Long term trends in gold exploration

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Abstract

In 2012, global expenditures for gold reached an all-time high of $10.5 billion. Since then, expenditures have dropped 55% to $4.7 billion in 2014.

MinEx Consulting estimates that over the last decade (2005-2014) $60.5 billion (in constant June 2015 US dollars) was spent on exploring for gold. During that time, 348 primary gold deposits (more than 100,000oz gold) were found, containing 820 moz. A further 62 (mainly base metal) discoveries containing 178 moz of by-product gold were also found; a total of 998 moz.

After adjusting for missing discoveries and factoring in the likely resource growth over time, the author estimates the 426 primary gold deposits found over the last decade are likely to contain approximately 1,246 moz. Adding in by-product gold increases adjusted total to 1,497 moz.

Based on the above, MinEx estimates the average unit discovery cost for 2005-2014 was $42/oz of gold-equivalent (in constant June 2015 US dollars). This is nearly double the discovery cost for the previous decade – $24/oz-eq for 1995-2004.

The main reason for the sudden increase in cost is due a dramatic rise in input costs – such as drilling, labour, land access and administration. All of these have doubled in real terms between 2000 and 2012 – with the key driver being the inflationary effects associated with the mining boom, coupled with stronger currencies for Australia and Canada. With the subsequent end of the mining boom, exploration costs should revert back over the next few years.

With regard to the depth of cover, the average depth of discovery for the world over the last decade was 64m – however half of the deposits found outcropped.

In terms of discovery performance, some regions do better than others. In particular, Canada accounted for 19% of the exploration expenditures, 11% of the deposits (by number) and 24% of the total ounces. It also accounted for 24% of the Tier 1 and 2 deposits found. For comparison, Pacific/Southeast Asia accounted for 7% of the spend, found 2% of the primary gold deposits (by number) but only 1% of the total ounces and zero Tier 1 and 2 deposits.

In terms of the value of discoveries made, versus the cost of exploration, the gold industry performed poorly over the last decade – achieving a notional “bang-per-buck” of 0.68. In practice, the true situation is better than this – as the analysis doesn’t capture the value of unreported discoveries or include the upside potential for projects to have their tier status upgraded through additional drilling. Finally, with the end of the mining boom, input costs for exploration (such as drilling and salaries) will be lower in the future.

With regard to the future, it is noted that the amount of gold mined in the world rose from 36 mozpa in 1975 to 92 mozpa in 2014. This is set to rise further in the future. By comparison, over the last two decades the amount of gold discovered has flat-lined at 120-160 mozpa. While this suggests the industry is finding more gold than it mines, it should be noted that due to a range of factors only 60-80% of gold found is extracted. On this basis, the industry is struggling to replace the ounces mined. This has profound implications on the future price of gold.

Background

The following paper updates and extends the key elements of two previous papers presented by the author at the 2011 and 2013 NewGenGold Conferences (Schodde, 2011 and Schodde 2013). The analysis uses data compiled by MinEx Consulting on mineral exploration expenditures and deposits discovered.

MinEx’s exploration expenditure database has high-level information on the historical expenditures on exploration by commodity and region from 1950 to present. The raw data came from a wide range of sources of varying reliability. Where possible, it used the actual historical data reported by the relevant government agencies (such as the ABS in Australia, NRCan in Canada, MOLAR in China and similar agencies in other countries) and the published expenditure data from the mining and exploration companies themselves. It also drew on estimates published by leading industry analysts – including the excellent set of expenditure surveys compiled annually by SNL (SNL-MEG various years) and data from the Raw Materials Group. These, in turn, were supplemented by earlier studies from Schreiber & Emerson (1984), Tilton et.al. (1988), Wallace (1992, 1993), Mackenzie et al (1997a, 1997b), Doggett & Mackenzie (1987, 1992) and others. Finally, any remaining gaps were filled by MinEx’s own estimates.

All of the expenditure data referred to in this paper has been adjusted for inflation using the US Consumer Price Index and, unless otherwise specified, are reported in constant June 2015 US dollars.

With regard to the discovery data, MinEx has compiled information on more than 55,000 mineral deposits around the world. This includes 25,818 deposits containing a pre-mined resource of more than 10,000oz gold, and within

this are 5,104 deposits of more than 100,000oz. After excluding "satellite" deposits (which are counted within the parent camp totals) the database has information on 4,510 unique gold deposits of more than 100,000oz. Of these, MinEx has discovery dates and histories for 3,543 deposits. A special effort has been made to ensure that that the coverage and data on those deposits of more than 1 moz is as complete and up-to-date as possible.

Unless otherwise specified, all figures refer to pre-mined resources. This is the sum of the current reported measured, indicated and inferred resources plus historic mine production (as reported on a head-grade basis).

For purposes of this study the author defines the discovery date as the year when the deposit was recognised as having significant value. This is usually set as the date of the first economic drill intersection.

The paper uses the same methodology reported by McKeith et al (2010) to attribute the ounces of gold associated with a discovery. In particular, the discovery growth in resource ounces within a camp was assigned back to the original discoverer and the corresponding discovery date. This includes ounces associated with satellite deposits that feed into an existing mill within an established camp. The only exceptions to this rule are new discoveries in brownfields settings which transform the understanding of the scale of the mineralised system. A recent example would Redback Mining's discovery in 2008 of 8 moz of gold in a parallel structure under cover at its Tasiast gold operation in Mauritania. The original Tasiast deposit was found by Normandy Mining in 1996 and is now owned by Kinross Gold.

For the purpose of this paper; new brownfields discoveries within existing camps require a minimum new resource of 2 moz gold to qualify as being transformational in scale. Similarly, any standalone deposits within an established mining district (or along strike from other companies' mines) are counted separately as brownfield discoveries.

Trends in exploration expenditures

The following Figure shows the general trend in global exploration expenditures on gold by region over the last four decades.

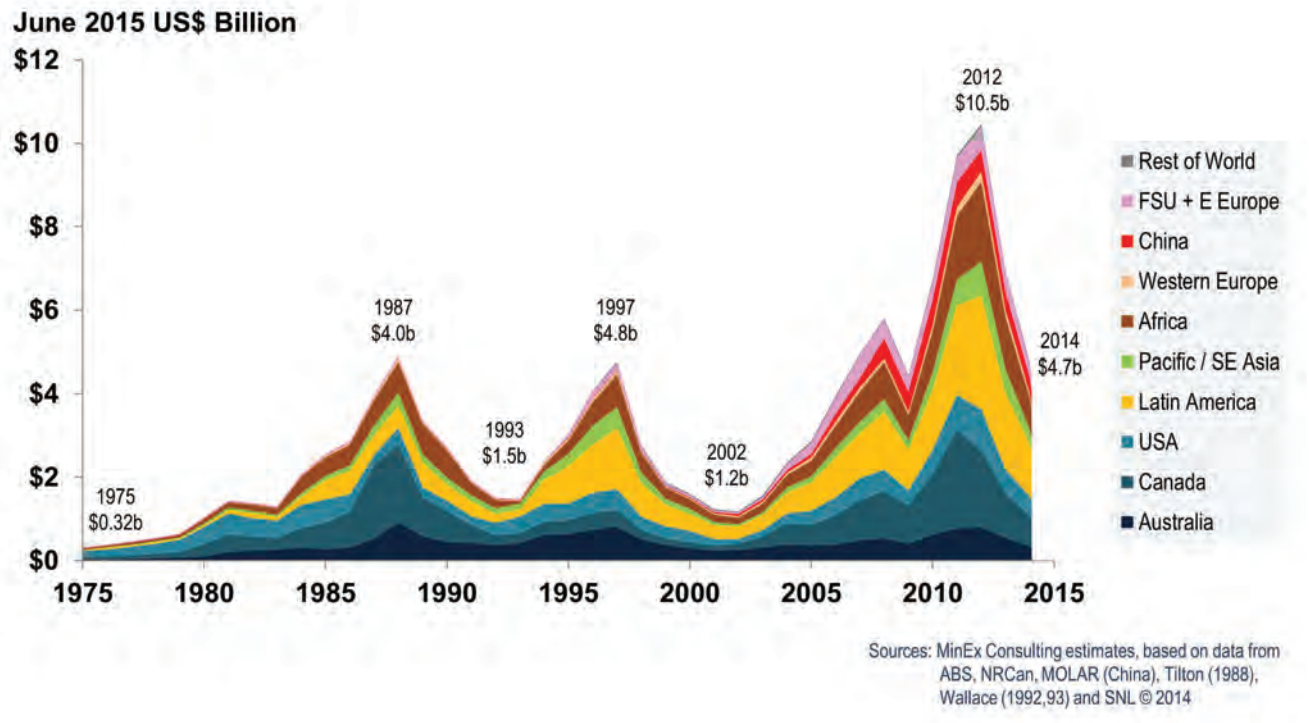

Figure 1: Trend in gold exploration expenditures in the world 1975-2014 in constant June 2015 US dollars

As can be seen, expenditures on gold exploration has increased (in constant dollars) from $300 million in 1975 to $4.7 billion in 2014. This is a 15-fold increase over the last four decades.

However, the chart also shows that these expenditures are cyclical – with a periodicity of around 8-10 years. In detail, spending peaked in 1988, 1997, 2008 and 2012. While each cycle is subtly different, expenditures can fall

by up to 75% of the peak amount. With regard to the latest cycle, reported expenditures in 2014 were 55% below the peak in 2012 – and are expected to fall by a further 10-20% over the next two years. Such a fall is in-line with previous cycles. Hopefully, the industry will correspondingly rebound in later years.

The two key drivers for the exploration activity are the general economic growth of the world's economy (and China in particular) and the price of gold. In practice, these factors are inter-related. Firstly, growth in the world's economy increases the overall demand for gold which increases the need for more production and, in turn, generates the need for companies to find new ounces to replace what's been mined.

Over the last 40 years, world gold production doubled from 39 mozpa (1,200t) in 1975 to 92 mozpa (2,860t) in 2014. As a general rule, stronger metal demand leads to higher prices. Over the same period, the price of gold (as measured in constant 2015 US dollars) increased from $720/oz to $1,277/zx.

Trends in the number and type of discoveries

After adjusting for the (mainly smaller and historical) deposits missing from the database, MinEx estimates there are around 8,000 primary gold deposits of more than 100,000oz in the world. These contain a total of around 12,000 moz (or 370,000t) of gold. This includes 215 deposits of more than 10 moz containing 5,700 moz; and 1,300 deposits of 1-10 moz in size containing 3,800 moz. The remaining 6,500 deposits contain around 2,500 moz.

In addition to the above, MinEx estimates 2,500 moz of by-product gold is tied-up in base metal and other deposits. This give a total pre-mined resource of around 14,500 moz (or 450,000t) of gold.

MinEx's database has information on 1,149 deposits of more than 1 moz that have been found in the world since 1950. This is made up of 932 deposits where gold is the primary metal, and 217 deposits where gold is a by-product of mining other metals (see Figure 2). With regard to the last decade (2005-2014) MinEx has data on 207 discoveries of more than 1 moz, of which 185 contain gold as a primary metal and 25 where gold is a by-product.

It should be noted that it does take time for a discovery to be publicly reported and a maiden resource figure published. Furthermore, it can take several years of drilling for the true size and value of the deposit be appreciated. As a consequence, any analysis based on the "raw" number of recently reported discoveries will give a misleading impression on the true discovery performance of the industry. To overcome this error, the author includes an estimate[1] of the likely size and number of deposits found but not yet reported in the last decade. As shown in Figure 2, MinEx estimates an additional 39 deposits have been found but not yet reported. This results in an adjusted figure of 246 primary and by-product gold deposits of more than 1 moz being found in the world over the last decade.

