

Recent trends in gold discovery

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Introduction

Industry wisdom is that it is getting harder to make good gold discoveries.

This paper reviews the general trends in gold exploration and discovery over the last 60 years with a particular focus on the last decade. It discusses the trends on the number, size, type and location of gold discoveries around the World.

It also includes a detailed analysis of how quickly new discoveries “grow”. In addition to the commercial importance in assessing the “blue-sky” potential of a new discovery, incorporating the growth factor into the analysis moderates some of the adverse trends in recent discovery rates. Even so, the author notes that unit discovery costs are rising over time and the industry continues to struggle to grow its resource base.

Background

The following analysis is based on a database compiled by MinEx Consulting, which has information on over 49,000 mineral deposits around the World, including 24,800 deposits containing >10 koz of gold. Within this are 4,443 deposits >100 koz. After excluding “satellite” deposits (which are counted within the parent camp totals) the database has information on 3,814 unique gold deposits >100 koz. Of these MinEx has discovery dates for 2,658 of these. Special efforts have been made to ensure that that the coverage and data on those deposits >1 Moz is as complete and up-to-date as possible.

It should be noted that whilst the database is comprehensive; coverage is by no means complete.

Based on analysis of the cumulative size-frequency of the known discoveries, MinEx estimates that its database includes 93% of the total ounces of all deposits with declared resources. For deposits >1Moz, the author estimates that the database captures 78% of the total number and 98% of total ounces of all such deposits. The totals used in this analysis include adjustments for missing deposits and under-reporting in the reported size of known deposits found in the last decade. The methodology used for the latter is discussed in more detail in a later Section.

The paper uses the same methodology reported by McKeith et al (2010) to define a discovery. In particular, the discovery growth in resource ounces within a camp was attributed 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 exception to this rule are new discoveries in Brownfields settings that transform the understanding of the scale of the mineralised system. Recent examples include the Pebble East discovery in 2002 by Northern Dynasty Minerals in Alaska and Kinross’s discovery in 2010 of 13 Moz of gold in a parallel structure under cover at its Tasiast gold operation in Mauritania. In both circumstances the project was attributed as a new brownfields discovery in the year in which it was made and the original Greenfield discovery is retained in the database at its initial delineated size.

For the purpose of this paper; new Brownfields discoveries require a minimum new resource of 2 Moz gold to qualify as being transformational in scale. Similarly, any stand-alone deposits within an established mining district (or along strike from other companies’ mines) are counted separately as Brownfield discoveries.

The discovery date refers to the date when the deposit was recognised as having significant value. This is usually set as the date of the first economic drill intersection.

Clearly there are many imprecise elements in the underlying data. Questions as to when and by whom discoveries are made are sometimes difficult to adequately capture with one date or one individual or company. For example I have selected the Oyu Tolgoi discovery in Mongolia to have been made by Ivanhoe Mines Ltd in 2002, rather than BHP Billiton Ltd in the late 1990's. BHPB recognised that a significant mineralised porphyry system was present at Oyu Tolgoi but did not advance the exploration to a stage where the full scale of hypogene porphyry Cu-Au mineralisation was properly understood.

It should be noted that a review of the discovery history of the deposit may show that there were pre-existing small-scale workings on the site. For purposes of this paper, if there is a order-of-magnitude step change in the known endowment of the deposit (ie from say 100kz to >1 Moz, the date of the upgrade is viewed as the discovery date for the main deposit. The smaller (earlier) discovery is listed under a separate entry.

The reported gold exploration expenditures are based on the Metal Economic Group's annual survey of the exploration industry which started in 1992. Prior data are estimates from MinEx Consulting based on published historical data from various government agencies (including the ABS and NRCan) and from earlier studies by Tilton et. al.(1988) and Wallace (1992, 1993).

Unless otherwise specified, all figures refer to pre-mine resources. This is the sum of the current reported Measured, Indicated & Inferred Resources plus historic production (on a head-grade basis).

Trends in exploration expenditures

Figures 1 and 2 show the general trend in exploration expenditures for the mining industry in the Western World since 1950. As can be seen, even after adjusting for inflation, expenditures are extremely cyclical and, at the time of writing, are currently at an all-time high of US\$13.7 billion¹. As at 2010, expenditures on gold exploration accounted for nearly \$5.3 billion or 38% of the total.

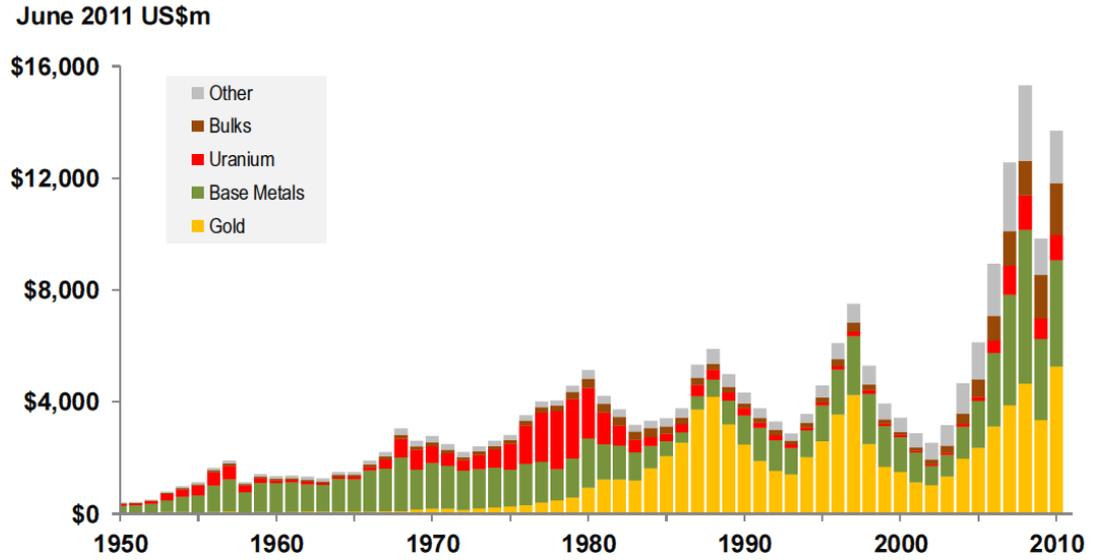
As can be seen, expenditures on gold exploration rapidly grew in the early 1980s. This was driven by a step increase in the price of gold in the preceding years, briefly peaking at \$895/oz on 25 April 1980 (equal to \$2450/oz in June 2011 dollars).

During this period, gold replaced uranium and base metals as the main exploration target for the mining industry (see Figure 2). This still remains the case.

The extreme cyclicity of the industry creates special challenges to individual explorers. In the "boom" part of the cycle the key challenges are gaining access to good ground, and being able to operate effectively in a "hot" market for labour and equipment. In the "bust" part of the cycle, the challenge is being able to maintain an effective level of expenditure in the face of limited access to funds. Exacerbating this is the fact that exploration is a high-risk endeavor and that there may be several years gap between major discoveries. It goes without saying that those that can demonstrate that they are successful in discovery and adding value, and continue exploring at a steady level throughout the business cycle will survive/grow in the longer term.

