

Recent Trends and Outlook for Global Exploration

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PDAC 2017

6th March 2017, Toronto

Overview

This is effectively an updated and extended version of my 2010 PDAC talk

1. Background and Context ... *Why do the study? What's its scope?*
2. Trends in exploration spend ... *How much money did we spend?*
3. Number of discoveries ... *How many deposits did we find?*
4. Quality of the discoveries made ... *How many good deposits were found?*
5. Where were the discoveries made? ... *Which countries did a good job?*
6. Who made the discoveries? ... *Which companies did a good job?*
7. Discovery performance ... *What was the cost per discovery?
Did exploration create/destroy value?*
8. Outlook for exploration ... *What's the level of spending over next decade?*
9. Conclusions ... *What can we learn from all of this?*

1. BACKGROUND & CONTEXT

Context & coverage

As compared to my 2010
PDAC presentation

- Study covers **all countries** in the World (previously mainly focused on the Western World)
- Study covers **all metals** (previously excluded Bulk Minerals)
- Have excluded discovery of satellite deposits feeding into an existing mill within an established mining camp
(i.e. count Ekati as one world-class discovery, not 20 small discoveries)
- Analysis is **based on deposits \geq “Moderate” in size** (previously only considered \geq “Major” deposits)
(i.e now capture deposits >100 koz Au, > 100 kt Cu, >5 kt U_3O_8)
- Assesses both the **quality and value** of the discoveries (previously only considered quality)

Data sources & coverage

- **Deposit info**

- Have a database of **60,352** mineral deposits around the world, including;
- 55,988 unique deposits (i.e. excluding satellite deposits), of which,
- 10,565 deposits are Moderate-sized (or larger), of which;
- 7,578 deposits have a discovery history, and of these;
- 5,234 Moderate-sized (or larger) deposits were found since 1950

As a result , my numbers vary
from what SNL report

- **Exploration expenditures**

- Relied on SNL[#] for non-bulk exploration spend data post-1992, modified with actual expenditure data for Canada, Australia and China, plus global uranium expenditure data from the International Atomic Energy Agency
- For prior years and bulk exploration spend, have made my own estimates based on various historical studies by industry, government agencies and published company reports

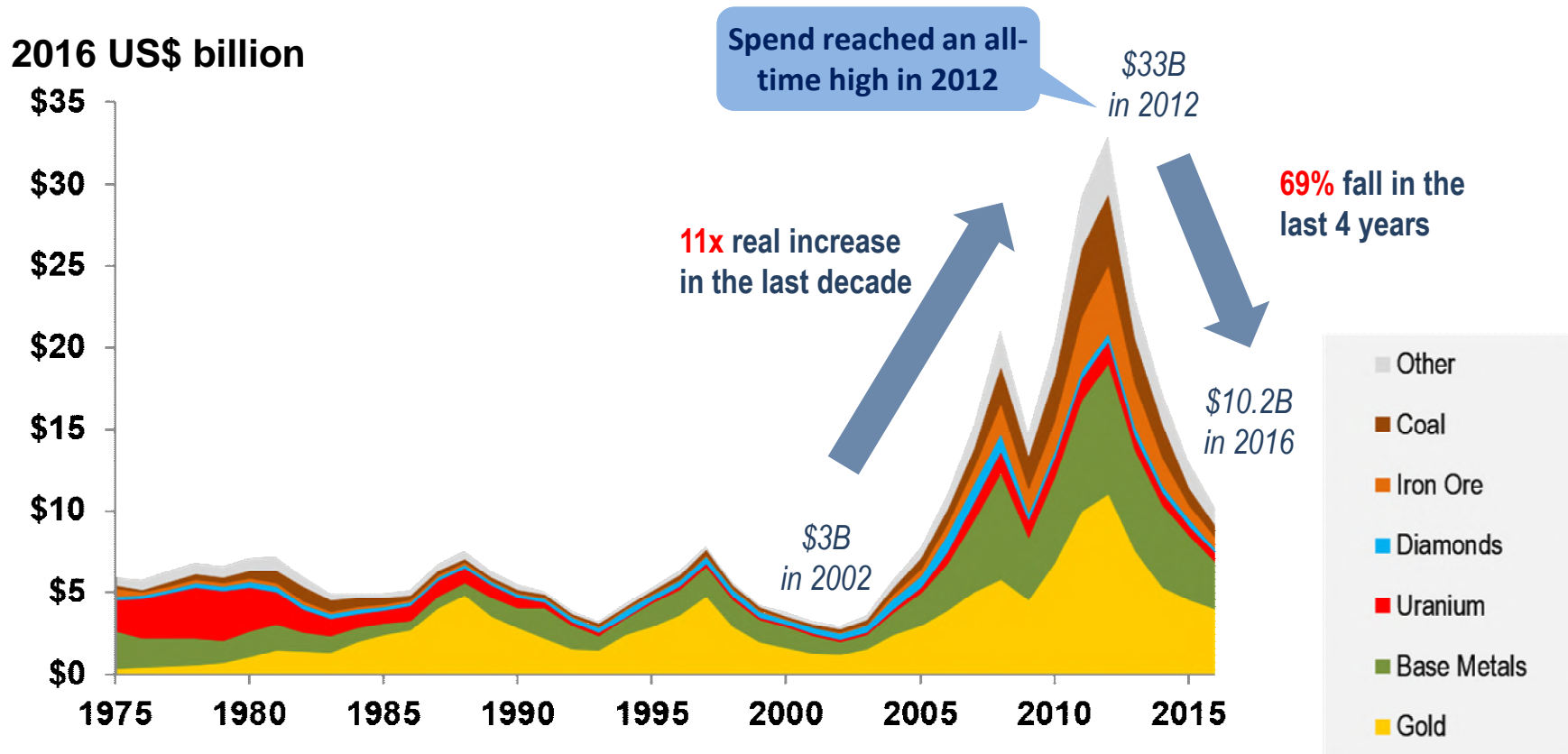
SNL Metals & Mining data, an offering of S&P Global Market Intelligence

Exploration expenditures reached an all-time high in 2011-2012

2. TRENDS IN EXPLORATION SPEND

Exploration expenditures: World

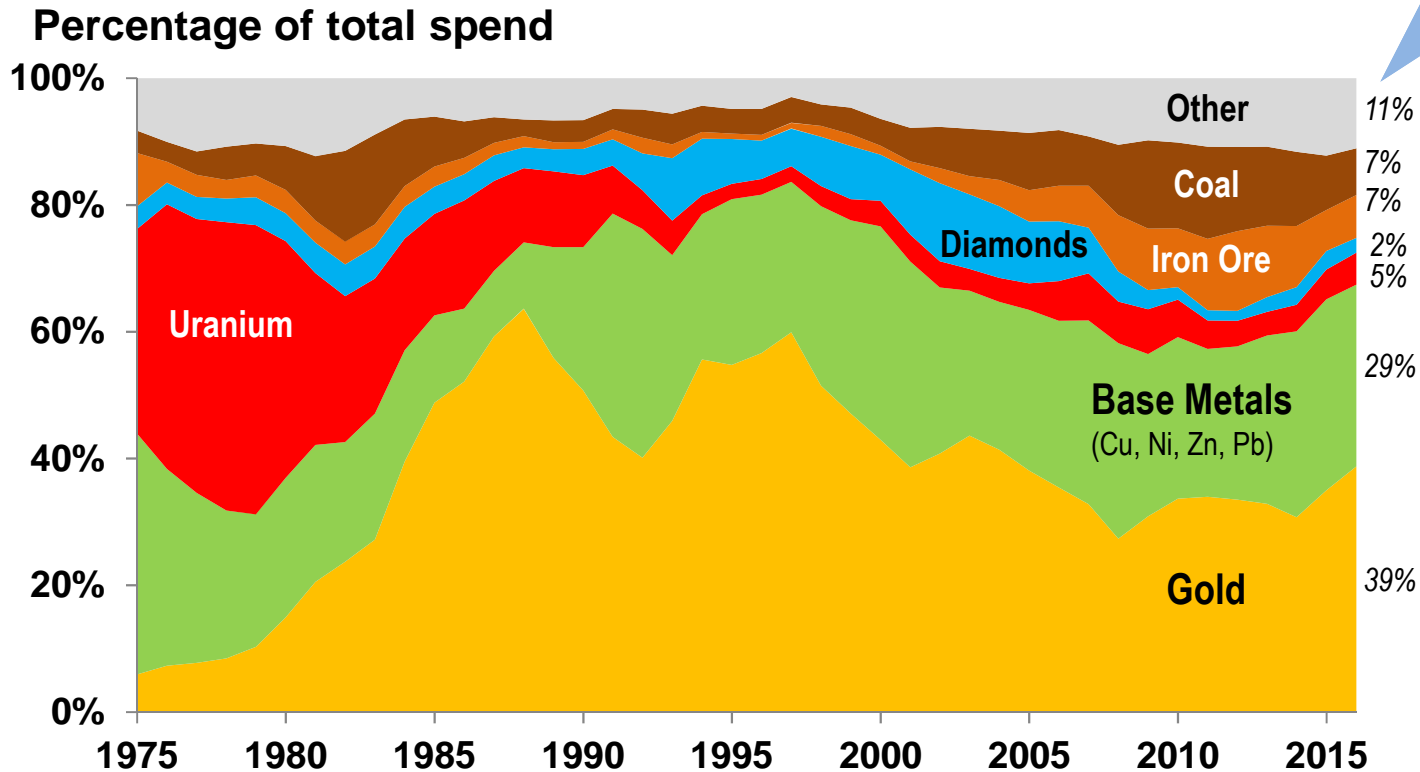
by Commodity : 1975-2016



Sources: MinEx Consulting estimates © March 2017, based on data from ABS, NRCAN, MLR (China), OECD and SNL Metals & Mining data, an offering of S&P Global Market Intelligence

Exploration expenditures: World by Commodity : 1975-2016

Major decline in spend on Bulk Minerals, partially offset by increase in "Other"

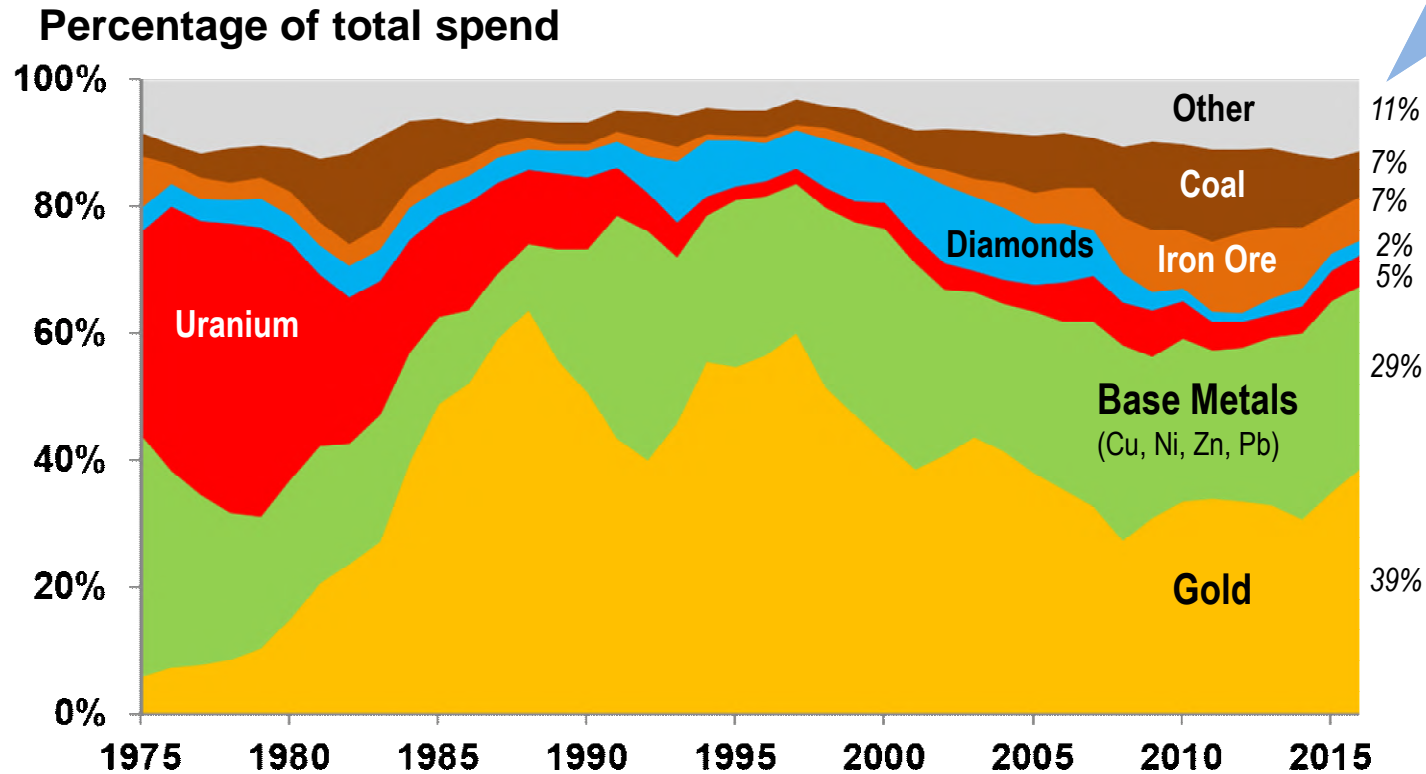


Gold continues to be the main target

Sources: MinEx Consulting estimates © March 2017, based on data from ABS, NRCAN, MLR (China), OECD and SNL Metals & Mining data, an offering of S&P Global Market Intelligence

Exploration expenditures: World by Commodity : 1975-2016

Major decline in spend on Bulk Minerals, partially offset by increase in "Other"

