchmarks for old, published in November 2012.

In part, the increase in the value of measured ounces listed in Australia can be ascribed to the decline in the implied value of indicated ounces. However, there has also been a noticeable re-rating of the value of ounces, generally, within individual companies such as Dacian and Gryphon (the latter, in part, occasioned by its takeover by Teranga). Note that Dacian appears to be a statistical outlier within the sample of Australian companies with all three categories of resources. Excluding it from the sample would decrease the average value of Australian measured ounces to US$58.27/oz, although there seems to be no fundamentally justifiable reason for adopting this approach.

As a result of all of the above factors, the average value of ounces overall has jumped by more in Australia than either of the other two markets – albeit from relatively more depressed levels – in both absolute and percentage terms.

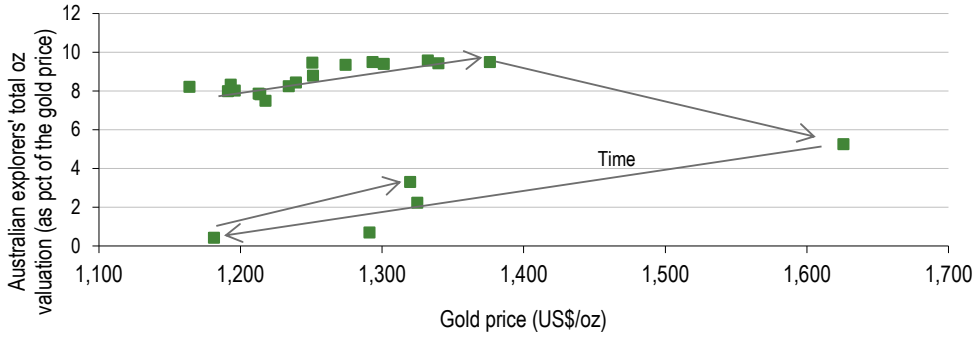
Exhibit 10: Average value of in-situ ounces listed in London, TSX and ASX vs gold price, July 2010 to August 2016 (US$/oz)



Source: Edison Investment Research

At just 1.28% of the price of gold however, the average value of all in-situ ounces in all markets nevertheless remains consistent with decidedly bear, rather than bull, market conditions. While this could superficially be attributed to the depressed Canadian valuation (which accounts for 82% of the in-situ ounces analysed), it is in fact true for each individual market as well, as demonstrated by the graph of the average in-situ valuation of Australian-listed ounces (as a percentage of the gold price) compared to the gold price in the graph below:

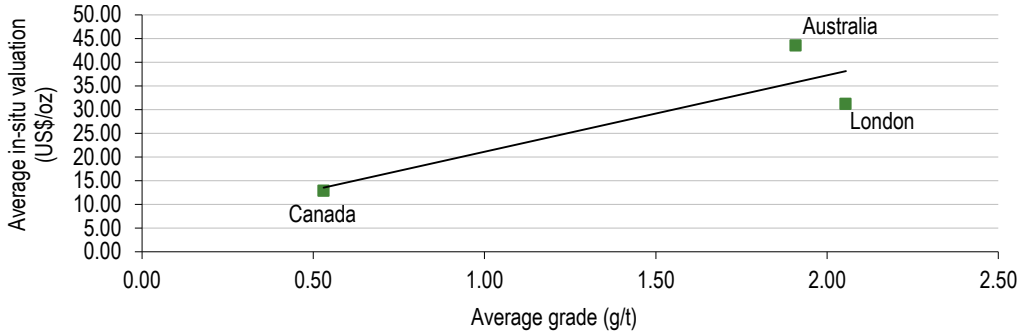
Exhibit 11: Australia total, average oz value (as a % of the gold price) vs gold price (US$/oz)



Source: Edison Investment Research

In addition, investors should be aware of the lower overall average grade associated with the sample of companies listed in Canada, of 0.53g/t, compared to c 2g/t for the samples in London and Australia, which may be depicted graphically as follows:

Exhibit 12: Average in-situ valuation (US$/oz) vs average grade (g/t), selected markets



Source: Edison Investment Research

Note the intriguing implication of the above graph that ounces listed at a grade of 0g/t could still attract an in-situ valuation of US$5/oz!

Notwithstanding the continued bear market valuations of in-situ ounces however, there nevertheless exists the possibility of a positive return for investors on exploration dollars in at least the London and Australian markets.

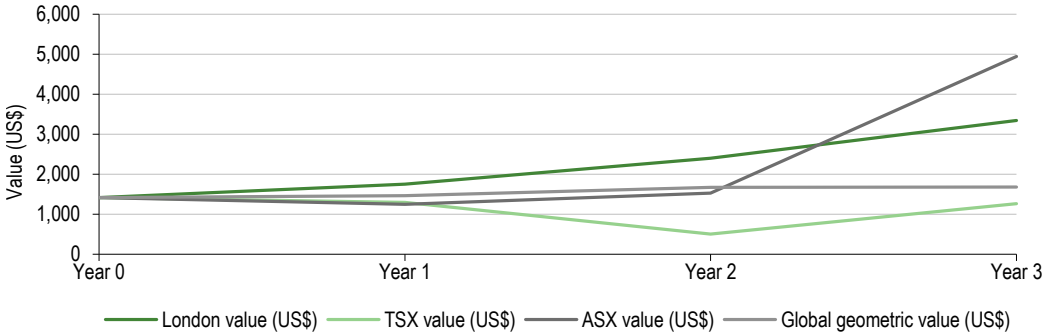
Financial returns on the gold exploration dollar

In the publication Gold – Valuation benchmarks are obsolete, Edison, in collaboration with BDO, calculated global, average costs of discovery of US$7.16 per inferred ounce, US$10.50 per indicated ounce, US$36.82 per measured ounce and US$8.81 per blended ounce.

Companies with indicated and inferred ounces only have them in the proportion 55:45, inferred:indicated, respectively, while companies with measured, indicated and inferred resources

have them in the proportion 18:53:29, respectively. On the basis of the unit cost estimates derived above, the cost to drill up a typical, average deposit of 100oz, in the ratio 18:53:29 would therefore be US$1,416 in aggregate. At the unit values shown in Exhibit 4, these resources would be worth US$3,347 in London, US$4,947 in Australia and US$1,263 in Canada (to the nearest dollar), representing returns of +136.3% in London, +249.3% in Australia and -18.9% in Canada. The global average return is 18.9%, with the evolution over time as follows:

Exhibit 13: Average gold exploration value evolution over time (US$)



Source: Edison Investment Research

Note that, in year 0, the company has cash of US$1,416; in year 2, it has a resource of 100 inferred oz and cash of US$700; in year 3, it has a resource of 55 inferred oz and 45 indicated oz and cash of US$551; and in year 4, it has a resource of 18 inferred oz, 53 indicated oz and 29 measured oz and no cash. At the end of the campaign, the value of the resource will be held in the following categories in each of the three markets:

Exhibit 14: Average gold resource values, by category, selected markets (%)

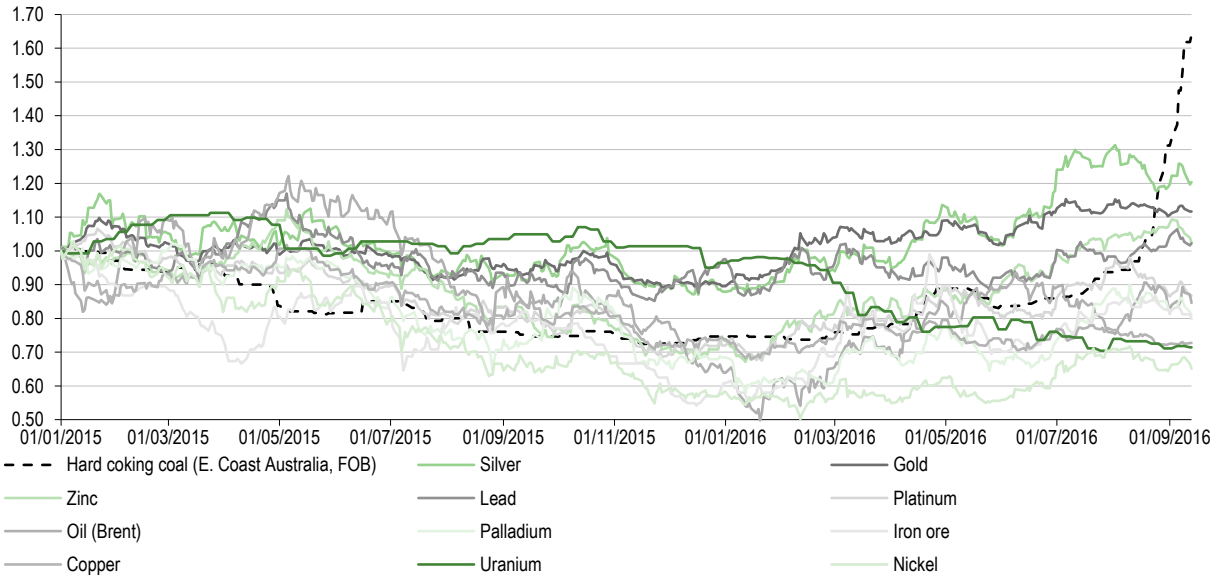
Resource category	London	Canada	Australia
Measured	46	122	80
Indicated	45	(36)	16
Inferred	9	14	3
Total	**100**	**100**	**100**

Source: Edison Investment Research

Uranium

In contrast to the moderate bull market experienced by gold in the past 20 months, the uranium market has been distinctly bearish, with yellow cake being the second worst performing major metal over the period:

Exhibit 15: Major metals and minerals price performance, 1 January 2015 to present (factor)



Source: Thomson Reuters Datastream, Edison Investment Research

Unsurprisingly therefore, the value of in-situ uranium resources has also fallen over the course of both the one-year and the two-year periods:

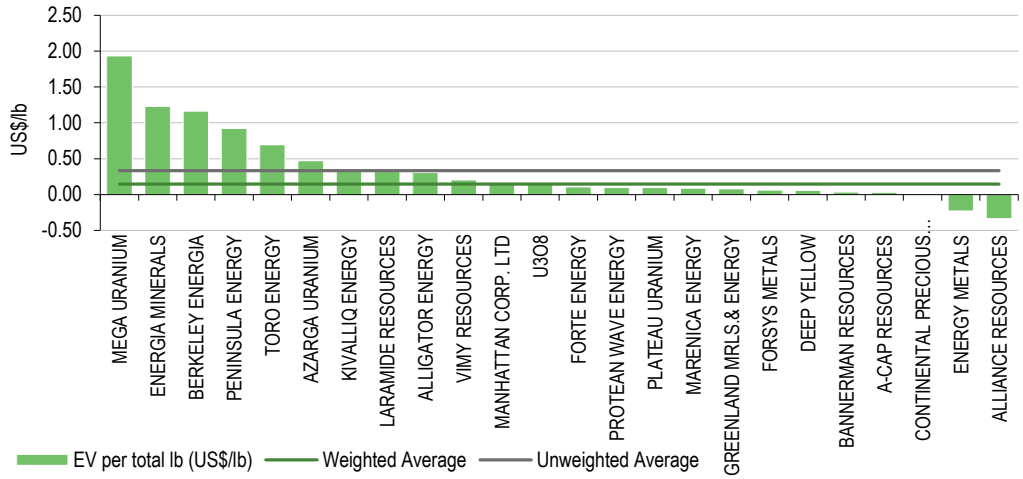
Exhibit 16: Global average value of in-situ explorers' uranium resources (US$/lb)

	August 2016				June 2015				June 2014			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ U_3O_8 value	3.40	(0.64)	0.28	0.12	(1.30)	0.92	0.07	0.21	4.04	0.13	0.08	0.14
Cost of discovery*	**1.37**	**0.92**	**0.09**	**1.02**	**1.37**	**0.92**	**0.09**	**1.02**	**1.37**	**0.92**	**0.09**	**1.02**

Source: Edison Investment Research, company sources, Thomson Reuters Datastream. Note: *See Gold: The value of gold and other metals, published in February 2015.

While none of the samples demonstrated any obvious anomalies, the fact that the implied value of indicated resources is negative, as well as being at a discount to the implied value of inferred resources, is, at first glance, nonsensical. One interpretation is that that the market values uranium explorers on the basis of total pounds in the ground, rather than pounds differentiated by geological category:

Exhibit 17: Implied value of total uranium lbs in-situ

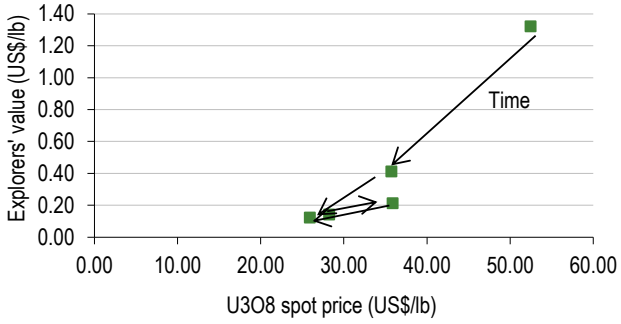


Source: Edison Investment Research

However, the result for the sample of companies with inferred resources only is extremely consistent. Moreover, there has been evidence of a large discount between the value of measured pounds and indicated pounds in four of the past five occasions on which data was gathered. An alternative interpretation therefore is that the market values both indicated and inferred resources at 8.2 US cents per pound and, within that context, measured resources at US$1.59/lb.

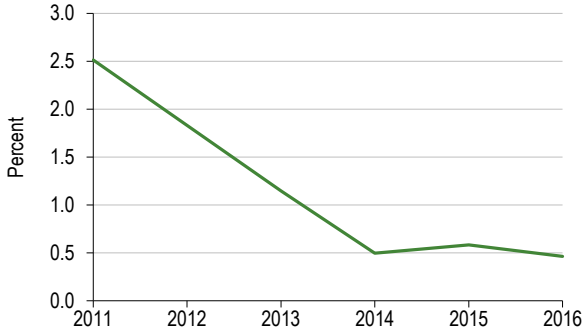
Considered within the context of total resources, the average in-situ value of uranium pounds is consistent with recent historical experience. However, in percentage terms, the in-situ value has now steadied with respect to the spot price of uranium oxide, which may indicate that any future declines on account of a declining uranium price will be of a smaller magnitude than the (previously geared) falls.

Exhibit 18: In-situ value of total uranium resources vs spot price of uranium, 2011-16



Source: Edison Investment Research

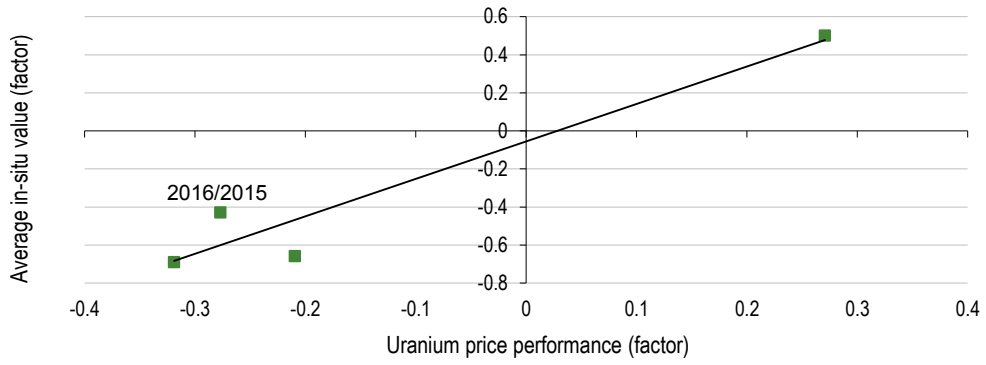
Exhibit 19: In-situ value of total uranium resources as percent of the spot price of uranium, 2011-16



Source: Edison Investment Research

With due regard to the small sample size, this conclusion is also supported, to some extent, by the experience of the past 12 months (marked):

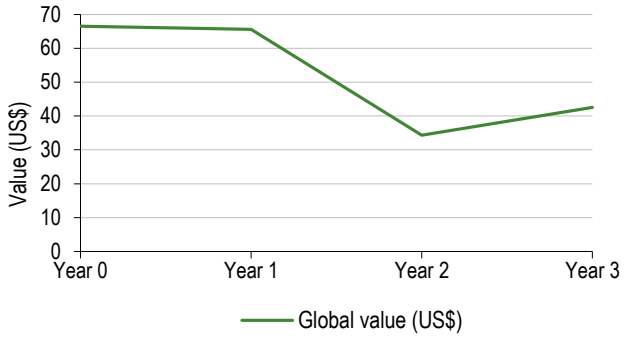
Exhibit 20: Uranium in-situ valuation change vs uranium spot price change, 2011-16



Source: Edison Investment Research

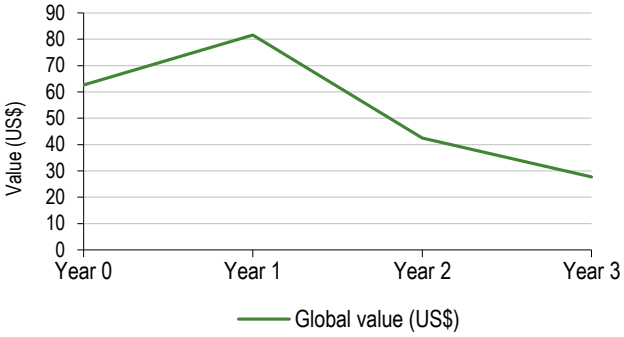
Nevertheless, as a result in the decline in in-situ values overall, returns on exploration spend have similarly declined. Whereas, the overall decline in economic value for a company looking to develop a 100lb resource was 36.1% in June 2014, this has now increased to 55.6% currently:

Exhibit 21: Value evolution of junior uranium explorer developing 100lb resource, 2014 (US$)



Source: Edison Investment Research

Exhibit 22: Value evolution of junior uranium explorer developing 100lb resource, 2016 (US$)

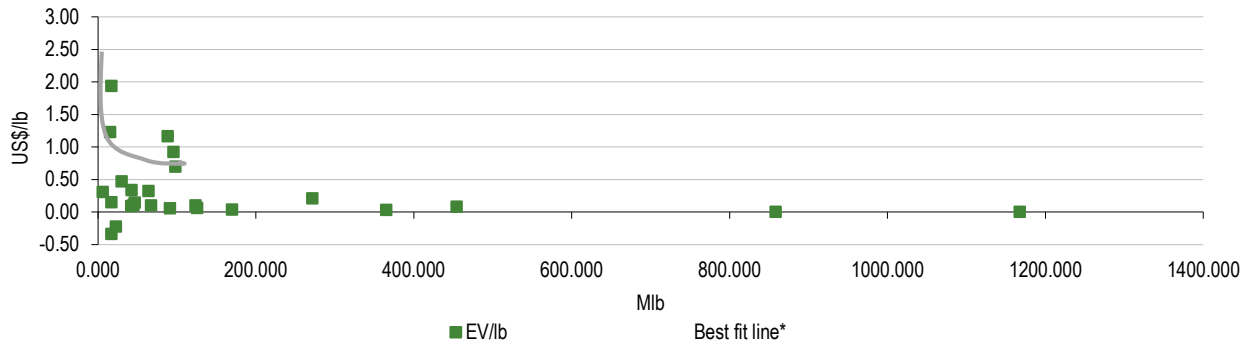


Source: Edison Investment Research

Notwithstanding the overall deterioration however, there is tangible evidence of the industry reacting to the decline in the implied value of indicated resources pounds. Whereas in June 2014 companies with indicated and inferred resources only possessed these in the ratio 40:60 respectively (corresponding to year 2 in Exhibits 21 and 22, above), this has now changed to 78:22 – ie companies appear to be delineating fewer indicated resources with respect to inferred resources. In addition, companies with all three categories of resources now possess them in the ratio 42:44:13 inferred:indicated:measured, respectively, whereas in June 2014 they possessed them in the ratio 35:57:8 (ie again companies appear to be delineating fewer indicated resources with respect to both inferred and measured resources, as well).

As in June 2014 however, there nevertheless also exists tangible evidence of the market continuing to discount future exploration success among uranium explorers (see Gold: The value of gold and other metals, published in February 2015).