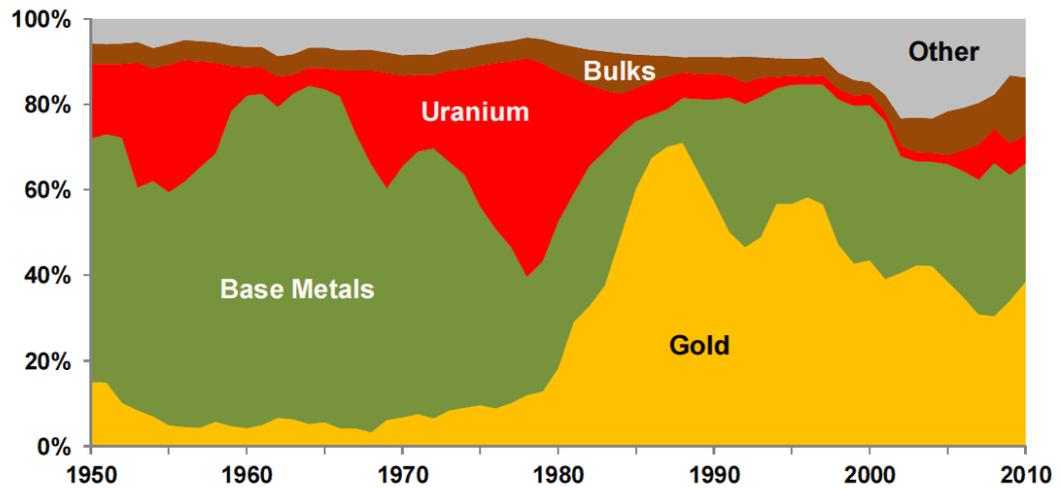
¹ MinEx's exploration figures includes bulk minerals (such as iron ore, coal and bauxite), but excludes expenditures in China and the Former Soviet Union. For comparison, the Metals Economics Group (MEG), a leading provider of exploration data, in its 21st edition of *Corporate Exploration Strategies (CES)* reported a 2010 exploration budget of \$12.1 billion for the World – though this figure excluded bulk minerals. The current analysis is derived from MEG data from 1992 onwards.

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Sources: MinEx Consulting estimates, based on data from ABS, NRCan, Tilton (1988), Wallace (1992,93) and Metal Economics Group © 2010

Figure 1: Trends in mineral exploration expenditures in the Western World 1950-2010 in constant June 2011 US dollars



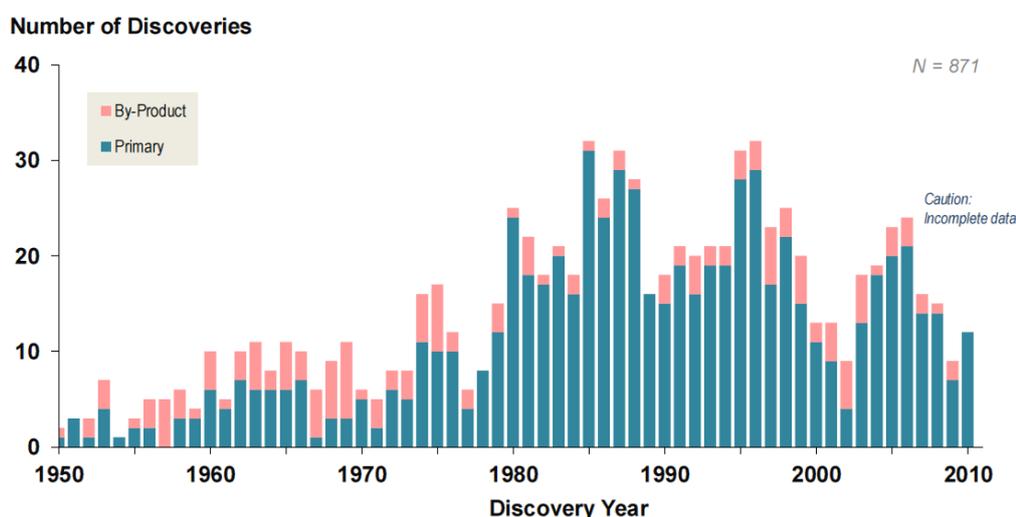
Sources: MinEx Consulting estimates, based on data from ABS, NRCan, Tilton (1988), Wallace (1992,93) and Metal Economics Group © 2010

Figure 2: Trends in mineral exploration expenditures in the Western World 1950-2010, normalised to 100%

Trends in the number & type of discoveries

After adjusting for the (mainly smaller) deposits missing from the database, MinEx estimates that there are around ~8,000 gold deposits >100koz in the World. These contain a total of around 11,800 Moz (or 380 kt) of gold. This includes 180 deposits >10 Moz, containing 5,900 Moz plus a further 1,620 deposits 1-10 Moz in size containing 3,800 Moz. The remaining 6,200 deposits contain 2,100 Moz. In other words, the top 2% of the deposits contain half of all of the World's gold resources.

MinEx's database has identified 871 deposits >1 Moz that have been found in the World since 1950. This is made up of 706 (Primary) deposits where gold is the main metal, and 165 deposits where gold is a by-product of mining other metals (see Figure 3). After adjusting for missing data and deposits smaller than 1 Moz, it is estimated that 6,634 Moz of gold has been found in the last 60 years. 5,186 Moz (or 78%) of this was associated with Primary gold deposits. An estimated additional 768 Moz is assigned to the total to adjust for those deposits found in the last decade (which are expected to grow in size) and/or not yet reported a resource (Figure 4).



Caution: Chart excludes adjustment or missing deposits or resource growth over time

Source: MinEx Consulting © November 2011

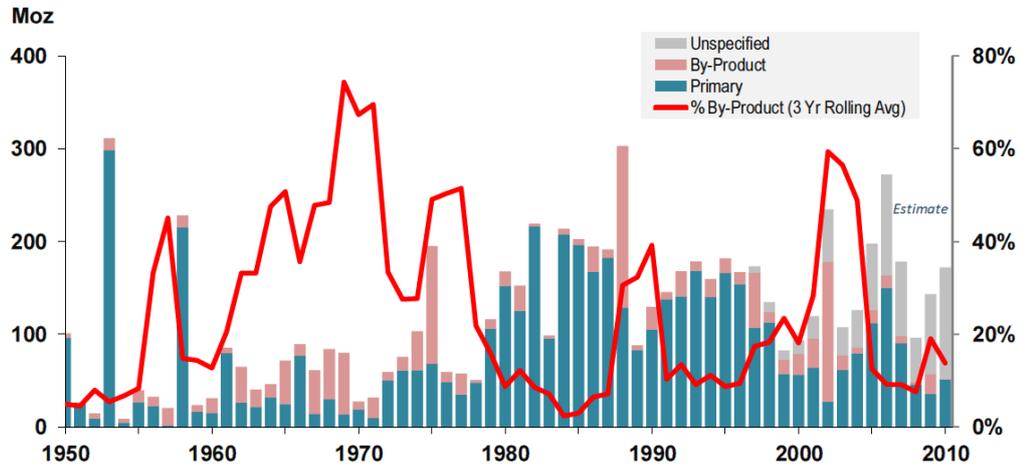
Figure 3: Number of deposits > 1 Moz found in the World 1950-2010 by type. Caution: Excludes deposits missing from the database and/or haven't yet grown to the threshold size

Going forward, 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 5 shows the total amount of ounces found by year. After adjusting for the likely growth in recent discoveries, over the last decade MinEx estimates that the industry was successful in finding on average 165 Moz of declared gold Resources per annum. While this exceeds the average annual production of 80 Moz over the same period, it should be noted that in the past (up to 1990) only 70-80% of all deposits end up being mined. Studies by McKeith et al (2010) suggest that the proportion of recent discoveries turning into mines is even lower. It should also be noted that on mining, 5-10% of the contained metal is lost in extraction and recovery.