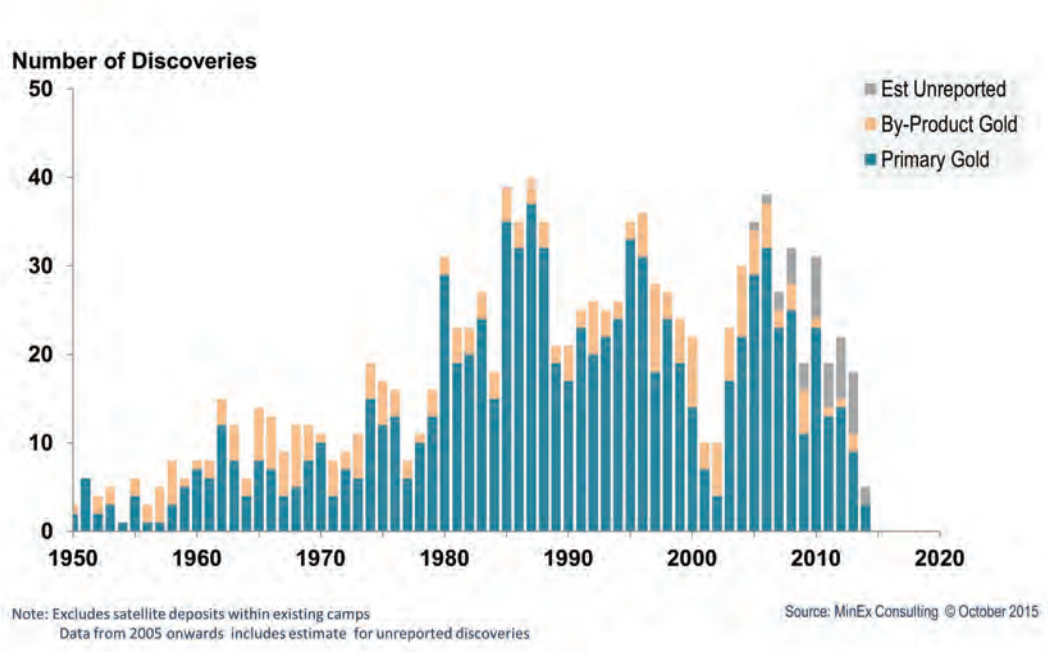

Figure 2: Number of deposits > 1 moz found in the world 1950-2010 by type

[1]The adjustment factors are based on a detailed analysis by the author of the resource growth histories of 60 major gold deposits discovered between 1980 and 1996 (Schodde, 2011).

After factoring in deposits smaller than 1 moz, it is estimated that around 7,000 moz of gold has been found in the world since 1950. Approximately 5,500 moz (or 72%) of the total amount discovered is associated with primary gold deposits (Figure 3).

After adjusting for 500 moz in unreported discoveries, 1,500 moz was found in the last decade. This is made up of 1,250 moz where gold is the primary metal and 250 moz where gold is a by-product.

Even after adjusting for the likely number and amount of (as yet) unreported discoveries, the rate of discovery in the world appears to have flat-lined in recent years. This is of serious concern to the long-term sustainability of the industry.

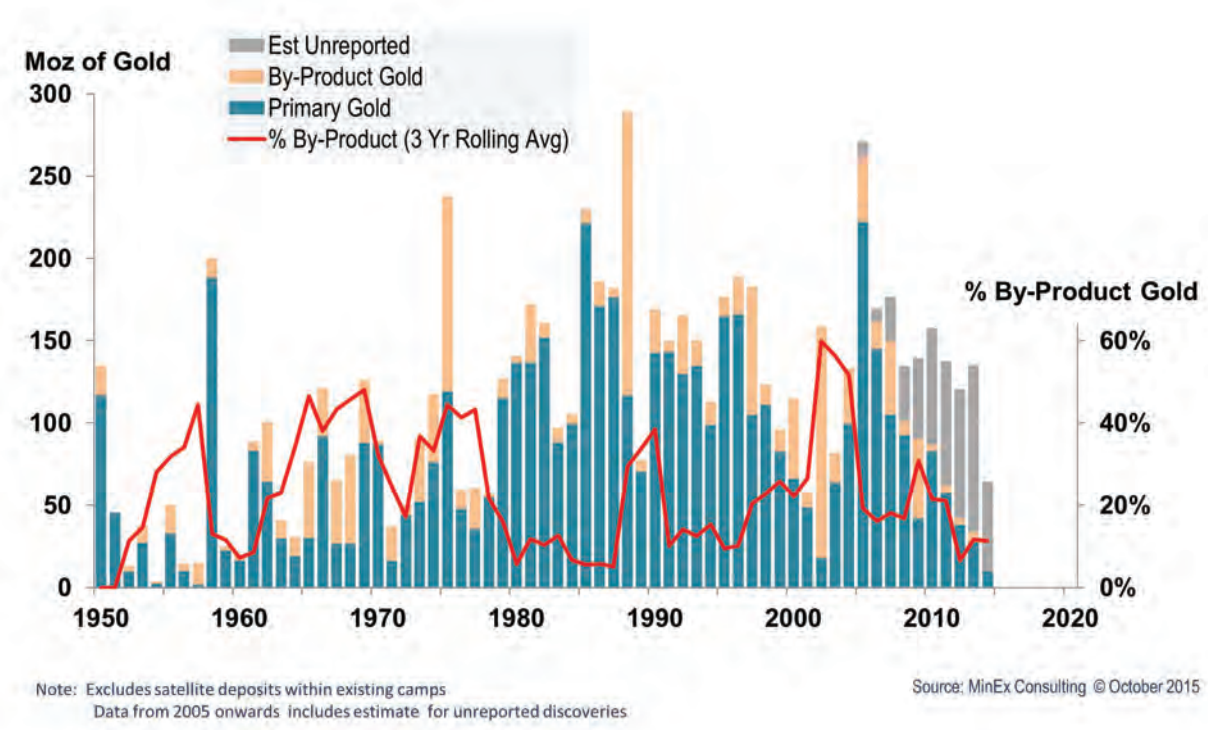

Figure 3: Total ounces found in the world 1950-2014 by source

From a methodological perspective, it is important to separate out the different sources of gold – as the industry treats them differently, both in terms of production and allocation of exploration costs.

As discussed above, 28% of the gold discovered in recent decades is associated with base metal and other deposits. At present, 7% of the world's gold production comes from such deposits. As the gold is a by-product, the decision to build and operate these mines is driven by the value of the other metals. Consequently, any change in the price of gold (both up or down) is not likely to significantly alter the supply response from these mines.

With regard to exploration, all expenditures associated with finding the deposit are assigned back to the primary metal. In other words, any by-product metal found is treated as a "bonus". Consequently, when calculating the unit discovery cost for gold (on say a $/oz basis) it is important to limit the analysis to primary gold deposits only.

A subtle, but important point, is that primary gold deposits can also benefit from by-product credits – such as silver and copper. Figure 4 shows the contribution of these credits, as converted into gold-equivalent metal[2]. It is estimated that, over the period 1950-2014, these by-product credits were equal to 11% of the contained value of the gold found.

As noted before, the cost (and value) of finding these by-product metals is carried by the primary metal. Consequently, adding in the by-product credits effectively reduces the calculated unit discovery cost for gold by around (11/(100+11)=) 10%.

[2] For purposes of this study, 1 g/t Au = 77 g/t Ag = 0.80% Cu = 4.14% Zn = 3.67% Pb. These conversion rates are based on the monthly average price for these metals over the last 3 years and include an adjustment for differences in the recovery rates and associated treatment & refining charges.

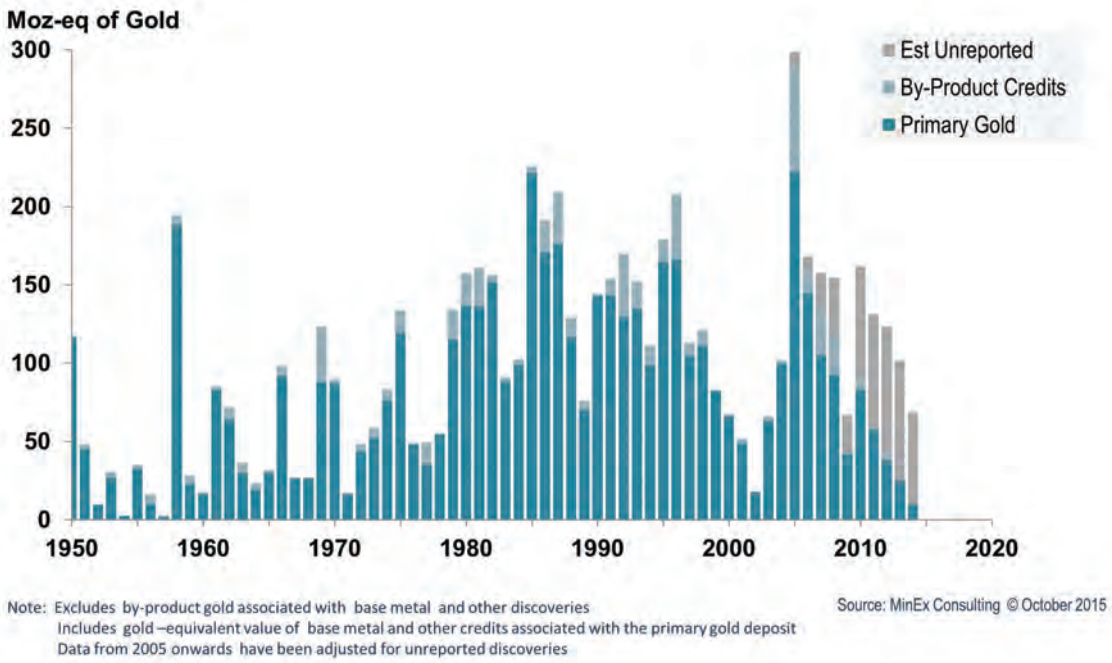

Figure 4: Total ounces of gold associated with primary gold deposits found in the world 1950-2014, including estimated value (in gold-equivalent ounce) of the silver, copper and other by-product credits

Trends in the location of discoveries

Figures 5 and 6 show the amount of gold (contained in primary gold deposits) discovered by region since 1950. On a percentage basis, in the 1950s to 1970s most of the discoveries were made in the Planned Economies (i.e. the Former Soviet Union, China and Eastern Europe). In the 1980s through to the early 1990s, the developed countries of the Western world (principally USA, Canada and Australia) accounted for more than 40% of all ounces found. In the 1990s the focus moved to developing countries (principally in Latin America and Africa). In the last decade, Canada has risen in importance – and accounted for 24% of all ounces found. Other regions of significance in the last decade are Latin America (22%) and Africa (20%). By comparison, Australia only accounted for 7% of primary ounces discovered.

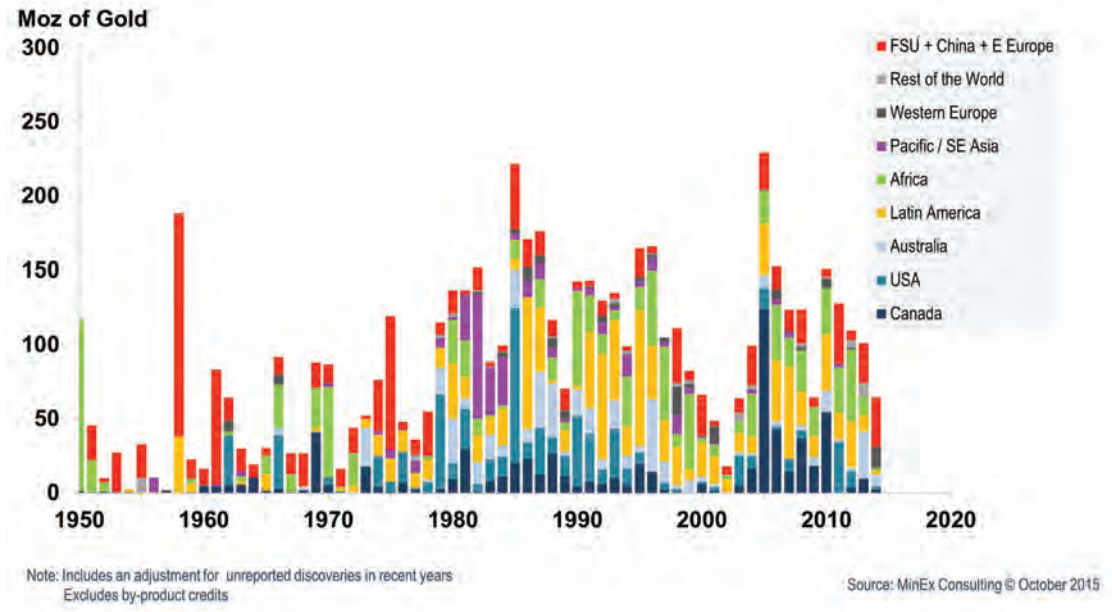

Figure 5: Amount of gold (in primary gold deposits) found by Region 1950-2014
Note: Data excludes by-product gold