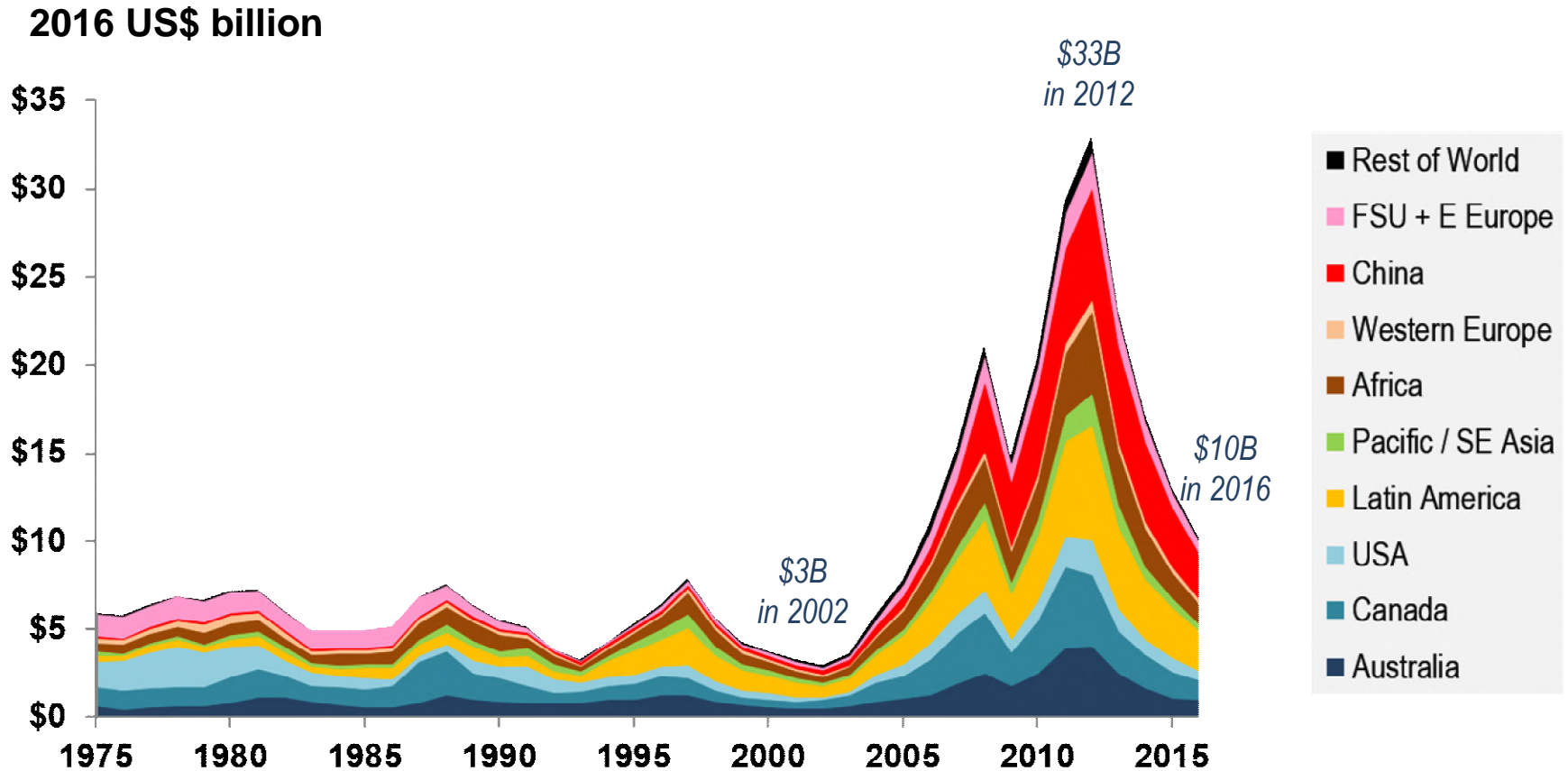


Gold continues to be the main target

Sources: MinEx Consulting estimates © March 2017, based on data from ABS, NRCAN, MLR (China), OECD and SNL Metals & Mining data, an offering of S&P Global Market Intelligence

Exploration expenditures: World

by Region : 1975-2016



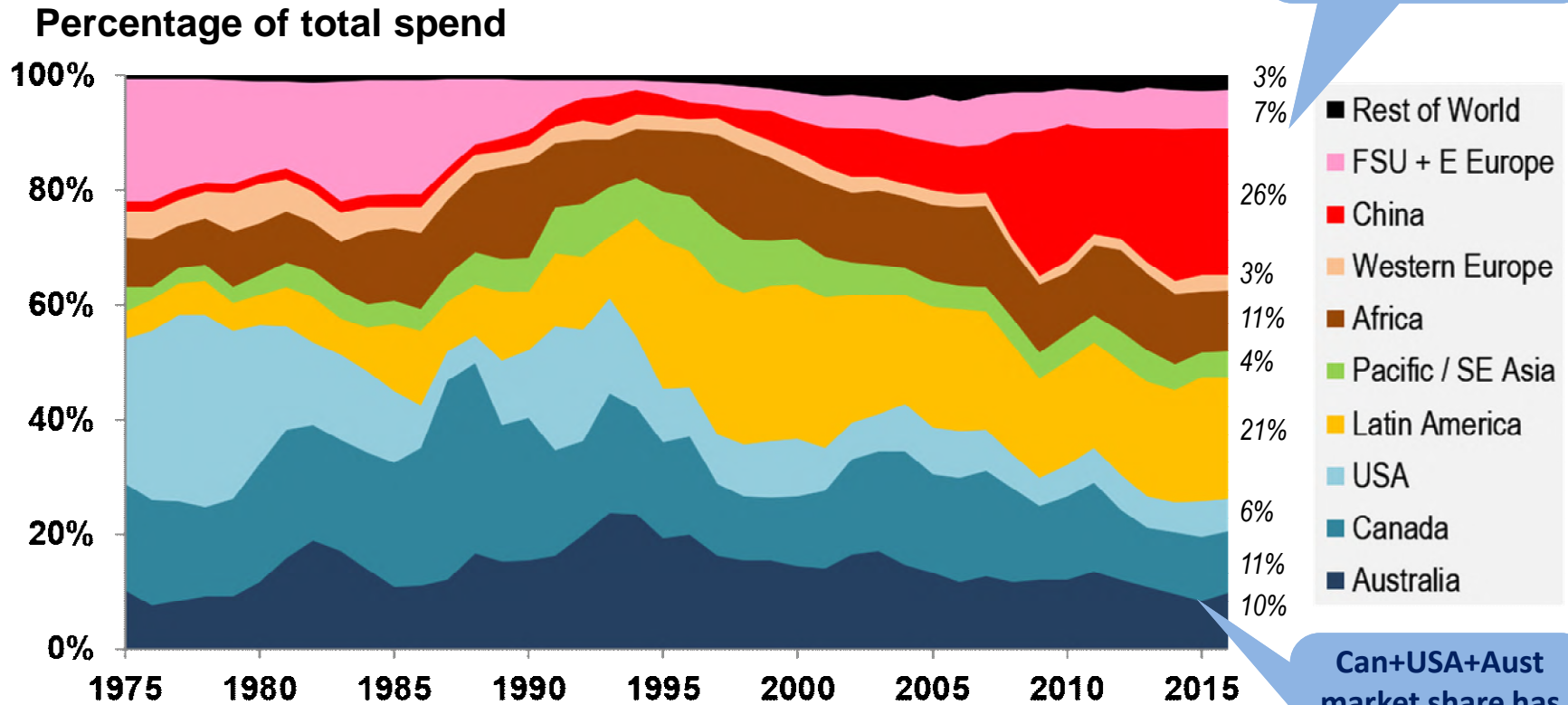
Note: "Rest of World" refers to, Mongolia, Middle East and South West Asia (including India and Pakistan)

Sources: MinEx Consulting estimates © March 2017, based on data from ABS, NRCAN, MLR (China), OECD and SNL Metals & Mining data, an offering of S&P Global Market Intelligence

Exploration expenditures: World

by Region : 1975-2016

China spends more on exploration than any other country in the World



Can+USA+Aust market share has halved in the last 2 decades

Note: Includes spend on Bulk Minerals
 "Rest of World" refers to Mongolia, Middle East and South West Asia (including India and Pakistan)

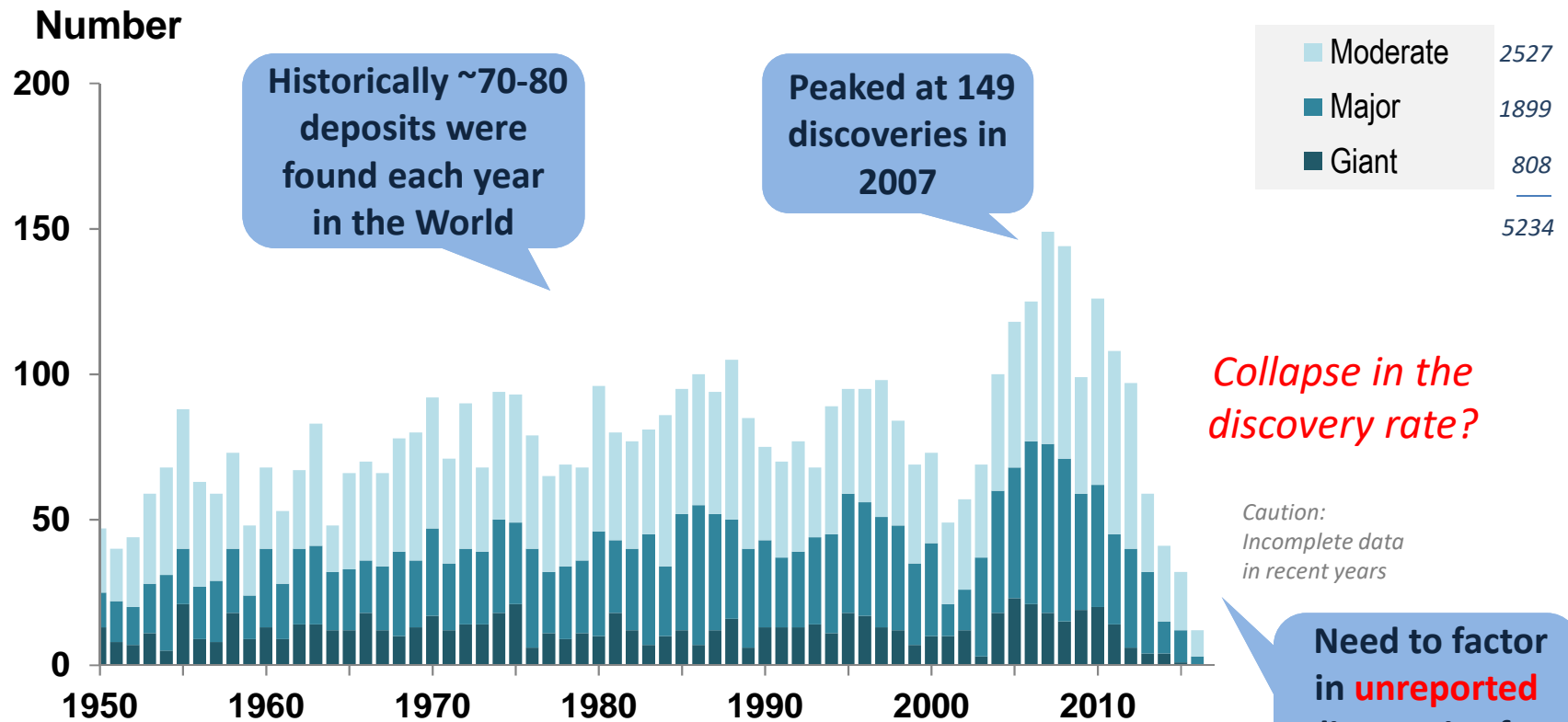
Sources: MinEx Consulting estimates © March 2017, based on data from ABS, NRCAN, MLR (China), OECD and SNL Metals & Mining data, an offering of S&P Global Market Intelligence

Number of discoveries – by size, commodity, quality and value

3. NUMBER OF DISCOVERIES

Number of discoveries by size

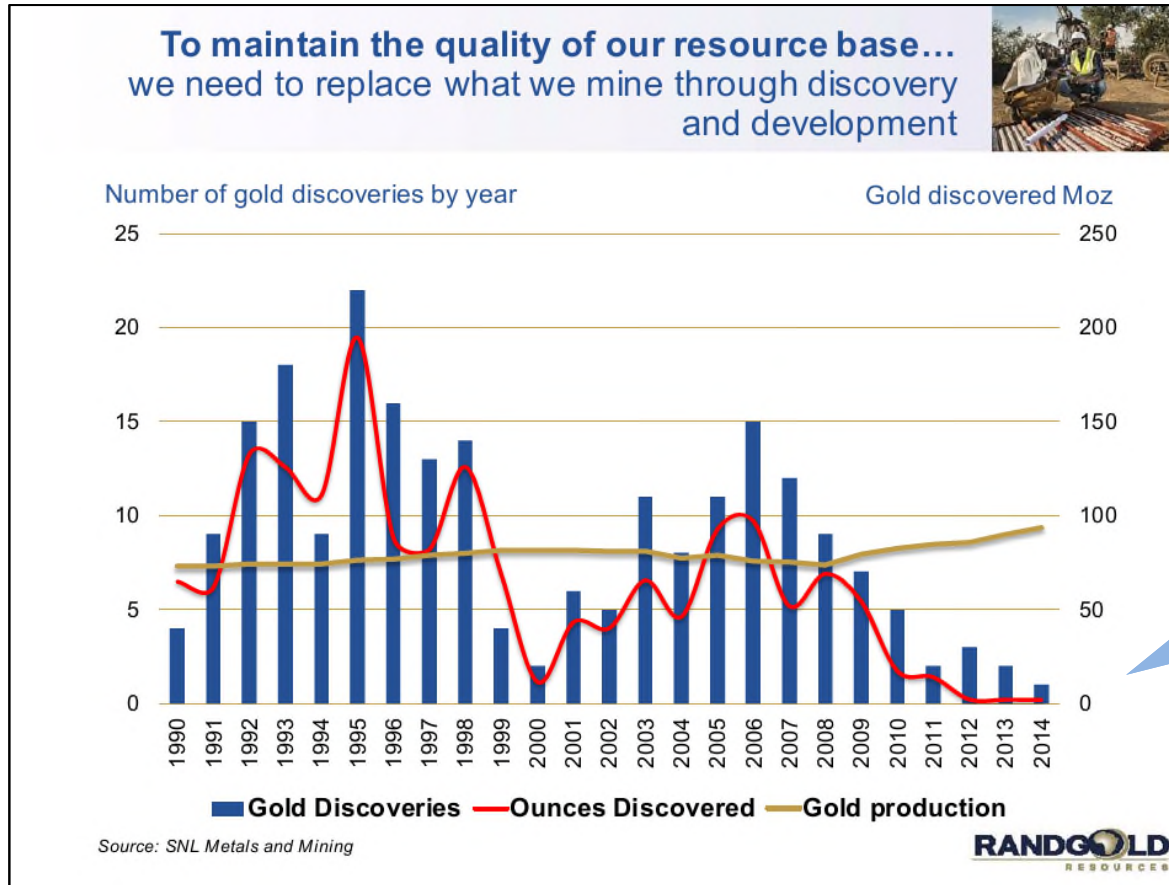
Mineral discoveries in the World : All Commodities : 1950-2016