GOLD DISCOVERY

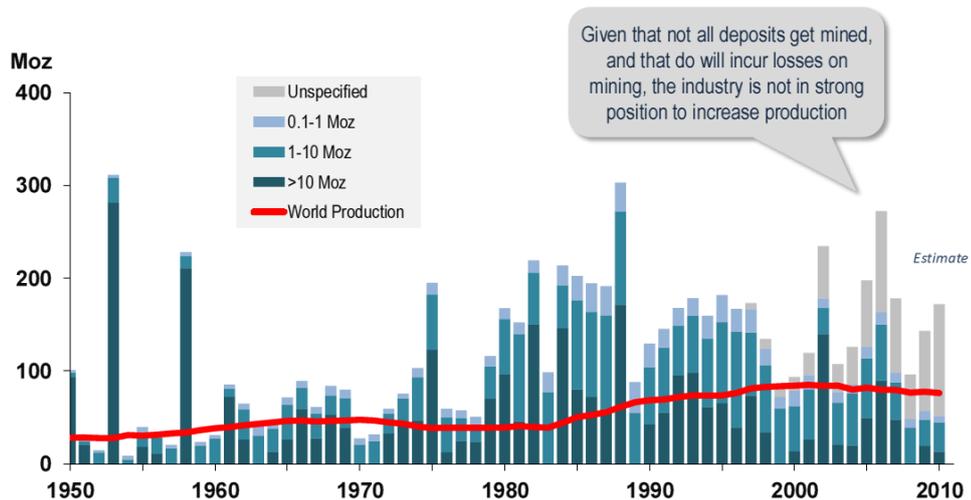
Finally, there is no guarantee that all (or indeed any) of the available resource is economically mineable. Consequently, at current discovery rates, the industry is struggling meet the future growth demand for metal.



Note: Annual figures have been increased by 15% to reflect deposits not in the database (as inferred from the cumulative frequency curve) or those deposits with no reported discovery date

Source: MinEx Consulting © November 2011

Figure 4: Total ounces found in the World 1950-2010 by source. Note: “Unspecified” refers to ounces associated with deposits found in last decade that are still growing in size



Note: Annual figures have been increased by 15% to reflect deposits not in the database (as inferred from the cumulative frequency curve) or those deposits with no reported discovery date

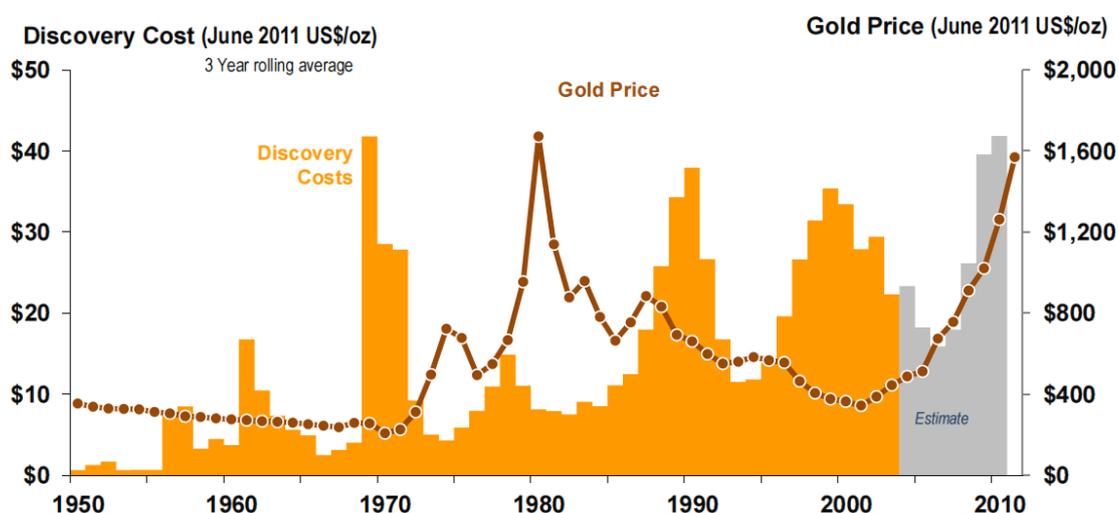
Source: MinEx Consulting November 2011

Figure 5: Total gold production and ounces found in the World 1950-2010. Mine production data from Mudd (2007) and Fellows (2010)

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 6, unit costs have been slowly rising over time – and for the last decade (2000-09) have averaged \$25/oz in constant June 2011 US Dollars. By comparison, average costs in the 1990s and 1980s were \$21/oz and \$16/oz respectively. The unit discovery cost is currently running at \$30 to \$40 per ounce. This figure includes an allowance for expected growth in recent discoveries².

It could be argued that part of the rise in discovery costs may simply be due to the rise in gold prices – as it makes smaller / lower grade targets more economic to explore for and develop. This may explain the low unit costs for the period 1950-70. During this time the gold price was fixed at a nominal US\$35/oz (equal to \$200-300/oz in today's dollars). Consequently, exploration efforts were restricted to searching for high grade deposits only. The absolute level of exploration activity and competition was also modest. However, looking at the period from 1985-2000, discovery costs rose during a period of a sustained fall in gold prices. This suggests that other factors may be at play – such as declining residual endowment and rising input and compliance costs. If so, these issues are likely to persist into the future.



Sources: MinEx Consulting © November 2011
LME

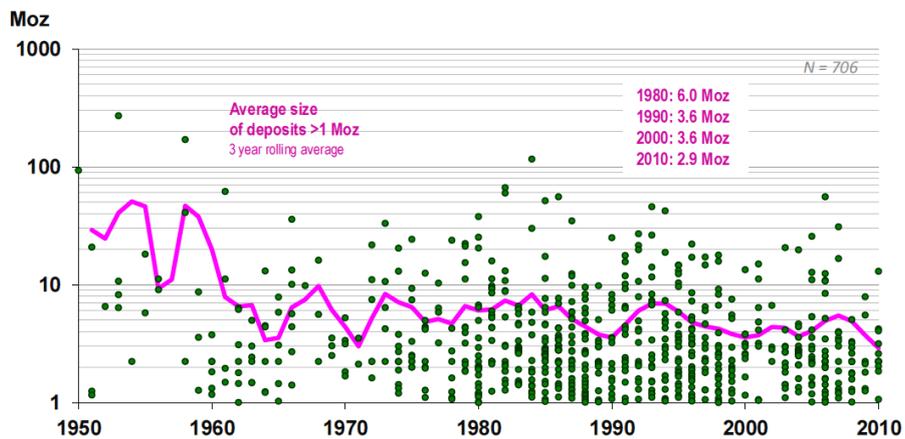
Figure 6: Unit discovery costs and price for gold in the Western World 1950-2010

² Leaving out this growth adjustment increases the 2000-09 discovery cost to \$41/oz.

Trends in the size of discoveries

Figure 7 plots the size distribution of 706 primary gold deposits >1 Moz found since 1950. For much of the period, the weighted average size of these discoveries varied between 3 to 7 Moz. It should be noted that the annual figure is strongly influenced by a handful of giant deposits. Although there has been a modest decline in size over the last 20 years (from 3.6 Moz in 1990-99 to 2.9 Moz in the period 2000-09) this may simply be an artifact of the time taken to fully delineate a given discovery.

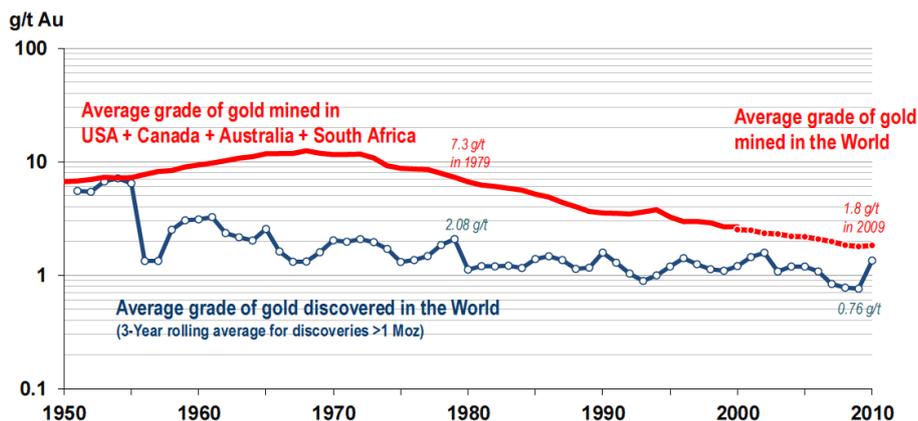
With regard to ore grades the downward trend over time is more apparent (see Figure 8) – from over 2 g/t in the 1960s to 1980s to less than 1 g/t Au at present. This is due to a range of factors – including changes in gold prices and mining practices that make it economic to mine low grade ore. Of more concern is the fact that average head grade of ore mined (i.e. the red line in Figure 8) has dropped faster – suggesting that the inventory of high-grade high-quality deposits is being depleted.