Exhibit 23: Graph of resource size (Mlbs) vs resource multiple (US$/lb) for U_3O_8 explorers



Source: Edison Investment Research. Note: * Best-fit line for a selection of small, highly valued stocks only

While the majority of the sector (with resource multiples below US$0.50/lb) has an average in-situ value per lb of uranium of 10.6 US cents, there exists a small sub-section with a resource multiple in excess of US$1.00 per lb. Within this sub-section moreover, there appears to be an apparent pattern whereby smaller resources command larger values, which suggests that the market is discounting the delineation of future resources, against which the EV of the company should be considered. A company with a valuation of US$1.00/lb and a resource of 10Mlbs might be expected to have a valuation of 50c at 20Mlbs therefore (ie the resource will have doubled but the EV will have remained the same), 25c at 40Mlbs and 12.5c (ie approximately the residual sector average) at a resource of 80Mlbs. Hence the market could be said to be discounting an eventual resource for that company of 80Mlbs. However, it is equally clear that only a few companies are accorded this privilege and that this effect wanes fairly rapidly once a resource of 100Mlbs is exceeded.

Silver

In contrast to uranium, investors in silver explorers exhibit a marked preference for indicated resource ounces at the expense of measured ones:

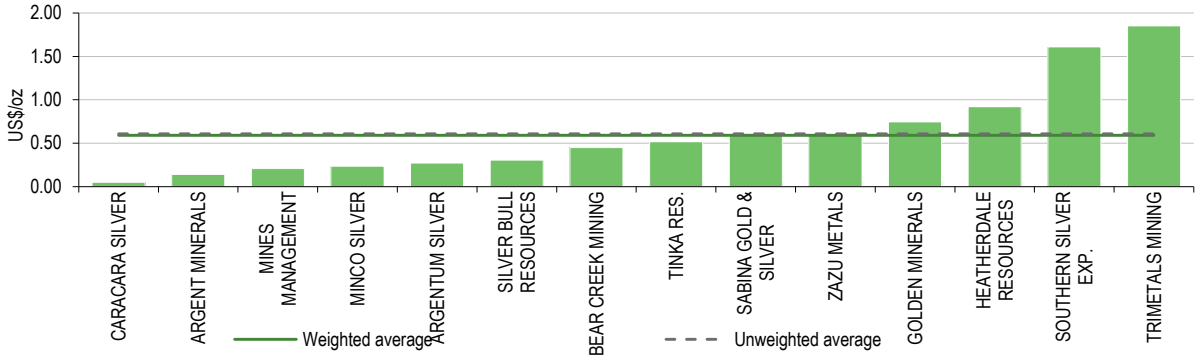
Exhibit 24: Global average in-situ value of explorers' silver resources (US$/oz)

	August 2016				June 2015				August 2014			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ silver value	(2.07)	1.16	0.13	0.59	(7.50)	1.56	0.02	0.45	(0.98)	1.12	0.04	0.85

Source: Edison Investment Research, company sources, Thomson Reuters Datastream.

This may imply that the market similarly values silver explorers on the basis of total oz in the ground, rather than oz differentiated by geological category:

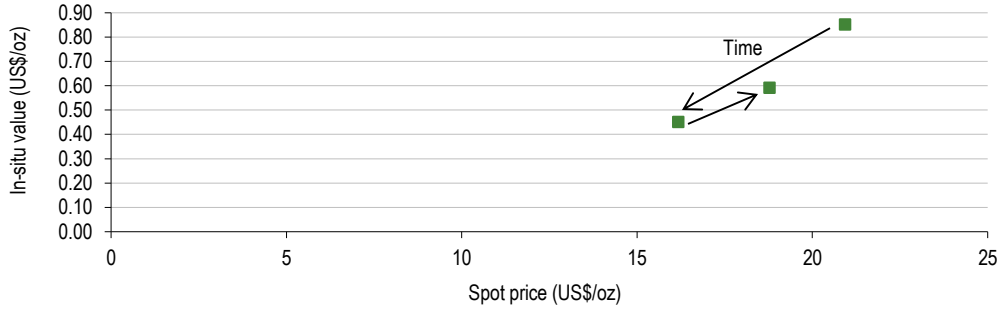
Exhibit 25: Implied value of total silver oz in-situ (US$/oz)



Source: Edison Investment Research

In addition, the overall value of silver ounces is approximately where it would be expected to be, given the silver price:

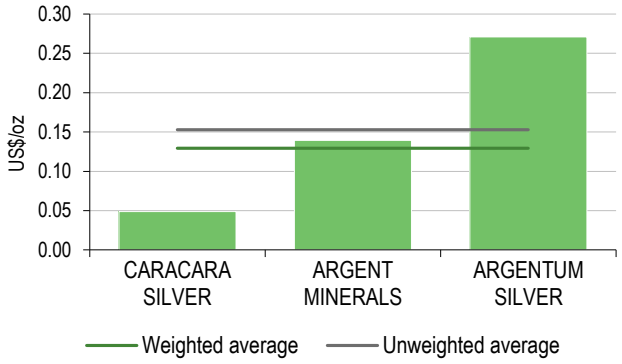
Exhibit 26: In-situ value of total silver resources vs spot price of silver, 2014-16



Source: Edison Investment Research

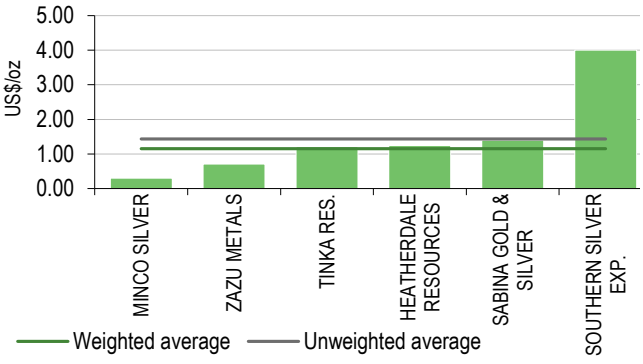
On the other hand, the grouping of results for companies with inferred resources and indicated & inferred resources only is relatively good – ie there are few/no anomalies or outliers.

Exhibit 27: Implied value of inferred silver oz in-situ (US$/oz)



Source: Edison Investment Research

Exhibit 28: Implied value of indicated silver oz in-situ (US$/oz)



Source: Edison Investment Research

Moreover, a discount of the value of measured silver ounces compared to the value of both indicated and inferred resources has been a feature of this analysis since Edison first performed a differentiated analysis of the value of silver resources in August 2014.

Iron ore

Like silver, iron ore explorers exhibit a premium of indicated resources over measured ones:

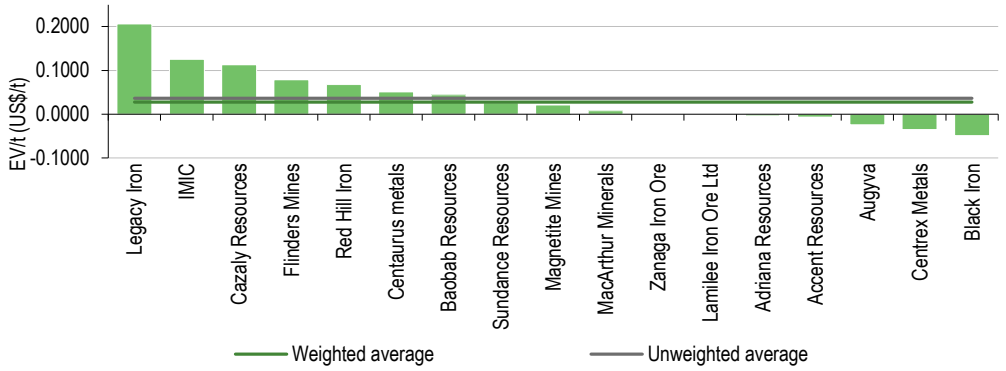
Exhibit 29: Global average in-situ value of explorers' iron ore resources (US$/t Fe)

	August 2016				June 2015				August 2014			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ iron ore value	(0.062)	0.120	(0.001)	0.028	(0.087)	0.137	0.009	0.031	(0.096)	0.231	0.005	0.055

Source: Edison Investment Research, company sources, Thomson Reuters Datastream

This too has been a consistent feature since Edison first performed a differentiated analysis on iron ore explorers in August 2014. Once again, this could be indicative of the market valuing iron ore companies and resources by total resources, rather than each separate category of resources:

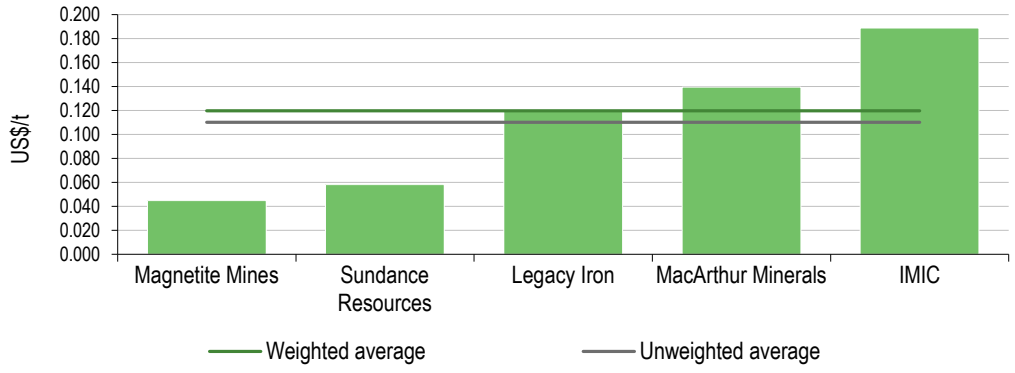
Exhibit 30: Implied value of total iron ore resources in-situ (US$/t Fe)



Source: Edison Investment Research

The differentiated approach is complicated by the fact that there is a small sample size of companies with inferred only resources and that the result of this sub-section of the market is negative. Nevertheless, the grouping of companies with indicated and inferred resources only is good (which militates against a 'total resource' interpretation):

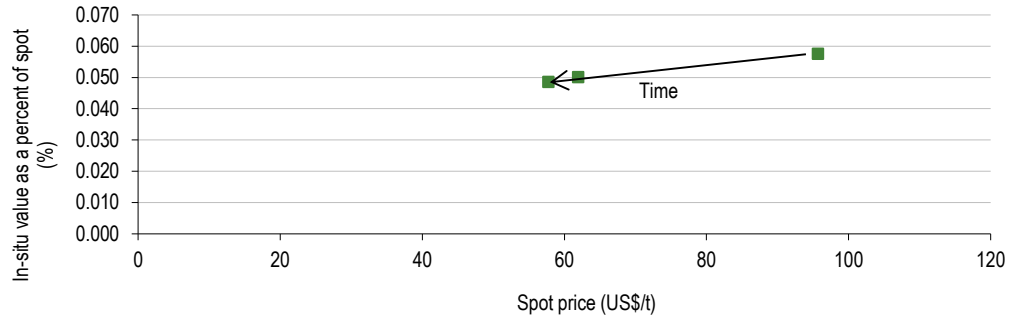
Exhibit 31: Implied in-situ value of indicated iron ore resources (US$/t Fe)



Source: Edison Investment Research

Of note however, is the fact that the in-situ value of iron ore resource tonnes has remained remarkably constant relative to the spot price of iron ore in percentage terms, at 0.052% ±0.005%, regardless of the prevailing spot price of the commodity:

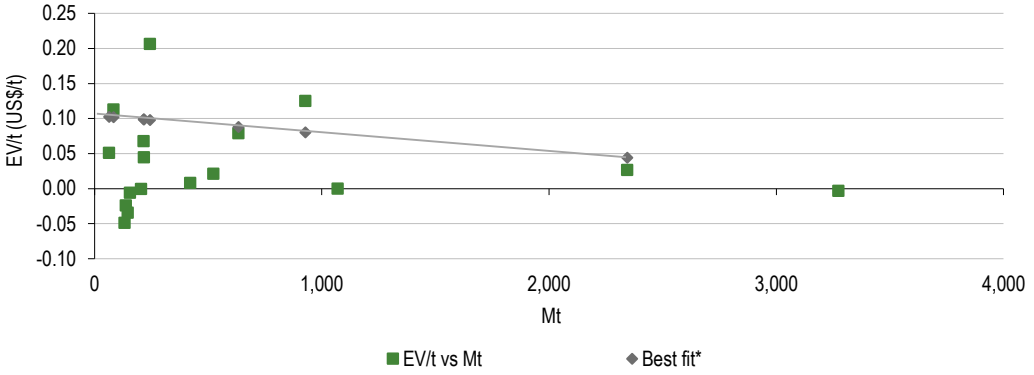
Exhibit 32: In-situ value of total iron ore resources vs spot price of iron ore, 2014-16



Source: Edison Investment Research

As in August 2014, there is evidence of the discounting of future discoveries in the sector:

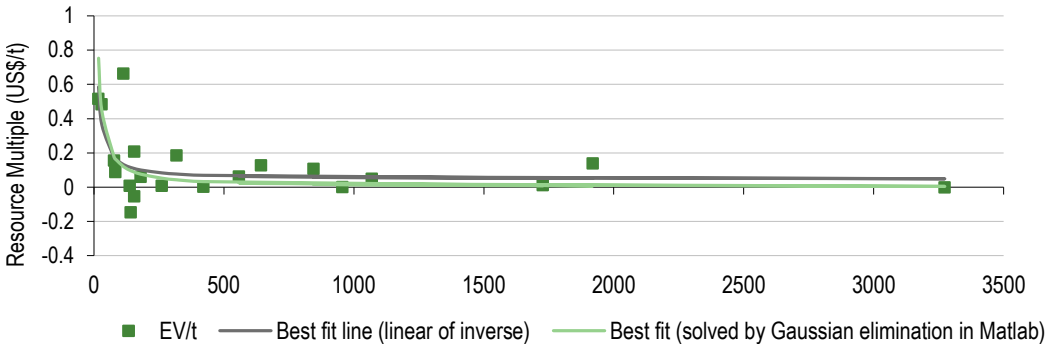
Exhibit 33: Graph of resource size (Mt) vs resource multiple (US$/t Fe) for iron ore explorers



Source: Edison Investment Research. Note: * Relevant sample only

Unlike in August 2014 however, the strength of the effect is much reduced, such that, rather than exhibiting an inverse relationship, the relationship between the in-situ valuation and the resource size now appears to be a weak linear one.

Exhibit 34: Graph of iron ore resource size (Mt) vs resource multiple (US$/t Fe), August 2014



Source: Edison Investment Research

This characteristic of the market provides an opportunity for companies however. If doubling a resource results in a less than halving of the resource multiple, then the potential arises to create value for a company's shareholders by increasing resource size (anecdotally) up to c 2,500Mt Fe.

Platinum group metals (PGMs)

The analysis of the platinum sector is complicated by the fact that the sample of explorers is small and there are no explorers with inferred resources only. Inevitably, the sample is dominated by South Africa and the Bushveld complex and therefore a relative absence of measured ounces relative to indicated and inferred ounces.

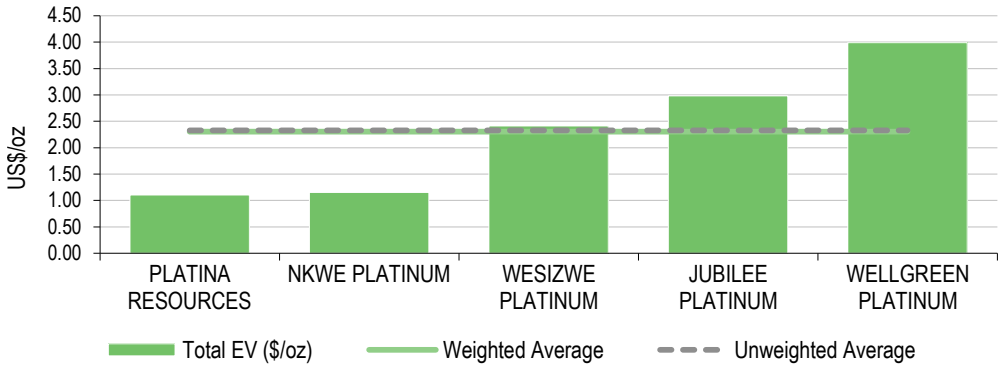
Exhibit 35: Global average in-situ value of explorers' PGM resources (US$/oz PtE)

	August 2016				June 2015				August 2014			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ iron ore value (US$/oz)	(9.24)	2.98	2.98	2.31	12.30	10.39	0.84	2.53	33.53	8.82	0.70	4.71
Cost of discovery (US$/oz PtE)*	4.18	1.26	0.90		4.18	1.26	0.90		4.18	1.26	0.90	

Source: Edison Investment Research, company sources, Thomson Reuters Datastream. Note: *Maximum cost of discovery derived for Witwatersrand gold ounces (assumed to be comparable to Bushveld PtE oz), see Gold – Valuation benchmarks are obsolete, published in January 2010. PtE = platinum equivalent.

Once again, the analysis is indicative of the fact that the market values PGM explorers with respect to total resources, rather than resources differentiated by geological category:

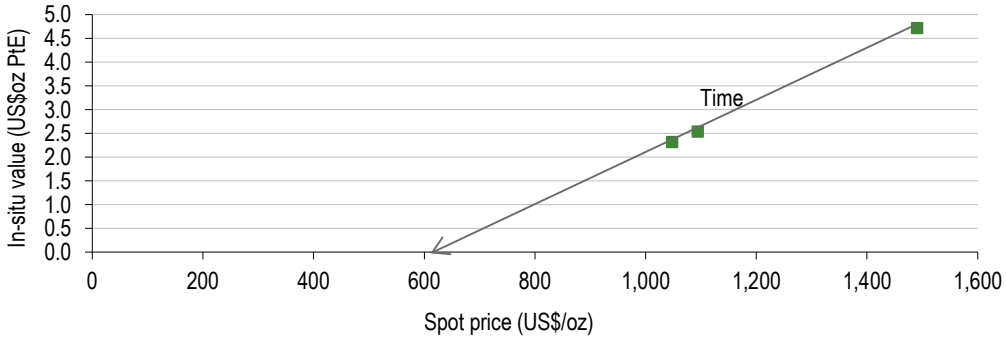
Exhibit 36: Implied in-situ value of total PGM resources (US$/oz PtE)



Source: Edison Investment Research

In addition, the unit value of overall resources is almost exactly where it would be expected to be, given the price of platinum:

Exhibit 37: In-situ value of total PGM resources vs spot price of platinum, 2014-16



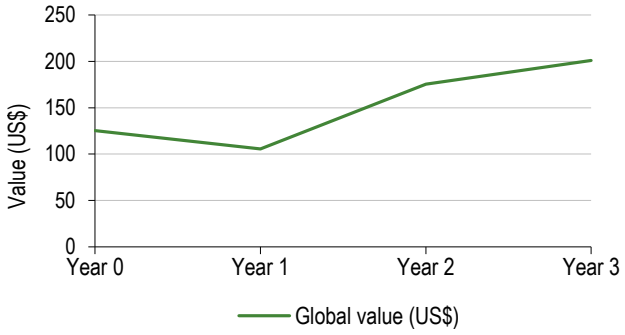
Source: Edison Investment Research

Of note is the implication that PGM resources have no in-situ value in the event that the platinum price falls to US$628/oz – which could be logical in the event that US$628/oz approximates the current, discounted capital and operating costs of bringing a platinum equivalent (PtE) ounce to account – although a shallowing may also be expected in the event that whatever forces are

responsible for the decline in the platinum price are also impinging on the global economy, generally. Also militating against a 'straight line' interpretation is the logical existence of an accounting minimum value equating to the book value of the discovery cost of platinum equivalent ounces.

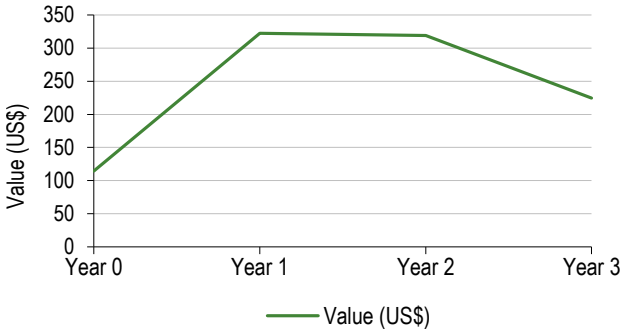
Nevertheless, the decline in the implied value of measured resources relative to indicated and inferred resources should not be ignored. Whereas, previously, PGM exploration could be seen to be value adding with increasing geological confidence, the likelihood is that it is now only value adding at the earliest stage of delineating resources:

Exhibit 38: Value evolution of junior PGM explorer developing 100oz PtE resource, 2014 (US$)



Source: Edison Investment Research

Exhibit 39: Value evolution of junior PGM explorer developing 100oz PtE resource, 2016 (US$)



Source: Edison Investment Research

Note that Edison's estimate that the value of inferred PGM resources should be the same as for indicated resources (ie representing an *a priori* maximum for the inferred category) potentially inflates the position of the graph at Year 1 in Exhibit 39. In the event that a value equal to half of this value was instead estimated (ie US$1.49/oz for inferred resources), the position of the graph at Year 1 would be approximately half the value shown in Exhibit 39 (in fact US$173.29/oz); however, the positions of the graph at Years 2 and 3 would be almost identical to those shown here – with a decline still occurring between Year 2 and Year 3. As a result, even in this instance, our conclusion would remain unchanged that, "the likelihood is that [PGM exploration] is now only value adding at the earliest stage of delineating resources", which, for these purposes may be interpreted as the delineation of the lowest two confidence categories of resources (ie inferred and indicated resources only), with the delineation of measured resources almost certainly proving to be a value destroying exercise in this instance.