Note: "Moderate" >100koz Au, >10kt Ni, >100Kt Cu, 250kt Zn+Pb, >5kt U₃O₈, > 10Mt Fe, >20Mt Thermal Coal
 "Major" >1Moz Au, >100kt Ni, >1Mt Cu, 2.5Mt Zn+Pb, >25kt U₃O₈, >100Mt Fe, >200Mt Thermal Coal
 "Giant" >6Moz Au, >1Mt Ni, >5Mt Cu, 12Mt Zn+Pb, >125kt U₃O₈, >500Mt Fe, >1000Mt Thermal Coal

Source: MinEx Consulting © March 2017

The perils of not factoring in unreported discoveries



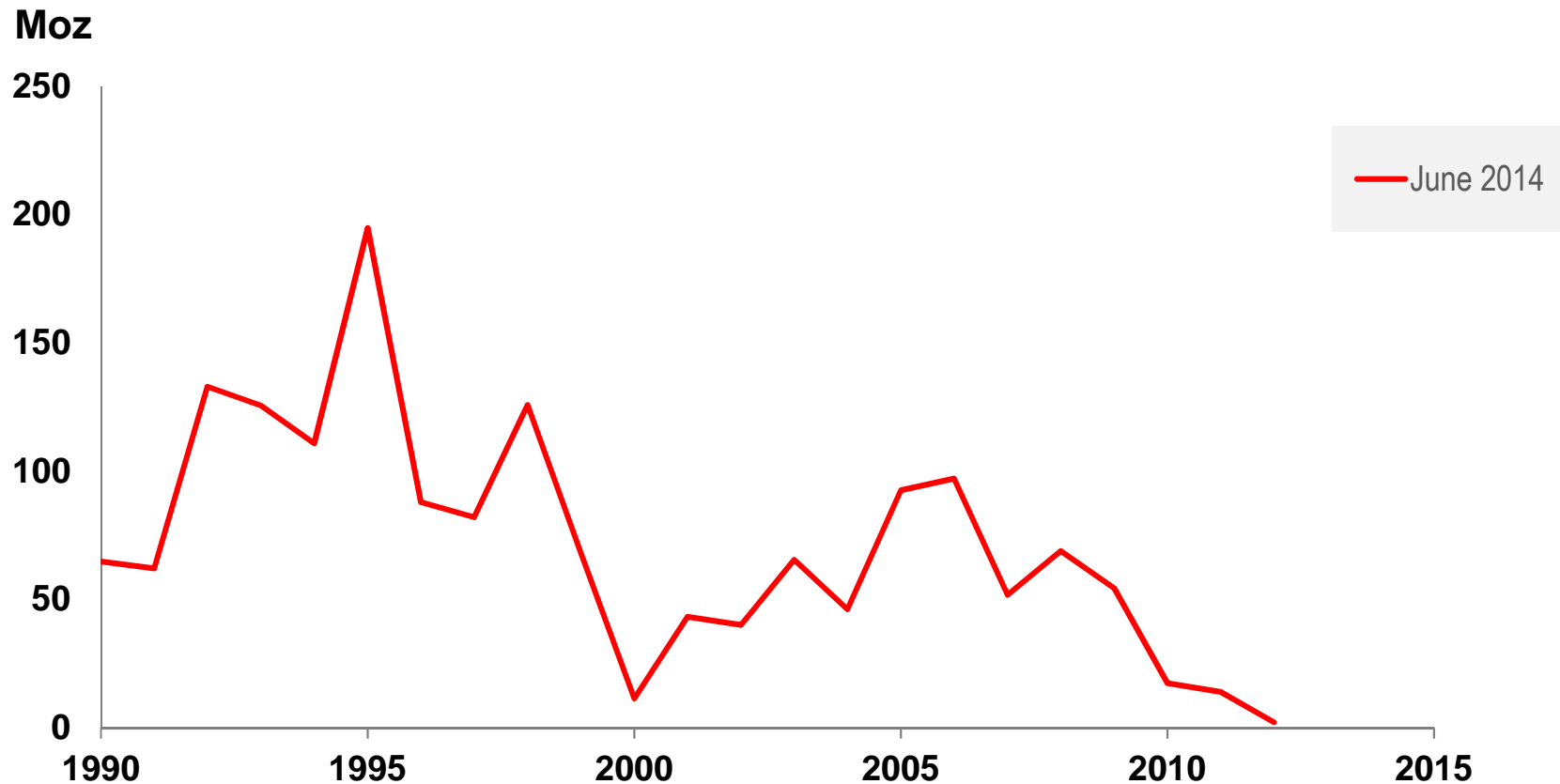
Observe only 1 major gold discovery in 2014 containing a total of 2 Moz

Conclusion

“exploration is not replacing the gold produced”

Source: Mark Bristow presentation at PDAC 2016

Mark's data came from a modified version of SNL's 2014 report on Gold Reserves Replacement Strategies



Note: SNL's analysis is limited to gold deposits containing >2 Moz of Resources or >1 Moz of Reserves

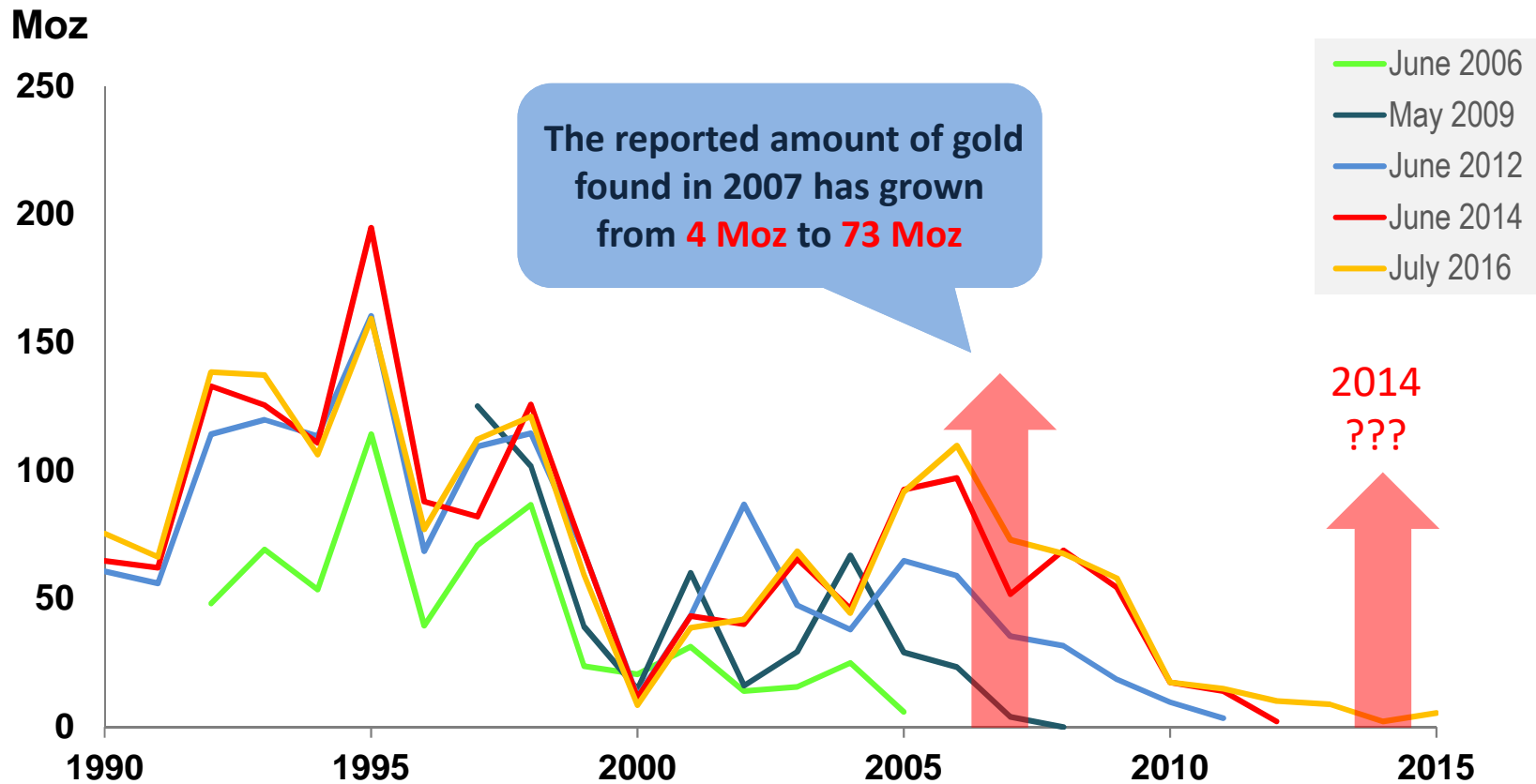
Source: SNL report on Gold Reserves Replacement Strategies © 2014, SNL Metals & Mining data, an offering of S&P Global Market Intelligence

... the problem is that he (and many other people in the industry) ignored SNL's health warning

As it generally takes at least three years for a deposit to progress from a promising discovery hole to a potentially economic resource, the number of discoveries can change from year to year as new resources are defined. As it takes time for drilling to define a sizable resource and for scoping studies to produce positive results, older discoveries are expected to be larger and more numerous annually than newer ones.

Source: SNL report on Gold Reserves Replacement Strategies © 2016,
SNL Metals & Mining data, an offering of S&P Global Market Intelligence

... Factoring this in results in a completely conclusion on the discovery performance of the industry

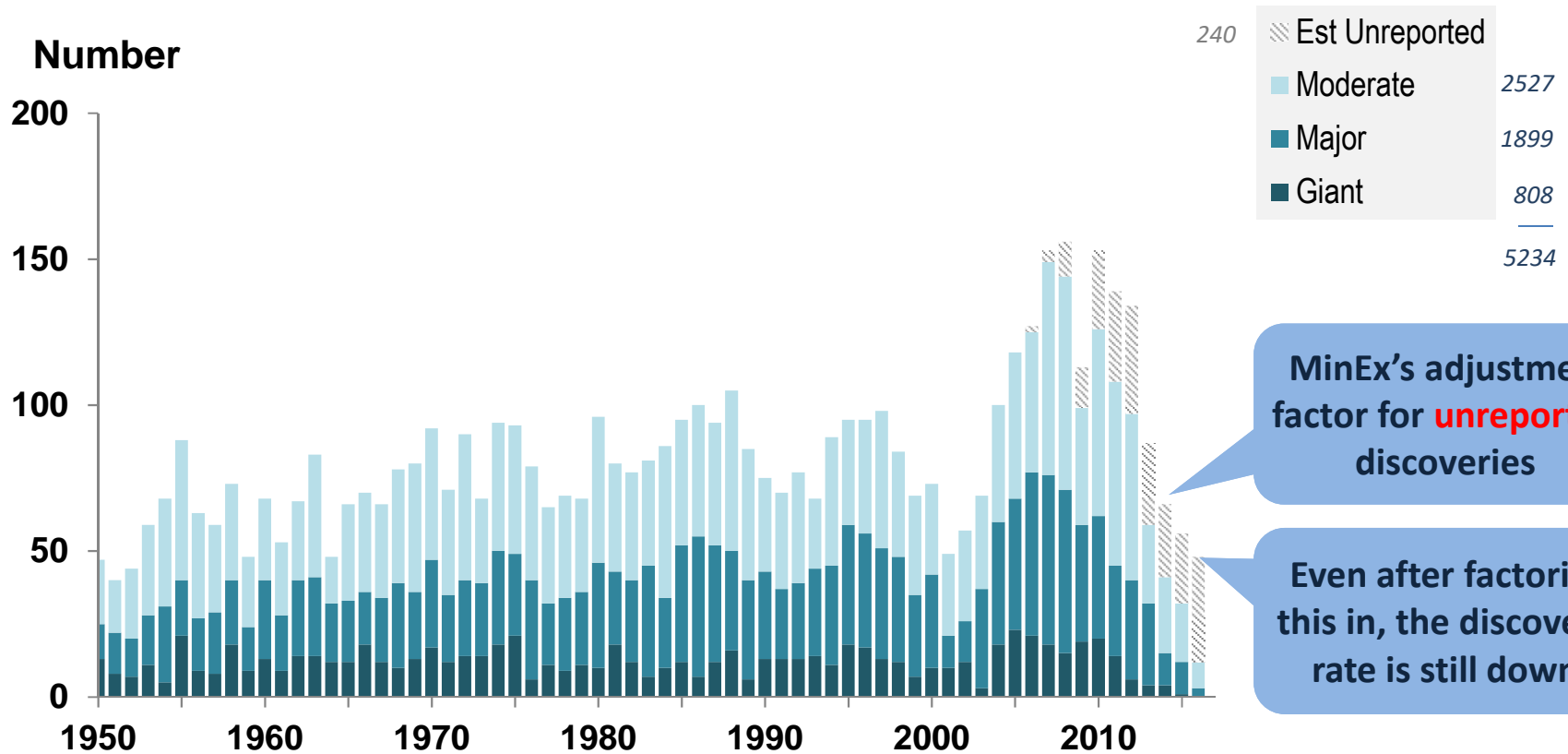


Note: SNL's analysis is limited to gold deposits containing >2 Moz of Resources or >1 Moz of Reserves