Note: Excludes deposits where gold is a by-product.
No adjustment made for growth in recent discoveries

Source: MinEx Consulting November 2011

Figure 7: Weighted average size of primary gold deposits > 1 Moz found in the World 1950-2010



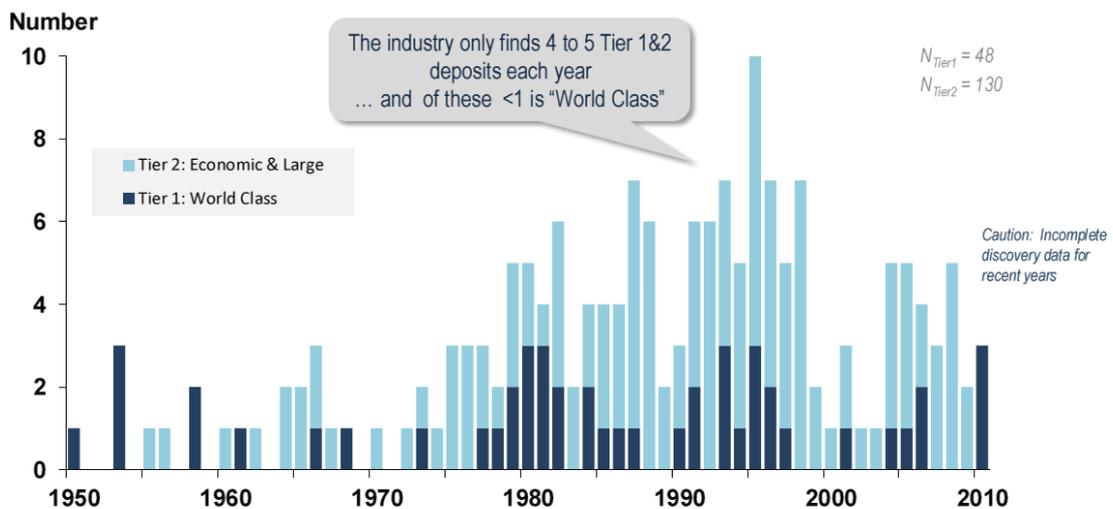
Note: Excludes deposits where gold is a by-product

Sources: MinEx Consulting November 2011
Mudd (2010), Fellows (2010)

Figure 8: Weighted average grade of primary gold deposits > 1 Moz found in the World 1950-2010. For comparison have included data on the reported head grades for (all) operating mines

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 9 shows that on average only one Tier 1 deposit³ is found in the World every 1 or 2 years. In addition, around four Tier 2 deposits are also found each year. Given the scale of the industry (spending \$2-5 billion pa on exploration) Tier 1 and 2 discoveries are very rare events.



Note: Primary gold deposits only

Source: MinEx Consulting © November 2011

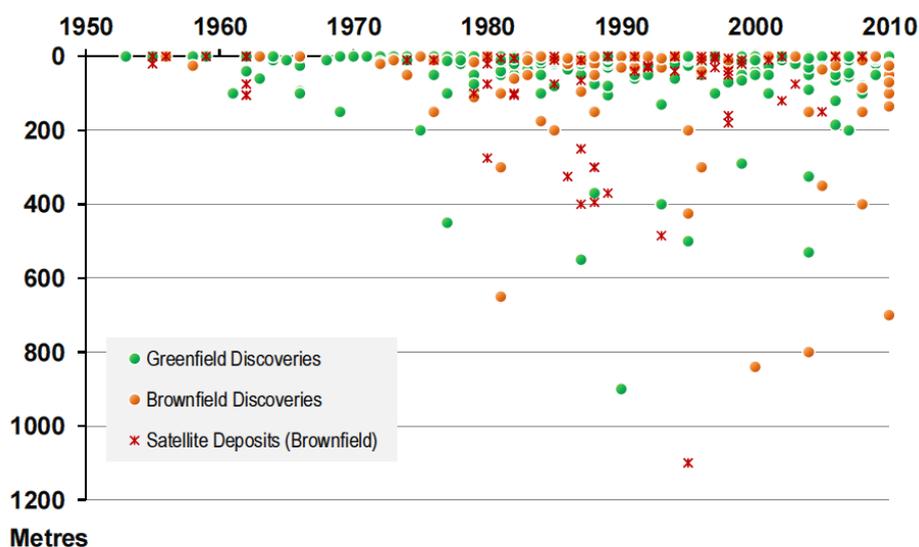
Figure 9: Number of Tier 1 and 2 discoveries made in the World 1950-2010

³ MinEx Consulting defines Tier 1 deposits as being “World-Class” mines. They are large, long life and low cost. Using long run commodity prices Tier 1 deposits generate >\$300m pa of revenue (i.e. >250ktoz pa of gold) for >20 years and are in the bottom 20% of the cost curve. These deposits have very robust economics and will be developed irrespective of where we 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. The NPV at the time of development is > \$1 billion.

Tier 2 deposits are defined as “Company-Making” or “Significant” mines. They 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 economically attractive / profitable in all but the bottom of the business-cycle. However they have limited “optionality” because of modest size or 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. The NPV at the time of development is around \$300-\$1000 million.

Trends in the depth of cover

One factor driving the decline in discovery performance is the inability for the industry to effectively explore and find deposits under deep cover. As plotted in Figure 10, most Greenfield discoveries continue to be made at- or near- surface. Over time this search-space becomes progressively depleted. As indicated in Table 1, the average depth of cover for Greenfield discoveries has remained unchanged at 29 metres, and nearly half of these deposits outcrop. The situation for Brownfield discoveries is different, and does show a steady trend towards deeper discoveries⁴.



Source: MinEx Consulting © November 2011

Figure 10: Depth of cover for Greenfield and Brownfield Primary gold discoveries in the World 1950-2010. Note: Due to their unique deposit style, the chart specifically excludes (deep) gold discoveries in the Witwatersrand in South Africa

Table 1: Average depth of cover for Primary gold discoveries (>1 Moz) in the World 1950-2010

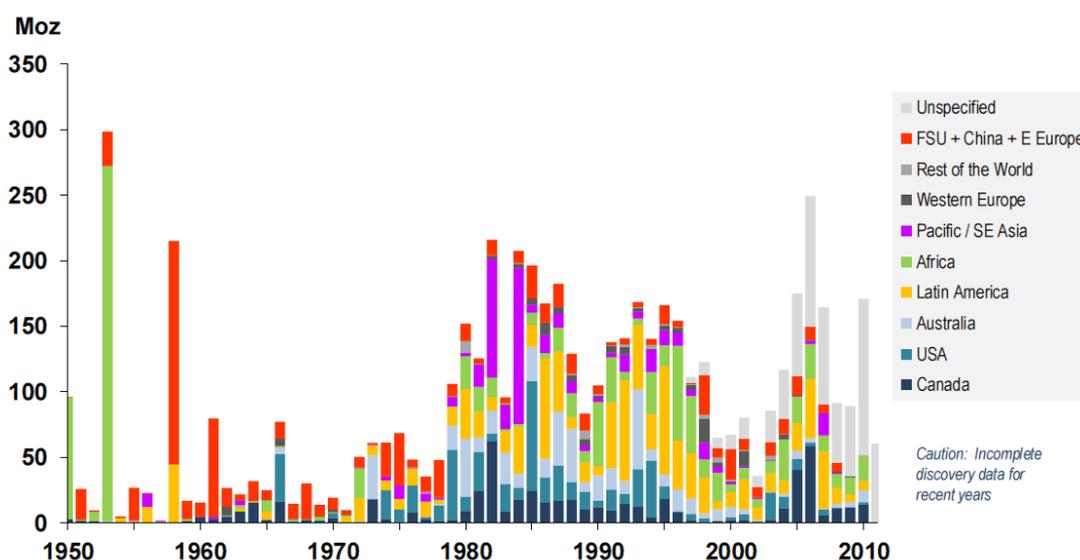
	Discovery Period					
	1950-59	1960-69	1970-79	1980-89	1990-99	2000-10
Greenfield Discoveries						
% of deposits outcropping	100%	47%	48%	42%	45%	45%
Average Depth (m)	0	31	38	21	29	29
Brownfield Discoveries						
% of deposits outcropping	na	na	10%	21%	35%	26%
Average Depth (m)	na	na	47	70	135	171

Caution: Depth-of-Cover analysis was based on 70% of the available deposits in the database

⁴ Figure 10 also includes data on discoveries of satellite deposits in existing gold camps. By definition these are Brownfield discoveries, however it should be noted that they have been excluded from the main analysis – as the associated ounces are already counted as part of the camp total.