Nickel

Our nickel analysis has been sub-divided into separate analyses for sulphide and laterite deposits to reflect the different natures and processing requirements of those ore-bodies.

Exhibit 40: Global average in-situ value of explorers' nickel resources (US$/t)

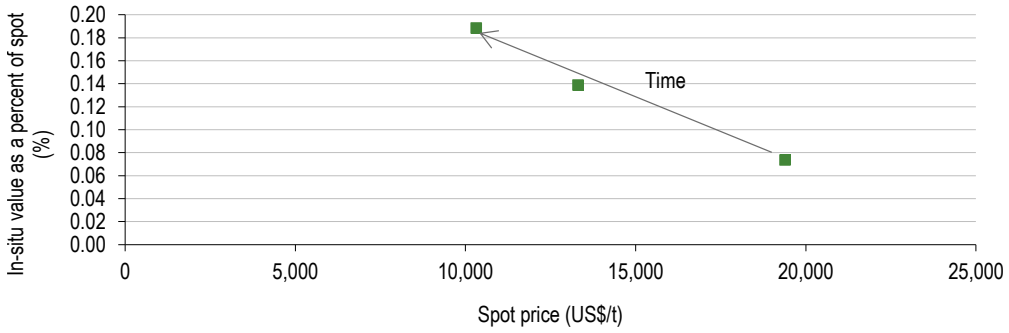
	August 2016				June 2015				August 2014			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ nickel value (US$/t)	106.62	22.11	5.87	19.43	60.66	(39.22)	58.92	18.44	(39.14)	36.49	10.40	14.25
Ditto (sulphide deposits)				21.20				29.87				25.69
Ditto (laterite deposits)				11.27				5.21				5.07

Source: Edison Investment Research, company sources, Thomson Reuters Datastream

Of immediate note is the premium valuation attributed to sulphide resources compared to laterite ones (as expected).

Even so, more than uranium, platinum and iron ore, the nickel market has been almost unremittingly bearish over the course of the past two years (see Exhibit 15). Within this context therefore, it is perhaps surprising to observe the aggregate value of an in-situ nickel tonne rising, albeit this may be seen within the context of a preternaturally low prior in-situ valuation relative to the value of nickel metal (see Exhibit 88):

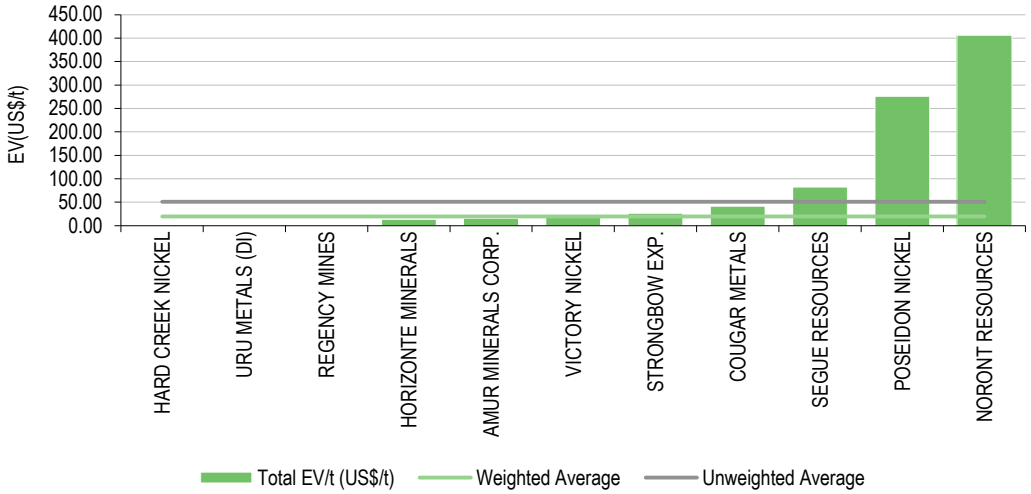
Exhibit 41: In-situ value of nickel resources as a percent of nickel spot price, 2014-16



Source: Edison Investment Research

At just eight companies, the overall size of the nickel sample was small. In addition, the only company with inferred resources only (Segue) was a clear statistical outlier. As a result, the differentiated analysis for nickel required a re-interpretation of the value of inferred resources, which were taken to be half way between zero and the value of indicated resources. While logical however, the implication of the above observations is that, in all likelihood, the market values nickel explorers on the basis of total, rather than differentiated, resources:

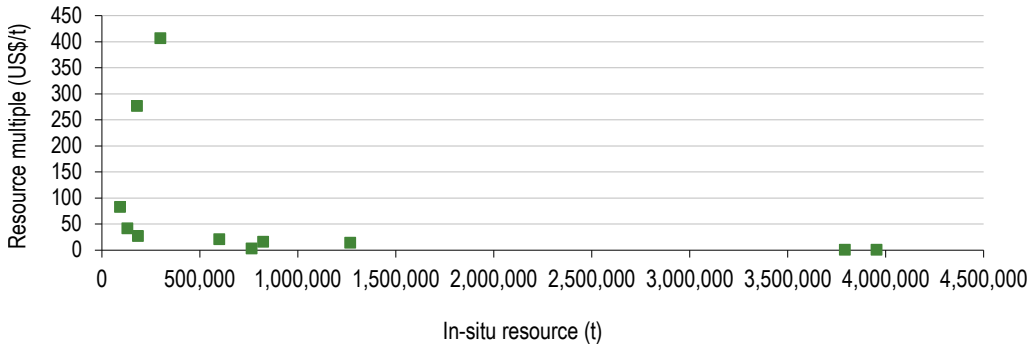
Exhibit 42: Implied in-situ value of total nickel resources (US$/t)



Source: Edison Investment Research

Statistically Noront Resources and Poseidon may be considered to be outliers. However, as with iron ore and uranium also, this is likely to reflect the market's discounting of future discoveries, as demonstrated in the graph below:

Exhibit 43: Resource size (t) vs resource multiple (US$/t) for nickel explorers



Source: Edison Investment Research

Potash

Like our nickel analysis, our potash analysis has been sub-divided into separate analyses for companies seeking to produce either sulphate or muriate of potash (SOP and MOP, respectively) and also into brines to reflect the different natures and processing requirements of those products and ore-bodies.

Exhibit 44: Global average in-situ value of explorers' potash resources, by type (US$/t)

	Measured	Indicated	Inferred	Total
Sulphate of potash	(6.44)	1.26	0.30	0.54
Muriate of potash	(2.76)	0.83	0.11	0.02
Brine	(2.16)	2.53	0.45	1.24

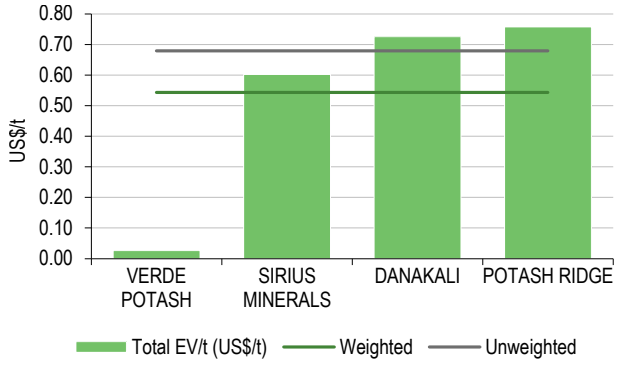
Source: Edison Investment Research

Two features of the analysis are immediately apparent:

- All three deposit types exhibit a clear premium valuation for the indicated category of resources.
- On average, brines attract a premium valuation relative to sulphates, which attract a premium valuation relative to muriates.

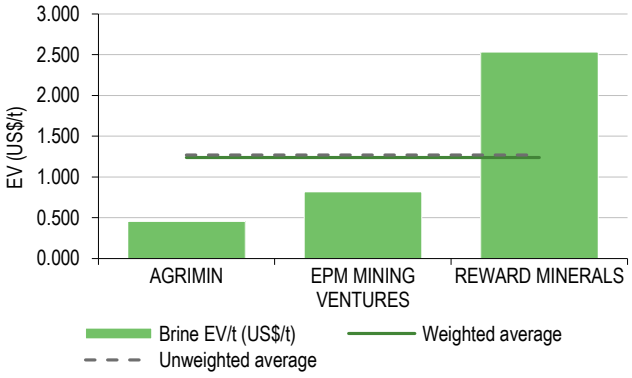
Sample sizes for each of the three sub-sectors are relatively small. In addition, neither the SOP nor the MOP samples had companies or projects with inferred resources only, complicating the differentiated analysis. As a result, and notwithstanding the indicated resource category premium (which remains relevant), it is likely that the market values these projects on the basis of total resources, rather than resources differentiated by resource categorisation.

Exhibit 45: Implied in-situ value of SOP resources (US$ per total tonne)



Source: Edison Investment Research

Exhibit 46: Implied in-situ value of SOP brine resources (US$ per total tonne)

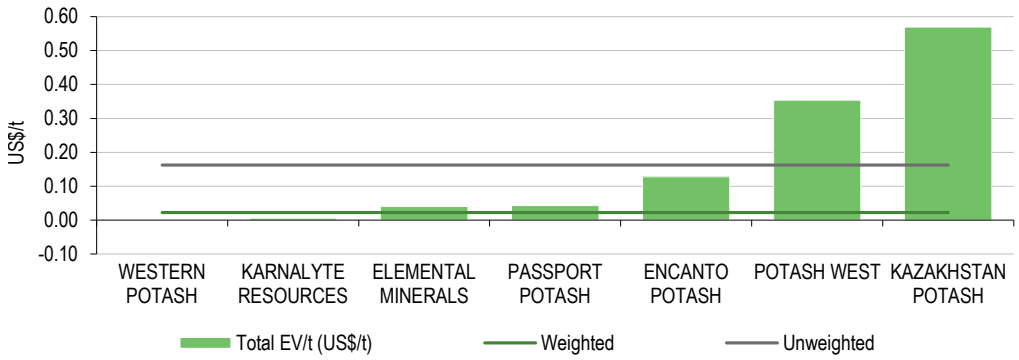


Source: Edison Investment Research

Note that the bottom of the range in-situ valuation for brine resources approximately corresponds to the top of the range in-situ valuation for 'conventional' SOP resources.

MOP resources may similarly achieve ratings comparable to SOP resources (note that a tonne of each contains roughly comparable numbers of potassium units). However, the weighted average valuation for in-situ MOP resources is markedly lower than for both SOP resources and brines:

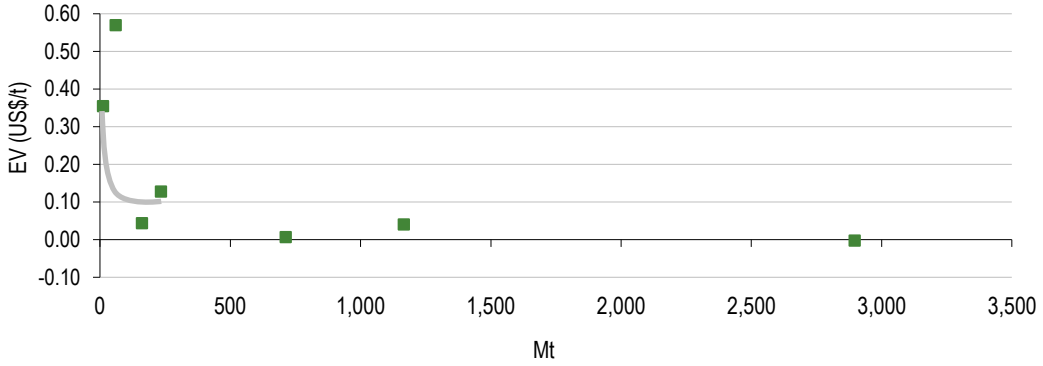
Exhibit 47: Implied in-situ value of MOP resources (US$ per total tonne)



Source: Edison Investment Research

In part however, this is a function of clear evidence of the discounting of the future discoveries by investors, which is not apparent in either the SOP or brine samples:

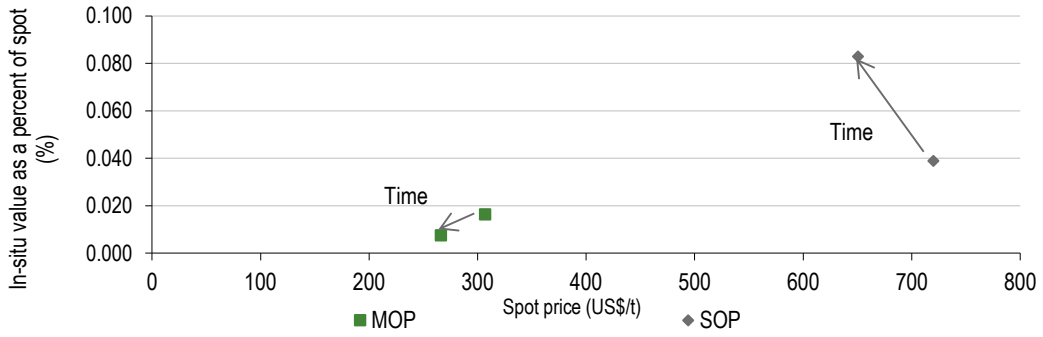
Exhibit 48: Graph of resource size (Mt) vs resource multiple (US$/t) for MOP explorers



Source: Edison Investment Research. Note: Grey line represents best fit for an inverse (1/x) relationship.

As a result – and given a bear market in SOP over the course of the last 12 months – a marked disparity has developed between the in-situ values of both MOP and SOP resources and the respective values of their end products:

Exhibit 49: In-situ value of MOP and SOP resources as percent of end products' prices, 2015-16



Source: Edison Investment Research

Copper

Like nickel, copper has been in the throes of a bear market since August 2014, which has led to sharp declines in the value of all three categories of resources.

Exhibit 50: Global average in-situ value of explorers' copper resources (US$/t)

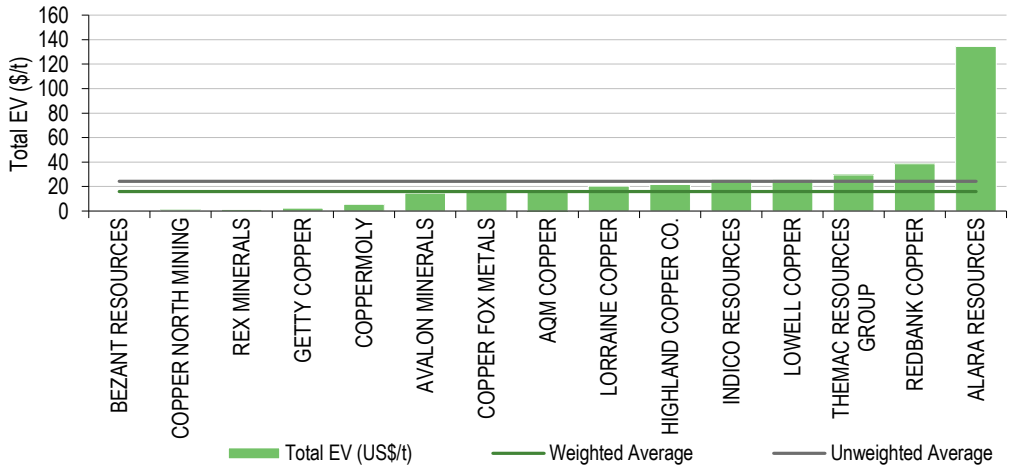
	August 2016				June 2015				August 2014			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ copper value (US$/t)	36.97	2.23	16.59	15.94	162.66	1.57	14.57	39.82	141.95	23.08	39.82	42.01

Source: Edison Investment Research, Thomson Reuters Datastream

Of note, within this analysis, is the unusual feature of an indicated resource discount relative to both measured and inferred resources. Moreover, in the period under review, indicated resources have lost the greatest value in percentage terms (90.3%), followed by measured resources (-74.0%) and then inferred resources (58.3%). Note that the in-situ value of a blended resource tonne has fallen by 62.1%.

This could be interpreted as, at first glance, evidence that the market values copper explorers with respect to total resources, rather than differentiated ones, and this appears to be supported by a graph of in-situ values per total resource tonne:

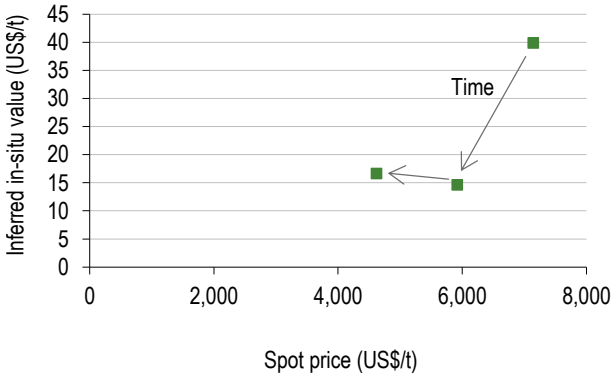
Exhibit 51: Implied in-situ value of copper resources (US$ per total tonne)



Source: Edison Investment Research

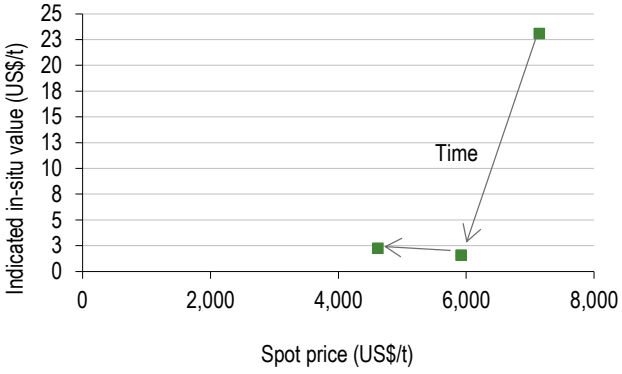
However, it is very noticeable that, over the course of the bear market, indicated and inferred resources lost their value first:

Exhibit 52: In-situ value of copper explorers' inferred resources vs spot price of copper, 2014-16



Source: Edison Investment Research

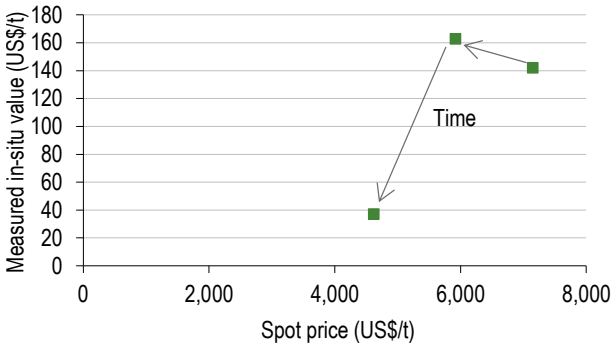
Exhibit 53: In-situ value of copper explorers' indicated resources vs spot price of copper, 2014-16



Source: Edison Investment Research

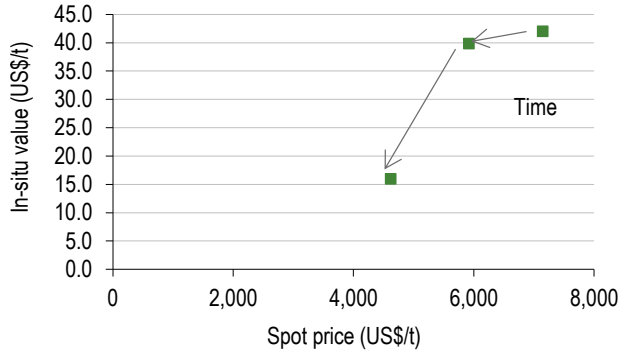
This was then followed by measured resources:

Exhibit 54: In-situ value of copper explorers' measured resources vs spot price of copper, 2014-16



Source: Edison Investment Research

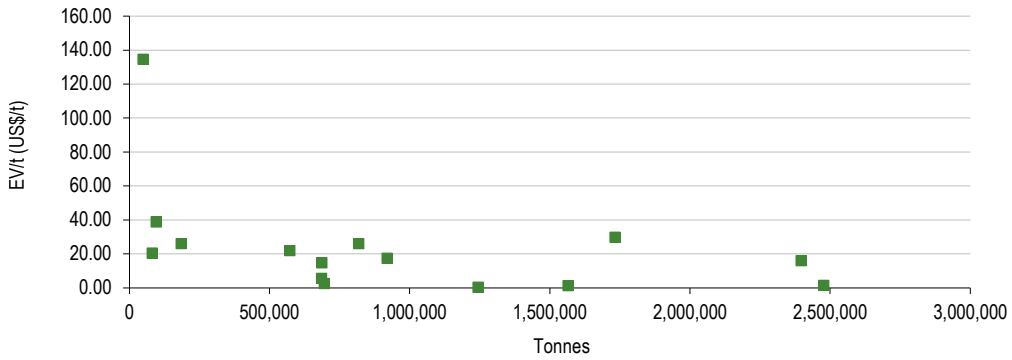
Exhibit 55: In-situ value of copper explorers' total resources vs spot price of copper, 2014-16



Source: Edison Investment Research

Also of note within the context of the copper analysis is the fact that there is some evidence of the market discounting future resource discoveries, a feature that it shares with uranium, iron ore and MOP, for example, but not gold:

Exhibit 56: Graph of resource size (Mt) vs resource multiple (US$/t) for copper explorers



Source: Edison Investment Research

Zinc (lead)

As zinc is often discovered in association with lead and since the price of the two is very similar, the analysis for zinc converts all associated lead resources into zinc equivalent. Note, that the same analysis could therefore have been used to generate in-situ values for lead resources and would have produced very similar results.