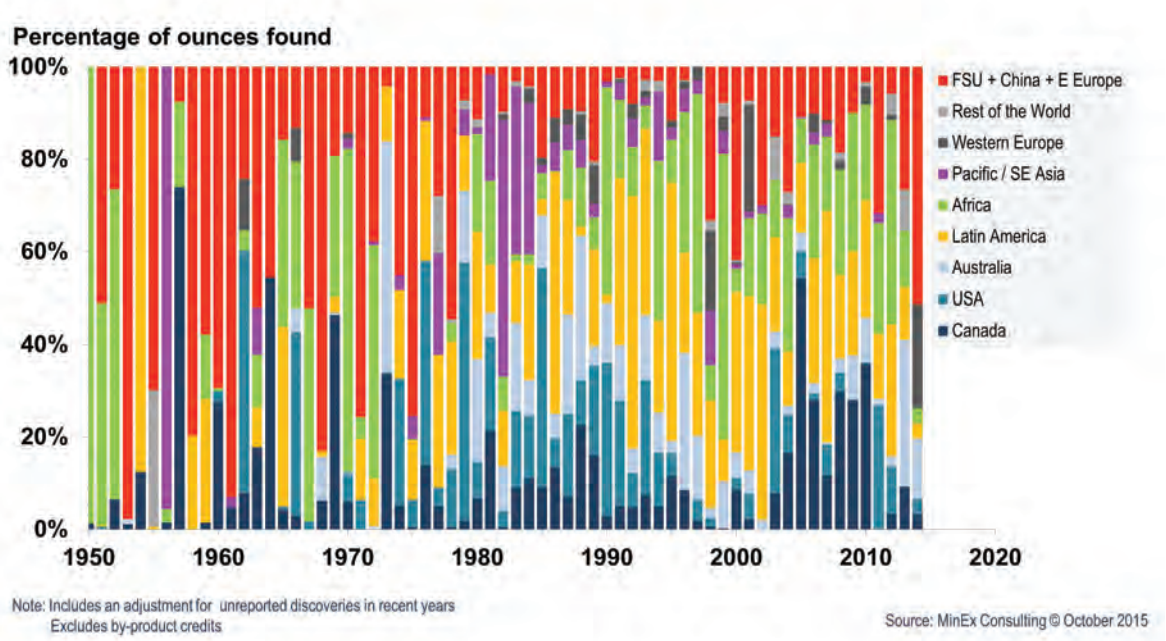

Figure 6: Amount of gold (in primary gold deposits) on percentage basis found by Region 1950-2014.
Note: Data excludes by-product gold

Major gold discoveries made in the last decade

MinEx has compiled data on 348 primary[3] gold discoveries (containing more than 100,000oz each) found in the period 2005-2014. These deposits have a current reported resource of 820 moz.

Table 1 lists 67 discoveries containing more than 1 moz made since 2010. Table 2 compares this against a similar list compiled by the author (Schodde, 2013) for the 2013 NewGenGold Conference.

These figures should be treated as being conservative, since they do not include unreported discoveries. Nor does it include an allowance for resource growth over time. As noted by the author (Schodde, 2011), on average there is a 3.7 year delay between making a discovery and reporting a maiden resource. Also, there are many examples where follow-up drilling led to the reported resource growing by a factor of 2-3 in subsequent years.

Adjusting for these factors increases the above reported discovery data for the last decade by 30-50%, especially for the more recent discoveries. Table 2 highlights this effect as it includes data on several discoveries not previously identified in the 2013 study.

Not counting the 12 new deposits in the intervening period, an additional 17 discoveries have been identified for the period 2010-2013. The analysis also includes nine previously known deposits that have grown in size to meet the 1 moz threshold. Two discoveries were taken off the list because they have now fallen below the minimum size threshold. After adjusting for other factors, since completing the previous study in 2013, the total number of known deposits (that are more than 1 moz in size) discovered in the period 2010-2013 grew from 31 to 55, and the reported amount of gold found increased from 95 to 138 moz[4].

Future surveys are certain to add more discoveries and ounces to the list.

Finally, it should be noted that only nine of the 348 primary gold discoveries made over the last decade were "world-class" or Tier 1. A further 28 were classified as Tier 2 and 160 discoveries were Tier 3. Of the discoveries, 151 were considered to be either too small (i.e. less than 1 moz) or low grade to receive a Tier rating[5] and, as such are referred to in this paper as "unclassified".

On a more general note, there is no certainty over how much of the reported resources will converted into mineable reserves.

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[3] An additional 67 Base Metal and PGM deposits were found that contain > 0.1 moz of by-product gold. The total amount of by-product gold was 156 Moz.

[4] No allowance has been made for the eleven deposits with no published Resource figure.

[5] See Appendix A for the author's definitions of the various Tier classifications

Figure 7 shows the size and location of the 410 primary and by-product gold deposits (of more than 100,000oz) found in the world since 2005. It also shows the current 10 “hot spots” for exploration activity. A similar map was presented by the author at the 2011 NewGenGold Conference (Schodde, 2011) which showed the top six hot spots. Additions/changes made since then include:

- The addition of four new hot spots in Southwest USA/Mexico, Western Australia, Turkey/Carpathian Belt and Far East Russia.
- Changes in the boundaries for the hot spots in Latin America (now extended down from Colombia/Ecuador to include Peru and Chile), and Central Africa (which has now extended northwards into Ethiopia and Sudan).

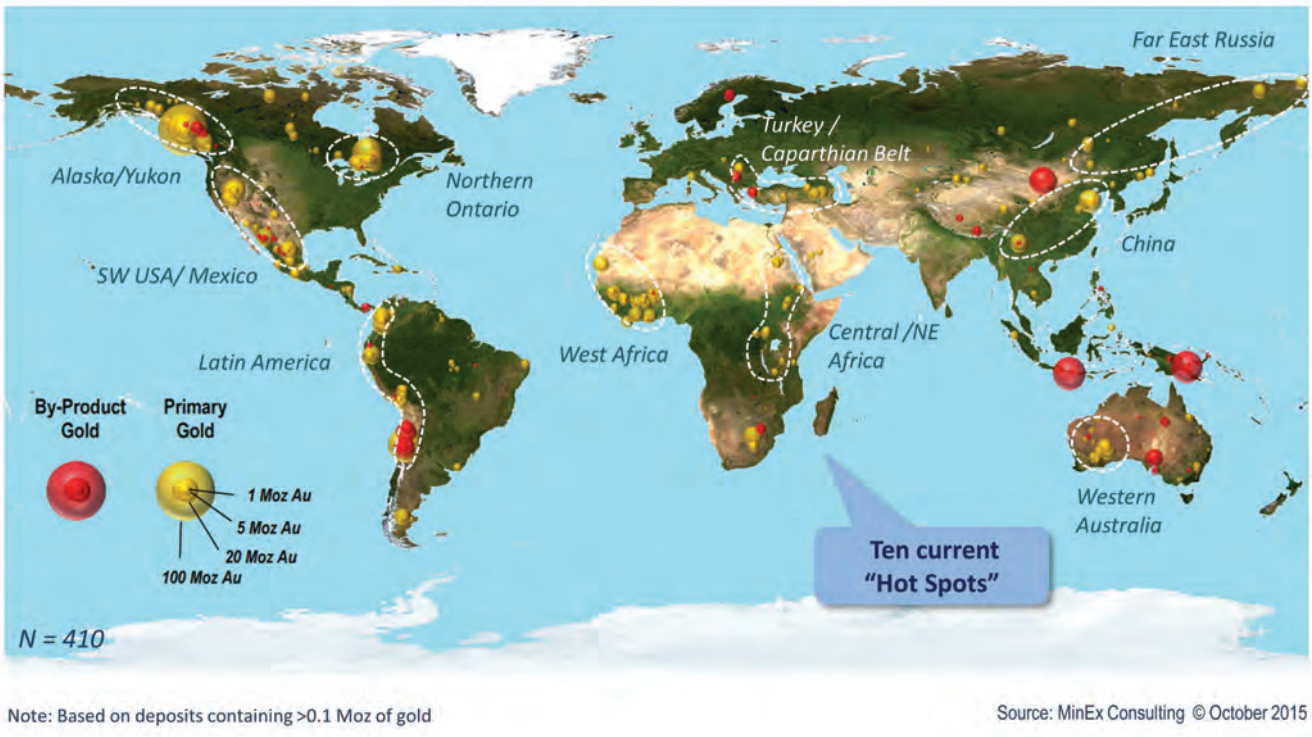

Figure 7: Map of the world showing size and location of gold deposits found in the period 2005-2014

With regard to Table 1 special mention should be made of the three Tier 1 discoveries rated by MinEx Consulting; these are

- **Red Hill/Goldrush** – discovered by Barrick Gold next to its existing operations in Nevada, USA in 2011. Barrick reported a resource of 96mt @ 5.0 g/t gold (15.4 moz) in December 2014.
- **Cote** – discovered by Trelawney Mining & Exploration in Ontario, Canada in 2010. Since reporting a maiden resource of 4.4 moz in March 2011 the deposit has grown to (331mt @ 0.80 g/t gold equivalent) 9.0 moz as at December 2011. Trelawney was acquired by IAMGOLD Corp in June 2012 for $C608 million.
- **Haiyu** – discovered by Laizhou Ruihai in China in 2011. The deposit is 1,250-1,800m deep in a well-established mining district within Shandong Province. Based on various reports, the author estimates the deposit currently contains 67mt @ 7 g/t gold (15.1 moz). In June 2015, Zhaojin Mining paid $US339 million for a 53% share in the deposit and plans to aggressively drill-out the immediate area

MinEx expects that, as further exploration and drilling is done, some of the 10 currently reported Tier 2 discoveries may get upgraded to Tier 1 status.