Source: SNL reports on Gold Reserves Replacement Strategies © various years
SNL Metals & Mining data, an offering of S&P Global Market Intelligence

Number of discoveries by size

Mineral discoveries in the World : All Commodities : 1950-2016



MinEx's adjustment factor for **unreported** discoveries

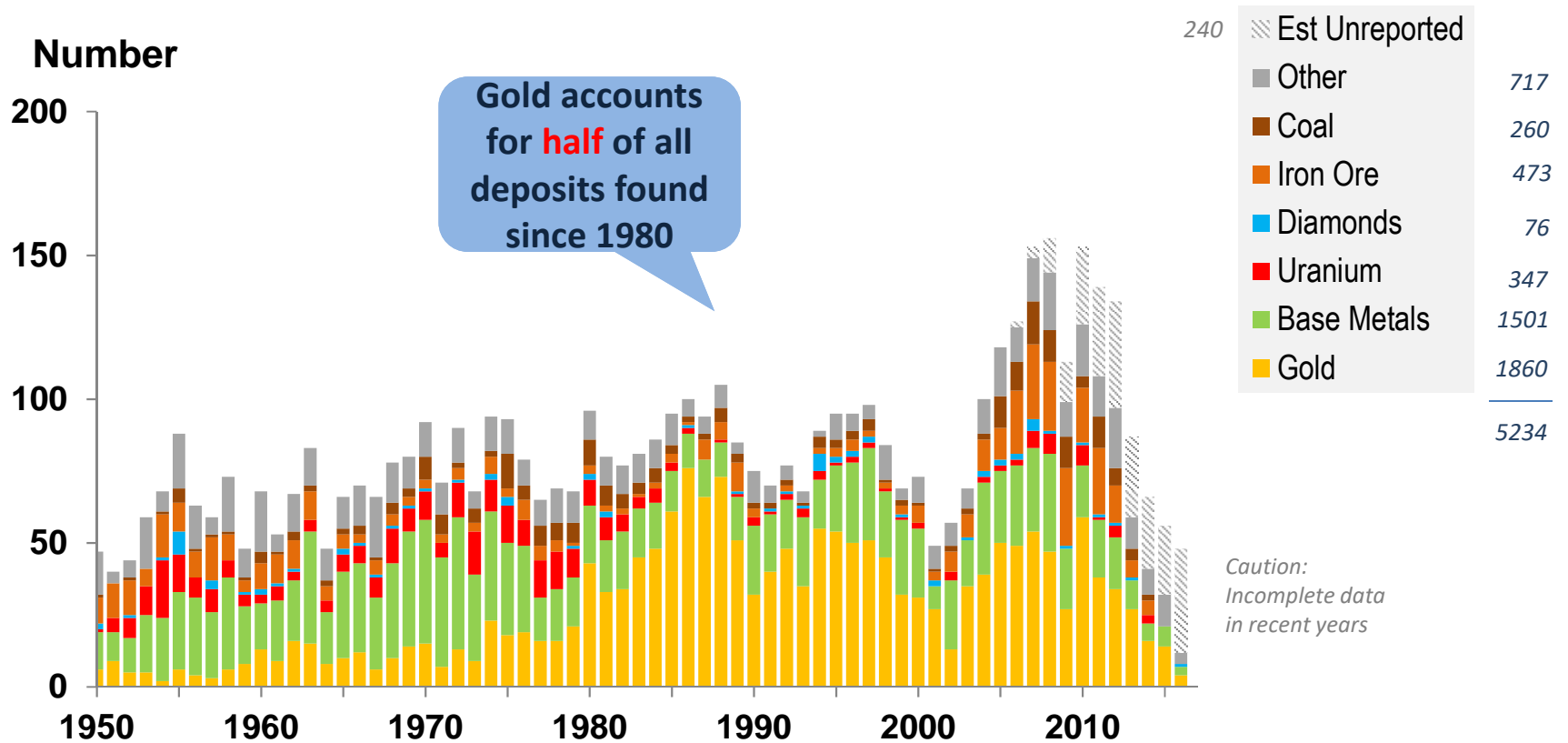
Even after factoring this in, the discovery rate is still down

Note: "Moderate" >100koz Au, >10kt Ni, >100Kt Cu, 250kt Zn+Pb, >5kt U₃O₈, > 10Mt Fe, >20Mt Thermal Coal
 "Major" >1Moz Au, >100kt Ni, >1Mt Cu, 2.5Mt Zn+Pb, >25kt U₃O₈, >100Mt Fe, >200Mt Thermal Coal
 "Giant" >6Moz Au, >1Mt Ni, >5Mt Cu, 12Mt Zn+Pb, >125kt U₃O₈, >500Mt Fe, >1000Mt Thermal Coal

Source: MinEx Consulting © March 2017

Number of discoveries by commodity

Mineral discoveries in the World : All Commodities : 1950-2016



Note: Based on discoveries >100koz Au, >10kt Ni, >100kt Cu, 250kt Zn+Pb, >5kt U₃O₈, > 10Mt Fe, >20Mt Thermal Coal

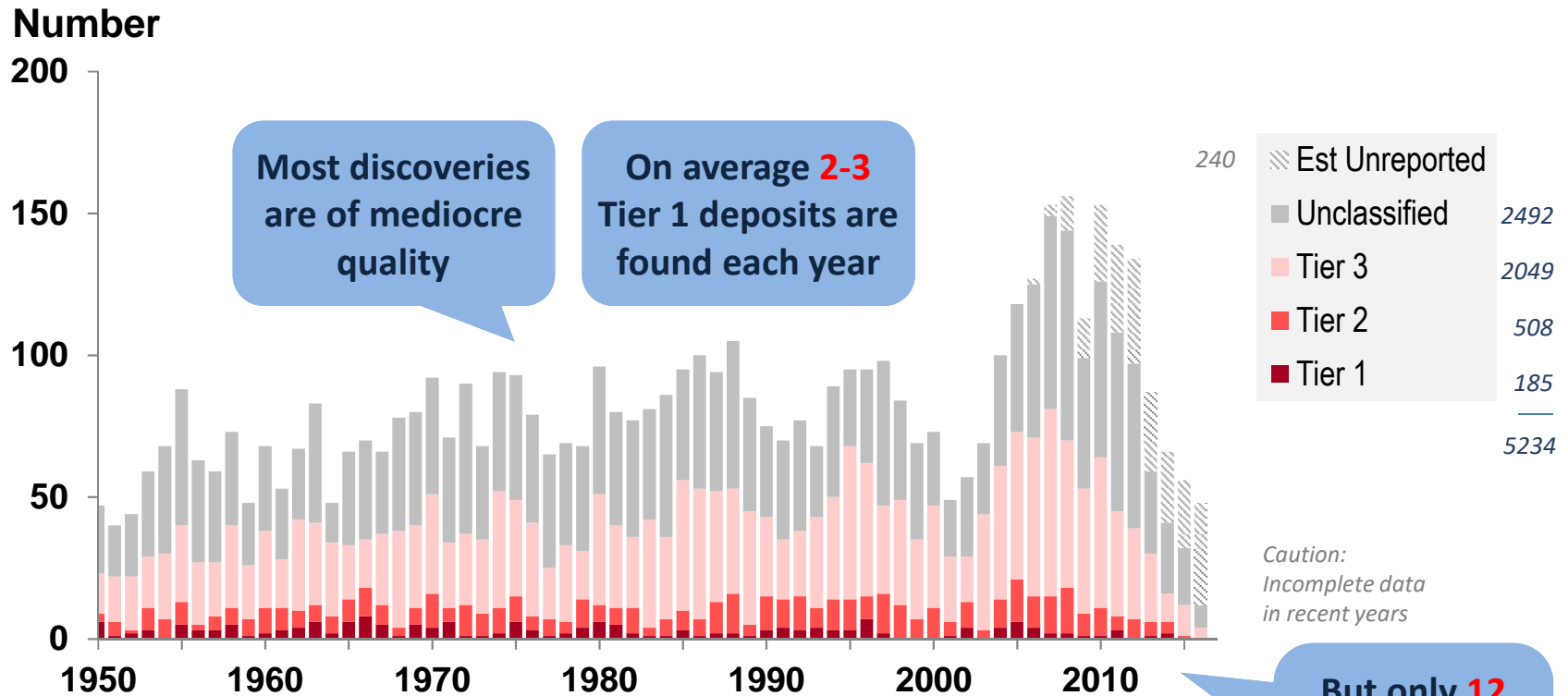
Source: MinEx Consulting © March 2017

Much of the value created from exploration is associated with a handful of Tier 1 (World Class) discoveries

4. QUALITY OF THE DISCOVERIES

Number of discoveries by quality

Mineral discoveries in the World : All Commodities : 1950-2016



Note: **Tier 1 deposits** are "Company making" mines. They are large, long life and low cost. ... ie >20 Years, >200 ktpa Cu or >250koz pa Au, and Bottom Quartile costs. Have an NPV of >\$1000m, and Expected Value of ~\$2000m in 2013 \$

Tier 2 deposits are "Significant" deposits - but are not quite as large or long life or as profitable as Tier 1 deposits.

They have an NPV of \$200-1000m and EV of ~\$500m in 2013 \$

Tier 3 deposits are small / marginal deposits While they can be profitable they often only get developed at the top of the business cycle.

At best they don't meet more than one of the Tier 1 or 2 criteria. NPV of \$0 to \$200m, EV of ~\$100m in 2013 \$

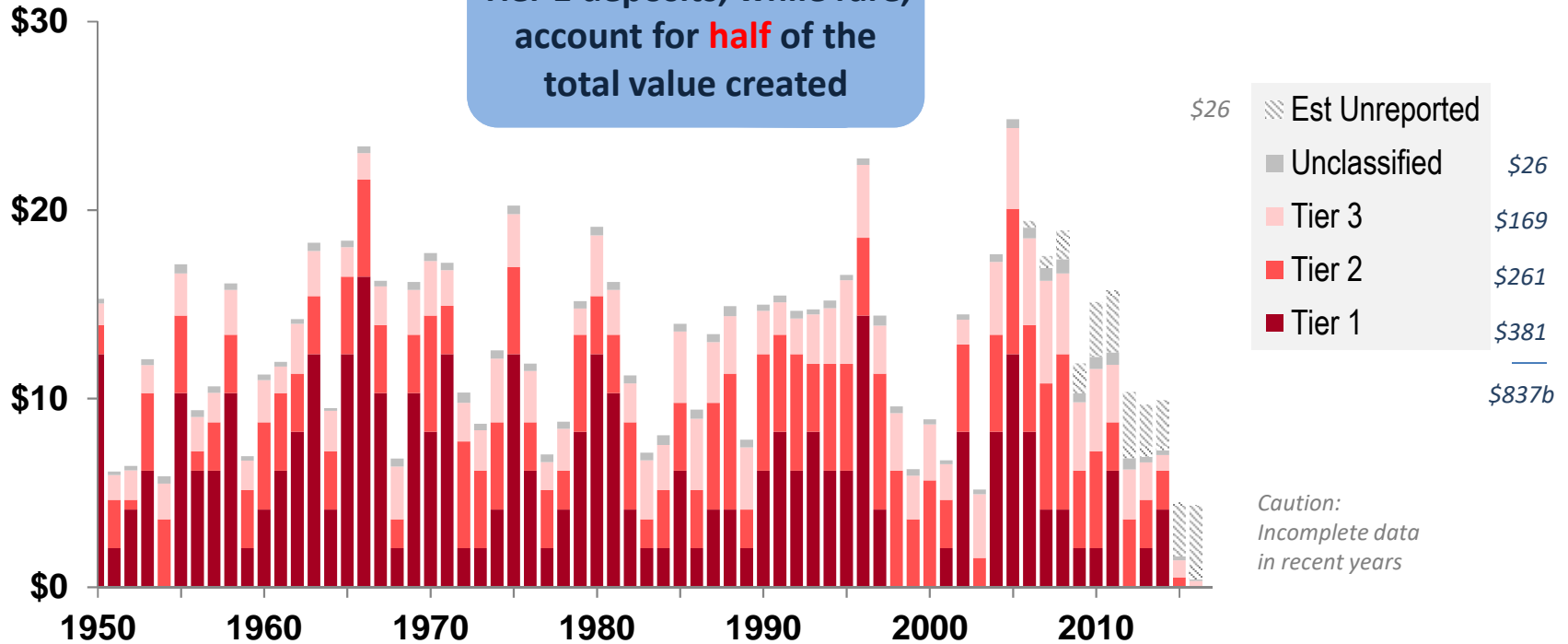
Unclassified deposits are small deposits that are less than "Major" in size and/or of minimal value. EV of (say) ~\$10m

Source: MinEx Consulting © March 2017

Number of discoveries by value

Mineral discoveries in the World : All Commodities : 1950-2016

2016 US\$ billion



Note: The analysis is based on a notional valuation (in constant 2013 US\$) of \$2000m, \$500m, \$80m and \$10m for Tier 1, 2, 3 and Unclassified deposits respectively.