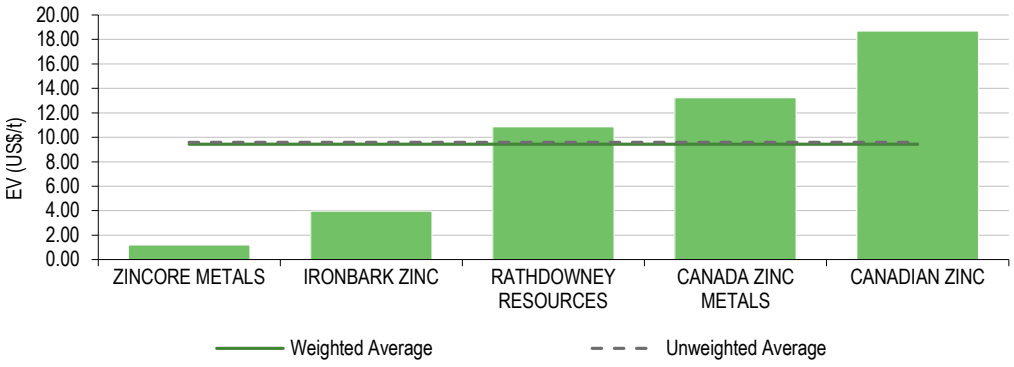
Exhibit 57: Global average in-situ value of explorers' zinc resources (US$/t)

	August 2016				June 2015				August 2014			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ zinc value (US$/t)	(7.03)	14.02	10.85	9.45	(7.65)	10.10	5.67	5.36	(7.88)	20.86	6.71	9.22

Source: Edison Investment Research, Thomson Reuters Datastream

Like PGMs, potash, silver and iron ore, zinc exhibits clear evidence of a premium rating for indicated resources, although, given the relative similarity between the values for indicated and inferred resources, in this case it might be perceived as a measured discount, rather than an indicated premium. Again, this may suggest that investors value zinc explorers on the basis of total, rather than differentiated, resources:

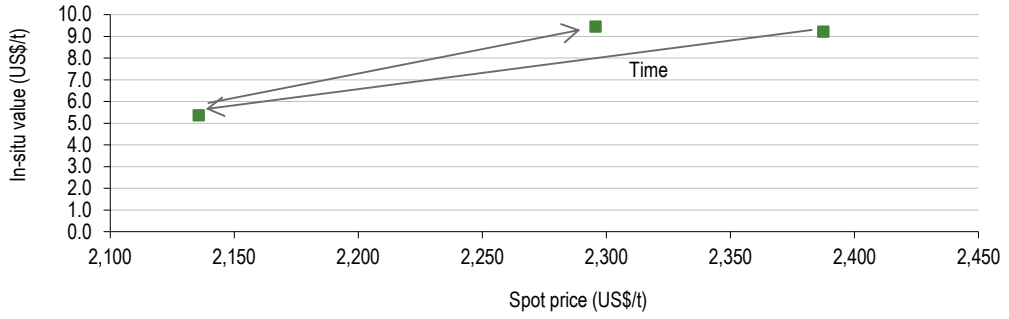
Exhibit 58: Implied in-situ value of zinc resources (US$ per total tonne)



Source: Edison Investment Research

Unlike copper for example, the zinc market has been through both a bear and a bull phase in the past two years. Interestingly, within this context, the average in-situ value of resources has returned almost to the level that they were at in August 2014, despite the fact that the zinc price remains 3.8% lower:

Exhibit 59: In-situ value of zinc equivalent resources vs spot price of zinc, 2014-16



Source: Edison Investment Research

Like gold, however, once again, there is little or no evidence of the market discounting future resource discoveries.

Lithium

As with our nickel and potash analyses, Edison's lithium analysis has been sub-divided, with Western Australian companies with spodumene resources being distinguished from the rest of the sector.

Exhibit 60: Global average in-situ value of explorers' lithium resources (US$/t)

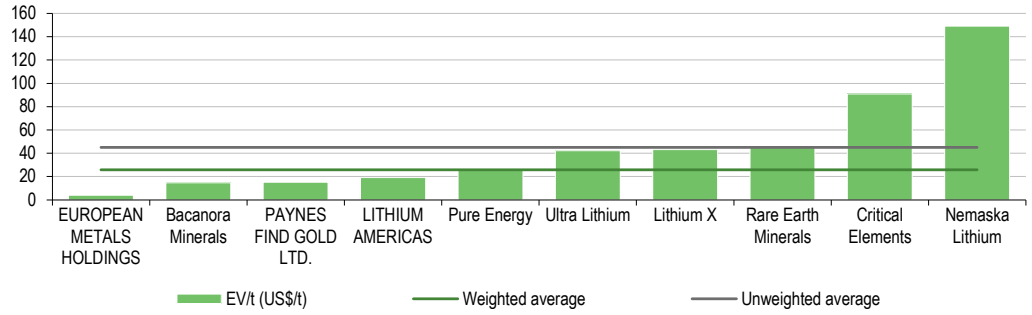
US$/t	August 2016			
	Measured	Indicated	Inferred	Total
In-situ lithium value	96.47	18.51	23.17	25.72
Western Australian spodumene companies	N/M	213.13	29.30	124.91

Source: Edison Investment Research, Thomson Reuters Datastream. Note that all lithium resources have been converted into lithium carbonate equivalent tonnes for the purposes of this analysis.

Of note, within the context of this analysis, is both the premium rating of Western Australian spodumene companies and also the premium rating of indicated resources located there (NB a historic trait of gold resources listed in Australia as well). More generally, however, it can be observed that the value of indicated resources approximates that of inferred resources, but that there is a premium accorded to measured resources. Taken together, lower confidence, indicated and inferred resources could be considered to be valued together at US$21.35/t, on average.

In the meantime, considered on an undifferentiated basis (below), there is some evidence of a discounted valuation being accorded to clay and clay-like deposits (eg Bacanora and European Metal Holdings) and an average valuation being accorded to brines (eg Lithium X, Pure Energy and part-Lithium Americas). It is notable that, on this basis, the two companies that are arguably the most advanced in terms of developing mining operations are also those that are statistical outliers in terms of their valuations (namely, Critical Elements and Nemaska Lithium).

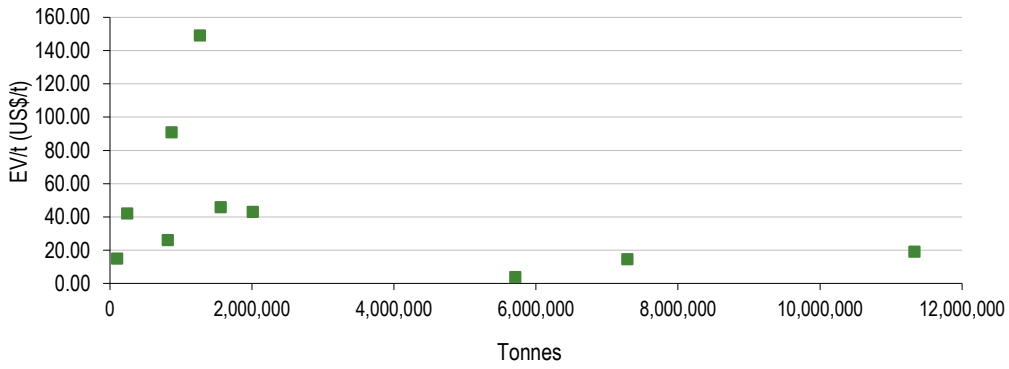
Exhibit 61: Implied in-situ value of lithium resources (US$ per total tonne)



Source: Edison Investment Research

In addition, there is also anecdotal (but not statistically significant) evidence that the market discounts future exploration success:

Exhibit 62: Graph of resource size (t) vs resource multiple (US$/t) for lithium explorers



Source: Edison Investment Research

Graphite

As with the results of our gold analysis, the results of Edison's graphite analysis demonstrated a 'logical' progression in in-situ values from inferred resources to measured resources. At the same time, a prior indicated premium, observed in June 2015, was observed to reverse and, thereby, 'regularise'.

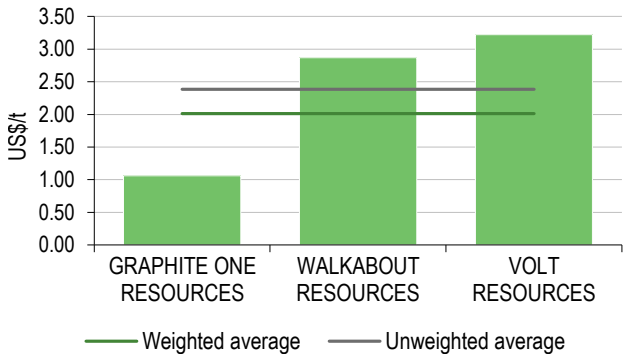
Exhibit 63: Global average in-situ value of explorers' graphite resources (US$/t)

	August 2016				June 2015			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ graphite value (US$/t)	36.10	11.38	2.01	6.42	4.13	14.43	0.97	3.79

Source: Edison Investment Research, Thomson Reuters Datastream

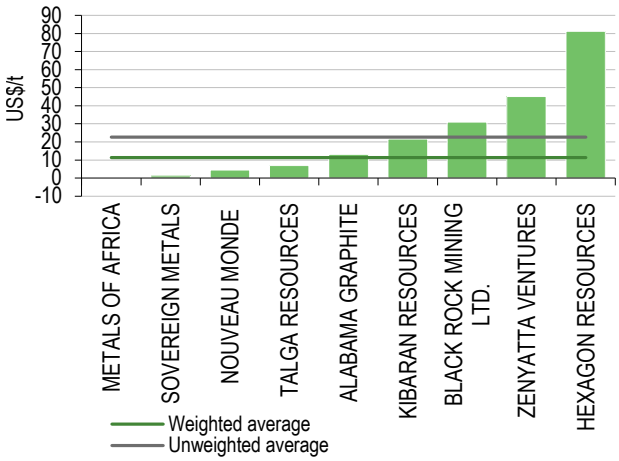
Within the context of the differentiated analysis, there is only one statistical outlier in the sample of companies with inferred resources only (Volt Resources).

Exhibit 64: Implied in-situ value of Inferred graphite resources (US$/t)



Source: Edison Investment Research

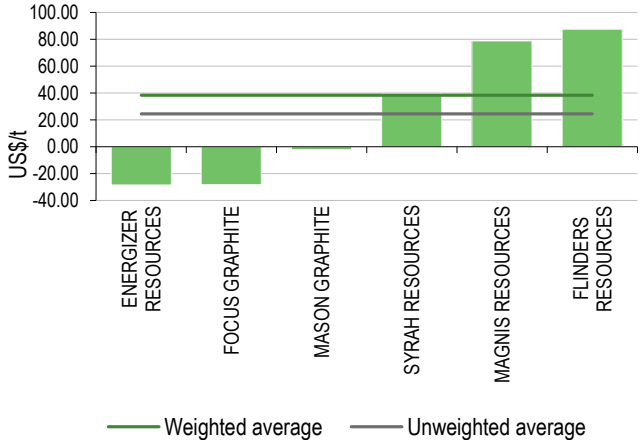
Exhibit 65: Implied in-situ value of Indicated graphite resources (US$/t)



Source: Edison Investment Research

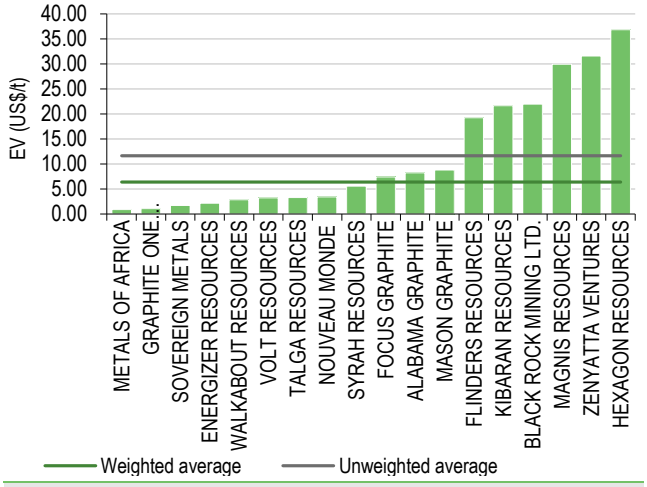
For companies with indicated and inferred resources only, there are two outliers (Zenyatta Ventures and Hexagon Resources); for companies with all three categories of resources, there are three outliers (Flinders [re-named Leading Edge Materials], Focus Graphite and Energiser Resources):

Exhibit 66: Implied in-situ value of measured graphite resources (US$/t)



Source: Edison Investment Research. Note: Leading Edge Materials formed in August 2016 via the merger of Tasman Metals Ltd with Flinders Resources Ltd.

Exhibit 67: Implied in-situ value of graphite resources (US$ per total tonne)

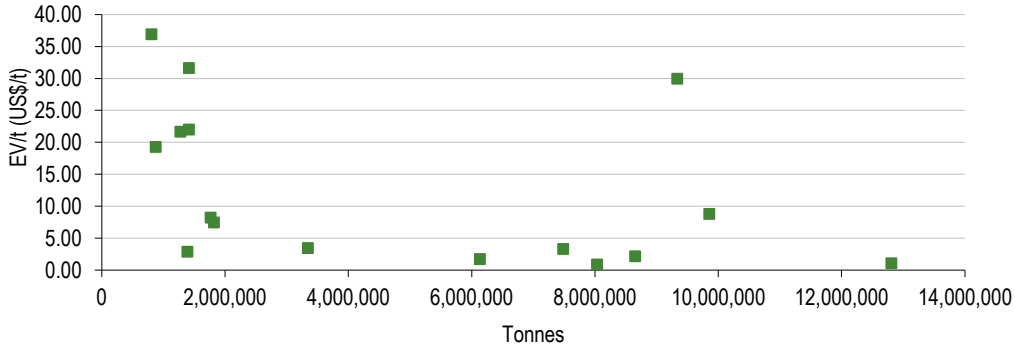


Source: Edison Investment Research. Note: Leading Edge Materials formed in August 2016 via the merger of Tasman Metals Ltd with Flinders Resources Ltd

In the context of the undifferentiated analysis, there appear to be two distinct groups within the population: a highly rated group (Flinders/Leading Edge Materials and above, which have a [simple] average resource multiple of US$26.88/t and are more than one standard deviation above the weighted average) and a lowly rated group (everything else, which have a [simple] average of US$4.04/t).

There is (statistically significant) evidence of the discounting of future resource discoveries by the market, although there also appear to be notable exceptions (eg Magnis Resources, which has a large fraction of jumbo flake graphite in its resource, of a type used in new-age battery manufacture, thereby attracting a relative valuation premium):

Exhibit 68: Graph of resource size (t) vs resource multiple (US$/t) for graphite explorers



Source: Edison Investment Research. Note: Excludes Syrah Resource merely on issues of scale.

Tungsten

As with a number of other metals, the sample of dedicated tungsten explorers is small.

Exhibit 69: Global average in-situ value of explorers' vanadium resources (US$/t)

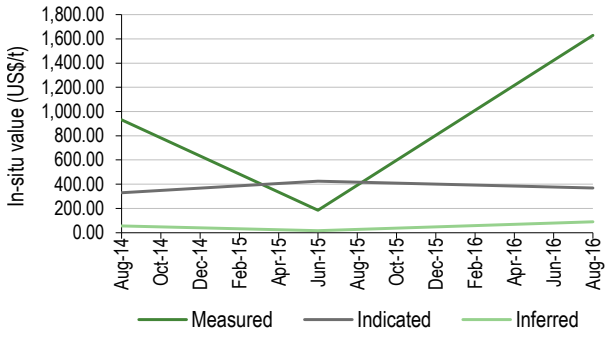
	August 2016				June 2015				August 2014			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ tungsten value	1,627.68	368.47	89.59	189.60	186.10	424.03	15.15	135.17	931.24	329.59	54.76	244.84

Source: Edison Investment Research, Thomson Reuters Datastream

Nevertheless, the major features of the analysis are:

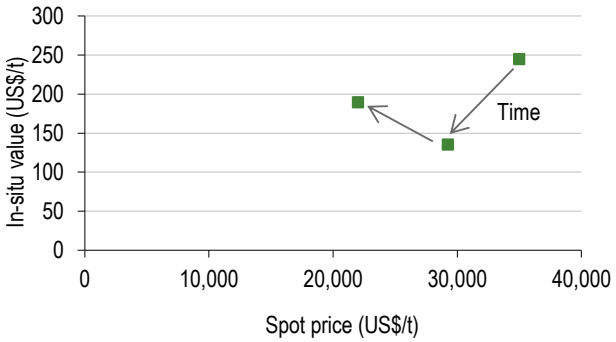
- A regularisation of the implied value of measured resources relative to indicated ones; and
- A recovery in the in-situ value of an average resource tonne in both absolute terms and relative to the price of ammonium paratungstate (APT).

Exhibit 70: In-situ value of tungsten resources differentiated by category, 2014-16



Source: Edison Investment Research

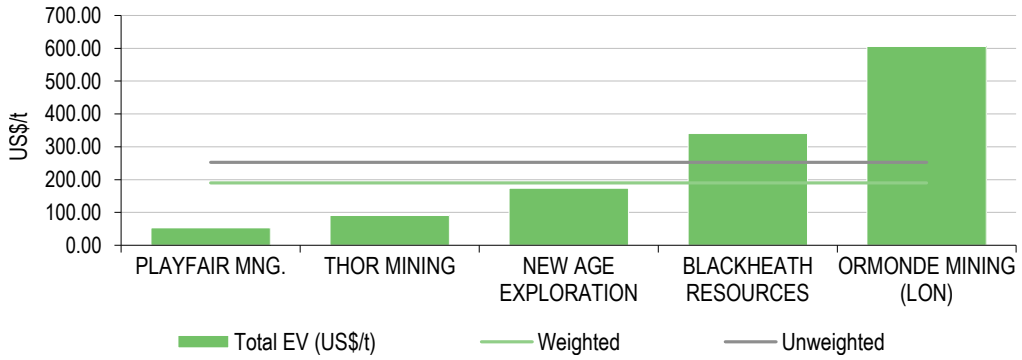
Exhibit 71: In-situ value of tungsten resources vs spot price of APT, 2014-16



Source: Edison Investment Research

Despite the small sample size however, the range of potential values for both inferred and indicated resource tonnes was small. In addition, the analysis of the sub-sector by total resource yielded a reasonably closely grouped series of results, with only one statistical outlier (Ormonde):

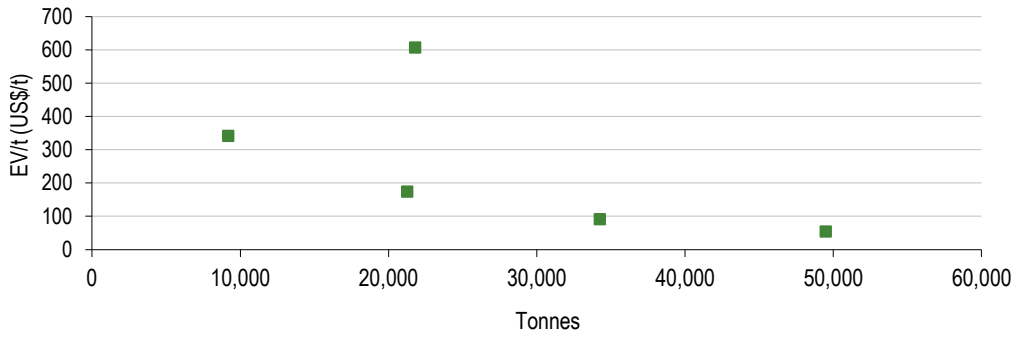
Exhibit 72: Implied in-situ value of tungsten resources (US$ per total tonne)



Source: Edison Investment Research

As with metallurgical coal (see below), there is anecdotal evidence of the discounting of future resource discoveries by investors although, in statistical terms and given the small sample size, the empirical data is weak (ie not statistically significant).