Discovery Year	Deposit Name	Country	Contained Metal	Size (Moz)	Tier	Discovery Company	Company Type	Brownfield / Greenfield
2014	Anuy River	Russian Federation	Au,Ag	NR	3	Government Geologists	State	Green
2014	Araxan	China	Au	NR	3	Government Geologists	State	Green
2014	Hot Maden	Turkey	Au,Cu,Zn,Mo	2.16	3	Lidya Madencilik + Mariana	Priv + Jun	Green
2013	El Barqueno	Mexico	Au,Ag	NR	3	Cayden Resources	Junior	Green
2013	Altan Nar	Mongolia	Au,Pb,Zn,Ag	NR	3	Erdene Resources	Junior	Green
2013	Xingyuan (?)	China	Au	NR	3	Government Geologists	State	Green
2013	Terneisky	Russian Federation	Au,Ag	NR	3	Government Geologists	State	Green
2013	Orochenskaya	Russian Federation	Au,Ag	NR	3	Government Geologists	State	Green
2013	Gruyere	Australia	Au	6.07	2	Gold Road Resources	Junior	Green
2013	San Metals Block 14	Sudan	Au	1.71	3	Shark Minerals	Junior	Green
2013	Bucks Reef West	Australia	Au	1.28	3	Resolute Mining	Moderate	Brown
2013	Amaruq	Canada	Au	2.02	2	Agnico Eagle Mines	Major	Green
2013	North Rok	Canada	Cu,Au	1.19	-	Colorado Resources	Junior	Green
2013	Kemess (East)	Canada	Cu,Au,Ag,Mo	5.15	3	AuRico Gold	Moderate	Brown
2012	Caramanta	Colombia	Au,Cu,Ag	NR	3	Solvista Gold Corp	Junior	Green
2012	Alturas	Chile	Au,Ag	NR	2	Barrick Gold	Major	Green
2012	Iceberg	United States	Au	NR	3	NuLegacy Gold + Barrick	Jun + Maj	Brown
2012	Tigrinaya	Russian Federation	Au,Ag	NR	3	Government Geologists	State	Green
2012	Umm Ash Shalaheeb	Saudi Arabia	Au,Zn,Cu	1.29	3	United Arabian Mining Co	Private	Green
2012	Tireo	Dominican Republic	Au,Ag,Cu,Zn,Mo	2.49	2	Goldquest Mining	Junior	Green
2012	Boto	Senegal	Au	1.87	3	IAMGold	Major	Green
2012	Natougou	Burkina Faso	Au	1.09	3	Mt Isa Metals	Junior	Green
2012	Media Luna	Mexico	Au,Ag,Cu	3.98	3	Torex Resources	Junior	Brown
2012	Yaoure	Cote d'Ivoire	Au	6.82	3	Amara Mining	Small Producer	Brown
2012	Bouly	Burkina Faso	Au,Cu	1.02	3	High River Gold	Small Producer	Brown
2012	Tankoro	Burkina Faso	Au	1.50	3	Sarama Resources	Junior	Green
2012	Bongou	Burkina Faso	Au	1.50	3	Predictive Discovery + Stratos	Jun + Jun	Green
2012	Galat Sufar South	Sudan	Au	1.98	3	Orca Gold + Meyas Nub	Jun + Priv	Green
2012	Brestovac-Metovnica	Serbia	Cu,Au	3.15	2	Freeport + Reservoir	Maj + Junior	Brown
2011	Blackrock	Ethiopia	Au	NR	3	ASCOM	Industrial	Green
2011	Cebollati	Uruguay	Au	NR	4	B2Gold	Moderate	Green
2011	Block 14 Artisinal Workings	Sudan	Au	NR	3	Artisinal Miners	Prospector	Green
2011	Block 15 Artisinal Workings	Sudan	Au	NR	3	Artisinal Miners	Prospector	Green
2011	Jilaye	Ethiopia	Au	NR	3	Midroc	Private	Green
2011	Red Hill/Goldrush	United States	Au	15.44	1	Barrick	Major	Brown
2011	Wonogiri	Indonesia	Au,Cu	1.01	3	Augur Resources	Junior	Green
2011	Mako	Senegal	Au	1.38	3	Toro Gold	Junior	Green
2011	Salares Norte	Chile	Au,Ag	3.10	3	Gold Fields Ltd	Major	Green
2011	West Omai Project	Guyana	Au	1.08	3	Azimuth	Junior	Brown
2011	Krasny (hard rock)	Russian Federation	Au	1.57	3	Kopy Goldfield	Small Producer	Green
2011	Enchi	Ghana	Au	1.08	3	Pinecrest	Junior	Green
2011	Haiyu	China	Au	15.13	1	Laizhou Ruihai	Private	Brown
2011	Waterberg	South Africa	PGE,Au,Ni,Cu	2.85	2	Plat Group Metals + JOGMEC	Jun + State	Green
2010	Vogue	Australia	Au	NR	2	AngloGold Ashanti	Major	Brown
2010	TV Tower	Turkey	Au,Ag,Cu	NR	3	Teck + Pilot Gold	Maj + Jun	Green
2010	Goose Lake	Canada	Au	5.16	3	Sabina Gold & Silver Corp	Junior	Green
2010	Borborema	Brazil	Au	2.43	3	Crusader Resources	Junior	Brown
2010	Coffee	Canada	Au	4.15	2	Shawn Ryan	Prospector	Green
2010	Hounde	Burkina Faso	Au	2.01	3	Avion Gold Corp	Small Producer	Green
2010	Makabingui	Senegal	Au	1.01	3	Bassari Resources	Junior	Green
2010	Borden	Canada	Au,Ag	4.36	3	Probe Mines Ltd	Junior	Green
2010	Bullabulling (new)	Australia	Au	3.22	3	Gibraltar Gold Mine (Australia)	Junior	Brown
2010	Buritica	Colombia	Au,Ag,Zn,Pb	9.08	2	Contintental Gold	Junior	Brown
2010	Cote	Canada	Au,Cu	8.96	1	Trelawney Mining and Explorn	Junior	Brown
2010	Del Carmen	Argentina	Au,Ag	1.01	3	Malbex Resources	Junior	Green
2010	Fekola	Mali	Au	4.77	2	Papillon Resources	Junior	Brown
2010	Somituri	Congo (DRC)	Au	1.68	3	Kilo Goldmines	Junior	Brown
2010	Lynn Lake Gold Project	Canada	Au,Ag	3.70	3	Carlisle Goldfields	Junior	Brown
2010	Ana Paula	Mexico	Au,Ag	1.80	3	Miranda Mining	Junior	Green
2010	Newton Hill	Canada	Au,Ag,Cu,Mo	1.57	3	Amarc Resources	Junior	Green
2010	Medvezhy	Russian Federation	Au	1.40	3	Polyus Gold	Major	Green
2010	Lucerito	Mexico	Au,Ag,Zn,Pb,Cu,Mn	1.80	3	Fresnillo	Major	Green
2010	Makapela	Congo (DRC)	Au	1.16	3	Loncor	Junior	Green
2010	Tanlouka	Burkina Faso	Au	2.53	3	Channel Resources Ltd	Junior	Green
2010	Ixtaca	Mexico	Au,Ag	2.01	3	Almaden Minerals	Junior	Green
2010	California	Colombia	Au,Ag	1.09	3	Galway Resources	Junior	Green
2010	Balboa	Panama	Cu,Au,Mo,Ag	2.64	3	Inmet Mining	Moderate	Brown

NR = Not Reported

Source: MinEx Consulting © October 2015

Table 1: Major (>1 moz) gold discoveries made in the world since 2010. Reported figures refer to measured, indicated and inferred resources

Discovery Year	Deposit Name	Country	Contained Metal	Size (Moz)		Tier		Comment
				in Oct 2015	in Oct 2013	in Oct 2015	in Oct 2013	
2014	Hot Maden	Turkey	Au,Cu,Zn,Mo	2.16		3		New discovery
2014	Anuy River	Russian Federation	Au,Ag	NR		3		New discovery
2014	Araxan	China	Au	NR		3		New discovery
2013	Gruyere	Australia	Au	6.07		2		New discovery
2013	Kemess (East)	Canada	Cu,Au,Ag,Mo	5.15		3		New discovery
2013	Amaruq	Canada	Au	2.02		2		New discovery
2013	San Metals Block 14	Sudan	Au	1.71		3		New discovery
2013	Bucks Reef West	Australia	Au	1.28		3		New discovery
2013	North ROK	Canada	Cu,Au	1.19	NR	-	3	
2013	Altan Nar	Mongolia	Au,Pb,Zn,Ag	NR		3		New discovery
2013	El Barqueno	Mexico	Au,Ag	NR	NR	3	3	
2013	Orochenskaya	Russian Federation	Au,Ag	NR		3		New discovery
2013	Terneisky	Russian Federation	Au,Ag	NR		3		New discovery
2013	Xingyuan (?)	China	Au	NR		3		New discovery
2012	Yaoure	Cote d'Ivoire	Au	6.82		3		New entry
2012	Media Luna	Mexico	Au,Ag,Cu	3.98	3.38	3	3	
2012	Brestovac-Metovnica	Serbia	Cu,Au	3.15	NR	2	-	Was previously <1 Moz
2012	Tireo	Dominican Republic	Au,Ag,Cu,Zn,Mo	2.49	NR	2	2	Was previously called Romero
2012	Galat Sufar South	Sudan	Au	1.98		3		New entry
2012	Boto	Senegal	Au	1.87	1.22	3	3	
2012	Tankoro	Burkina Faso	Au	1.50		3		New entry
2012	Bongou	Burkina Faso	Au	1.50		3		New entry
2012	Umm Ash Shalaheeb	Saudi Arabia	Au,Zn,Cu	1.29		3		New entry
2012	Natougou	Burkina Faso	Au	1.09	1.78	3	3	Smaller resource due to higher c/off grade
2012	Bouly	Burkina Faso	Au,Cu	1.02		3		New entry
2012	Alturas	Chile	Au,Ag	NR		2		New entry
2012	Iceberg	United States	Au	NR		3		New entry
2012	Tigrinaya	Russian Federation	Au,Ag	NR		3		New entry
2012	Caramanta	Colombia	Au,Cu,Ag	NR	NR	3	3	
~~2012~~	~~Golden Lake~~	~~Canada~~	~~Au,Cu,Ag~~	XX	1.56	XX	3	Reclassified as a satellite deposit to Juby
2011	Red Hill / Gold Rush	United States	Au	15.44	14.05	1	1	
2011	Haiyu	China	Au	15.13		1		New entry
2011	Salares Norte	Chile	Au,Ag	3.10	NR	3	3	
2011	Waterburg	South Africa	PGE,Au,Ni,Cu	2.85	1.01	2	2	
2011	Krasny (hard rock)	Russia	Au	1.57	NR	3	-	Was previously <1 Moz
2011	Mako	Senegal	Au	1.38	NR	3	-	Previous discovery date was 2007
2011	Enchi	Ghana	Au	1.08		3		New entry
2011	West Omai Project	Guyana	Au	1.08		3		New entry
2011	Wonogiri	Indonesia	Au,Cu	1.01	-	3	-	Was previously <1 Moz
2011	Blackrock / Beninshangul	Ethiopia	Au	NR	NR	3	3	
2011	Block 14 Artisinal Workings	Sudan	Au	NR		3		New entry
2011	Block 15 Artisinal Workings	Sudan	Au	NR		3		New entry
2011	Cebollati	Uruguay	Au	NR	NR	4	3	Downgraded its Tier Rank
2011	Jilaye	Ethiopia	Au	NR		3		New entry
2010	Buritica	Colombia	Au,Ag,Zn,Pb	9.08	5.39	2	2	
2010	Cote	Canada	Au,Cu	8.96	9.07	1	1	Was previously called Chester/Cote Lake
2010	Goose Lake	Canada	Au	5.16	4.64	3	3	Smaller resource due to higher c/off grade
2010	Fekola	Mali	Au	4.77	5.15	2	2	
2010	Borden	Canada	Au,Ag	4.36	4.82	3	3	Smaller resource due to higher c/off grade
2010	Coffee	Canada	Au	4.15	3.24	2	2	
2010	Lynn Lake Gold Project	Canada	Au,Ag	3.70	4.94	3	3	
2010	Bullabulling (New)	Australia	Au	3.22	3.76	3	3	
2010	Balboa	Panama	Cu,Au,Mo,Ag	2.64	2.64	3	3	
2010	Tanlouka	Burkina Faso	Au	2.53	-	3	-	New entry
2010	Borborema	Brazil	Au	2.43	2.43	3	3	
2010	Hounde	Burkina Faso	Au	2.17	2.17	3	3	Discovery date was previously 2009
2010	Ixtaca	Mexico	Au	2.01	NR	3	-	Was previously <1 Moz
2010	Ana Paula	Mexico	Au,Ag	1.80	NR	3	-	Was previously <1 Moz
2010	Lucerito	Mexico	Au,Ag,Zn,Pb,Cu,Mn	1.80	NR	3	-	Was previously <1 Moz
2010	Somituri	Congo (DRC)	Au	1.68	1.87	3	3	Smaller resource due to higher c/off grade
2010	Newton Hill	Canada	Au,Ag,Cu,Mo	1.57	1.57	3	3	
2010	Medvezhy	Russia	Au	1.40	1.38	3	3	
2010	Makapela	Congo (DRC)	Au	1.16	NR	3	-	Was previously <1 Moz
2010	California	Colombia	Au,Ag	1.09	-	3	-	New entry
2010	Del Carmen	Argentina	Au,Ag	1.01	0.82	3	-	Was previously <1 Moz
2010	Makabingui	Senegal	Au	1.01	0.24	3	-	Was previously <1 Moz
2010	TV Tower	Turkey	Au,Ag,Cu	NR	NR	3	3	
2010	Vogue	Australia	Au	NR	NR	2	2	
~~2010~~	~~Drazhnoye~~	~~Russia~~	~~Au~~	XX	13.60	-	2	Excluded as now < 1 Moz, reported "Geological Potential" is 21.11 Moz
~~2010~~	~~Hutite~~	~~Egypt~~	~~Au~~	XX	NR	XX	3	Excluded as now < 1 Moz
~~2010~~	~~Tasiast Extension~~	~~Mauritania~~	Au	XX	7.72	XX	2	Changed the discovery date to 2008

NR = Not Reported XX = Deleted

Source: MinEx Consulting © October 2015

Table 2: Comparison between the current list of major gold discoveries and that previously identified by the author in 2013 (for the four year period 2010-2013)

Trends in the size of discoveries

Figure 8 plots the size distribution of 932 primary gold deposits of more than 1 moz found since 1950. It should be noted that the trend-line figure is strongly influenced by a handful of giant deposits. As can be seen, over the last 60 years there has been a slow decline in the weighted average size; from 6.7 moz in 1960-69 to 4.6 moz in 2009-09. The dramatic decline in the last five years, to 2.9 moz in 2010-14, may simply be an artifact of the time taken to fully delineate a given discovery.