Caution: Values are indicative / approximate-only

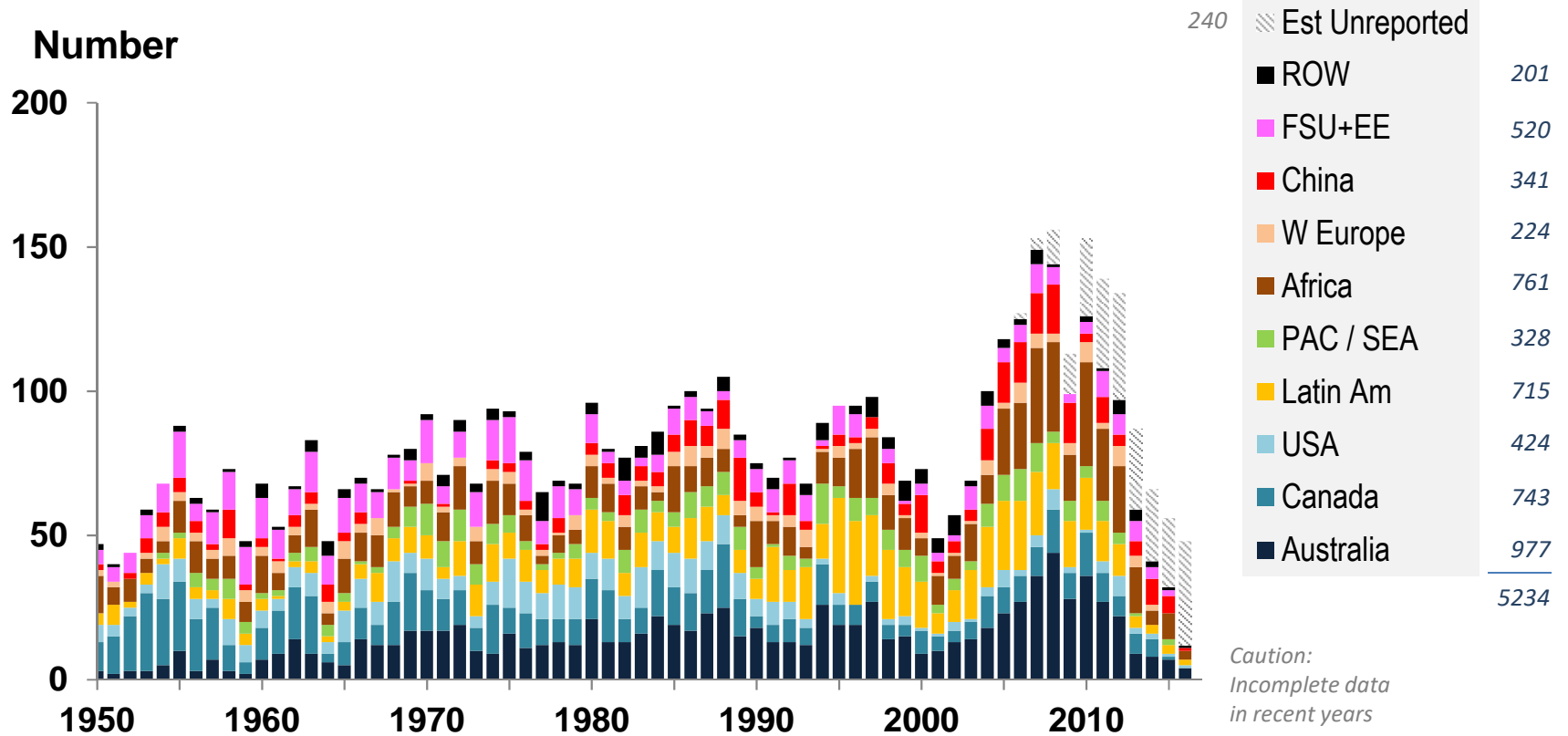
Source: MinEx Consulting © March 2017

Over the last decade 414 Tier 1, 2 & 3 deposits were found in the World

5. WHERE WERE THE DISCOVERIES MADE?

Number of discoveries by region

Mineral discoveries in the World : All Commodities : 1950-2016



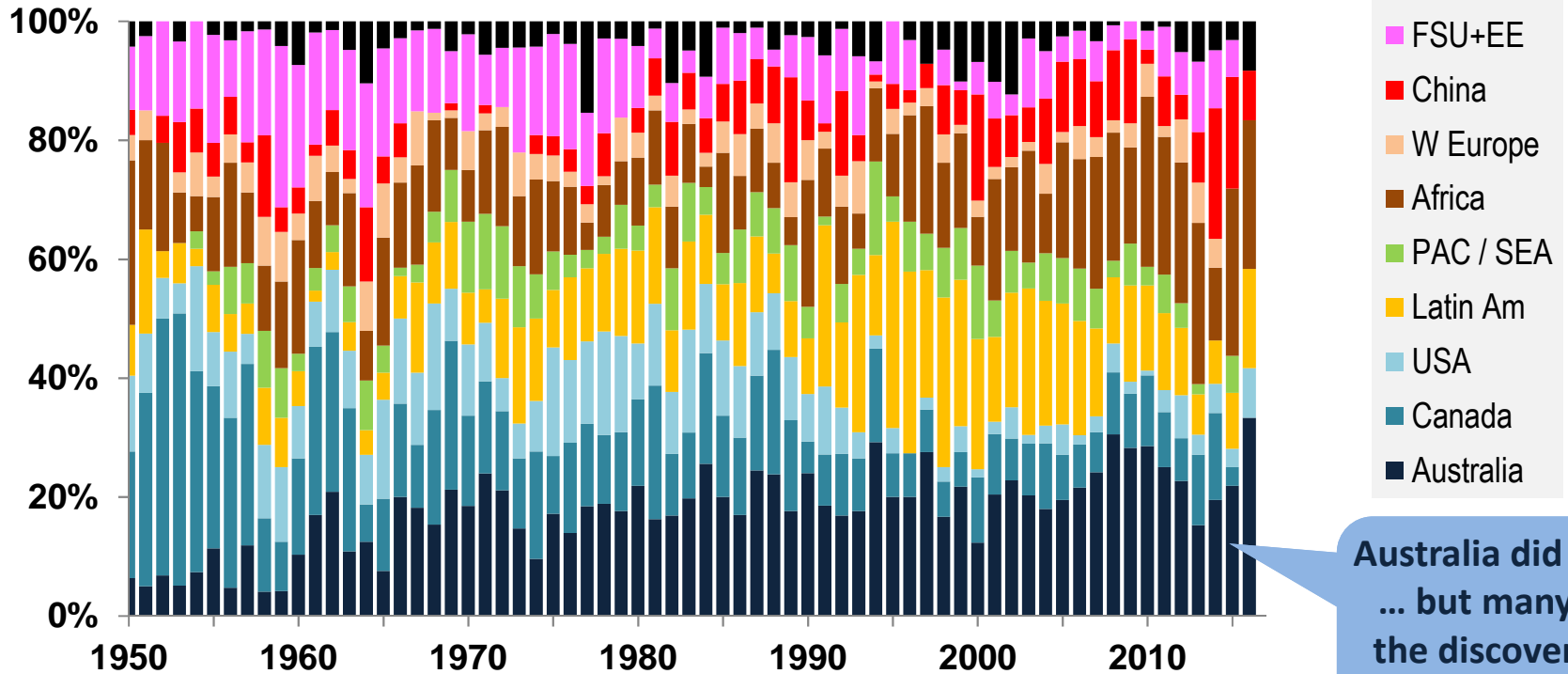
Note: Based on discoveries >100koz Au, >10kt Ni, >100kt Cu, 250kt Zn+Pb, >5kt U₃O₈, > 10Mt Fe, >20Mt Thermal Coal

Source: MinEx Consulting © March 2017

Number of discoveries by region

Mineral discoveries in the World : All Commodities : 1950-2016

Percentage Share

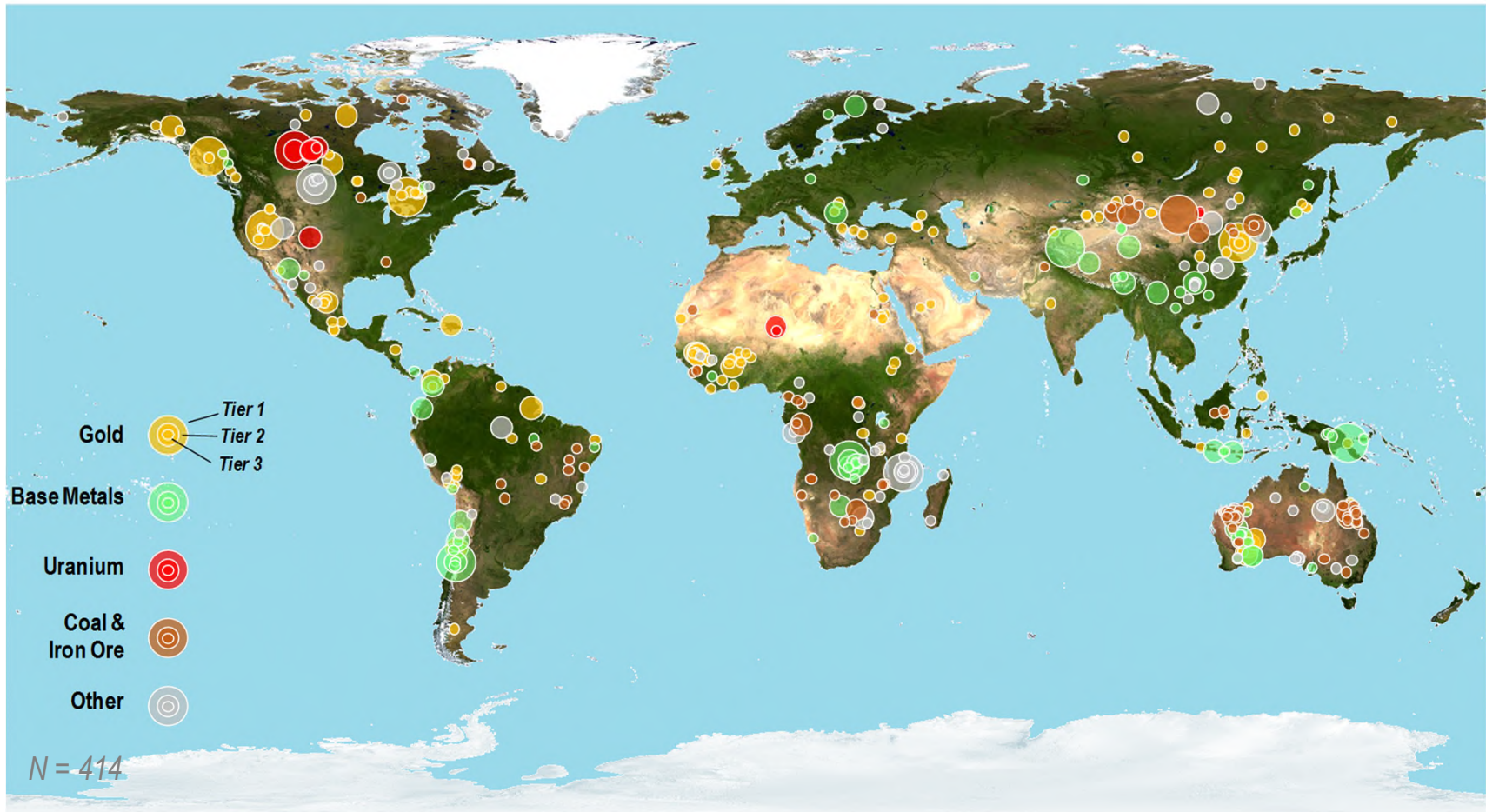


Australia did well ... but many of the discoveries were small size

Note: Based on discoveries >100koz Au, >10kt Ni, >100kt Cu, 250kt Zn+Pb, >5kt U₃O₈, > 10Mt Fe, >20Mt Thermal Coal