Exhibit 73: Graph of resource size (t) vs resource multiple (US$/t) for tungsten explorers



Source: Edison Investment Research

Vanadium

Of all of the metals and minerals analysed by Edison, the most crushing decline in in-situ values has been experienced in the vanadium sector.

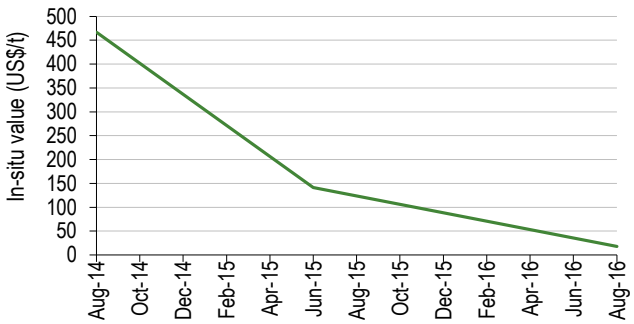
Exhibit 74: Global average in-situ value of explorers' vanadium resources (US$/t)

	August 2016				June 2015				August 2014			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ vanadium value (US$/t)	135.15	-6.73	9.64	18.01	1,103.03	30.57	6.64	141.40	1,677.73	71.97	33.03	466.64

Source: Edison Investment Research, Thomson Reuters Datastream

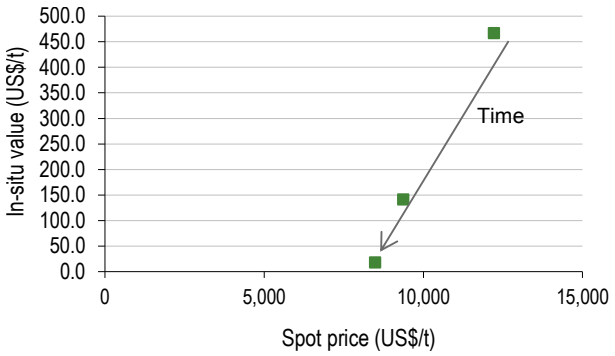
This de-rating has occurred over time and within the context of a falling vanadium price.

Exhibit 75: In-situ value of vanadium resources, 2014-16



Source: Edison Investment Research

Exhibit 76: In-situ value of vanadium resources vs spot price of vanadium, 2014-16



Source: Edison Investment Research

Over the period, the average value of in-situ resources has declined by 96.1%, while the vanadium price has fallen by 30.5%. Although such falls in in-situ resources relative to metal prices are consistent with other sub-sectors of the resources market (eg gold, see Gold: The value of gold and other metals, published in February 2015), in this case, part of the reason for the de-rating has been the re-focusing of erstwhile vanadium explorers (in particular, the relatively highly rated Syrah and Energizer Resources) away from vanadium to other metals and minerals (eg graphite), with the result that they have now been excluded from the sample of companies being analysed. At the same time, new entrants to the market, which are now therefore included in the sample, appear to have been afforded markedly lower ratings than their predecessors.

As a result, while measured resources have maintained their premium, the market now appears to distinguish little between inferred and indicated resources, which have a blended average value of US$5.48/t.

There also appears to be little or no evidence of the market discounting future resource discoveries.

Metallurgical coal

The main feature of Edison's analysis of the value of metallurgical coal resources is the de-rating of those resources, both in nominal terms and as a percentage of the spot price of metallurgical coal.

Exhibit 77: Global average in-situ value of explorers' metallurgical coal resources (US$/t)

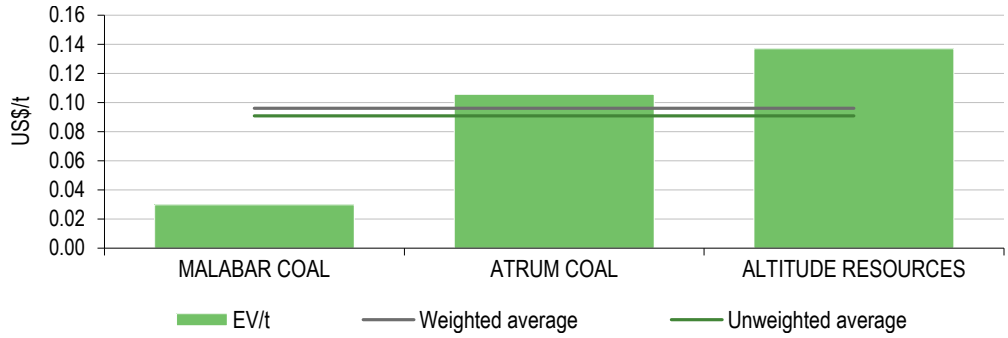
	August 2016				June 2015				August 2014			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ metallurgical coal value (US$/t)	5.87	0.04	0.02	0.10	(3.01)	0.71	0.27	0.16	(5.64)	(0.14)	0.42	0.14

Source: Edison Investment Research, Thomson Reuters Datastream

The analysis is complicated by the fact that a) the sample is small and b) there are no companies or projects that have inferred resources only (which account for 60% of all resources in the sample). As a result, we applied a value to inferred resources that was half way between zero and the blended average multiple for companies with indicated and inferred resources only. In addition, while they appear to have regularised in value with respect to other resources, measured resources account for only 1.2% of total resources, with the result that (almost) all under-value or over-value in the sector is concentrated into this category and hence their value is inclined to whipsaw in both absolute and percentage terms.

In fact, the market almost certainly conceives of metallurgical coal deposits in terms of total, rather than differentiated resources:

Exhibit 78: Implied in-situ value of metallurgical coal resources (US$ per total tonne)

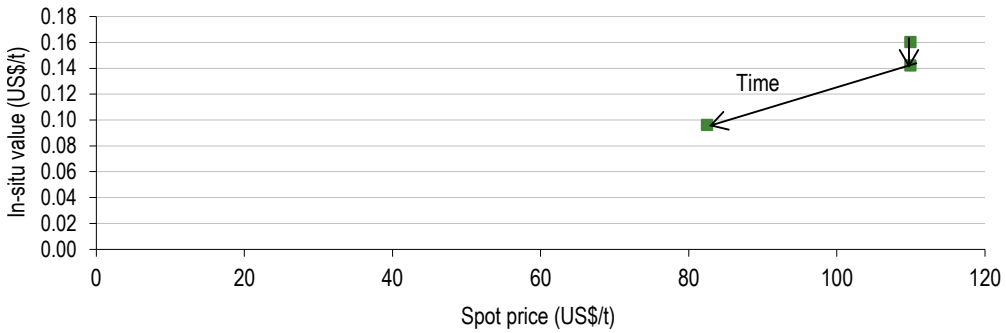


Source: Edison Investment Research.

Within this context, it is notable that the blended average value of indicated and inferred resources is 2.98 cents per tonne.

Note that this analysis was performed before the recent, extraordinary jump in the price of metallurgical coal in September 2016 (shown in Exhibit 15 on page 11) as a result of China's reforms to domestic industry. As a result, its de-rating should be seen within the context of a bear market for metallurgical coal:

Exhibit 79: In-situ value of metallurgical coal resources vs spot price, 2014-16



Source: Edison Investment Research

There is possible, but only weak (ie not statistically significant) evidence for the discounting of future resource discoveries by the market.

Thermal coal

Thermal coal resources have never yielded themselves to a differentiated analysis and have never been presented in this way. In keeping with recent experience therefore, results here are presented solely in terms of companies' total resource bases:

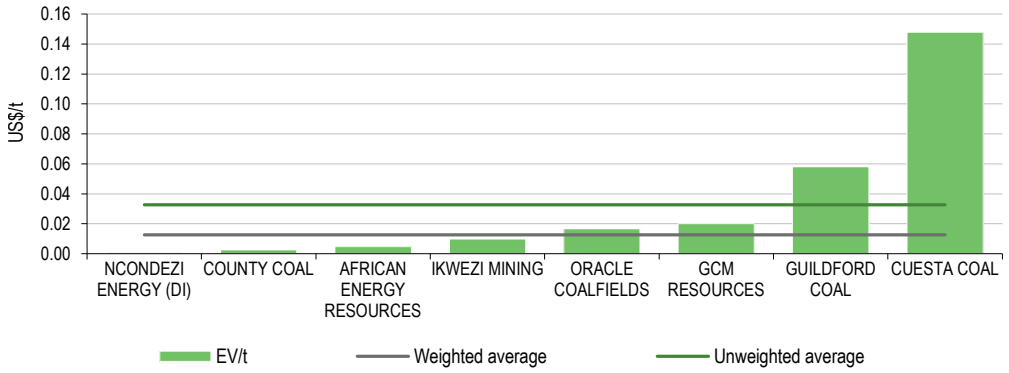
Exhibit 80: Global average in-situ value of explorers' thermal coal resources (US$/t)

	August 2016	June 2015	August 2014
In-situ thermal coal value (US$/t)	0.013	0.020	0.007

Source: Edison Investment Research, Thomson Reuters Datastream

The range of values for thermal coal resources is 14.7c per tonne, or 3.1 standard deviations from the weighted average:

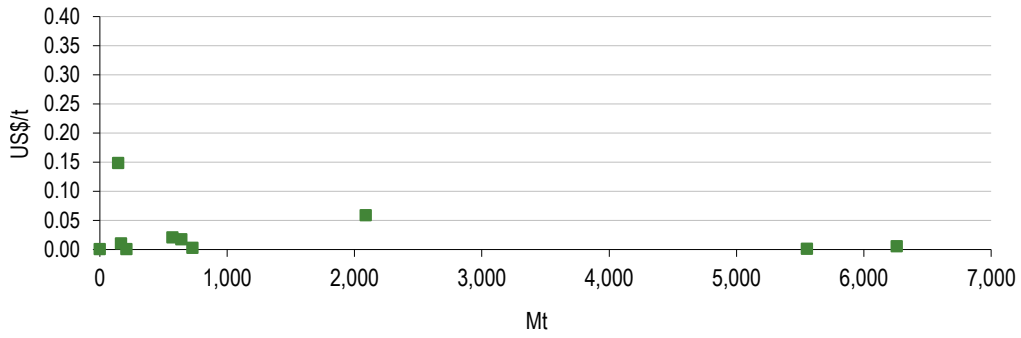
Exhibit 81: Implied in-situ value of thermal coal resources (US$ per total tonne)



Source: Edison Investment Research. Note: Guildford Coal renamed TerraCom.

Finally, there is weak (ie just statistically significant) evidence for the discounting of future resource discoveries by the market:

Exhibit 82: Graph of resource size (t) vs resource multiple (US$/t) for thermal coal explorers



Source: Edison Investment Research

Bauxite

As with thermal coal, bauxite resources do not yield themselves readily to a differentiated analysis.

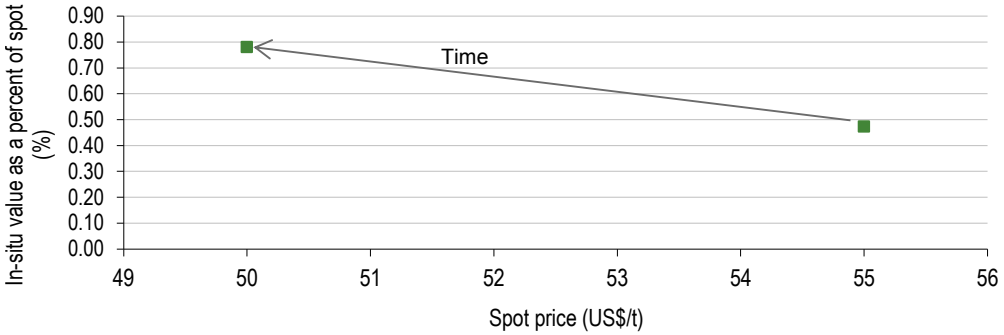
Exhibit 83: Global average in-situ value of explorers' bauxite resources (US$/t)

	August 2016	June 2015
In-situ bauxite value (US$/t)	0.39	0.26

Source: Edison Investment Research, Thomson Reuters Datastream

Of note however is the increase in the value of in-situ bauxite resources at a time when the bauxite price has simultaneously declined, leading to bauxite's in-situ value as a percentage of the spot price of bauxite rising to 0.77% (cf 0.05% for iron ore, 0.02% for thermal coal, 0.05% for metallurgical coal and 0.01-0.45% for potash, depending on the nature of the deposit):

Exhibit 84: In-situ value of bauxite resources vs spot price, 2015-16



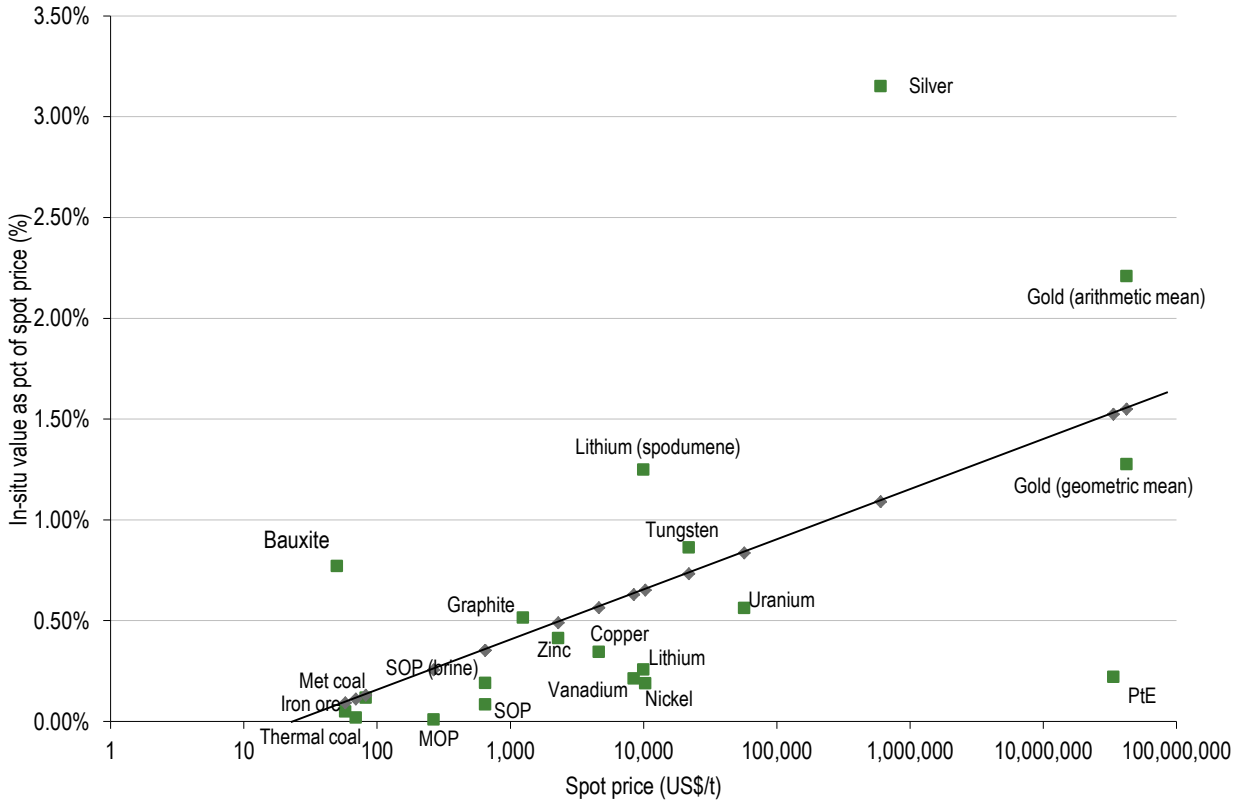
Source: Edison Investment Research

By contrast however, there is absolutely no evidence of the discounting of future resource discoveries by investors.

Undifferentiated analysis

In addition to its differentiated analysis, Edison has also performed undifferentiated analyses on 19 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$16.84/oz (geometric average), which equated to 1.28% 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 1.28% of the value of a refined ounce. The chart below shows this analysis performed for the other 18 metals and minerals covered in this report as well. Note that all metal prices have been converted into US dollars per tonne in order that they may be shown on the same scale (for example, gold at the time was US$1,320/oz, or US$42,439,320/t). As such, the x-axis scale – being the spot price of the metal or mineral in question – may be considered a proxy for economic scarcity relative to utilisation.

Exhibit 85: In-situ resource values vs spot prices, selected metals and minerals



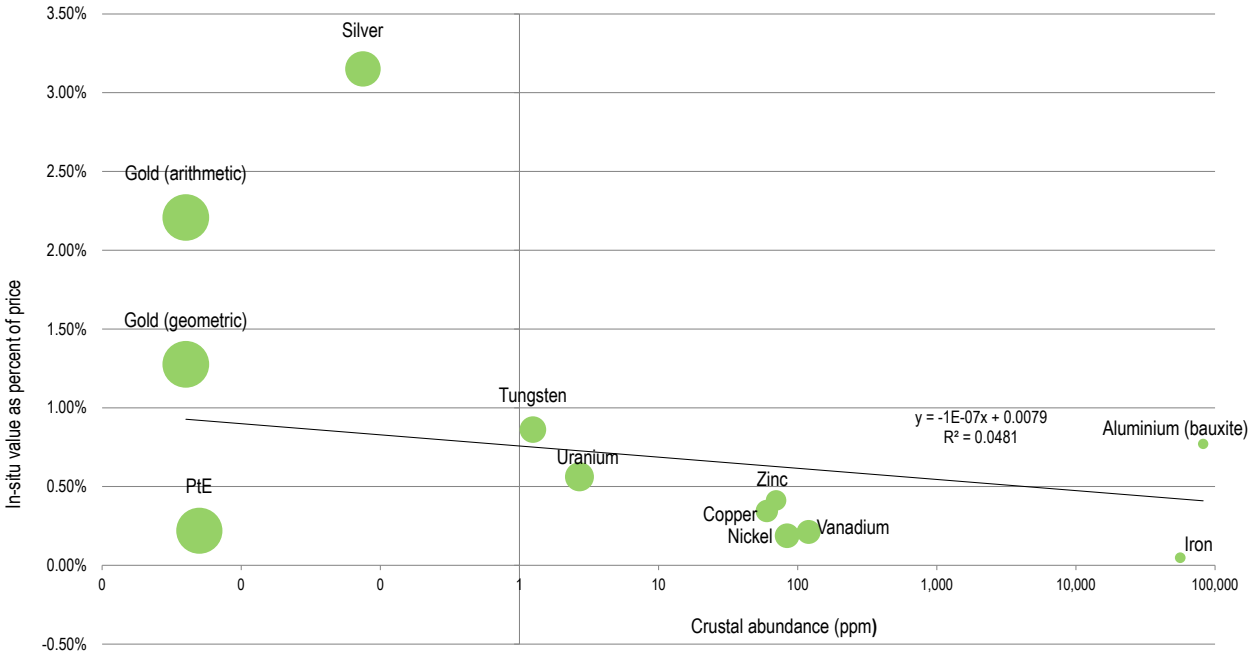
Source: Edison Investment Research

A number of features of the analysis are immediately apparent:

- Within the sample, there is a statistically significant correlation between spot prices and in-situ values.
- In-situ values for the majority of metals and minerals are 'below trend', given their spot prices.
- Excluding the arithmetic mean of gold, five metals and minerals have in-situ values 'above trend' given their spot prices; of these four might be regarded as relatively 'new' in terms of their existence on publicly traded stock markets. The exception appears to be silver.
- Companies with deposits of metals or minerals with a spot price of US$18.82/t or less should not expect to be afforded any in-situ value for their resources.