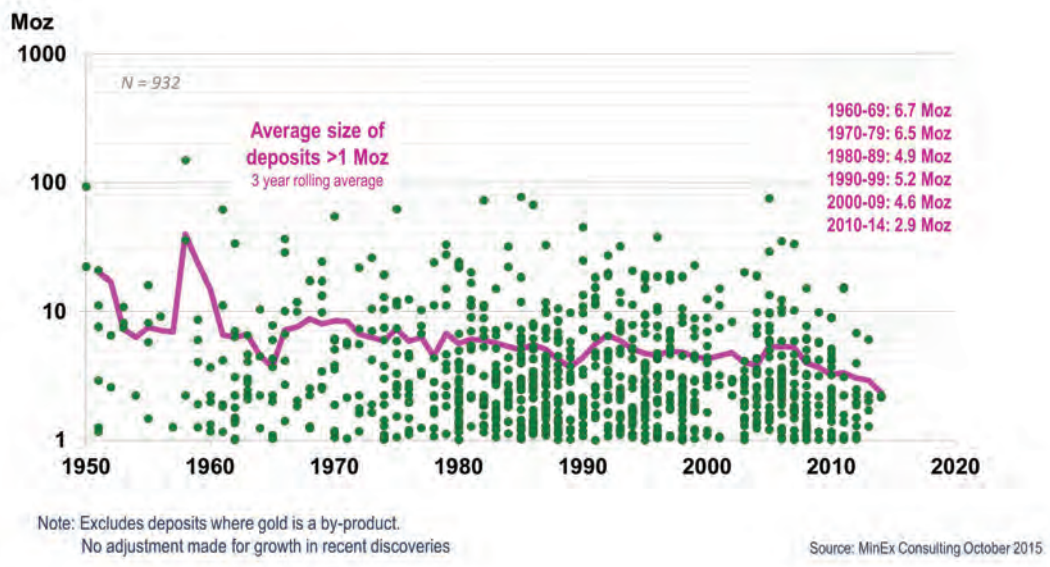

Figure 8: Weighted average size of primary gold deposits >1 moz found in the world 1950-2014

Trends in the grade of discoveries

As shown in Figure 9, the observed trend in ore grades since the mid-1970s has been sideways – with the weighted average grade fluctuating between 0.9 and 1.5 g/t. The recent uptick to 1.47 g/t in 2014 is due to a number of large high-grade (generally underground) deposits being found[6].

Of more concern is the fact average head grade of ore mined (i.e. the red line in Figure 9) has been dropping – suggesting that the inventory of high-grade high-quality deposits is being depleted.

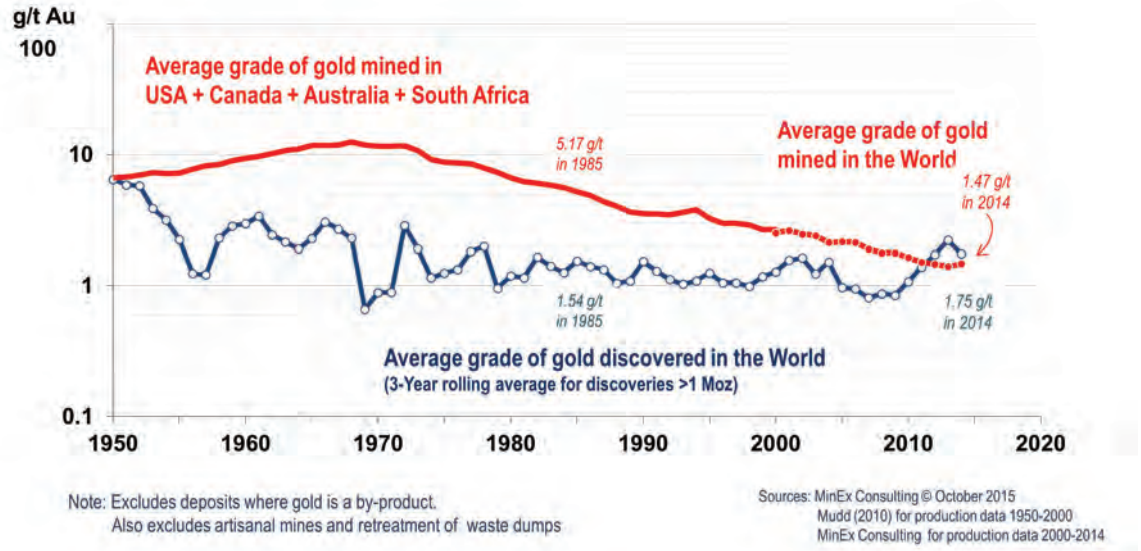

Figure 9: Weighted average grade of primary gold deposits > 1 moz found in the world 1950-2014. For comparison have included data on the reported head grades for operating mines

[6] These include Umm Ash Shalaheeb (1.3 moz @ 16 g/t). Buritica (9.1 moz @ 9.9 g/t), Haiyu (15.1 moz @ 7 g/t), Goose Lake (5.1 moz @ 6.4 g/t), Red Hill/Goldrush (15.4 moz @ 5.0 g/t) and Haiyu (15.1 moz @ 7 g/t).

Trends in the depth of cover of discoveries

One commonly cited factor driving the decline in discovery performance is the industry's inability to effectively explore and find deposits under deep cover[7]. As plotted in Figure 10, while there has been a general trend of increasing depth of discovery, this mainly applies to brownfield discoveries. By comparison, most greenfield discoveries continue to be made at or near surface.

Figure 11 shows the distribution of depth of cover for 300 primary deposits found in the world in the last decade. It is a mix of brown and greenfield discoveries. As measured in terms of the number of deposits found, 52% of all of the discoveries were under zero cover; i.e. they outcropped. In terms of contained ounces 38% of all gold found was under no cover.

The average depth of cover for recent discoveries was 64m; rising to 90m if one takes the weighted average of the contained ounces of gold. This implies that many of the deposits currently being found at surface are small in size; and the larger deposits tend to be under deeper cover.

It should be noted the average depth of cover varies by location. Figure 12 shows the average (by number) of all primary gold discoveries by region over the last decade. In mature countries like Australia, Canada and the United States the current generation of discoveries tend to be under deeper cover.

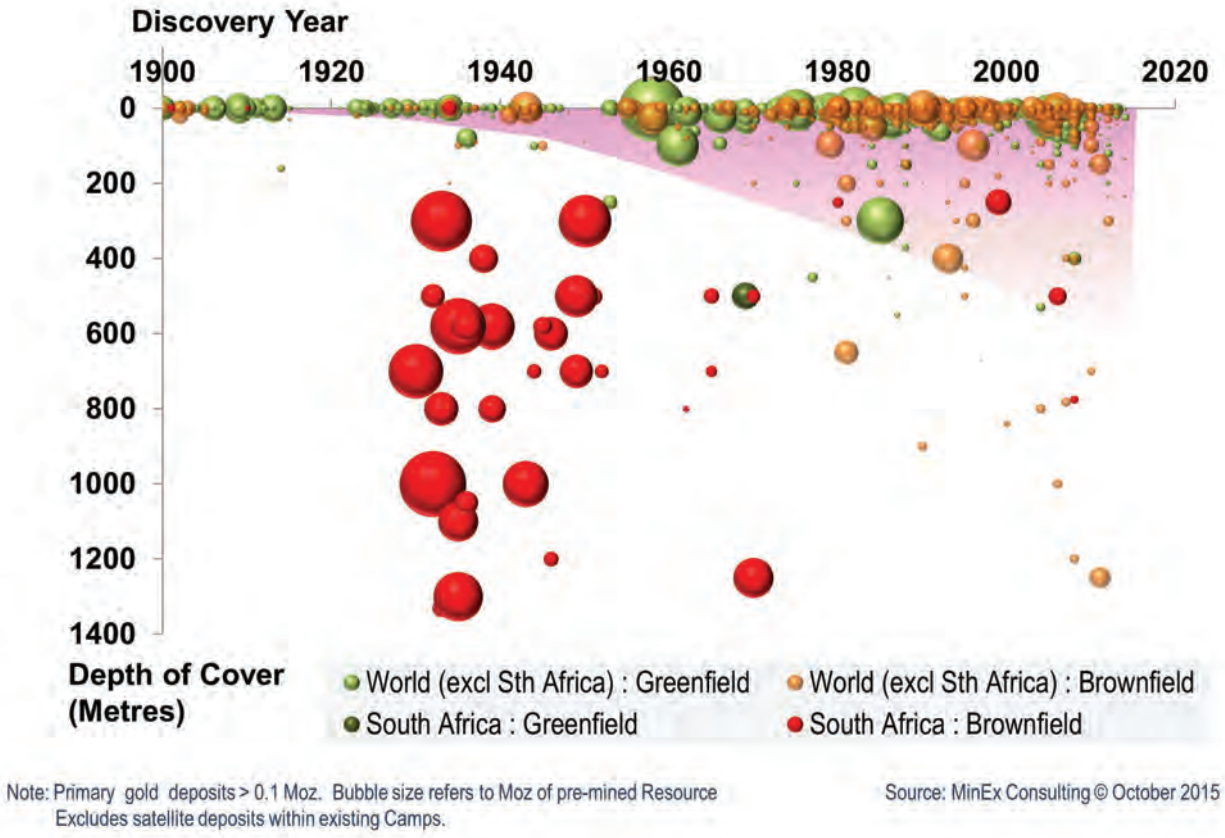

Figure 10: Size and depth of cover for greenfield and brownfield primary gold discoveries in the world and South Africa 1900-2014

[7]The main exception to the rule is South Africa – where several giant deposits were found at depths greater than 1000 metres. The reason for this is associated with the unique characteristics of the Witwatersrand – whose deposits are both large, high grade and (more importantly) uniform and predictable. Consequently it was a relatively straight-forward process of using geophysics and drilling along known geological structures to find the deposits at depth. For this reason, the South African discoveries have been plotted separately in Figure 10.

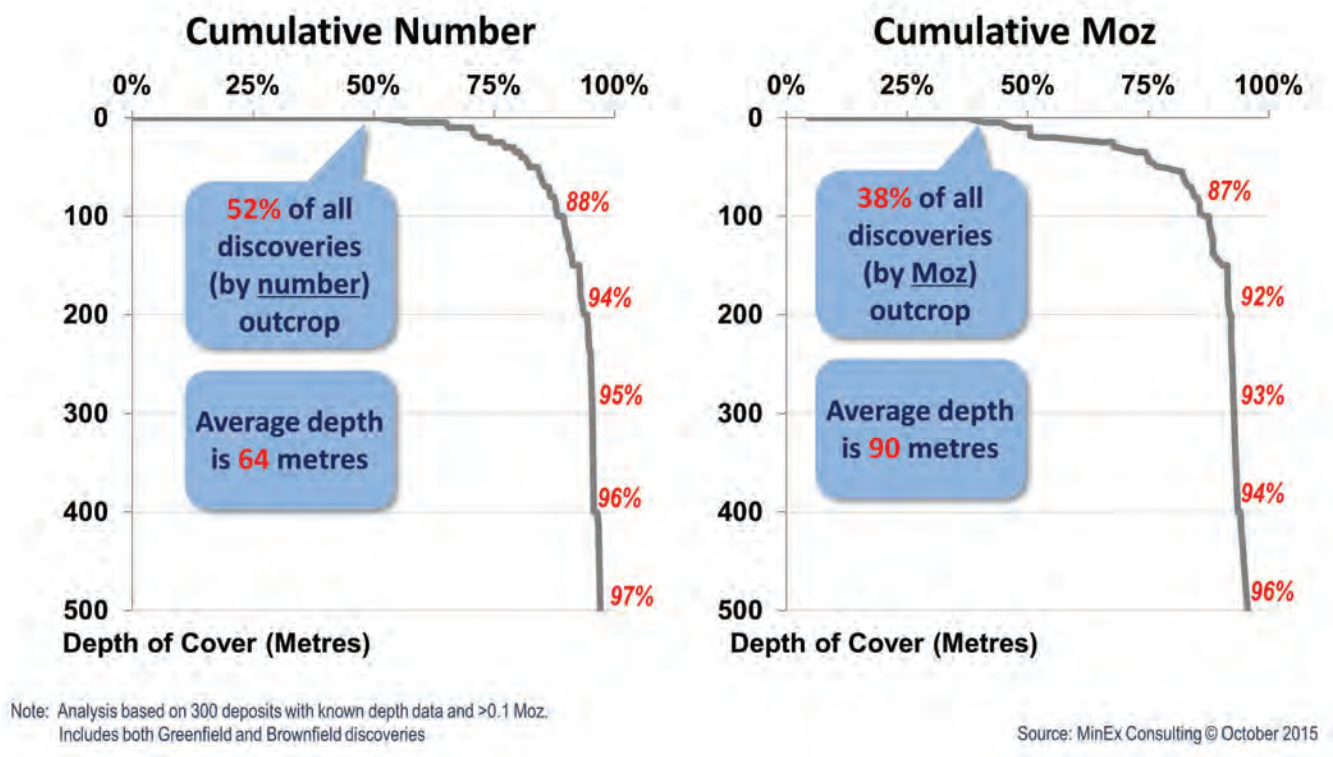

Figure 11: Distribution of depth of cover(by number and by contained ounces) of primary gold deposits >0.1 moz found in the world 2005-2014