Trends in the location of discoveries

Figure 11 shows the amount of gold (contained in Primary deposits) discovered by region since 1950. On a percentage basis, in the 1950s to 1970s most of the discoveries (albeit small in total ounces) were made in the Planned Economies (i.e. the Former Soviet Union + China + Eastern Europe). In the 1980s through to the early 1990s the highly developed countries of the Western World (principally USA, Canada and Australia) accounted for over 40% of all ounces found. In the 1990s the focus moved over to developing countries (principally in Latin America and Africa). In recent years, Canada has risen in importance – and in 2010 accounted for 28% of all ounces being found. This was only exceeded by Africa – which totaled 37%. The apparent recent decline in Planned Economies World may be due their progressive transition to a market economy – which has resulted in a major reduction in funds available to the State Owned geological bureaus.



Source: MinEx Consulting © November 2011

Figure 11: Amount of gold (in Primary gold deposits) found by Region 1950-2010. Note: Data excludes by-product gold

The following Table summarises the average discovery costs by region over the last decade. It shows an average discovery cost for the World of US\$25/oz in constant June 2011 dollars. Unit costs for Greenfield discoveries are estimated to be \$31/oz – however, the actual cost may be lower as the author has notionally assigned all of the costs associated with late stage exploration and feasibility studies to this group⁵.

⁵ In practice some of these costs should be assigned to Brownfield exploration. However, on the other hand some of the mine site exploration is associated with exploration on deposits reported as Greenfield discoveries in previous years. Further complicating the story is the fact that some junior companies report all of their expenditures as being grassroots – even though they are exploring in mature districts on what the author would define as Brownfield targets. Consequently, to keep things simple, the author has assigned all of the late stage exploration and feasibility study costs to Greenfield discoveries. Sufficient data is provided for the reader to do their own analysis on Greenfield / Brownfield discovery costs.

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Table 2: Estimated discovery costs for Primary gold by region 2001-2010

	Ounces Found (Moz) ^(a)			Exploration Expenditures (June 2011 US\$ B)				Discovery Cost (June 2011 US\$/oz)		
	Greenfield	Brownfield	Total	Grassroots	LS+Feas	Mine Site	Total	Greenfield ^f	Brownfield	Total
Canada	139	153	292	2.1	2.7	0.9	5.7	\$35	\$6	\$20
USA	46	33	79	1.1	1.2	1.0	3.3	\$50	\$29	\$42
Australia	41	34	75	1.7	1.4	1.4	4.5	\$76	\$41	\$60
Latin America	259	69	327	3.0	2.8	1.7	7.6	\$22	\$25	\$23
Africa	145	148	293	1.6	1.7	1.3	4.6	\$23	\$9	\$16
Pac/SEA	38	3	41	0.7	0.6	0.5	1.8	\$34	\$162	\$44
Europe	23	3	26	0.4	0.4	0.1	0.9	\$34	\$42	\$35
EE+FSU+China	94	24	118	1.1	1.4	1.1	3.6	\$27	\$46	\$31
ROW	6	0	6	0.2	0.1	0.0	0.3	\$46	\$17	\$45
Western World	697	443	1140	10.9	10.9	6.9	28.7	\$31	\$16	\$25
World	791	467	1257	12.0	12.3	8.0	32.3	\$31	\$17	\$26

(a) Ounces found include adjustment for deposits missing from the database and expected growth in recent discoveries

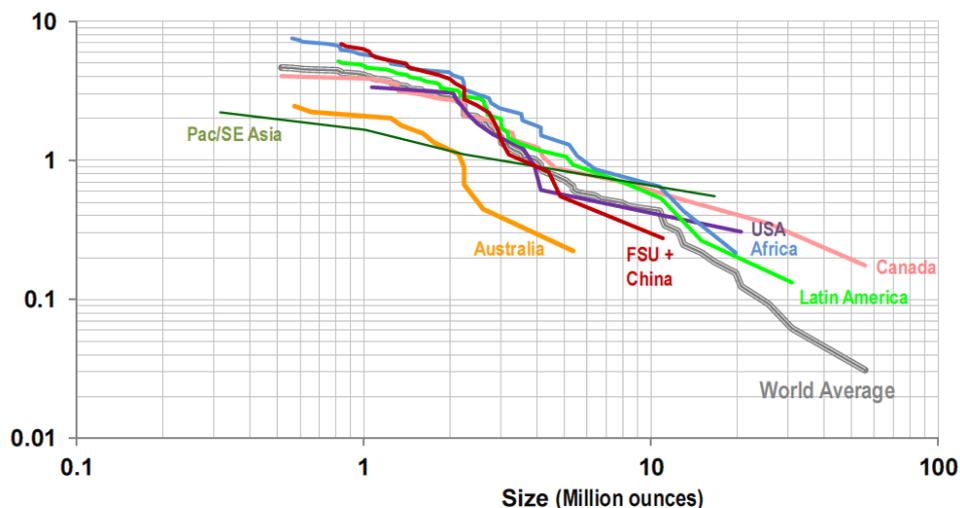
Caution: Have notionally assigned all of the exploration expenditures for Grassroots + Late Stage + Feasibility Study to Greenfield discoveries

Source: Analysis by MinEx Consulting November 2011, based on exploration expenditure data from Metal Economics Group © 2010

The above Table indicated that, in terms of Greenfield targets, the two cheapest regions to explore in is Latin America and Africa - at \$22 and \$23/oz respectively. It should be noted that within all regions individual countries and provinces do better/worse than average.

The following Figure plots the estimated number of Primary gold discoveries per billion dollars spent on exploration. It covers the period 2001-10 and excludes any adjustment for the likely growth in deposits over time. It includes both Brownfield and Greenfield discoveries. Using a minimum size threshold of (say) 1 Moz, the chart suggests that the industry is currently finding 4.1 deposits in the World per billion dollars spent. At a minimum size threshold of (say) 10 Moz, the frequency falls to only 0.45 deposits per billion dollars spent.

Cumulative Number of Deposits found per \$1billion (in June 2011 US\$)



Based on Primary Greenfield and Brownfield gold deposits found between 2001-10. Excludes Satellite Deposits

Source: MinEx Consulting © November 2011

Figure 12: Cumulative number and size distribution of Primary gold discoveries per Billion US Dollars spent on exploration 2001-10

Given that much of the wealth created is contained in a handful of giant deposits, of most interest to companies would be the frequency of discoveries at the larger end of the curve. As implied in Figure 12, the best regions to explore for multi-million ounce deposits are Africa, Latin America and Canada. However it should be noted that the results for Canada are biased by a few giant discoveries; namely Detour Lake (25.7 Moz), Snowfield-Brucejack (55.7 Moz) and Canadian Malartic (12.7 Moz). The latter two deposits are considered to be Brownfield discoveries. Removing these discoveries from the analysis brings Canada's performance back to the World average.