The same data may be represented, explicitly relating in-situ values to crustal abundance (subject to availability), as follows:

Exhibit 86: In-situ resource values vs crustal abundance, selected metals and minerals

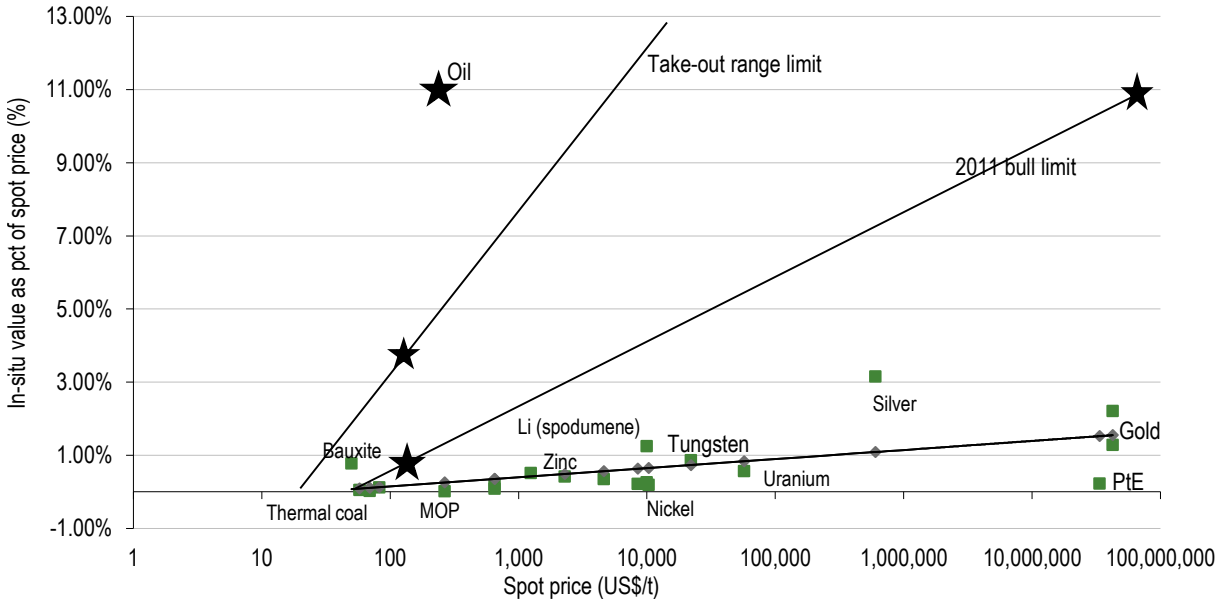


Source: Edison Investment Research. Note: Bubble size represents Log (Price US$/t).

Note that the depressed position of the point relating to platinum (PtE) may be explained by its bimodal distribution in the earth's crust (ie its being found specifically in the Bushveld complex in South Africa and Norilsk in Russia), compared to gold and silver, which might be considered to be 'universally rare'.

Even so, in-situ values remain a long way from those that were typical during the bull market in 2011-12 and also those at which premium acquisitions occurred, when transactions as high as 35% of the spot price of gold and 3.9% of the spot price of iron ore were recorded (see Gold: The value of gold and other metals, published in February 2015):

Exhibit 87: In-situ resource values vs spot prices, within historical range, selected metals and minerals



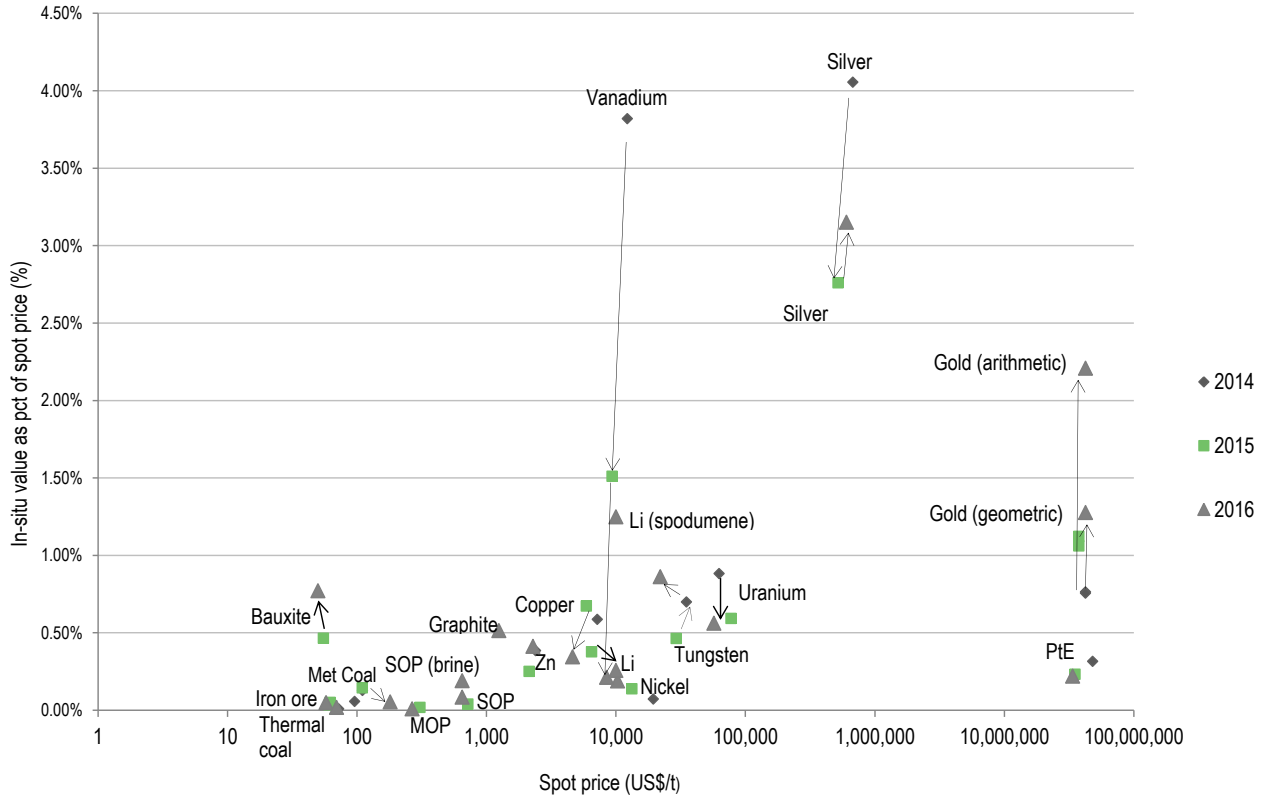
Source: Edison Investment Research

Aside from the lower limit line of best-fit, two additional lines are shown. These are identical to those depicted in Exhibit 7 of our last report on the subject, Gold: The value of gold and other metals, published in February 2015, and represent the estimated position of the line of best-fit at the top of the bull market in 2011 and the upper limit of the range of in-situ values achieved in corporate transactions during the recent cycle – represented by the acquisition of African Iron by Exxaro in January 2012 at a price equivalent to a resource multiple of US$5.70/t Fe (3.9% of the spot price of iron ore) and Newmont's acquisition of Fronteer at an in-situ resource multiple of US$475/oz Au, or 32-35% of the spot price of gold (excluding the Pilot Gold spin-out), in February 2011. Note that not all points on the chart have been labelled owing to space constraints; however, they are no more and no less than those that are depicted in Exhibit 85.

For reference, a point has been added to the graph to show the 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 and their relatively lower unit costs of development.

Of the 17 distinct metals and minerals profiled, 11 have experienced bear market conditions since Edison's last note on the subject (Gold: The value of gold and other metals, published in February 2015). Nevertheless, at least six have increased their in-situ valuations as a percentage of the spot price over the period:

Exhibit 88: In-situ resource values vs spot prices, selected metals and minerals, 2014-16



Source: Edison Investment Research

Several aspects of the graph are noteworthy:

- The increases in in-situ value as a percentage of the spot price for gold, sulphate of potash (despite a bear market), nickel (from a very low relative position, but despite another relatively severe bear market), tungsten and bauxite.
- The recovery in the in-situ value of silver as a percentage of the spot price – in conjunction with a bull market in 2015-16, but from a relatively high position within the sample.
- Declines in the in-situ value as a percentage of the spot price of uranium, iron ore, PGMs, copper, metallurgical coal and thermal coal.
- The extreme decline in the in-situ value of vanadium relative to its spot price, from a very high position within the sample to a relatively low one.

A summary of the various characteristic of each metal and mineral profiled by Edison is as follows:

Exhibit 89: In-situ resource valuation characteristics, by metal/mineral

	Gold	Uranium	Silver	Iron ore	PGMs	Nickel	SOP	MOP	SOP (brine)	Copper	Zinc	Lithium	Graphite	Tungsten	Vanadium	Met coal	Thermal coal	Bauxite
Market conditions	Bull	Bear	Bull	Bear	Bear	Bear	Bear	Bear	Bear	Bear	Mixed	Bull	Neutral	Bear	Bear	Bear	Mixed	Bear
Amenable to differentiated resource valuation	✓					✓							✓	✓				
Amenable to valuation with respect to total resource		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	
Measured resource discount											✓							
Indicated resource premium			✓	✓	✓		✓	✓	✓									
Indicated resource discount		✓								✓		✓			✓			
Evidence of discounting for size		✓		Weak		Weak	Weak	✓		✓		Weak	✓			Weak	Weak	
No evidence of size discounting	✓				✓		✓				✓				✓			✓
Small sample size					✓		✓		✓		✓			✓	✓	✓		✓

Source: Edison Investment Research

In summary:

- Metals amenable to a differentiated resource analysis tend to be rare (eg gold) or unusual in terms of the market's knowledge of those metals and minerals (eg tungsten, graphite and lithium).
- Metals and minerals that demonstrate evidence of the discounting of future discoveries tend to be of a 'bulk' nature (eg iron ore, thermal coal, metallurgical coal, muriate of potash, etc). The one exception to this appears to be uranium, which has now demonstrated this characteristic fairly consistently over two years (2015-16).
- Metals and minerals that demonstrate a premium valuation for indicated resources also tend to be of a 'bulk' nature (eg iron ore and potash). The two exceptions to this appear to be PGMs (perhaps on account of their unique Bushveld geology, which could be interpreted as imbuing them with 'bulk' characteristics) and silver.

NonSuch Gold

The physical limitations created by financial boundaries

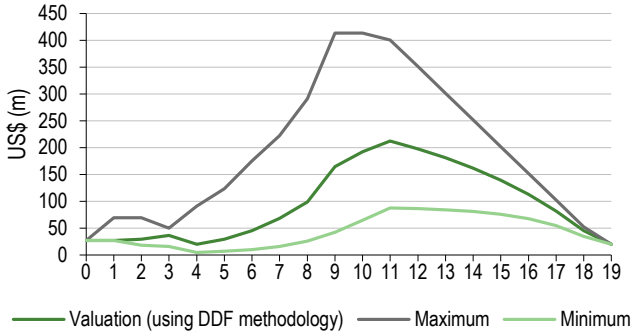
In the report Gold – New benchmarks for old, published in November 2012, we created a notional mining company, which we then valued at every year of its existence, from initial funding to the end of the life of its operations. The characteristics of this company were designed to approximate those to which many junior gold mining companies aspire, namely:

- The delineation of a 1.316Moz resource, 76% of which (being the measured and indicated portion of the resources) was then converted into reserves and mined at a rate of 100koz per year for 10 years. The company was deemed to be listed in London and it was financed in 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).
- After raising its initial finance, NonSuch Gold then delineated an inferred resource in year 1, an indicated and inferred resource in year 2 (in the ratio 45:55 indicated: inferred) and a measured, indicated and inferred resource in year 3 (in the ratio 21:55:24 measured:indicated:inferred). It then raised additional equity funds in year 4 in order to commission a scoping study, a pre-feasibility study and a bankable feasibility study in years 4, 5 and 6, respectively. In year 7 it completed a final round of equity, in addition to debt funding, such that its leverage (debt/(debt+equity)) peaked at 50%, and embarked on the first of three years of capital expenditure. Production ramp-up began in year 8 and full production was achieved in year 9. Full production was maintained from years 9 to 18 inclusive (ie 10 years). Working capital was then released in year 19 when the company reverted to being an exploration entity with cash and an inferred resource.
- In years 0 to 3, the company was 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 13 on page 10. 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 the 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 in Edison's report Gold – Valuation benchmarks are obsolete, published in January 2010, namely US$7.16 per inferred ounce, US$10.50 per indicated ounce and US$36.82 per measured ounce.
- Of the company's 1.316Moz 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 pre-feasibility study costs, and pre-feasibility study costs towards bankable feasibility study 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 a gold price of US$1,350/oz and total cash costs of US$625/oz.
- Profits are taxed at 28% (after depreciation); there is no write-off for past exploration expenses.

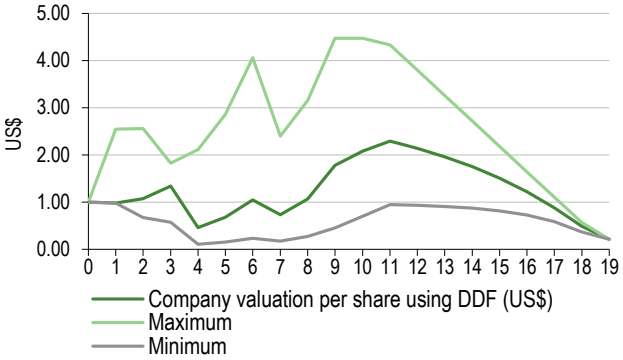
On the basis of the assumptions set out above, the undiscounted value of the dividends paid out to shareholders is US$410.9m, comprising cash flow from operations (US$459.9m), minus total life-of-mine capex (US$121.4m), plus total equity funding (US$89.5m) minus terminal cash balances (US$17.2m). Graphs of the resultant value of NonSuch Gold and its share price, as calculated by Edison, are provided below. Note that full financials for the company are provided on page 42 of Gold – US$2070 by 2020, published in November 2013.

Exhibit 90: NonSuch Gold value by year, US$m



Source: Edison Investment Research

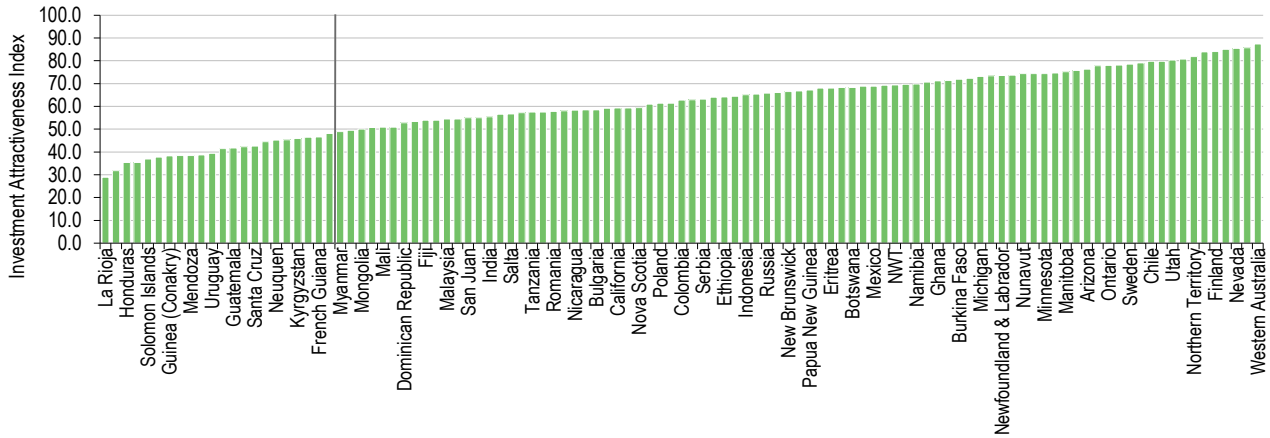
Exhibit 91: NonSuch Gold share price by year, US$



Source: Edison Investment Research

However, the company must negotiate a critical funding point in year 7. If the project is not deemed sufficiently viable to generate a positive return on invested funds, it will not be financed. This occurs when a 40.7% discount rate is applied to future dividends, within a range from 8.0% to 62.0% (see Gold – US$2070 by 2020, published in November 2013). If political risk is then deemed to be measured by the Fraser Institute's Investment Attractiveness Index and the lowest-risk mining investment destination (Western Australia in 2015, with a score of 87.4) is assumed to correspond to a discount rate of 8.0% and the highest risk mining investment destination (La Rioja in 2015, with a score of 28.9) is assumed to correspond to a discount rate of 62.0%, then a discount rate of 40.7%, as applied to potential future dividends, occurs at a Fraser index score of 48.7 – between Myanmar and New Caledonia:

Exhibit 92: Fraser Institute Investment Attractiveness Index, 2015 survey

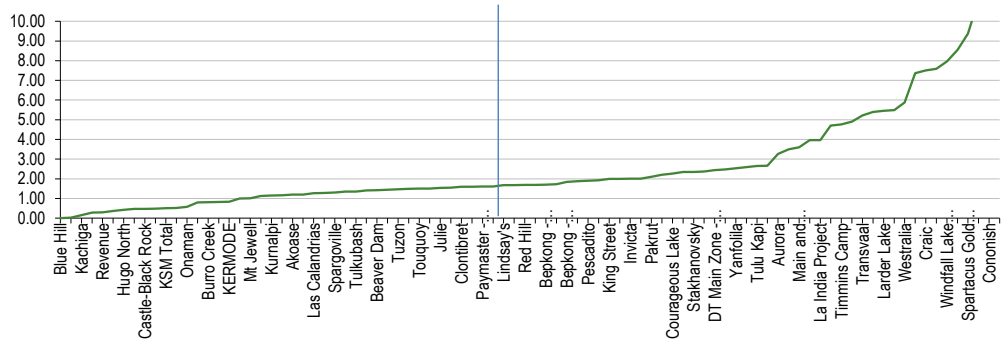


Source: Fraser Institute, Edison Investment Research

If one considers a mining project or company to attract five principal risks – namely sovereign, geological, engineering, metallurgical and management – then, all other things being equal, an 'average' gold mining project (ie one with average geological, engineering, metallurgical and management risk) will struggle to attract finance in jurisdictions with a lower Investment Attractiveness rating than Myanmar.

A similar process may be undertaken for any of the other four main risks in the event that a suitable, quantitative measure of each can be identified. For example, grade could be used as a measure of geological risk. This is not a perfect measure and, in reality, other factors such as continuity, orientation and profile also need to be considered. Nevertheless, the results of such a process are instructive. Once again, taking the sample of projects considered in Edison's in-situ analysis elsewhere in this report, if the lowest grade project is assumed to correspond to the highest geological risk and the highest grade project is assumed to correspond to the lowest geological risk, then a risk-adjusted discount rate of 40.7% is obtained for a project with a grade of 1.66g/t, within the range shown below:

Exhibit 93: Global gold projects, by grade (g/t)



Source: Edison Investment Research

Hence, a gold company with a project that is in all other respects 'average' (ie average engineering, metallurgical, management and sovereign risk – which, using the Fraser Institute survey, corresponds approximately to the DRC, Poland, Colombia, Brazil and Madagascar with Investment Attractiveness ratings between 59.4 and 62.9) is likely to find that project similarly difficult to finance unless it has a grade of at least 1.66g/t.

Gold price

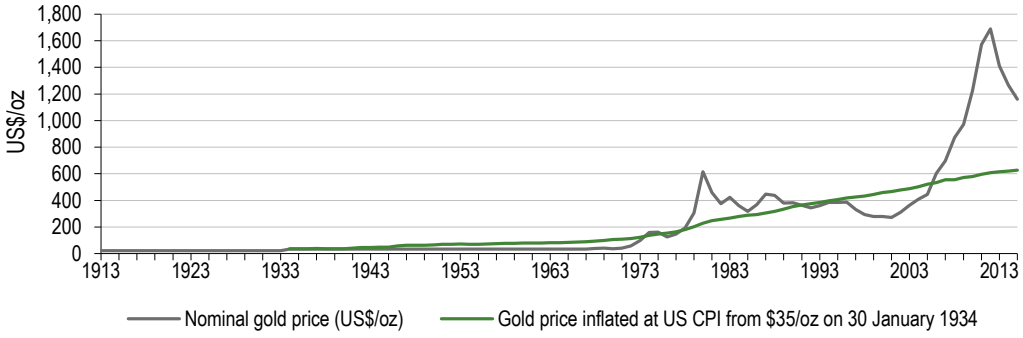
Edison's long-term gold price forecasts remain based on its historic relationships to both inflation and the US monetary base.