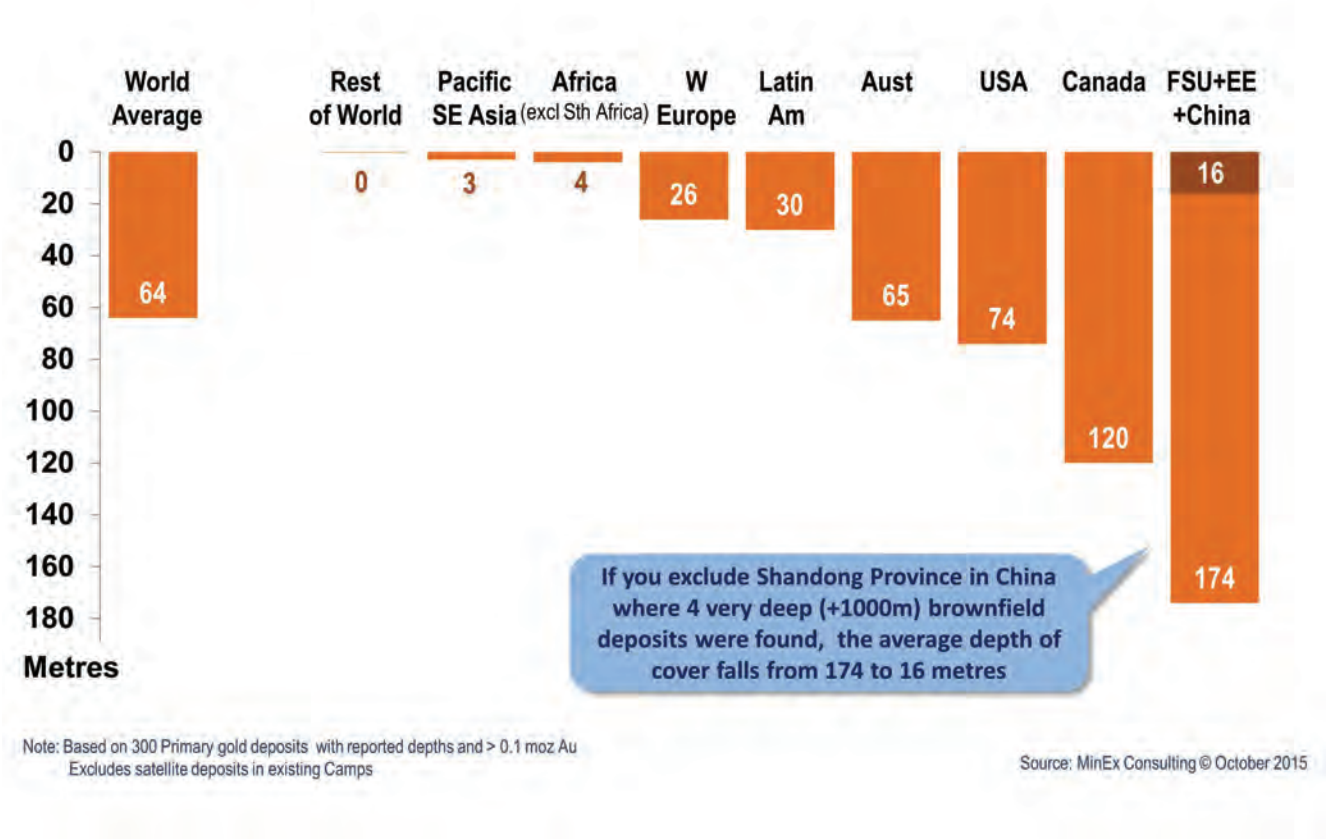

Figure 12: Average depth of discovery (by number) of primary gold deposits >0.1 moz found 2005-2014

Trends in the quality of discoveries

While the number of deposits and ounces found is important, of more importance is the total number of deposits that are economically significant (i.e. company-making mines) – as these contain most of the wealth generated by the industry. Figure 13 shows that on average only one Tier 1 deposit[8] is found in are found in the world every one or two years. In addition, around four Tier 2 deposits are found each year. Given the scale of the industry (spending $2-6 billion pa on exploration) Tier 1 and 2 discoveries are very rare events.

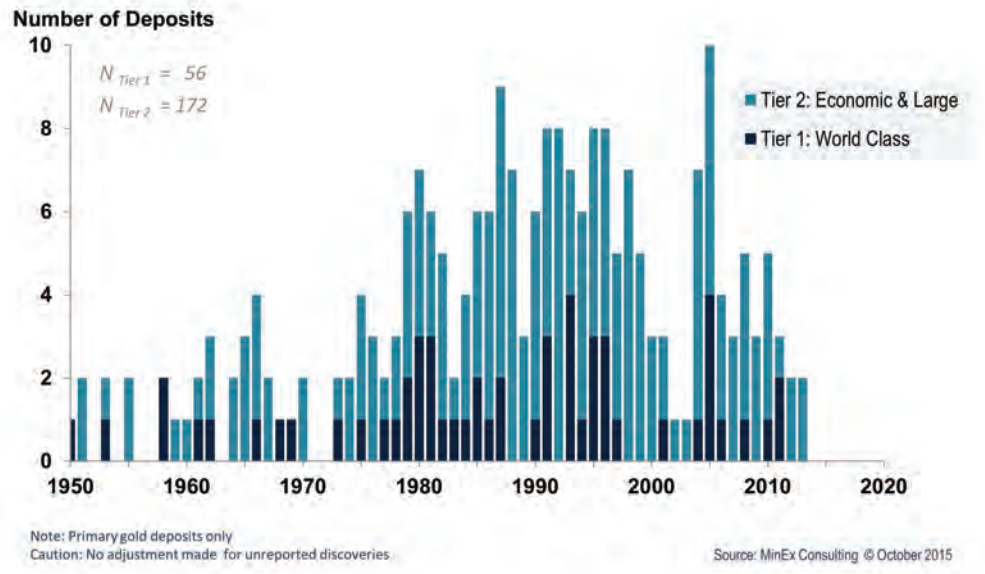

Figure 13: Number of Tier 1 and 2 discoveries made in the world 1950-2014

Tonnes/grade characteristics of Tier 1 and other deposits

Tier 1 mines are world-class in every sense. They are large, low cost and long life. They often, but not always[9], have high grades. Other modifying factors are mining costs, recovery rates, infrastructure requirements and country risk.

As indicated in Figures 14 and 15, for a deposit to have the potential to be considered Tier 1, it generally needs to be more than 10 moz in size and have a grade of more than 0.8 g/t gold equivalent if it is an open pit mine, or more than 4 g/t gold equivalent if it is an underground mine. In practice, 90% of all Tier 1 deposits meet these criteria, and account for half of all deposits in this range (with the others being Tier 2 or 3 deposits).

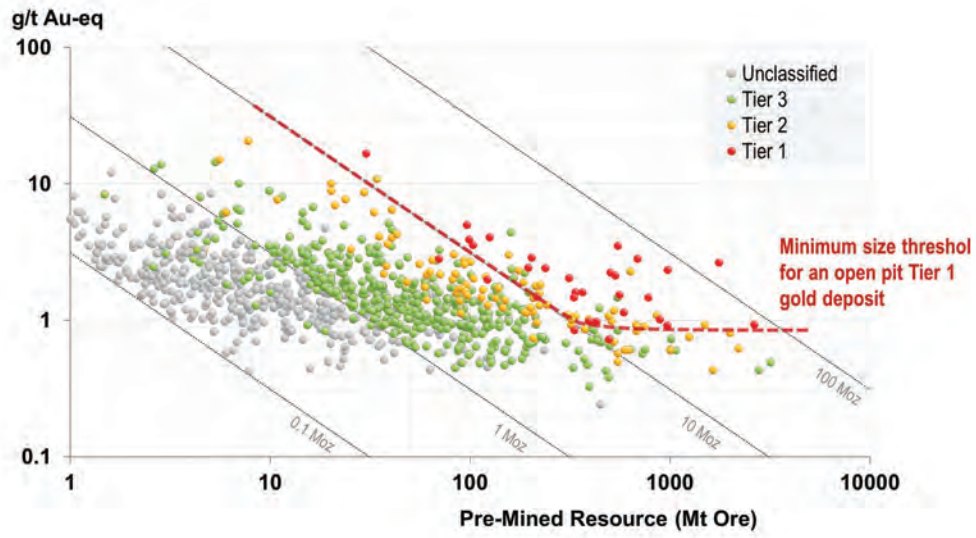

Figure 14: Tonnes and grade of open pit Tier 1 and other primary gold deposits in the world

[8] See Appendix A for definitions of the various Tiers.

[9] Examples of low grade Tier 1 deposits would be Yanacocha (with a pre-mined resource of 2638 Mt @ 0.79 g/t Au), Cadia (3678 @ 0.42 g/t Au + 0.24% Cu) and Cripple Creek (844 Mt @ 0.67 g/t Au). Their key to success is their low mining costs (driven by economies of scale and/or low stripping ratios) and ease of processing (such as heap leaching).

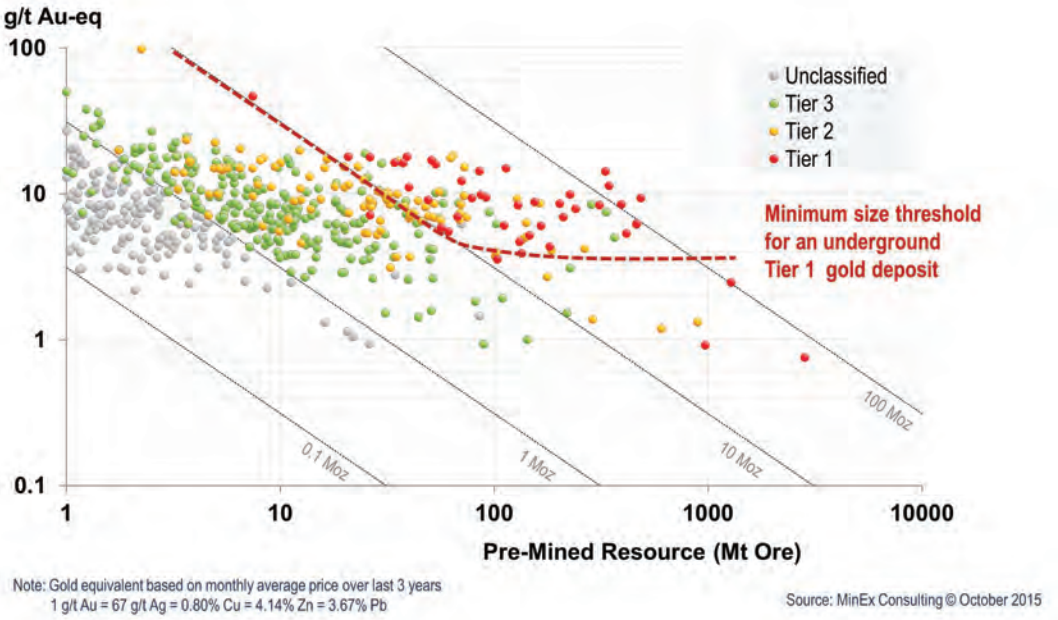

Figure 15: Tonnes and grade of underground Tier 1 and other primary gold deposits in the world

Trends in unit discovery costs

Dividing the total exploration expenditures by the amount of gold found gives the unit discovery cost per ounce. As can be seen in Figure 16, unit costs have been progressively rising over time – and for the last decade (2005-2014) the unit discovery cost for the world averaged $42/oz of gold-equivalent[10]. By comparison, average costs in the previous two decades were $24/oz (for 1995-2004) and $18/oz (for 1985-1994) respectively. The unit discovery cost is currently running at more than $70/oz gold equivalent.

It should be noted that the above cost figure of $42/oz gold equivalent for 2005-2014 includes an allowance for the expected growth in recent discoveries, leaving this out increases the cost to $62/oz.