Source: MinEx Consulting © March 2017

Tier 1, 2 & 3 Discoveries: 2007-2016

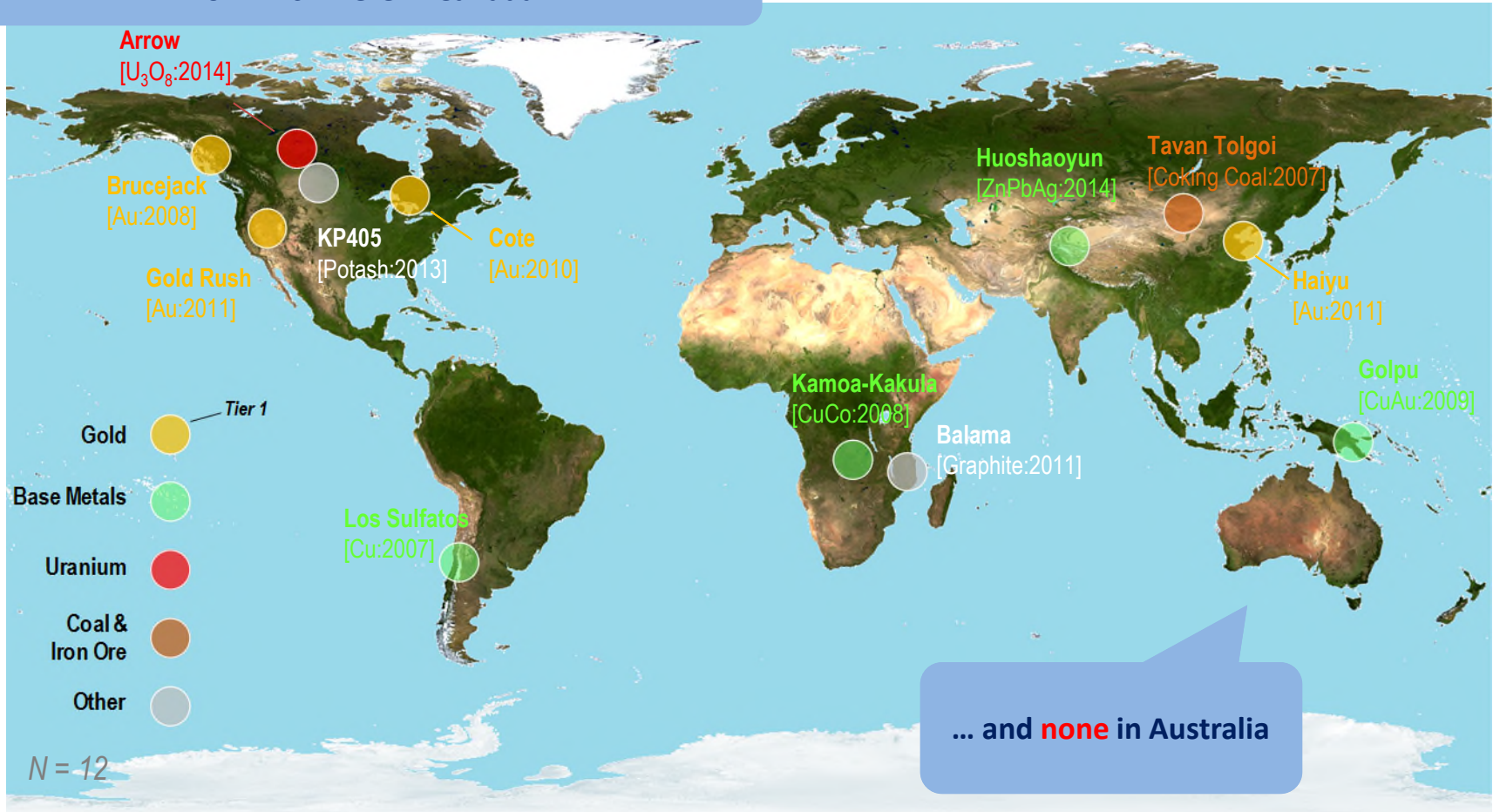


Note: Over the last decade, 12 Tier-1, 69 Tier-2 and 333 Tier-3 discoveries were made. Although not plotted, an additional 453 unclassified discoveries were made, and an estimated 238 discoveries (of unknown Tier) are yet to be reported

Source: MinEx Consulting © March 2017

Tier 1 Discoveries: 2007-2016

Over the last decade there were **12** Tier-1 discoveries ...
4 of which were in Canada



Source: MinEx Consulting © March 2017

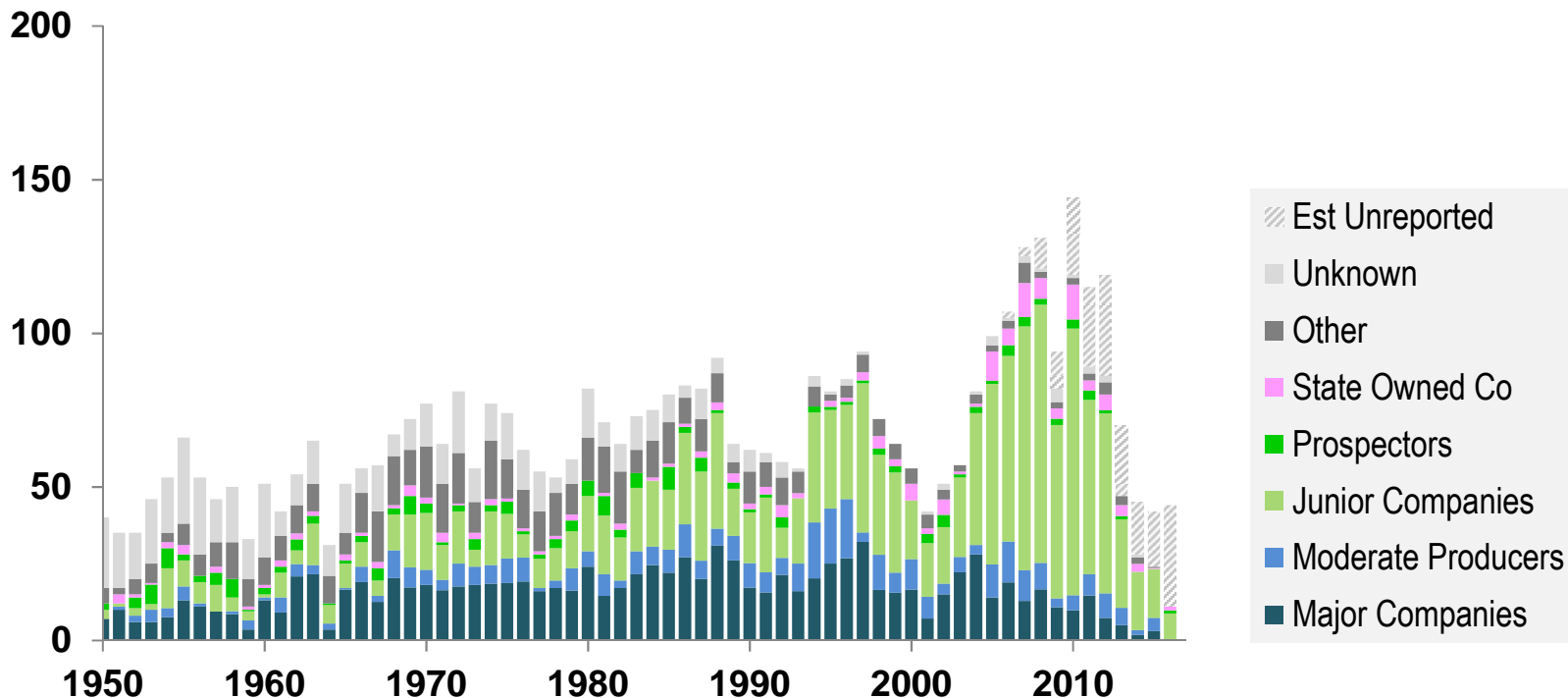
In recent years most discoveries were made by Junior companies

6. WHO MADE THE DISCOVERIES (IN THE WESTERN WORLD) ?

Number of discoveries made by Company Type

Moderate+Major+Giant primary gold discoveries in **Western World**: 1950-2016

Number of Discoveries



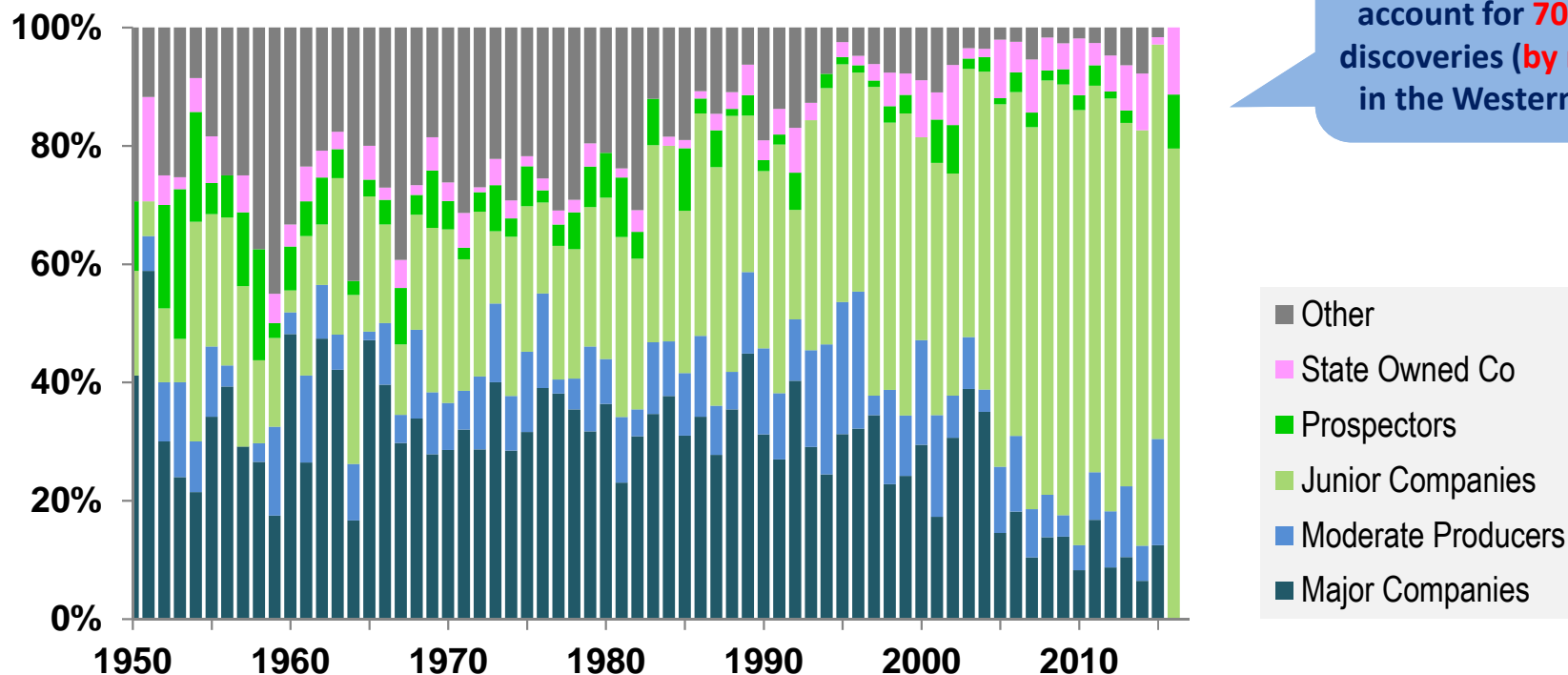
Note: "Other" refers to Oil Companies, Private Companies and Industrial Companies
Figures are adjusted for shared discoveries

Source: MinEx Consulting © March 2017

Number of discoveries made by Company Type

Moderate+Major+Giant primary gold discoveries in **Western World**: 1950-2016

Percentage Share



Junior Companies now account for **70%** of all discoveries (**by number**) in the Western World

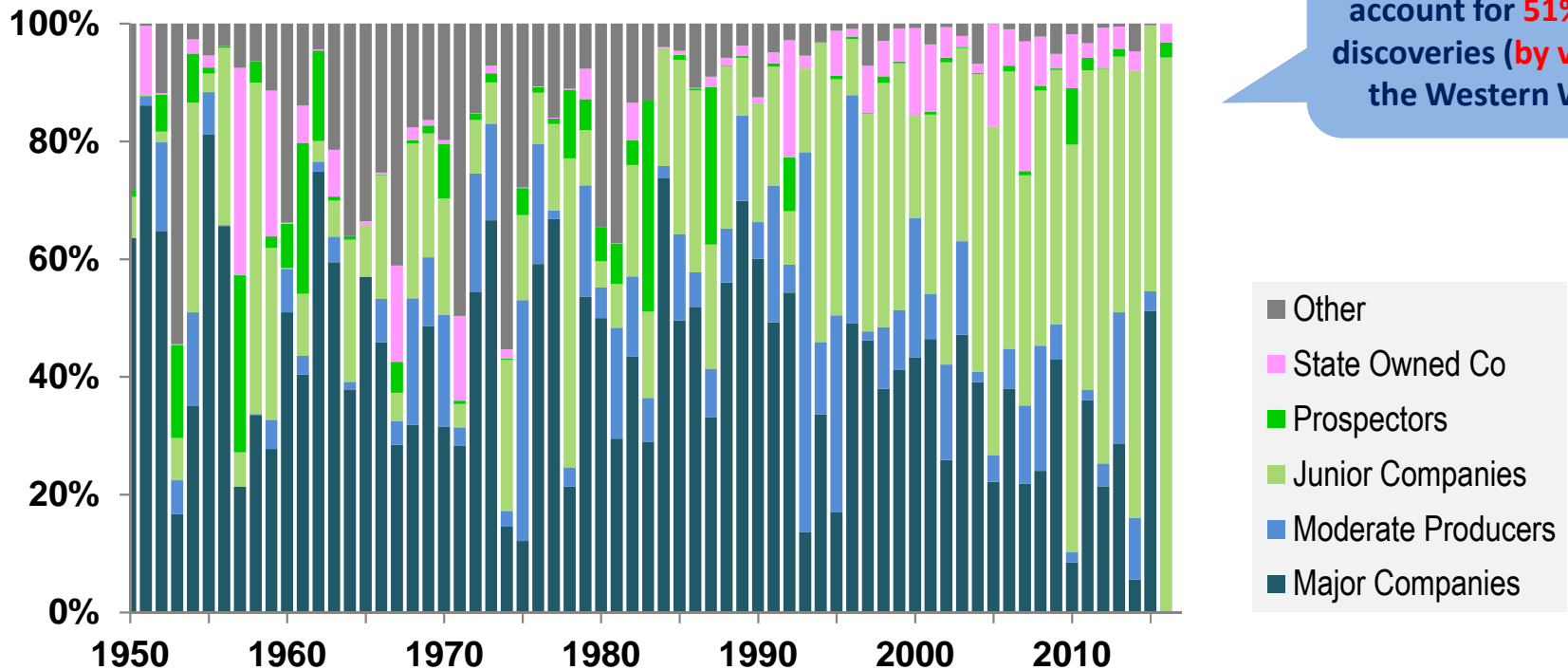
Note: "Other" refers to Oil Companies, Private Companies and Industrial Companies
 Discoveries by unknown companies have been prorated
 Figures are adjusted for shared discoveries

Source: MinEx Consulting © March 2017

Value of discoveries made by Company Type

Moderate+Major+Giant primary gold discoveries in **Western World**: 1950-2016

Percentage Share



Junior Companies now account for **51%** of all discoveries (**by value**) in the Western World