A key observation from Figure 12 is that the mediocre discovery performance for Australia – especially for larger targets. In the last decade, the biggest Primary gold discovery in Australia was Tropicana at 5.4 Moz.

The following Figure shows the size and location of the 298 gold deposits (>100 koz) found in the World since 2000. It also shows the current "hot spots" for exploration activity.

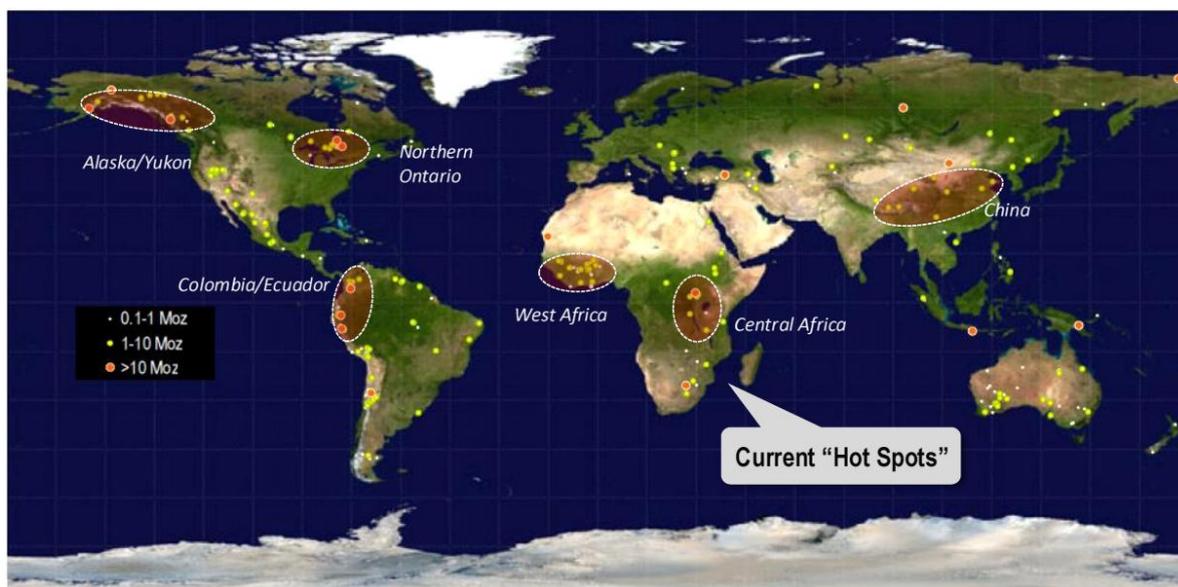


Figure 13: Map of the World showing size and location gold deposits found in the period 2000-2011.
Note: It includes discoveries of both Primary and By-Product gold

Table 3 lists details of 40 significant (>1 Moz) discoveries made since 2008. Special mention should be made of the four discoveries rated by MinEx Consulting as being Tier 1; these are

- **Tasiast Extension** discovered by Kinross at its existing operation in Mauritania in 2010. Kinross reported a resource of 350 Mt @ 1.55 g/t Au (13.0 Moz) in June 2011
- **Golpu Deeps**, a copper-gold deposit jointly discovered by Harmony Newcrest in PNG in 2009. Early drill intersections included 331 metres at 0.93% Cu and 0.51 g/t Au from 694 metres depth. In June 2011 Newcrest reported a resource of 870 Mt @ 1.02% Cu and 0.69 g/t Au (19.4 Moz)
- **Cote Lake** deposit (Chester Project) discovered by Trelawney Mining & Exploration in Ontario Canada in 2010. In March 2010 drilling intersected 107 metres at 8.2 g/t Au starting at 222 metres depth. In March 2011 the company reported an open pit resource of 131 Mt @ 1.0 g/t Au (4.2 Moz) and is actively drilling there to expand the resource
- **Vogue** deposit found by AngloGold Ashanti in 2010 beneath existing workings at its existing Sunrise Dam camp in Western Australia. Drill intercepts include 166 metres at 4.7 g/t Au and 229 metres at 5.1 g/t Au. The deposit is at 600-800 metres depth. At the time of writing a resource has not been published.

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Table 3: Significant gold discoveries in the World since 2008

Discovery Year	Deposit Name	Country	Contained Metal	Size (Moz)	Tier	Discovery Company	Company Type	Brownfield
2011	Red Hill	USA	Au	3.54	2	Barrick	Major	Brown
2011	Beninshangul	Ethiopia	Au	NR	3	ASCOM	Industrial	Green
2011	Cebollati	Uruguay	Au	NR	3	B2Gold	Moderate	Green
2011	Goldrush	USA	Au	NR	2	Barrick	Major	Brown
2010	Tasiast Extension	Maurutania	Au	13.00	1	Kinross	Major	Brown
2010	Cote Lake	Canada	Au,Cu	4.22	1	Trelawney Mining and Explorn	Junior	Green
2010	Borden Lake	Canada	Au,Ag	4.06	3	Probe Mines	Junior	Green
2010	Buritica	Colombia	Au,Ag,Zn,Pb	3.16	2	Continental Gold	Junior	Brown
2010	Bullabulling (New)	Australia	Au	2.60	3	Gibraltar Gold Mines	Junior	Brown
2010	Boddington South (New)	Australia	Au	NR	3	Ausgold	Junior	Green
2010	Coffee	Canada	Au	NR	2	Kaminak Gold (Shawn Ryan)	Junior	Green
2010	Osiris	Canada	Au	NR	3	ATAC Reserources	Junior	Green
2010	Vogue	Australia	Au	NR	1	AngloGold Ashanti	Major	Brown
2010	Somituri	DRC	Au	2.04	3	Kilo Goldmines	Junior	Brown
2010	Borborema	Brazil	Au	1.85	3	Crusader Resources	Junior	Brown
2010	Bell Mountain	USA	Au,Ag,Pb	1.07	3	Laurion Mineral Exploration	Junior	Green
2009	Golpu Deeps	PNG	Cu,Au,Mo	19.36	1	Harmony + Newcrest	Maj + Maj	Green
2009	Blackwater	Canada	Au	7.90	3	Richfield Ventures Corp	Junior	Green
2009	Goukono	Mali	Au	5.53	2	RandGold Resources	Moderate	Brown
2009	Magambazi	Tanzania	Au	NR	2	Canaco Resources	Junior	Green
2009	Garden Well	Australia	Au	2.14	3	Regis Resources	Junior	Green
2009	Cerro Maricunga	Chile	Au,Cu	1.81	3	Gold Fields + Atacama Pacific	Maj + Jun	Green
2009	North Madsen	Canada	Au	1.32	3	Mega Precious Metals	Junior	Brown
2009	Crucero	Peru	Au	1.26	3	Minera Pacacorral	Private	Green
2009	Cordero	Mexico	Ag,Zn,Pb,Au,Cu,Mo	1.22	3	Levon Resources	Junior	Green
2008	Canhuire	Peru	Au,Cu,Ag	5.07	2	Buenaventura + Gold Fields	Maj + Maj	Green
2008	Beattie (New)	Canada	Au	3.29	3	Clifton Star Resources	Junior	Brown
2008	Un-Named (is south of Jiao Jia)	China	Au	3.20	2	State Owned Company	Govt	Green
2008	Cirestata	Romania	Au,Cu	2.94	3	Carpathian Gold	Junior	Brown
2008	Ollachea	Peru	Au,Ag	2.63	3	Minera	Junior	Green
2008	Mangalisa	South Africa	Au	NR	3	Superior Mining International	Junior	Brown
2008	Rau	Canada	Au	NR	2	ATAC Reserources	Junior	Green
2008	Batie West	Burkina Faso	Au	2.22	2	Ampella Mining	Junior	Green
2008	Bell Creek	Canada	Au	1.79	3	Lake Shore Gold	Junior	Brown
2008	Athena-Hamlet	Australia	Au	1.76	2	Gold Fields	Major	Brown
2008	White Gold	Canada	Au,Pb	1.58	3	Underworld Resources	Junior	Green
2008	Hillside	Australia	Cu,Au	1.40	2	Rex Minerals	Junior	Green
2008	Cuiu-Cuiu	Brazil	Au	1.30	3	Magellan Minerals	Junior	Green
2008	El Sid	Egypt	Au	1.24	3	SMW Gold	Junior	Green
2008	Nambonga	PNG	Au,Cu	1.01	3	Newcrest + Abelle	Maj + Jun	Brown

NR = Not Reported

Source: MinEx Consulting © November 2011

It should be noted that resources reported in the above Table are likely to grow with further drilling. Furthermore, as more information is collected it is possible that the Tier rating for some discoveries may be upgraded.