Gold price relationship with US dollar inflation

Since 1945, gold can be seen to have undergone at least two completed bull and two completed 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).
- A bear market from 2012 to the present characterised by the expectation of a resumption of positive real interest rates.

Exhibit 94: Nominal gold price (1913-2015) 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 to 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, among other things, 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. As a result, 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.

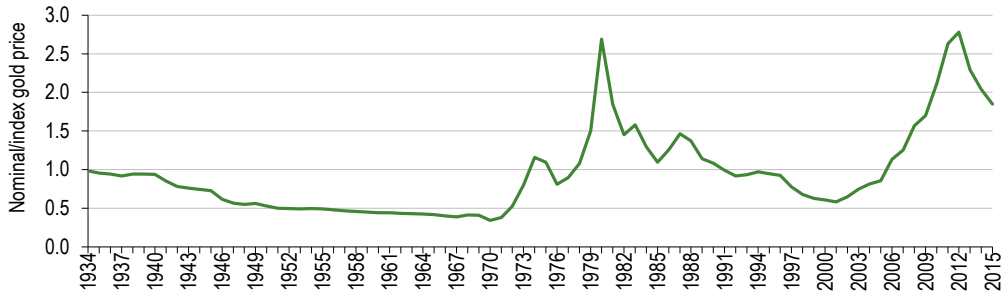
As positive real interest rates reasserted themselves in 1980, so currency markets stabilised and gold returned to a bear market phase (analogous to the period of 1945-68), which lasted until 2001. Hence, whereas the German mark appreciated by 66% against the US dollar during the 1970s, in 1999 the DEM/US$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

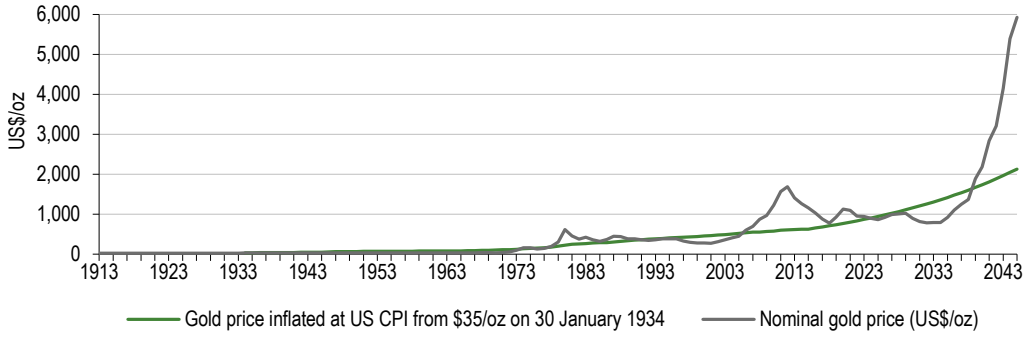
Exhibit 95: Nominal gold price divided by index gold price, 1934-2015



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 2015 and then applying the same cyclical discount or premium depicted above generates the following future gold price profile:

Exhibit 96: Gold price, historic and forecast with respect to 1934 price (indexed), 1913-2045



Source: Edison Investment Research and (historic) South African Chamber of Mines, US Department of Labor.

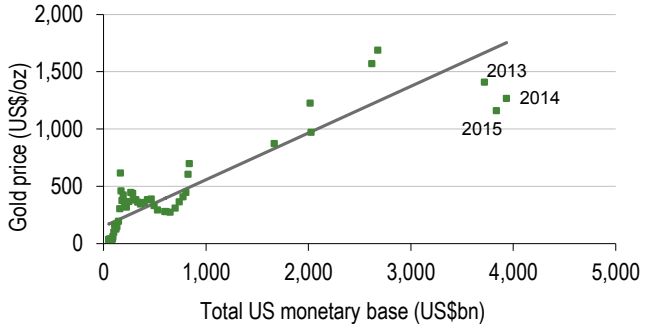
Note: Prices are annual averages

That is to say, on this basis, gold will trade between US$778/oz and US$1,126/oz before starting another bull run in 2035. Note that, according to this analysis, 2016 in the new cycle equates to 1983 in the last one.

Gold price relationship with US total monetary base

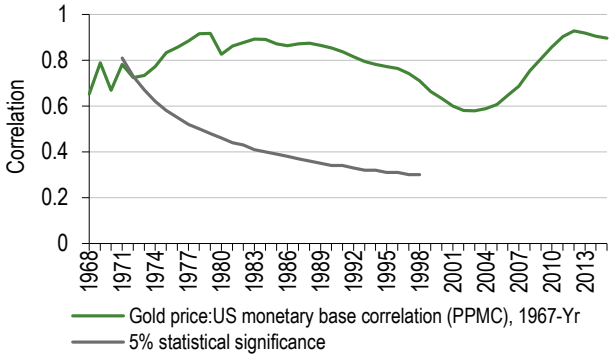
In addition to its relationship with inflation however, gold also exhibits a very close, statistically significant relationship with the US total monetary base. At the present time, the relationship between the two elicits a Pearson product-moment coefficient (PPMC) of 0.896 (vs 0.904 at the time of Edison's last note, Gold: The value of gold and other metals, published in February 2015), 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 97: Gold price vs US total monetary base, regression analysis, 1959-2015



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

Exhibit 98: Gold price and US total monetary base correlation, 1968-2015

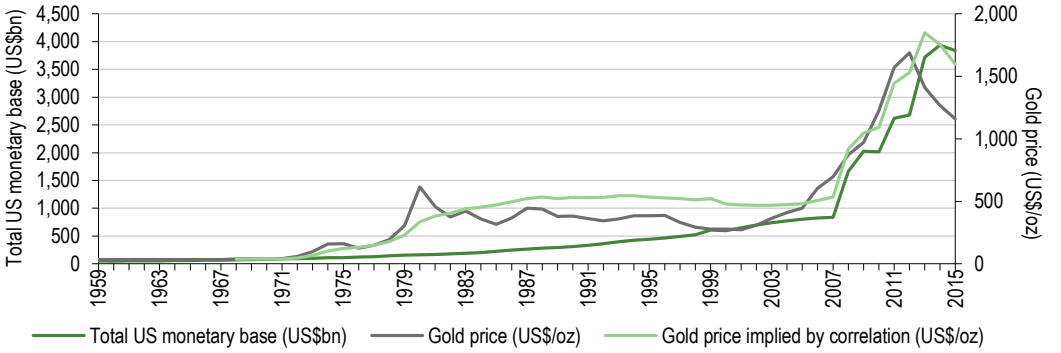


Source: Edison Investment Research and (underlying data) Federal Reserve, dollardaze.org

Since 2007, the US Federal Reserve has increased the US total monetary base by 4.6 times or US$3.0tn to US$3.8tn, although note that there was actually a (albeit slight) decline in the US total monetary base between 2014 and 2015. It also compares to losses in the US economy at the height of the economic crisis of around US$9.0tn. However, US$4.8tn of the US$9.0tn 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 been largely recouped, at least in nominal terms. That being the case, the Federal Reserve has in fact 'printed' US$3.0tn in new money in order to cover a nationwide loss of c US$4.2tn in home equity – ie it has covered at least 71% of the loss (excluding subsequent recoveries in house prices).

Exhibit 99 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 its relationship with the US total monetary base as it would have been perceived at the time:

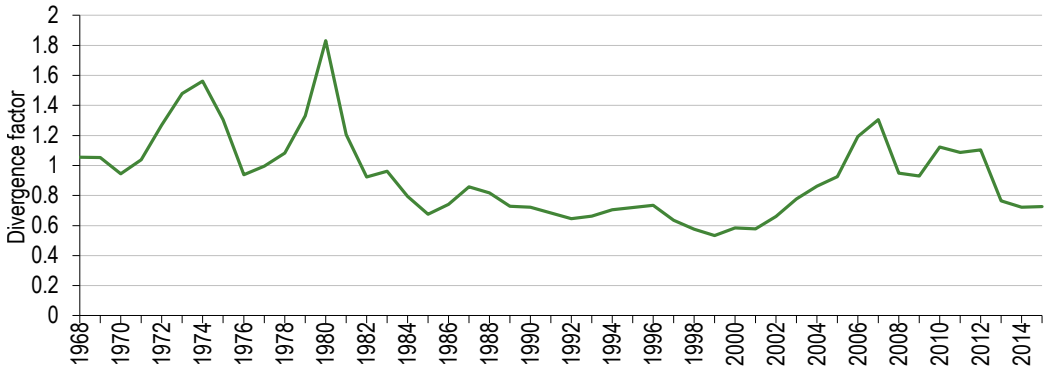
Exhibit 99: Gold price, US total monetary base and predicted gold price, 1959-2015



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

In 2015 therefore, the discount of the actual price of gold compared to the predicted one was 27.3%, which represented a small decline compared to the 27.8% discount recorded in 2014. Note that, statistically, the error of estimation of the regression analysis is ±US$180/oz. Exhibit 100 graphs the variation of the actual gold price from the predicted one since 1968.

Exhibit 100: Variation of actual gold price from predicted, 1968-2015



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

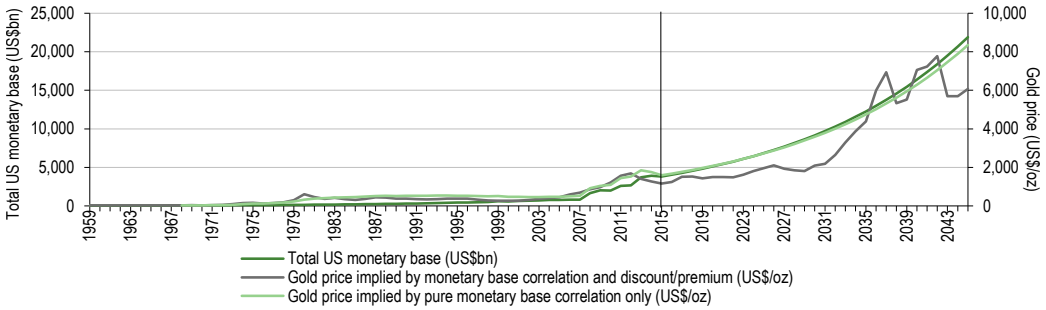
On this basis, the gold price can be said to have reverted rapidly from the premiums that were typical in bull market conditions (in 2012) to those that are typical in bear market conditions (2013-15). Once again, this is akin to the period 1983-85, after which there was a two-year period of respite, when the discount narrowed again in 1986 and 1987.

On the basis of the historic correlation between the two:

- The current gold price (US$1,320/oz at the time of writing) discounts a US total monetary base of US$3.1tn (cf US$2.7tn when QE3 was announced).
- The end-2015 total monetary base implies a gold price of US$1,597/oz.
- The forecast end-2016 total monetary base implies a gold price of US$1,682/oz.

If the historic cycle (1980-2007) is to be repeated again in 2012-39, with the peak in 2012 equating to the peak in 1980 and 2015 equating to 1985, then the gold price may be expected to evolve as shown in Exhibit 101, assuming the same discounts and premiums in future years as in the corresponding years of the past cycle (see Exhibit 100). Note, however, that the maximum premium in the most recent cycle occurred in 2007 (Exhibit 100) and not, as might be expected, in 2012.

Exhibit 101: Historic and forecast gold price (forecast made with respect to US total monetary base)



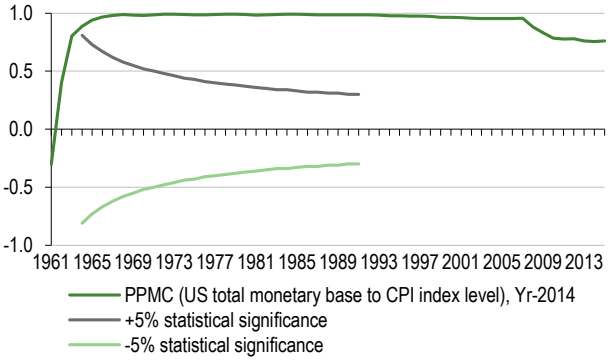
Source: Edison Investment Research and (underlying historic data) Federal Reserve, South African Chamber of Mines, dollardaze.org

From 2015 onwards, the US total monetary base is assumed to increase at its long-term historic (geometric) average rate of 6.0% per annum. On this basis, the gold price would average US$1,246/oz in 2016 (very close to its year-to-date average), before rising above US$1,500/oz in 2017. It would then trade within US$100/oz of US$1,500/oz until 2023, at which point it would begin a (fairly) steady rise to reach US$2,000/oz in 2026.

Reflecting a monetary paradox

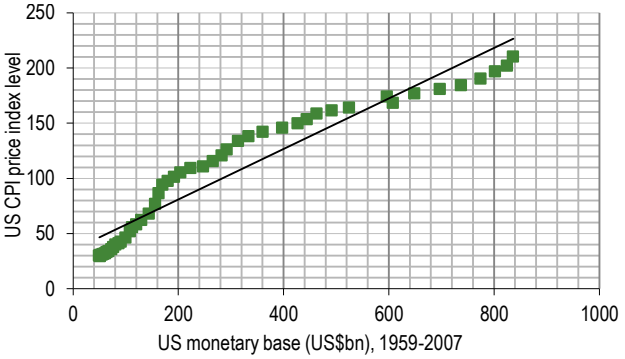
The gold price can be seen to be expensive with respect to indexed prices (or, stated alternatively, it has more than acquitted itself as a store of value and a hedge against inflation), but cheap relative to the monetary base. At first glance this appears to be a paradox, especially since the historic relationship between prices in general and the total US monetary base has been extremely close (eg a Pearson product-moment coefficient of 0.957 between 1959 and 2007:

Exhibit 102: Correlation (PPMC), total monetary base to price levels, 1961-2015



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

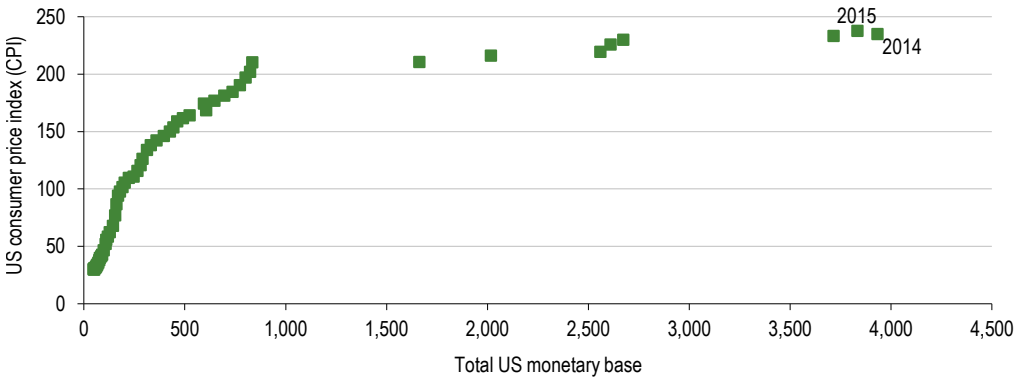
Exhibit 103: Scattergram, total monetary base vs price levels, 1959-2007



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% 6% and -3%, while (over the same timeframe) prices have increased by only 13.0% (or 1.5% per annum, on average):

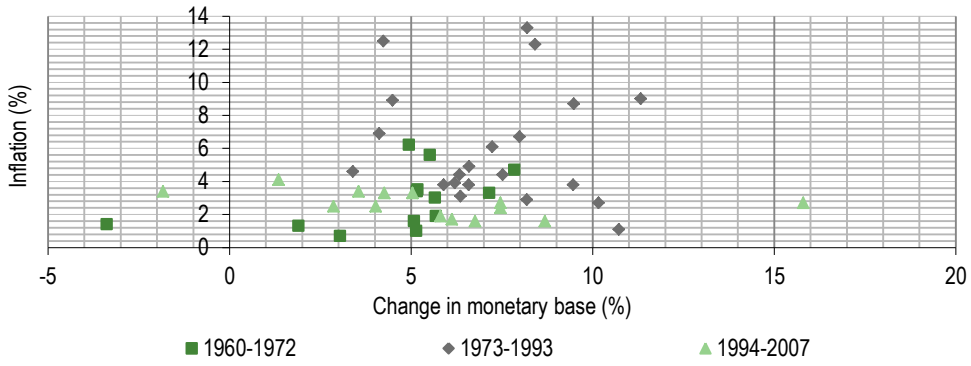
Exhibit 104: Scattergram, total monetary base vs price levels, 1959-2015



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 certainly was between 1973 and 1992. Moreover, as Exhibit 105 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 105: Scattergram, US CPI inflation vs change in total US monetary base, 1960-2007

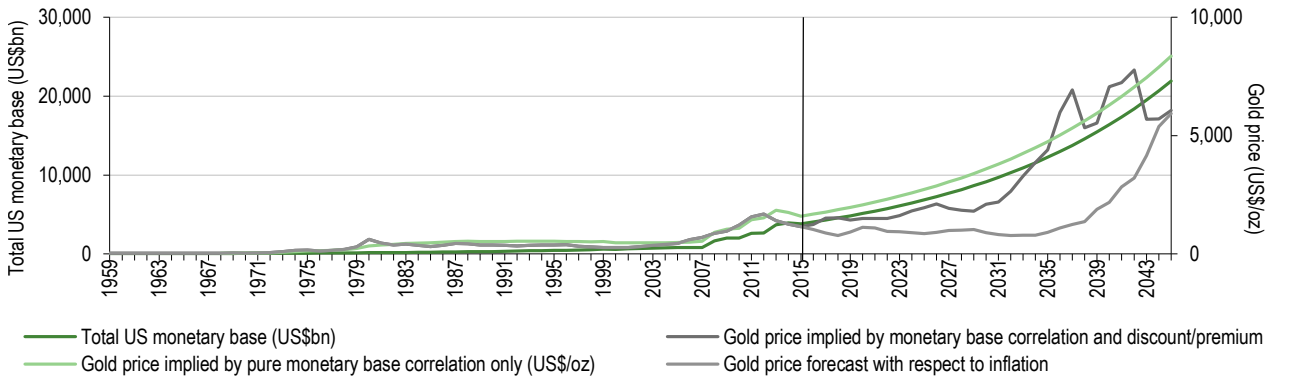


Source: Edison Investment Research, US Department of Labor, Federal Reserve, dollardaze.org

In fact, were the two to maintain the relationship that they had prior to the first tranche of quantitative easing, given the current total US monetary base, the CPI index should be 912.6, or 3.8x its current level.

Given the historic relationship between the two, the obvious conclusion is that price rises in the general economy have not kept pace with increases in the total monetary base. 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 – but not as much as the increase in narrow money. As a result, it is at a premium to its indexed level, but at a discount to the level implied by its correlation with the total US monetary base. This disparity is depicted in Exhibit 106 (effectively a combination of Exhibits 101 and 96):

Exhibit 106: Historic and forecast gold price (forecast made with respect to 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

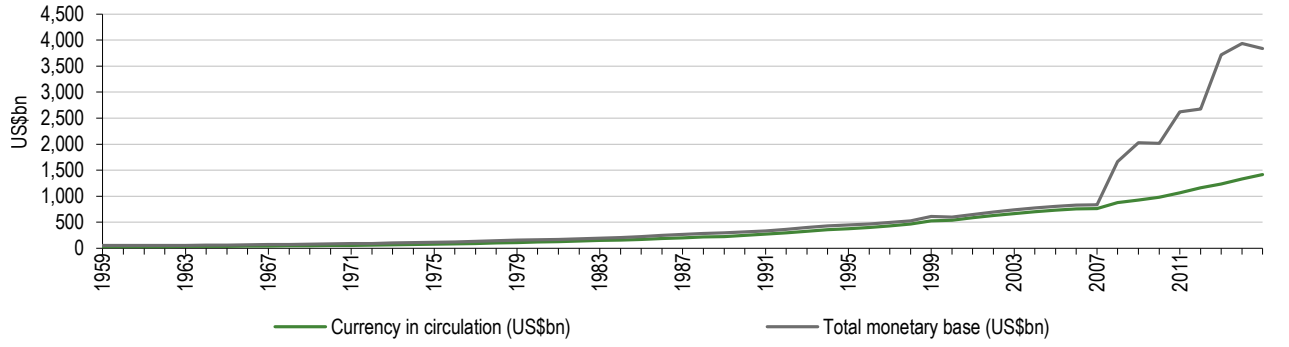
Currency in circulation vs total monetary base

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:

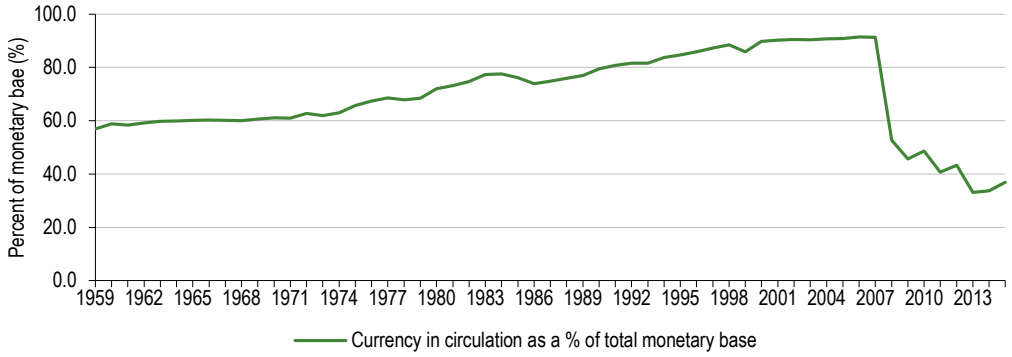
Exhibit 107: US currency in circulation vs total monetary base, 1959-2015



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 just 37% – above 2013's post-1959 low, of 33%, but still just half of the pre-2007 average.