Note: "Other" refers to Oil Companies, Private Companies and Industrial Companies
 Discoveries by unknown companies have been prorated
 Figures are adjusted for shared discoveries

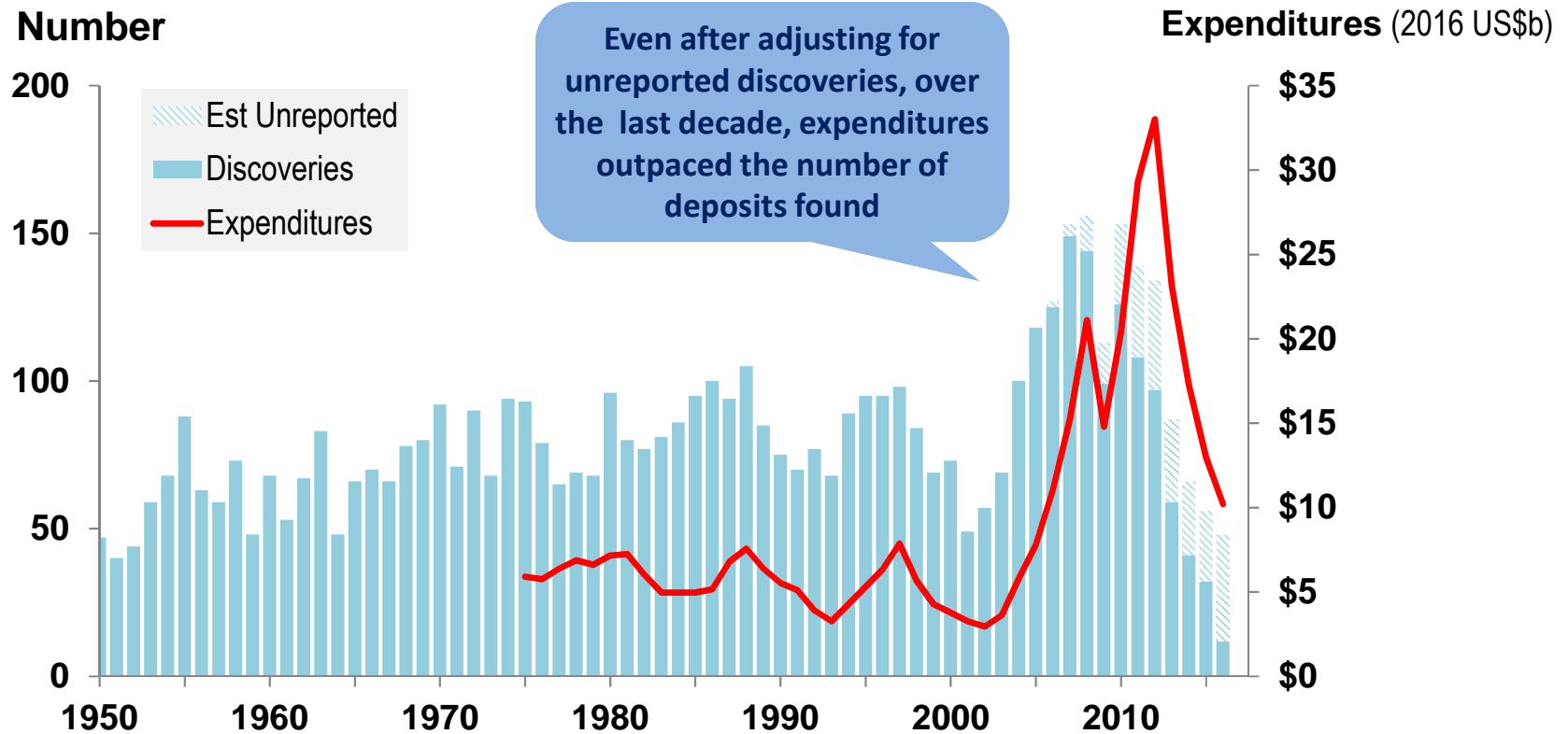
Source: MinEx Consulting © March 2017

What is the average cost per discovery and which countries and commodities performed better?

7. DISCOVERY PERFORMANCE

Number of discoveries versus expenditures

Mineral discoveries in the **World** : All Commodities : 1950-2016



Note: Discoveries based on deposits >="Moderate" in size
 i.e. >100koz Au, >10kt Ni, >100Kt Cu, 250kt Zn+Pb, >5kt U₃O₈, > 10Mt Fe, >20Mt Thermal Coal

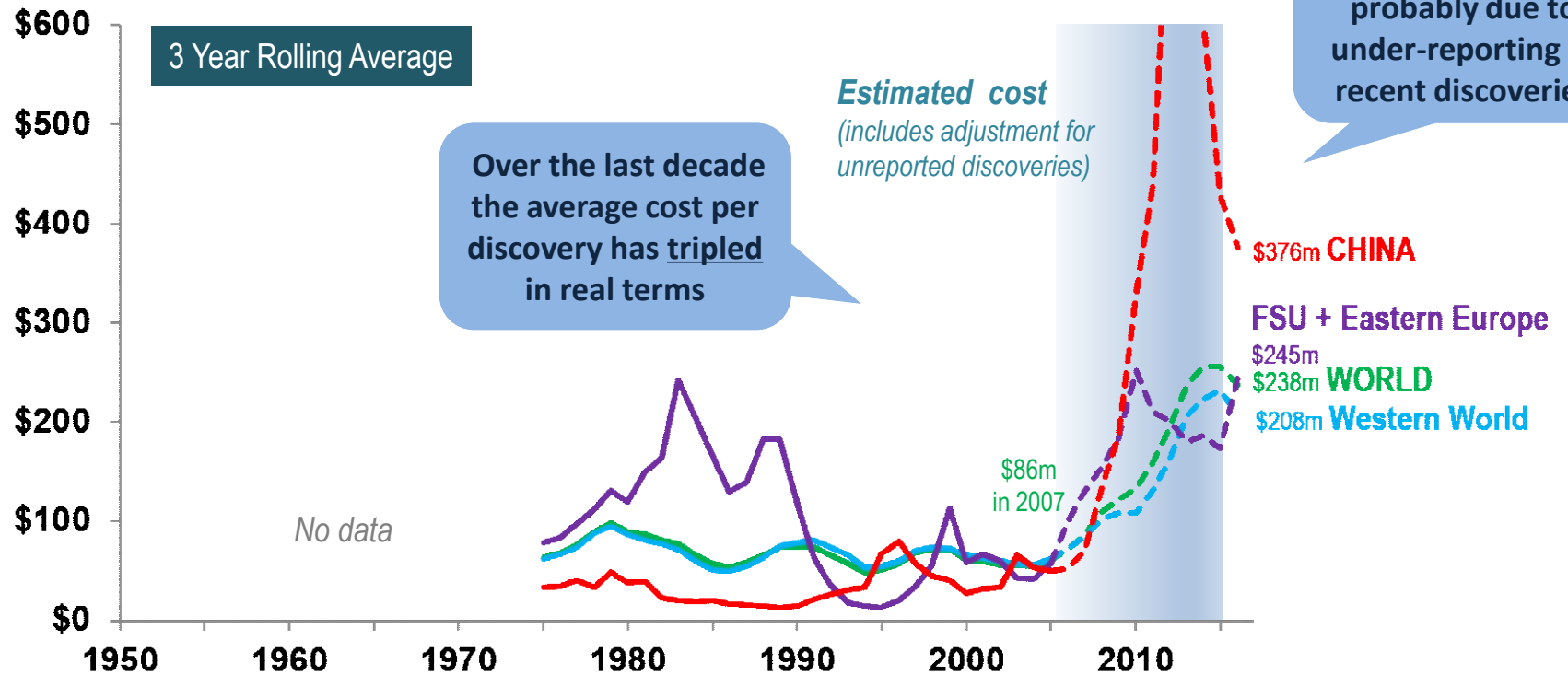
No World exploration data prior to 1975

Source: MinEx Consulting © March 2017

Unit cost per discovery

Mineral discoveries in the **World** : All Commodities : 1975-2016

2016 US\$ million



The apparent blowout in China is probably due to under-reporting of recent discoveries

Note: Discoveries based on deposits >="Moderate" in size
i.e. >100koz Au, >10kt Ni, >100Kt Cu, 250kt Zn+Pb, >5kt U₃O₈, > 10Mt Fe, >20Mt Thermal Coal

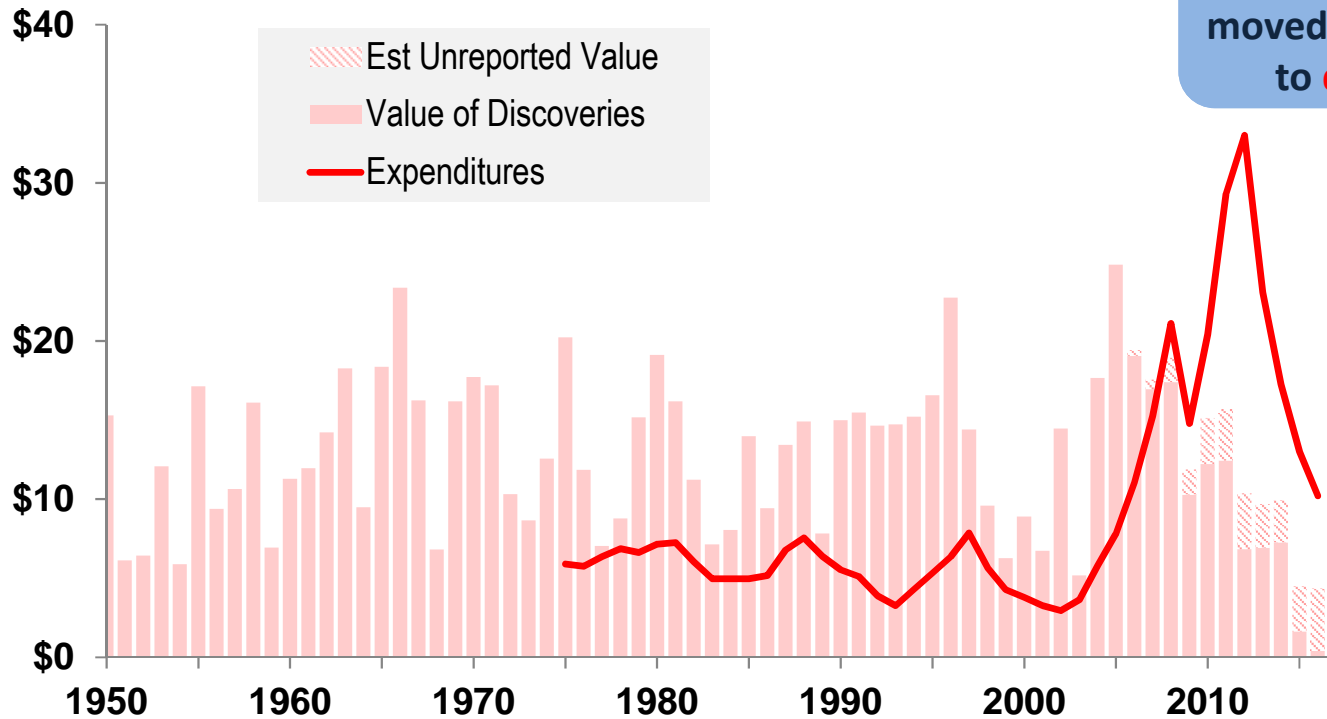
No exploration data available prior to 1975

Source: MinEx Consulting © March 2017

Estimated value of discoveries versus expenditures

Mineral discoveries in the **World** : All Commodities : 1950-2016

2016 US\$ billion



Over the last decade the exploration industry has moved from **creating** wealth to **destroying** wealth

This situation **should improve over time** as discoveries are drilled-out

Caution:
Incomplete data
in recent years

Caution: Values are indicative / approximate-only
No World exploration expenditure data prior to 1975

Source: MinEx Consulting © March 2017

Discovery performance by Region: 2007-2016

i.e. "Bang-per-Buck"

Region	Exploration Spend (2016 \$b)		No of Discoveries #		Tier 1+2 Discoveries		Estimated Value (2016 \$b)		Value / Spend
Australia	\$23	12%	221	25%	0 + 12	15%	\$12	13%	0.54
Canada	\$27	13%	80	9%	4 + 10	17%	\$16	18%	0.62
USA	\$12	6%	31	4%	1 + 3	5%	\$5	5%	0.42
Latin America	\$38	19%	109	13%	1 + 11	15%	\$13	14%	0.33
Pacific/SE Asia	\$10	5%	39	4%	2 + 2	5%	\$7	7%	0.69
Africa	\$25	12%	197	23%	2 + 15	21%	\$20	21%	0.80
W Europe	\$4	2%	34	4%	0 + 1	1%	\$2	2%	0.40
China	\$42	21%	82	9%	2 + 12	17%	\$13	14%	0.32
FSU + EE	\$13	7%	52	6%	0 + 2	2%	\$4	4%	0.26
Rest of World	\$5	3%	22	3%	0 + 1	1%	\$2	2%	0.28
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TOTAL	\$197	100%	867	100%	12 + 69	100%	\$92	100%	0.47

???