The Table also highlights the fact that two-thirds of the discoveries were made by Junior Companies, and that over 40% of the deposits were Brownfield discoveries within existing mining camps.

Growth trends for recent discoveries

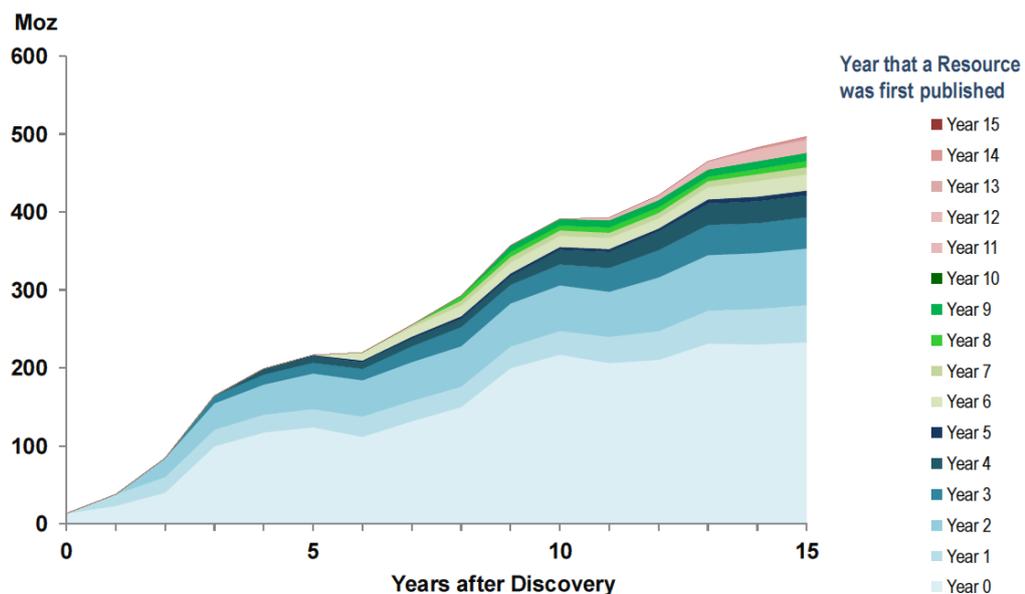
As discussed before, the current reported number and size of recent discoveries understates the true situation. It takes time for companies to announce their discoveries and publish a resource. Furthermore, as drilling is carried out, the reported resource will invariably grow over time.

To get a more robust assessment of the true resource position, a detailed analysis was carried out on the resource history of 60 major (>1 moz) discoveries found in the period 1980-96. They covered a range of sizes, countries, mining methods and target quality (see Table 4).

Table 4: Number and type of gold deposits included in the growth study

Deposit Type	Number				Total Size in Yr 15 after discovery
	Tier 1	Tier 2	Tier 3	Total	
Orogenic Mesothermal	1	5	14	20	76
Epithermal (Low, Intermediate and High Sulphidation)	4	5	12	21	123
Sediment Hosted Disseminated Gold (Carlin Style)	2	2	5	9	91
Porphyry (gold-rich)	3	1	6	10	207
TOTAL	10	13	37	60	497 Moz

Figure 14 summarises the overall growth in reported resources over time. As can be seen, total resources grew from 38 Moz at the end of the first year after discovery to 497 Moz by year 15 – a twelve-fold increase. In practice, the real rate of growth is much less than this – as only 19 of the 60 deposits had published a resource by the end of the first year. The average time lag between discovery and reporting the maiden Resource was 3.7 years (Figure 15).



Source: MinEx Consulting © November 2011

Figure 14: Resource growth (in Moz) over time for sample of 60 gold deposits found between 1980-96. Data has been sorted by year when the maiden Resource was first reported

GOLD DISCOVERY

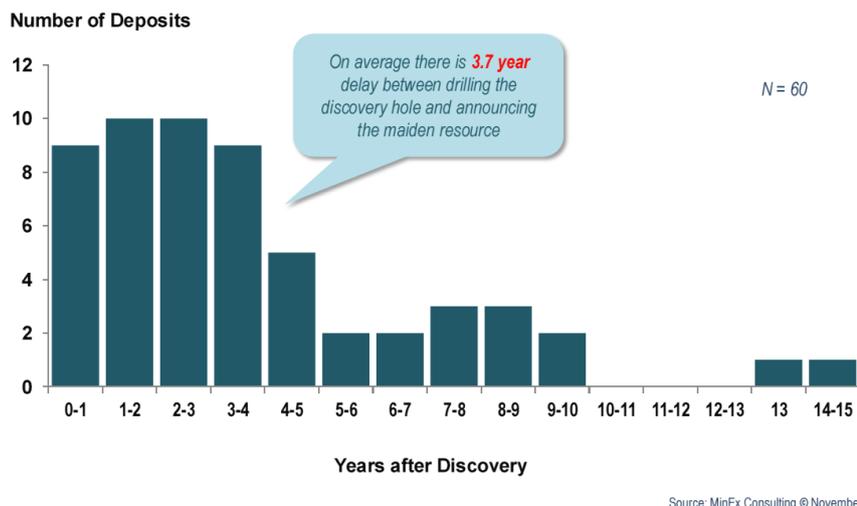


Figure 15: Years delay between discovery and first reporting of a resource, for a sample of 60 gold deposits found between 1980-96

A second factor impacting on the growth in reported amount of ounces has been the practice of many companies to change the cut-off grade used to calculate the resource. This is driven by increased data on the deposits through ongoing drilling programs, changes in gold prices and lower operating costs (through economies of scale). Figure 16 gives an example of the typical growth pattern for many of the deposits in the survey. It refers to the Shahuindo gold deposit which was found in Peru in 1995. A maiden Resource of 18 Mt @ 1.14 g/t Au was announced 1.5 years after discovery. Over time a series of new Resources were reported – with the most recent being 182 Mt @ 0.58 g/t Au – a five-fold increase in contained ounces (from 0.65 to 3.31 Moz). It is interesting to note that using the reported tonnes-grade grade curve for the deposit, the current resource of 182 Mt @ 0.58 g/t Au shrinks to 45 Mt @ 1.14 g/t Au. This is only 2.5-times the size of the maiden Resource reported 13 years earlier. In other words, over the life of the project half of the overall growth in this deposit came from changes in the cut-off grade. By inference, the other half of the growth must have come from “exploration” success in delineating extensions and repetitions to the original ore body.