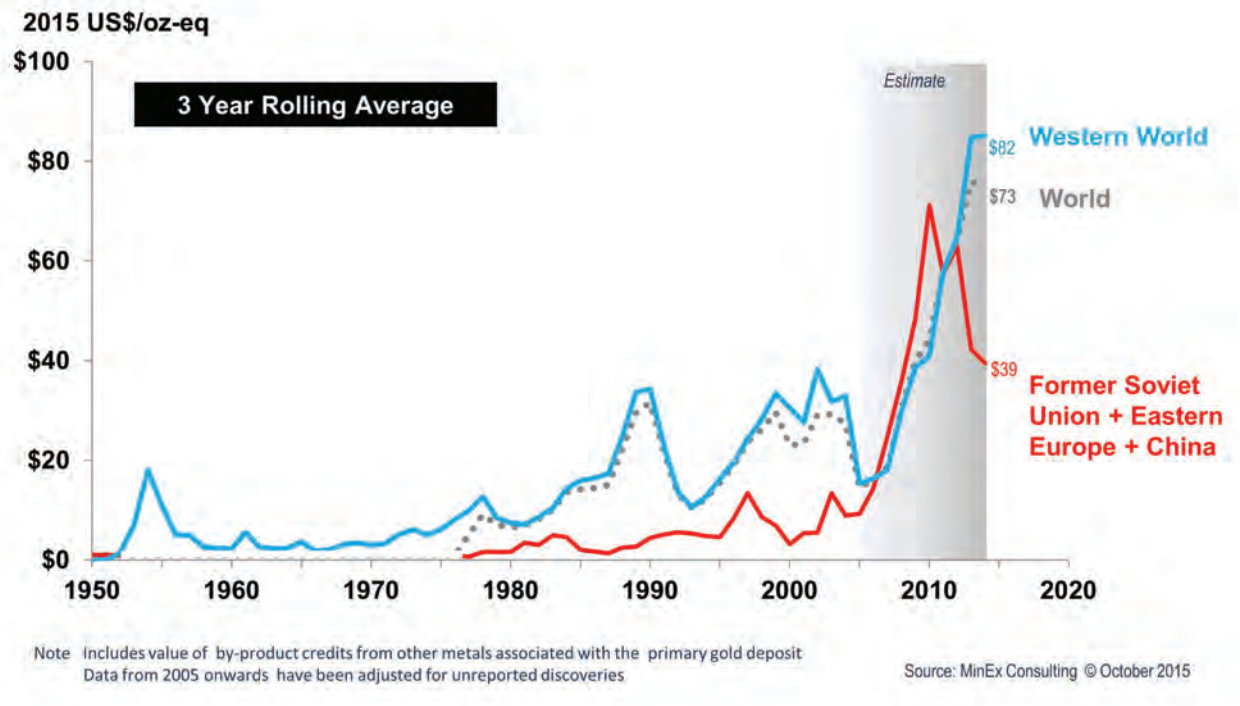

Figure 16: Unit discovery costs and price for gold in the Western world and the Former Soviet Union-Eastern Europe-China 1950-2014

[10]This figure rises to US$49/oz for the last decade if one excludes the value of the silver, copper and other by-product credits. The corresponding discovery costs for 1995-2004 and 1985-1994 are $26 and $20/oz respectively

One oft-cited explanation for the decline in performance is the view that the world is running out of easy targets, and that it is progressively becoming more difficult to make a discovery. Figure 17 confirms that it is getting expensive to make a discovery – with the average cost per gold deposit found increasing from $55 million to $142 million over the last three decades.

Many industry commentators lament that *"all of the deposits sticking out of the ground have now been found"*. While this makes for a good sound-bite, it doesn't match the fact that, as discussed earlier, over the past decade, 52% of gold deposits recently found in the world outcropped.

Another, more telling observation, is that the transition away from outcropping gold deposits has been gradual and, as such, does not fully explain why there has been a sudden decline in exploration productivity in recent years.

The author argues that a more likely culprit is the dramatic and sustained increase in input costs such as drilling, labour, land access and administration. All of these have doubled in real terms in recent years. For example, data compiled by the author (Schodde, 2013a) for Canada found that, between 2000 and 2012 average drilling costs[11] (as measured in constant June 2012 US dollars) increased from $US112 to $US210/m, and the cost of hiring an experienced exploration manager increased from $US93,000 to $US170,000 pa.

Similar rises have been experienced by other services and in other countries. Consequently, given that it cost twice as much to do the same amount of work in the field, it should be of no real surprise to the reader that the cost per discovery has also correspondingly doubled over the same timeframe.

Ironically, the main factor behind the rise in input costs is the mining boom itself – which drove up the demand for exploration services, as well as strengthening the currencies in many resource-rich countries. Stronger currencies made locally-sourced inputs expensive when measured in US dollar terms.

Given that the recent mining boom has come to an end, industry is starting to see a return to lower exchange rates, cheaper drilling and more reasonable labour costs. However, input costs associated with operating in remote areas and/or addressing safety, social and environmental concerns continue to remain high and even increase over time. Furthermore, the challenge of exploring under deeper cover will continue to increase over time.

Offsetting some of the cost rises are continued innovations in search technologies, drilling methods and better management practices. The application of innovative geoscience practices along with adoption of technological advancements represents one of the few avenues to substantially unwind and reduce these cost pressures in exploration.

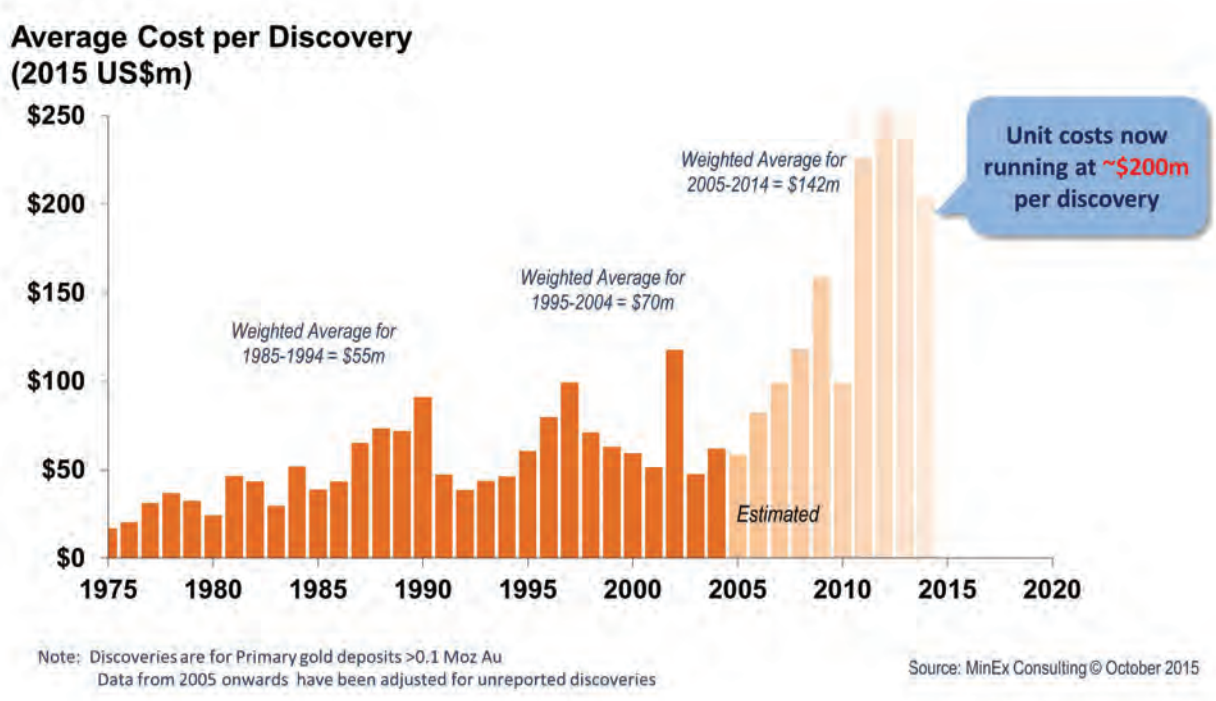

Figure 17: Average cost per discovery in the world for primary gold deposits >0.1 moz 1975-2014

[11] The reported unit drilling cost excludes the associated cost of analytical services.

Discovery performance over the last decade by region

Table 3 summarises the average discovery performance and costs by region over the last decade. In summary:

- In terms of the average cost per deposit found, the figures ranged from $76 million per deposit in the Rest of the world to $398 million in Pacific/Southeast Asia.
- The average size of deposit found in the world was 3.39 moz. Australia was well below average, at 1.80 moz, whereas Canada was the largest at 8.26 moz. It should be noted though that the Canadian figure was skewed by a handful of giant discoveries – such as Kerr-Sulphurets (75.3 moz) and Snowfield (35.0 moz).
- In terms of the average unit cost per ounce found, the figures varied from a low of $31/oz gold equivalent in Canada through to $334/oz gold equivalent in Pacific/Southeast Asia. Australia ($61/oz gold equivalent) and the United States ($71/oz gold equivalent) were significantly higher than the global average of $42/oz gold equivalent.
- In terms of the number of Tier 1 and 2 deposits found (which are the most valuable targets), Canada and Latin America faired best, with respectively nine and 10 deposits each.
- It is estimated that the world generated $40.9 billion in value from exploration. Over the same time period industry spend a total of $60.5 billion on gold exploration, giving a "bang-per-buck" of 0.68. The best performers were Canada (0.96) and Australia (0.87).

With regard to the final dot-point, the analysis implies that over the last decade exploration (on average) has been an unprofitable activity. In practice, the true situation is better than this – as the analysis doesn't capture the value of unreported discoveries or include the upside potential for projects to have their tier status upgraded through additional drilling. Finally, with the end of the mining boom, input costs for exploration (such as drilling and salaries) will be lower in the future.

	No of Discoveries			Ounces Found (Moz)			By-Product Credits (Moz-eq)	Avg Deposit Size (Moz-eq)	Exploration Expenditures		Discovery Cost (2015$)		No of Tier 1&2 Deposits		Est Value Found (c)		Estimated (d) Bang-per-Buck
	Identified	Adjusted [(a)]		Identified	Adjusted [(a)]		Adjusted [(a) (b)]	Adjusted Basis	(2015 US$b) [A]		per Discovery ($m/deposit)	per Oz-eq ($/oz-eq)	Found		(2015 US$b) [B]		[B] / [A]
TOTAL																	
Australia	37	48	*11%*	38.6	82.6	*7%*	3.8	1.80	$5.3	*9%*	$109	$61	5	*14%*	$4.6	*11%*	0.87
Canada	38	46	*11%*	245.9	304.8	*24%*	75.1	8.26	$11.6	*19%*	$252	$31	9	*24%*	$11.1	*27%*	0.96
USA	17	19	*4%*	46.3	77.5	*6%*	2.6	4.22	$5.7	*9%*	$298	$71	3	*8%*	$2.8	*7%*	0.49
Latin America	68	82	*19%*	194.2	274.9	*22%*	77.8	4.30	$14.4	*24%*	$176	$41	10	*27%*	$8.3	*20%*	0.57
Pac/SEA	9	10	*2%*	8.2	10.4	*1%*	1.5	1.19	$4.0	*7%*	$398	$334	0	*0%*	$0.4	*1%*	0.09
Africa	107	128	*30%*	159.0	251.6	*20%*	0.7	1.97	$9.5	*16%*	$74	$38	6	*16%*	$6.3	*16%*	0.67
W Europe	13	16	*4%*	14.3	30.9	*2%*	5.4	2.27	$1.4	*2%*	$86	$38	0	*0%*	$0.5	*1%*	0.36
FSU+EE+China	54	64	*15%*	107.3	195.8	*16%*	17.4	3.33	$8.2	*14%*	$128	$38	4	*11%*	$6.7	*16%*	0.82
ROW	5	7	*2%*	6.5	17.7	*1%*	2.9	2.94	$0.5	*1%*	$76	$26	0	*0%*	$0.2	*1%*	0.43
Western World	***294***	***360***	*85%*	***713.0***	***1050.4***	*84%*	***169.7***	***3.39***	***$52.3***	*86%*	***$145***	***$43***	***33***	*89%*	***$34.2***	*84%*	***0.65***
World	***348***	***426***	*100%*	***820.3***	***1246.2***	*100%*	***187.1***	***3.36***	***$60.5***	*100%*	***$142***	***$42***	***37***	*100%*	***$40.9***	*100%*	***0.68***

(a) Data has been adjusted for unreported discoveries and forlikely resource growth over time. The scale of the adjustment varies with how recent the reported discovery was made.

(b) The by-product credit refer to the value (in gold-equivalent) of copper, silver and other metals associated with the primary gold deposit.

(c) An indicative value was calculated for the discoveries based on an average (in 2013 US Dollars) of $2000m, $500m, $80m and $10m for a Tier 1, 2, 3 and Unassigned discovery. These figures refer to the value at the "Decision to Build" stage. An adjustment factor was applied to those projects still at the initial discovery, drill-out and feasibility study stage. The respective factor was 50%, 67% and 83%.

(d) The "Bang-per-Buck" refers to the ratio of the *Estimated Value of the Discovery* [B] versus *Exploration Expenditures* [A] . No adjustment has been made for the time-value of money, or for the likelihood that the current reported resource (and Tier classification) may grow /increase in value over time.