Exhibit 108: Currency in circulation as a percentage of the US total monetary base, 1959-2015



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

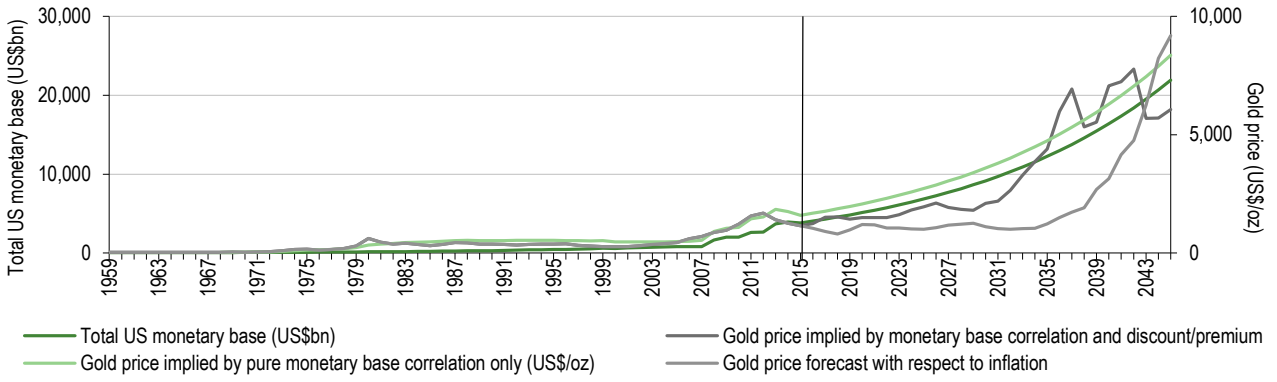
The correlation between the gold price and currency in circulation is not as strong as between the gold price and the total monetary base. In addition, the error of estimation is larger. Nevertheless, it is significant and, at the current time, US currency in circulation of US$1.4tn implies a gold price of US$1,379/oz (note that currency in circulation increased in 2015 in contrast to the total monetary base).

In future, on the assumption that it continues its 'upward-only' trajectory, currency in circulation would have to increase from US$1.3tn currently to at least between US$2.3tn and US$3.5tn in order to revert to its traditional range of 57-91% of the total monetary base. This being the case, the gold price could be expected to rise (on the basis of its historic correlation) to US$1,860-2,093/oz.

Gold price forecasts

Given the difference in timing that has developed between the two analyses presented above (ie 2016 is analogous to 1983 in the inflation model, but 1986 in the total monetary base model), rationalisation of the two outcomes presents difficulties. As a result, an iterative process has been adopted, such that the peak 2045 price predicted by the inflation model equals the peak 2042 price predicted by the total monetary base model indexed for inflation. Among other things, the result of this process implies a future long-term inflation rate in the US of 5.7%, which compares to a historic average of 4.2% between 1972 and 2015. The aligned analysis is presented in Exhibit 109, below:

Exhibit 109: Historic and forecast gold price (forecast made with respect to 1. US total monetary base and 2. enhanced inflation), 2016-2045e



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

Note that the lag between the inflation analysis and the monetary base analysis anecdotally supports the theory that there is a time-lagged effect between expansion in the monetary base and inflation.

A summary of Edison's gold price forecasts from 2017-24 on the basis of the preceding four analyses is as follows:

Exhibit 110: Edison forecast gold price range, 2017-24e (US$/oz)

	2017	2018	2019	2020	2021	2022	2023	2024
Monetary base correlation	1,773	1,870	1,972	2,080	2,195	2,317	2,445	2,582
Monetary base correlation & cycle	1,519	1,529	1,438	1,502	1,499	1,494	1,619	1,818
Top of the range	1,773	1,870	1,972	2,080	2,195	2,317	2,445	2,582
Middle of the range*	**1,328**	**1,324**	**1,451**	**1,603**	**1,647**	**1,635**	**1,694**	**1,741**
Enhanced long-term inflation	908	813	986	1,211	1,200	1,057	1,060	1,026
Long-term inflation (bottom of range)	882	778	930	1,126	1,099	954	943	900

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

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, for miners, this should, to some extent, be mitigated by lower associated costs of mining.

In the event that there is an unequivocal return to positive real dollar interest rates however, Edison would discard its 'Monetary base correlation' analysis (the only analysis pertaining to a definitively negative real interest rate environment), in which case its forecast range of gold prices for 2017-24 is as follows:

Exhibit 111: Forecast gold price range, 2017-24e (US$/oz)**

	2017	2018	2019	2020	2021	2022	2023	2024
Monetary base correlation & cycle	1,519	1,529	1,438	1,502	1,499	1,494	1,619	1,818
Top of the range	1,519	1,529	1,438	1,502	1,499	1,494	1,619	1,818
Middle of the range*	**1,200**	**1,154**	**1,184**	**1,314**	**1,299**	**1,224**	**1,281**	**1,359**
Enhanced long-term inflation	908	813	986	1,211	1,200	1,057	1,060	1,026
Long-term inflation (bottom of range)	882	778	930	1,126	1,099	954	943	900

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$520/oz (±US$195/oz) to the price of gold

Gold considered as a currency

Implicitly, the analysis above, which relates the price of gold to inflation and money supply, recognises certain characteristics of gold that render it amenable to analysis as if it were an official currency – which, of course, it was, formally, for centuries and remains so for many millions of people (investors and otherwise) without access to a credible fiat currency alternative and who wish to own it simultaneously as a store of value and also as a medium of exchange. In this case therefore, the future gold price can be explicitly valued relative to the US dollar on the basis of the two entities' respective inflation and interest rates. Initially, the interest rate associated with gold will be assumed to be zero (NB it could be considered to be the gold lease rate), as the metal is assumed to be bought and held, in physical form, by investors. Similarly, the inflation rate associated with gold is assumed to be zero, as it is assumed to be purchased by investors precisely on account of its 'real' attributes. This being the case, from a spot price of US$1,320/oz at the time of writing, the future price of gold in one year's time may be expressed in US dollars, relative to expected future US inflation and US interest rates according to the following table:

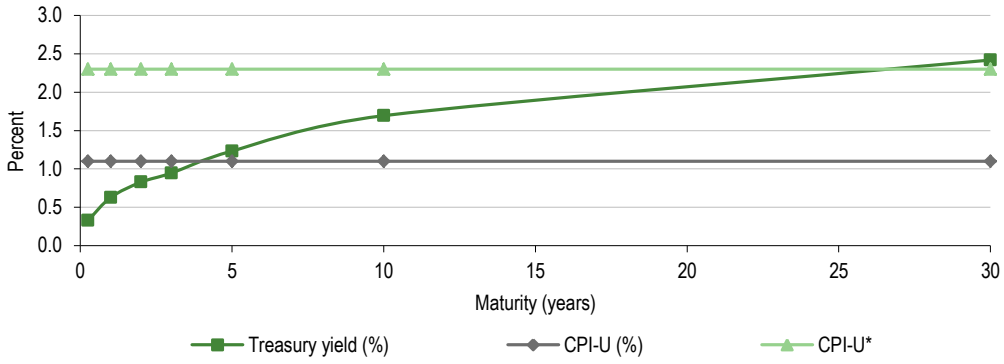
Exhibit 112: Gold price predicted as a currency with respect to US dollar inflation and interest rate environment over one year

US$/oz		Future interest rate (%)										
		0.0%	1.0%	2.0%	3.0%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%
Future inflation rate (%)	(3%)	1,280	1,268	1,255	1,243	1,231	1,219	1,208	1,197	1,186	1,175	1,164
	(2%)	1,294	1,281	1,268	1,256	1,244	1,232	1,220	1,209	1,198	1,187	1,176
	(1%)	1,307	1,294	1,281	1,269	1,257	1,245	1,233	1,221	1,210	1,199	1,188
	0%	1,320	1,307	1,294	1,282	1,269	1,257	1,245	1,234	1,222	1,211	1,200
	1%	1,333	1,320	1,307	1,294	1,282	1,270	1,258	1,246	1,234	1,223	1,212
	2%	1,346	1,333	1,320	1,307	1,295	1,282	1,270	1,258	1,247	1,235	1,224
	3%	1,360	1,346	1,333	1,320	1,307	1,295	1,283	1,271	1,259	1,247	1,236
	4%	1,373	1,359	1,346	1,333	1,320	1,307	1,295	1,283	1,271	1,259	1,248
	5%	1,386	1,372	1,359	1,346	1,333	1,320	1,308	1,295	1,283	1,272	1,260
	6%	1,399	1,385	1,372	1,358	1,345	1,333	1,320	1,308	1,296	1,284	1,272
	7%	1,412	1,398	1,385	1,371	1,358	1,345	1,332	1,320	1,308	1,296	1,284
	8%	1,426	1,411	1,398	1,384	1,371	1,358	1,345	1,332	1,320	1,308	1,296
	9%	1,439	1,425	1,411	1,397	1,383	1,370	1,357	1,345	1,332	1,320	1,308
	10%	1,452	1,438	1,424	1,410	1,396	1,383	1,370	1,357	1,344	1,332	1,320

Source: Edison Investment Research

Within this context, it should be noted that one-year market US interest rates, as calculated from the US Treasury bond with the appropriate maturity, are 0.629% and that historic US inflation to August 2016 is 1.1%, as measured by the CPI for All Urban Consumers (CPI-U), or 2.3%, as measured by the CPI for All Urban Consumers less food and energy (the so-called 'core inflation rate), as depicted in the graph below:

Exhibit 113: US yield curve (%) and inflation rate (%), October 2016



Source: Bloomberg, U.S. Bureau of Labor Statistics. Note: * Core rate (less food and energy)

Over five years, time compounds the effect of both US dollar inflation and interest rates on the price of gold:

Exhibit 114: Gold price predicted as a currency with respect to US dollar inflation and interest rate environment over five years

US$/oz	Future interest rate (%)										
Future inflation rate (%)	0.0%	1.0%	2.0%	3.0%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%
(3%)	1,134	1,079	1,027	978	932	888	847	808	771	737	704
(2%)	1,193	1,135	1,081	1,029	981	935	892	851	812	775	741
(1%)	1,255	1,194	1,137	1,083	1,032	984	938	895	854	816	779
0%	1,320	1,256	1,196	1,139	1,085	1,034	986	941	898	858	820
1%	1,387	1,320	1,257	1,197	1,140	1,087	1,037	989	944	902	861
2%	1,457	1,387	1,320	1,257	1,198	1,142	1,089	1,039	992	947	905
3%	1,530	1,456	1,386	1,320	1,258	1,199	1,143	1,091	1,041	995	950
4%	1,606	1,528	1,455	1,385	1,320	1,258	1,200	1,145	1,093	1,044	997
5%	1,685	1,603	1,526	1,453	1,385	1,320	1,259	1,201	1,147	1,095	1,046
6%	1,766	1,681	1,600	1,524	1,452	1,384	1,320	1,259	1,202	1,148	1,097
7%	1,851	1,762	1,677	1,597	1,522	1,451	1,383	1,320	1,260	1,203	1,150
8%	1,940	1,845	1,757	1,673	1,594	1,520	1,449	1,383	1,320	1,261	1,204
9%	2,031	1,932	1,840	1,752	1,669	1,591	1,518	1,448	1,382	1,320	1,261
10%	2,126	2,023	1,925	1,834	1,747	1,666	1,589	1,516	1,447	1,382	1,320

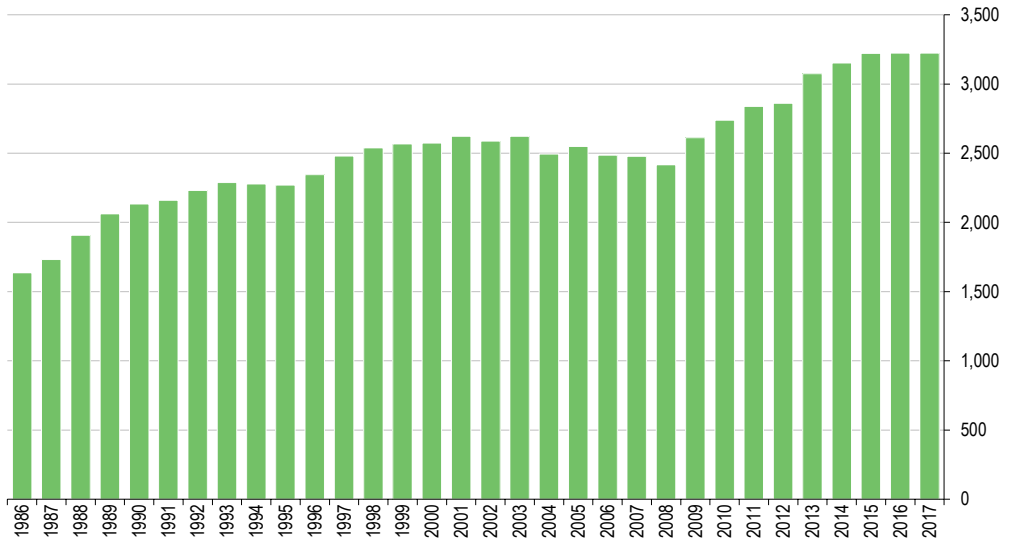
Source: Edison Investment Research

In both cases, investors should note the diagonal line of equivalence (highlighted), at which future interest rates and inflation are the same, such that real interest rates are zero, with the result that there is no expected change in the gold price.

A refinement on the above analysis would be to consider newly mined gold as representing a form of inflation – analogous to monetary inflation as a result of increases in the money supply. All other things being equal, this would be expected to result in a gradual decline in the price of gold with time. However, it should properly be considered within the context of a rising global population, which utilises gold and therefore accords it its value.

In the last 29 years, the annual supply of newly mined gold has doubled, from 1,637t per annum in 1986 to 3,221t in 2015 – equivalent to growth of 2.4% per annum (although it is notable that this appears to occur in distinct waves, arguably lagging a prior price rise) – such that above ground stocks reached an estimated 165,000 tonnes:

Exhibit 115: World mine supply of gold, 1986-2015 (tonnes)



Source: South African Chamber of Mines, Metal Focus

Thus, after the gold price last peaked in 2012, there has been a reduction in investment in the sector, combined with an effort to run existing mines at, or near, full capacity to maximise economies of scale and to minimise the effect of fixed costs on unit costs of production. With these

two effects having now largely run their course, it seems unlikely that new mines will do any more than fill the shortfall resulting from the natural decay in output from existing operations in the absence of an external stimulus (eg the gold price). All other things being equal therefore, having reached 3,221t of output in 2015, future output is expected to be no more than flat for the next two years (source: Metal Focus) before probably declining modestly thereafter. Relative to initial above ground stocks of 165,000t, this equates to an initial gold inflation rate (ie acting to deflate the real value gold) of 2.0% in 2016, declining to no more than 1.8% in 2020.

At the same time, global population growth is expected to continue its declining trend, since it peaked above 2% in the early 1960's. In 2016 therefore, it is expected to grow at 1.016% (source: Wikimedia Commons), followed by 0.9917% in 2017, 09833% in 2018, 0.9417% in 2019 and 0.9333% in 2020. This can be likened to a gold interest rate in that it reflects the change in the size of the population 'interested' (or potentially interested) in gold.

Adjusting for these 'real' factors, the future price of gold in one year's time may be expressed in US dollars (again relative to expected future US inflation and US interest rates), according to the following table:

Exhibit 116: Gold price predicted as currency with respect to the global inflation of 'real' assets as well as US monetary inflation and interest rates

US$/oz	Future interest rate (%)										
Future inflation rate (%)	0.0%	1.0%	2.0%	3.0%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%
(3%)	1,269	1,256	1,244	1,232	1,220	1,208	1,197	1,186	1,175	1,164	1,153
(2%)	1,282	1,269	1,257	1,244	1,232	1,221	1,209	1,198	1,187	1,176	1,165
(1%)	1,295	1,282	1,269	1,257	1,245	1,233	1,222	1,210	1,199	1,188	1,177
0%	1,308	1,295	1,282	1,270	1,258	1,246	1,234	1,222	1,211	1,200	1,189
1%	1,321	1,308	1,295	1,282	1,270	1,258	1,246	1,235	1,223	1,212	1,201
2%	1,334	1,321	1,308	1,295	1,283	1,271	1,259	1,247	1,235	1,224	1,213
3%	1,347	1,334	1,321	1,308	1,295	1,283	1,271	1,259	1,247	1,236	1,225
4%	1,360	1,347	1,334	1,321	1,308	1,295	1,283	1,271	1,259	1,248	1,237
5%	1,373	1,360	1,346	1,333	1,320	1,308	1,296	1,283	1,272	1,260	1,248
6%	1,386	1,373	1,359	1,346	1,333	1,320	1,308	1,296	1,284	1,272	1,260
7%	1,399	1,386	1,372	1,359	1,346	1,333	1,320	1,308	1,296	1,284	1,272
8%	1,413	1,399	1,385	1,371	1,358	1,345	1,333	1,320	1,308	1,296	1,284
9%	1,426	1,411	1,398	1,384	1,371	1,358	1,345	1,332	1,320	1,308	1,296
10%	1,439	1,424	1,410	1,397	1,383	1,370	1,357	1,345	1,332	1,320	1,308

Source: Edison Investment Research.

Over five years, it is as follows:

Exhibit 117: Gold price predicted as currency with respect to the global inflation of 'real' assets as well as US monetary inflation and interest rates (over five years)

US$/oz	Future interest rate (%)										
Future inflation rate (%)	0.0%	1.0%	2.0%	3.0%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%
(3%)	1,084	1,031	982	935	891	849	810	773	738	704	673
(2%)	1,141	1,086	1,033	984	938	894	853	813	777	742	708
(1%)	1,200	1,142	1,087	1,035	987	941	897	856	817	780	745
0%	1,262	1,201	1,143	1,089	1,037	989	943	900	859	820	784
1%	1,327	1,262	1,202	1,144	1,090	1,039	991	946	903	862	824
2%	1,394	1,326	1,262	1,202	1,145	1,092	1,041	994	948	906	865
3%	1,463	1,392	1,325	1,262	1,203	1,147	1,093	1,043	996	951	909
4%	1,536	1,461	1,391	1,325	1,262	1,203	1,148	1,095	1,045	998	954
5%	1,611	1,533	1,459	1,390	1,324	1,262	1,204	1,149	1,096	1,047	1,000
6%	1,689	1,607	1,530	1,457	1,388	1,324	1,262	1,204	1,150	1,098	1,049
7%	1,770	1,684	1,603	1,527	1,455	1,387	1,323	1,262	1,205	1,151	1,099
8%	1,855	1,765	1,680	1,600	1,524	1,453	1,386	1,322	1,262	1,205	1,152
9%	1,942	1,848	1,759	1,675	1,596	1,522	1,451	1,385	1,322	1,262	1,206
10%	2,033	1,934	1,841	1,754	1,671	1,593	1,519	1,449	1,384	1,321	1,262

Source: Edison Investment Research.

Valued on these terms as a currency therefore, it can be seen that:

- Edison's gold (negative real interest rate scenario – Exhibit 110) price forecast of US$1,603/oz in 2020 discounts real interest rates of approximately minus 5% (grey shading, approximately).
- Edison's 2020 gold price forecast of US$1,314/oz in 2020 (Exhibit 111) discounts a real interest rate of approximately minus 1% (green shading, approximately).

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