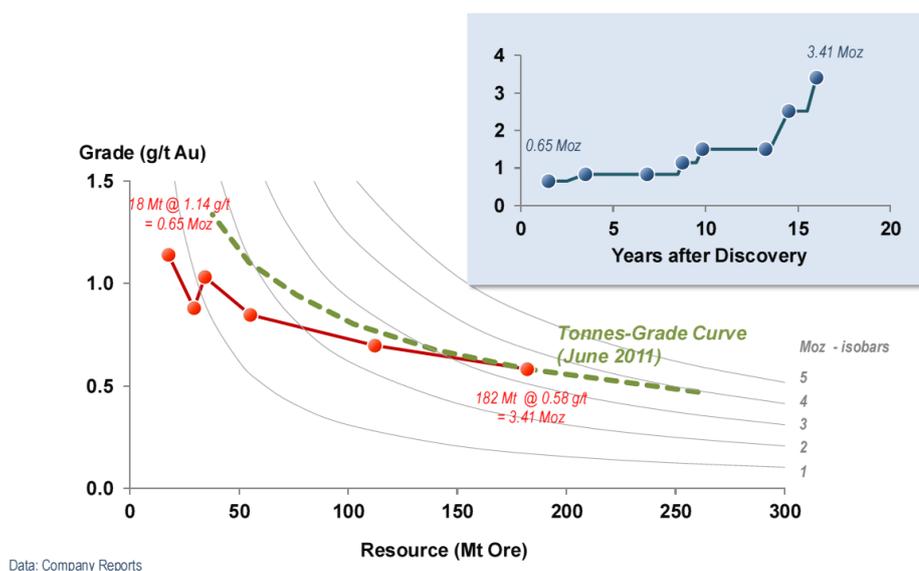


Figure 16: Changes in the reported tonnes and grade for the Shahuindo gold deposit in Peru 1996-2011

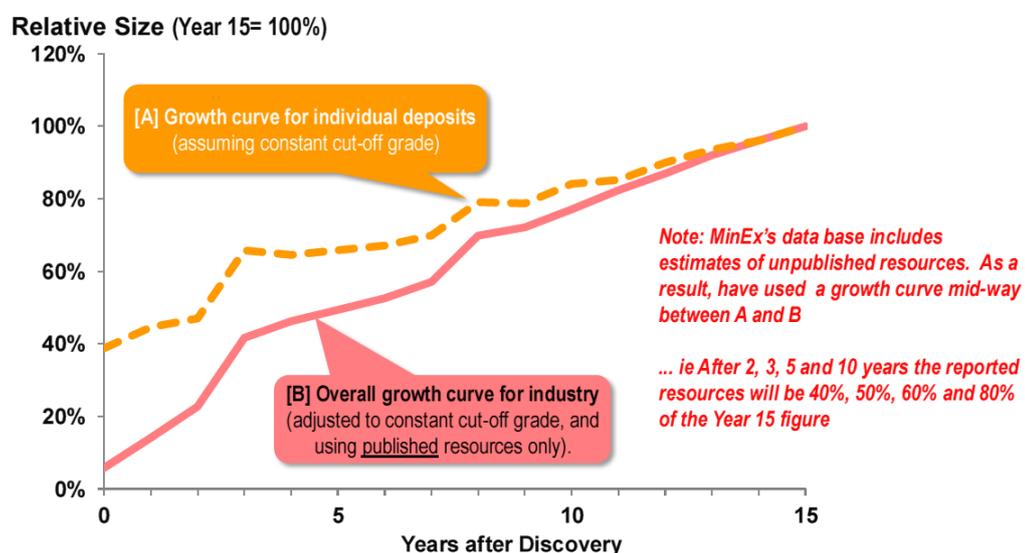
MinEx used the above approach to generate a set of “real” growth curves for each of the 60 deposits in the sample set. The key results are summarized below. It shows that, on average (after netting out the effect of missing data and changes in cut-off grades), the resource for an individual deposit grows at a declining rate over time (Curve [A] in Figure 17). **It is estimated that two years after discovery, the identified resource for a given gold deposit is 50% of that at year 15. This figure rises to 65% by year 5 and 85% by year 10.** This is effectively a measure of the “blue-sky” exploration potential of a given deposit. Independent of this, the geologist (or more correctly, the engineer) always has the option to increase the resource through lowering the cut-off grade.

Curve [B] in Figure 17 refers to the apparent growth rate of a portfolio of gold deposits (after adjusting for the effect of changes in cut-off grades). As discussed before, it often takes several years before a company publishes a resource on its discovery. Consequently, a survey of the industry’s reported discoveries (as seen by an outside observer) will follow this curve.

The reader should be cautioned that the growth curves are based on averages, and that the growth of an individual deposit is almost certain to take a different path. Furthermore, the rate of growth is highly dependent on the deposit style, ore body geometry, the level of exploration activity and the skills of the local geologist.

The author is also mindful that the curves are based on a limited sample of deposits – and that these deposits may not be truly representative of the entire population of discoveries⁶.

Given that MinEx’s analysis of the discovery performance of the gold industry includes estimates of unpublished resources for some of the identified discoveries, the resource growth trend used to estimate the likely available resource for the industry will fall between curves [A] and [B]. **For purposes of this paper, the author has assumed that the reported resource for recent discoveries in year 2 is only 40% of the ultimate resource, progressively growing to 50% by year 5 and 80% by year 10 before reaching 100% in year 15.**



Note : Percentage figures are based on the growth profiles of each deposit. Results give equal-weighting to all 60 deposits.

Source: MinEx Consulting © November 2011

Figure 17: Estimated growth curve for major gold deposits over time. Note: Curve [B] refers to a portfolio of projects that have a distribution of time delays in the reporting of their maiden resource.

⁶ In particular there is the risk that it may be biased by a “survivor” effect – as it is based on those deposits that ultimately grew to >1 Moz in size (i.e. it leaves out those that failed to grow).

Conclusions

Gold continues to be the dominant commodity for mineral exploration.

In spite of expenditures being at a record high (in excess of US\$5.3 Billion in 2010) the number of deposits and total amount of gold being found remains modest. After adjusting for deposits missing from the database, and the expected growth in resources for recent discoveries (see notes below), MinEx Consulting estimates that the industry is currently finding around 150-200 Moz pa in Resources. While this exceeds current mine production of 80 Moz pa it should be noted that not all of deposits end up being mined and those that do typically incur 5-10% losses on extraction and recovery. Furthermore, there is no guarantee that all of the available resource is economically mineable. Consequently, at current discovery rates, the industry is struggling to meet the future demand for metal.

An analysis the discovery rates and exploration costs show that unit discovery costs per ounce of Resource have been rising over time in real terms – up from US\$16/oz (in constant June 2011 Dollars) in the 1980s to US\$25/oz in the last decade. The current discovery cost is now running at around \$30-40/oz. Over the last decade, the discovery cost for Greenfield exploration in the World averaged \$31/oz versus \$17/oz for Brownfield exploration. It is noted that the average discovery cost varies by country and region – and that at present, the cheapest places to explore for large Greenfield targets in is Latin America and Africa. This is driven by a string of high quality multi-million ounce discoveries in new geological frontiers in Columbia and West Africa respectively.

The author argues that part of the decline in discovery performance is due to the industry's inability to effectively explore under cover. In the case of Greenfields exploration, the average depth of cover for discoveries has remained unchanged at 29 metres for the last two decades. During this time the search space get in established districts gets progressively depleted. One solution is to look for new search spaces – in new countries and using new geological models.

Finally, the author would like to highlight that the current apparent lack of large discoveries in recent times may be due to the inherent delays by companies to identify, delineate and report a resource on their discoveries. This is not a new problem. A detailed analysis of 60 major discoveries made in the period 1980-96 showed that the reported resource base grew rapidly over time. After adjusting for changes in cut-off grades, it is estimated that, on average, two years after discovery the identified resource of a given gold deposit is 50% of that at year 15. This figure rises to 65% by year 5 and 85% by year 10 before leveling out at 100% in year 15. This is effectively a measure of the "blue sky" exploration potential of the deposit. The reader should be cautioned that this growth curve is based on averages and that growth trend for a given deposit is almost certain to take a different path.

In conclusion, the industry is facing several challenges and opportunities. Persistence, good science and the ability to operate effectively in new frontiers (and new countries) are the keys to success to finding, growing and developing the next generation of high quality gold mines.

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The reader should develop their own opinion on the reasonableness and robustness of the analysis.

The author accepts responsibility of any errors and omissions for data that is in the public domain and apologises in advance for them. It is emphasized that the views and opinions expressed by the author in this paper do not necessarily reflect that of Goldfields, MEG or the Conference Organisers.