Sources: Discovery data - MinEx Consulting © October 2015
Expenditure data - Derived from SNL's Annual Corporate Exploration Strategy Surveys, reported Government Statisitics and MinEx's own estimates

Table 3: Performance and estimated costs for primary gold exploration by region 2005-2014
Based on primary gold discoveries >0.1 Moz

How much of the world's gold resource have been mined to date?

As discussed earlier, it is estimated that the total known pre-mined gold resource for the world is around 14,500 moz. By comparison, as at the end of 2014, the world Gold Council estimates the world's surface stocks of gold to be 183,600t – equal to 5,900 moz (world Gold Council, 2015). Assuming that 10-20% of the current available gold has been lost during mining, processing and consumption, the total amount of gold mined in the world (on an in-situ basis) is estimated to be around 6,500-7,100 moz. On this basis, the author estimates the world has consumed to date around 45-50% of its known resources.

Is the world finding enough gold to meet future needs?

One of the challenges facing the mining industry is the question of whether its exploration efforts are sufficient to grow the resource base and meet the future demand for metal.

Figure 18 shows that over the last four decades, the amount of gold mined in the world has increased from 36 mozpa in 1975 to 92 mozpa in 2014, giving a compound annual growth rate of 2.2%.

Figure 18 also shows that over the last two decades the annual amount of gold being discovered in the world has flat-lined at around 120-160 mozpa (with an average of 141 mozpa over the period 1995-2014). While this suggests the world is finding more gold than it consumes, it should be noted that not all of the gold found is economic, and for those deposits that do eventually get developed, 10-20% of the of the contained gold will be lost during mining and processing.

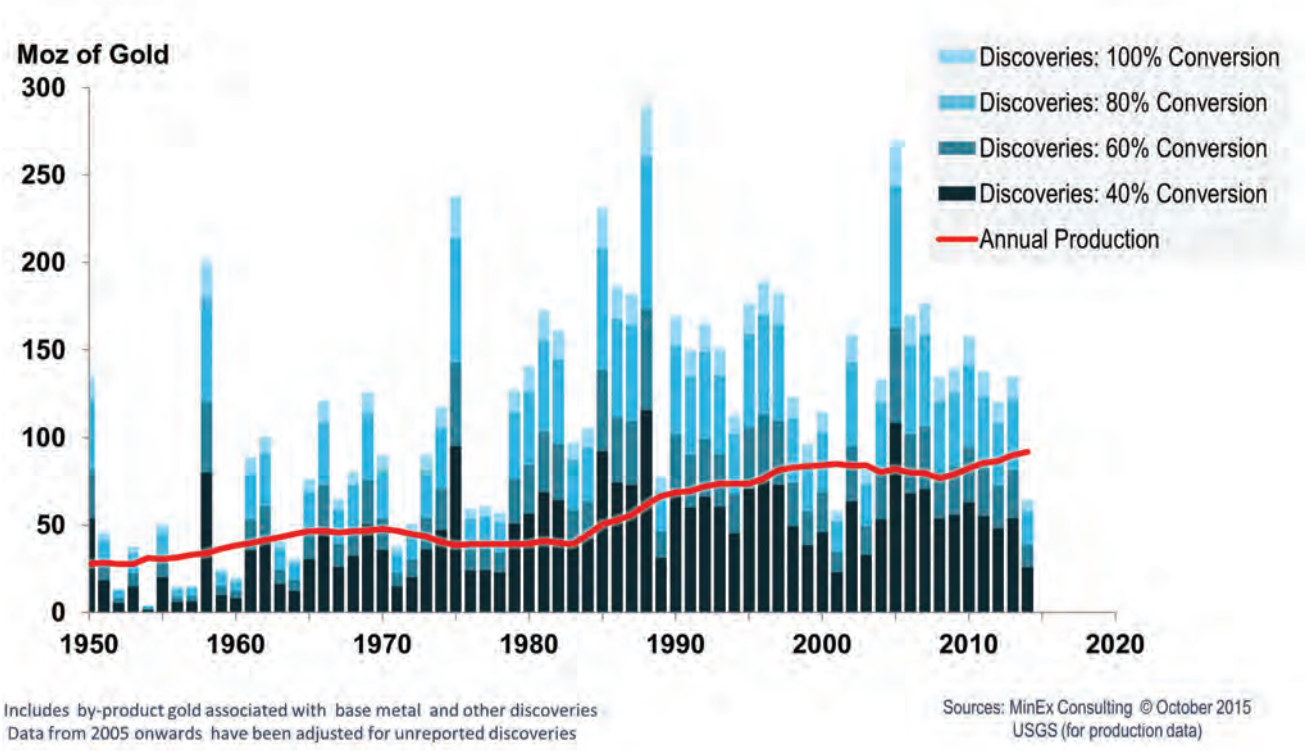

Figure 18: Amount of gold mined in the world versus discovery rate: 1950-2014

As a rule-of-thumb, typically only 60-80% of the gold found will be converted into metal. For comparison, the current mining rate is equal to (92/141 =) 65% of the current average discovery rate. This suggests the gold industry is struggling to replace the ounces mined. Assuming that demand continues to grow without any corresponding increase in the current discovery rate, there is the risk that a supply gap may open up over time. Adding to the challenge is the fact that there is, on average, a 10-year delay between discovery and development (Schodde, 2014) which means industry is not in a strong position to quickly respond to find and build new mines. This has profound implications on the future price of gold.

Summary/conclusions

In 2012 global expenditures for gold reached an all-time high $10.5 billion – up from $0.32 billion (in constant June 2015 US dollars) spent back in 1975. Since then, expenditures have dropped by 55% to $4.7 billion in 2014. A review of past business cycles suggests expenditures may fall by a further 10-20% before entering the next up-cycle.

MinEx estimates that over the last decade (2005-2014) a total of $60.5 billion (in constant June 2015 dollars) was spent on exploring for gold. During that time, 348 primary gold deposits (>0.1 moz) were found containing 820 moz. A further 62 (mainly base metal) discoveries were made where gold is a by-product. These contained 178 moz, giving a total of 998 moz found over the decade.

Using a minimum size threshold of 1 moz, the corresponding figures are 185 primary gold deposits plus a further

25 deposits where gold is a by-product, containing a total of 753 moz and 163 moz respectively, for a total of 916 moz found over the decade

The above reported discovery figures should be treated as being conservative, as they do not include unreported discoveries or take into account the inherent delays in drilling out and proving up the deposit. Based on previous work by the author on the reporting and growth history of major gold deposits, it is estimated the adjusted number of primary gold deposits found over the last decade is likely to be around 426 deposits containing 1,246 moz. Adding in by-product gold increases the adjusted total to 1,497 moz.

With regard to the primary gold deposits, it is noted that silver, copper and other metal by-product credits effectively boost the value of the gold discovered in the last decade by 10%.

Based on the above, MinEx Consulting estimates that the average unit discovery cost for 2005-2014 was $42/oz of gold equivalent (in constant June 2015 US dollars). This is nearly double the discovery cost for the previous decade – of $24/oz for 1995-2004.

A similar story applies on the unit cost per gold deposit found. For primary gold deposits of less than 100,000oz, the average cost over the last decade was $142 million versus $70 million in the previous decade.

The author contends the main reason for the sudden increase in cost is due to a dramatic increase in input costs – such as drilling, labour, land access and administration. All of these have doubled in real terms between 2000 and 2012 – with the key driver being the inflationary effects associated with the mining boom, coupled with stronger currencies for Australia and Canada. With the subsequent end of the mining boom, exploration costs should return back to normal over the next few years.

With regard to the depth of cover issue, over the last decade, half of all primary gold discoveries (by number) were outcropping. The average depth of cover was 64m. This is set to rise over time.

In terms of discovery performance, some regions do better than others. In particular, Canada accounted for 19% of the exploration expenditures, 11% of the deposits (by number) and 24% of the total ounces. It also accounted for 24% of the Tier 1 and 2 deposits found. For comparison, Pacific/Southeast Asia accounted for 7% of expenditures, found 2% of the primary gold deposits (by number) but only 1% of the total ounces and no Tier 1 and 2 deposits.

The 10 current “hot spots” for exploration success are Alaska/Yukon, Northern Ontario., southwest USA/Mexico, the Cordillera in Latin America, West Africa, Central/Northeast Africa, Turkey/Caparthian Belt, China, Far East Russia and Western Australia.

In terms of the value of discoveries made, versus the cost of exploration, the industry performed poorly over the last decade – achieving a notional “bang-per-buck” of 0.68. The best performing regions were Canada (0.96) and Australia (0.87) and the worst was Pacific/Southeast Asia (0.09). In practice the true situation is better than this as the analysis doesn’t capture the value of unreported discoveries or include the upside potential for projects to have their tier status upgraded through additional drilling.

Finally, with the end of the mining boom, input costs for exploration (such as drilling and salaries) will be lower in the future.

Most of the value created by industry is associated with Tier 1 and 2 discoveries – with a weighted average value of $2 billion and $500 million (in 2013 US dollars) respectively. Unfortunately, they are difficult to find. On average only four Tier 2 deposits are found in the world each year. Tier 1 deposits are even rarer – with only one being found every 1-2 years.

As a rule of thumb, for a gold discovery to be considered Tier 1 the deposit needs to be at least 10 moz in size and have a grade of more than 0.8 g/t gold if it is an open pit, or more than 4 g/t if it is underground. Even so, only half of the deposits that meet these criteria are rated Tier 1. This emphasises the scarcity of these deposits.

With regard to the future, it is noted that the amount of gold mined in the world rose from 36 mozpa in 1975 to 92 mozpa in 2014. This is set to rise further in the future. By comparison, over the last two decades, in spite of a massive increase in exploration expenditures, the amount of gold discovered has flat-lined at 120-160 mozpa. While this suggests that the industry is finding more gold than it mines it should be noted that in practice only 60-80% of gold found is extracted. This is because not all discoveries are economic. Also, for those deposits that are mined not all of the resources will be extracted, and 10-20% of the contained metal will be lost during mining and processing. On this basis, the industry is struggling to replace the ounces mined. This has profound implications on the future price of gold.

Appendix A: Tier definitions

The reader should be cautioned that there are no industry-agreed set of rules regarding the definition of a Tier 1, 2, 3 or 4 discovery. The following are the working definitions used by MinEx Consulting to assess their "quality":

- **Tier 1 deposits** are "company-making" mines. They are large, long life and low cost.

  Using long run commodity prices it generates more than $300-600 million pa of revenue (i.e. more than 200,000 tpa copper or more than 800,000 tpa zinc-lead or more than 5,000 tpa of U3O8 or more than 250,000 ozpa gold) for more than 20 years and is in the bottom quartile of the cost curve. The project has very robust economics and will be developed irrespective of where we currently are in the business cycle and whether the deposit has been fully drilled out. The resource is of a size/quality that it creates multiple opportunities for expansion.

  As at January 2013, Tier 1 deposits have a risk-adjusted NPV at the decision-to-build stage of more than $US1 billion, as based on forecast long-run commodity prices. For purposes of modelling, the weighted aver age expected value is set at $2 billion in 2013 US dollars

- **Tier 2 deposits** are "significant" deposits - but are not quite as large or long life or as profitable as Tier 1 deposits; i.e., it only meets some of the Tier 1 criteria.

  Typically, Tier 2 deposits are profitable in all but the bottom of the business-cycle. However, they have limited "optionality" because of modest size and mine life.

  It is noted that, over time, through additional delineation and/or changes in costs or business risk some Tier 2 deposits may ultimately become Tier 1 deposits.

  As at January 2013, Tier 2 deposits have a risk-adjusted NPV at the decision-to-build stage of $US200-1,000 million. The expected value is set at $500 million in 2013 US Dollars.

- **Tier 3 deposits** are small / marginal deposits (most deposits found fall into this category) While they can be profitable – at best they don't meet more than one of the Tier 1 or 2 criteria.

  Typically these projects only get developed during the top of the business cycle and/or developed only if they are satellite operations to an existing business (i.e. they would never be developed as a stand-alone mine).

  As at January 2013, Tier 3 deposits have a risk-adjusted NPV at the decision-to-build stage of $US0-200 million. The expected value is set at $80 million in 2013 US dollars.

- **Tier 4 deposits** are uneconomic deposits. Using long run price forecasts, the deposit has a negative NPV at the decision-to-build stage and is unlikely to be developed (even at the top of the business cycle).

As a general rule the above tier classifications only apply to deposits that "major" (or larger) in size, where "major" is defined as deposits containing a pre-mined resource more than 1 moz gold. For purposes of this study, moderate-sized gold deposits in the range 0.1-1 moz as "unclassified" and are assigned a notional value of $10 million in 2013 US dollars.

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