Note: Estimated value of discoveries is based on average notional value (in 2013\$) of \$200m, \$500m, \$80m & \$10m for Tier 1, 2, 3 and Unassigned discoveries respectively. Valuations are indicative only, and exclude unreported discoveries

Source: MinEx Consulting © March 2017

Discovery performance by Commodity: 2007-2016

i.e. "Bang-per-Buck"

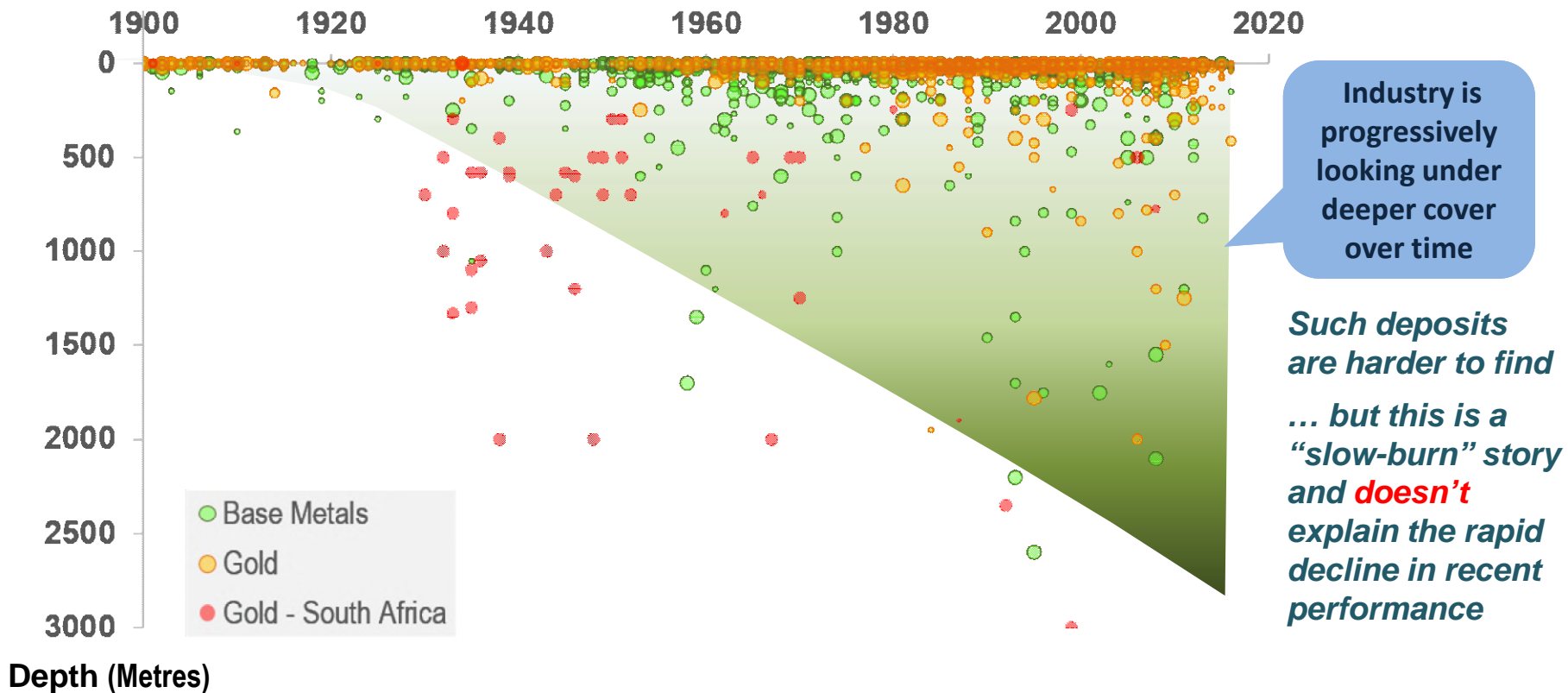
Region	Exploration Spend (2016 \$b)		No of Discoveries #		Tier 1+2 Discoveries		Estimated Value (2016 \$b)		Value / Spend
Gold	\$65	33%	320	37%	4 + 17	26%	\$30	32%	0.46
Copper	\$35	18%	102	12%	3 + 15	22%	\$17	18%	0.47
Nickel	\$7	4%	34	4%	0 + 4	5%	\$3	4%	0.47
Zinc+Lead	\$11	5%	30	3%	1 + 4	6%	\$5	6%	0.50
Uranium	\$10	5%	28	3%	1 + 7	10%	\$6	7%	0.61
Diamonds	\$6	3%	11	1%	0 + 1	1%	\$1	1%	0.19
Iron Ore	\$20	10%	143	16%	0 + 3	4%	\$6	7%	0.33
Coal	\$24	12%	64	7%	1 + 6	9%	\$8	8%	0.33
Other	\$21	11%	135	16%	2 + 12	17%	\$16	17%	0.75
	-----	-----	-----	-----	-----	-----	-----	-----	-----
TOTAL	\$197	100%	867	100%	12 + 69	100%	\$92	100%	0.47

Note: Estimated value of discoveries is based on average notional value (in 2013\$) of \$200m, \$500m, \$80m & \$10m for Tier 1, 2, 3 and Unassigned discoveries respectively. Valuations are indicative only, and exclude unreported discoveries

Source: MinEx Consulting © March 2017

Depth of cover versus discovery year:

Gold and Base Metal discoveries in the World : 1900-2016



Note: Size of the bubble refers to Moderate, Major and Giant discoveries
Analysis excludes Nickel laterites

Source: MinEx Consulting © March 2017

Expenditure have bottomed in 2016 and are forecast to increase by ~60% over the next four years

8. EXPLORATION OUTLOOK

Exploration spend versus gold and copper price

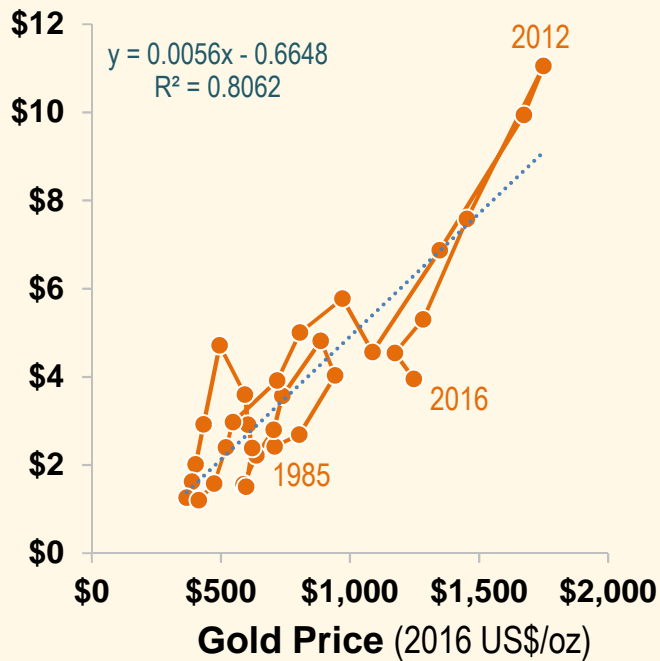
World: 1985-2016

Exploration spend moves in-line with commodity prices

With adjustments for other factors this can be used as a tool for predicting future exploration expenditures

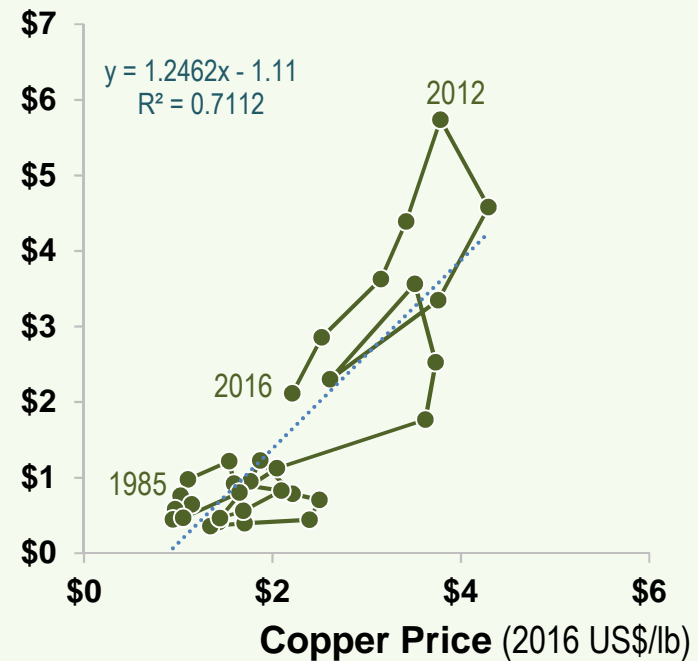
Gold Exploration Expenditures

(2016 US\$ billion)



Copper Exploration Expenditures

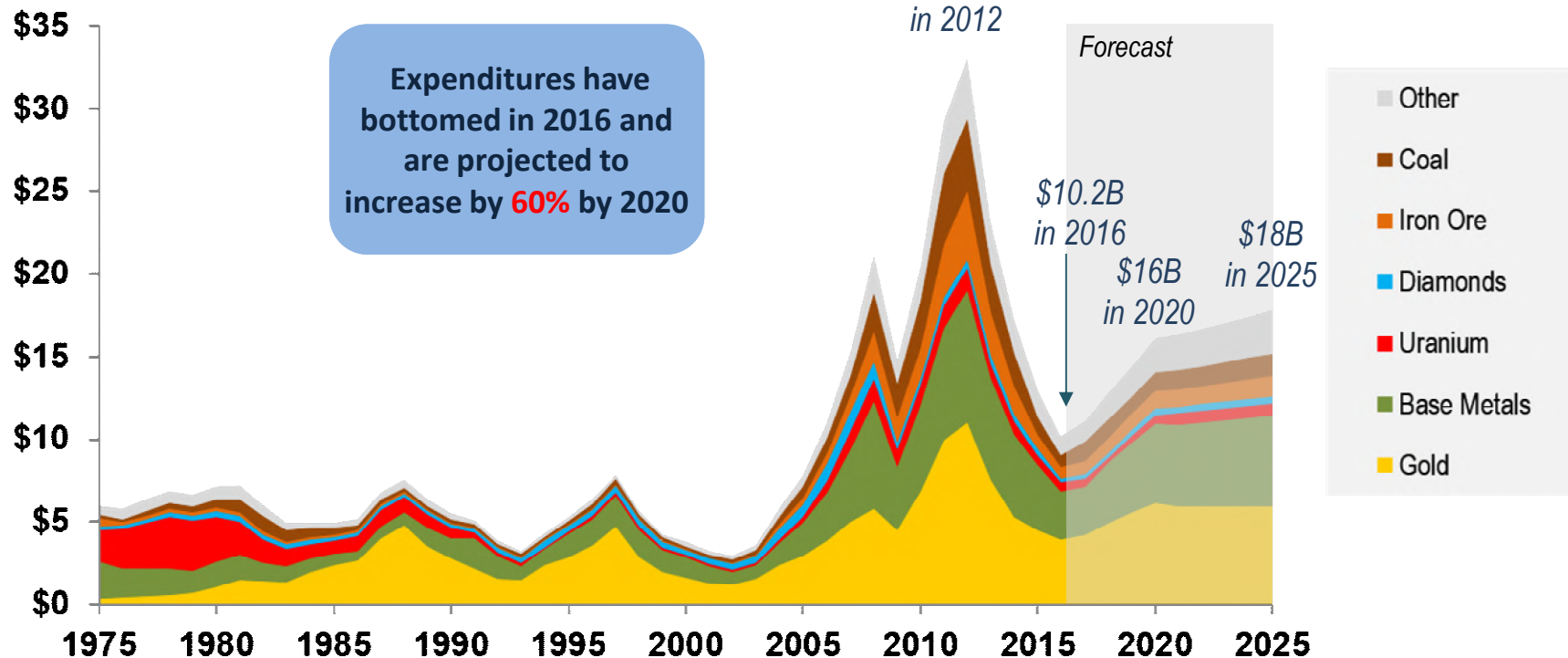
(2016 US\$ billion)



Sources: LME (for prices) and SNL Metals & Mining data, an offering of S&P Global Market Intelligence

Forecast exploration expenditures: World by Commodity : 1975-2025

2016 US\$ billion



WARNING: Forecast expenditures are highly sensitive to future commodity prices and economic activity

Sources: MinEx Consulting estimates © March 2017, based on data from ABS, NRCan, MLR (China), OECD and SNL Metals & Mining data, an offering of S&P Global Market Intelligence and commodity price estimates from Consensus Economics Feb 2017

9. CONCLUSIONS

Conclusions [1/4]

- Global exploration expenditures (for bulks and non-ferrous) reached an all-time high in 2012 (of US\$33 billion). In the 4 years since then it has dropped by 69% to \$10.2 billion
 - Gold continues to be the main target (39%) followed by base metals (29%) and bulk minerals (14%).
 - The country with the most exploration is China (26%) followed by Canada (11%) and Australia (10%)
- Historically, ~70-80 Moderate-sized (or larger) deposits were found each year in the World. This peaked at 149 discoveries in 2007 and has fallen dramatically since then
 - However, we need to remember that it does take time for discoveries to be reported and fully-drilled out
- Most of the discoveries were of small size and low value
 - Tier-1 deposits (ie World Class) deposits are rare ... and typically only 2-3 found each year. Over the last decade only 12 were found
 - In the last decade 4 of the Tier-1 discoveries were in Canada. None were found in Australia

Conclusions [2/4]

- Over the last 20 years the role and importance of the junior sector has risen.
 - In the Western World, Juniors accounted for ~70% of the total number of deposits found and 50% of the value created. Major & Moderate Producers found 18% of the number and 35% of the value.
- Over the last decade, due to a massive increase in spend and only modest increase in the number of deposits found, industry performance declined
 - Average cost per discovery went up 3x (\$86 to \$238m in constant 2016 Dollars)
- Due to the lack of Tier-1 discoveries the industry **switched from Wealth Creation to Wealth destruction** ... with the Value/Cost Ratio declining to 0.47
 - This should improve over time as more discoveries are reported
 - China massively increased its domestic spend but, to date, has little to show for it resulting in a V/C ratio of 0.33
 - Canada was much better - with a V/C ratio of 0.62. Australia was 0.54, and was let down by the lack of Tier-1 discoveries.
 - Latin America performed poorly with a V/C ratio of just 0.33.

Conclusions [3/4]

- Most of the commodities generated a similar V/C ratio. The outliers were Diamonds (0.19) and “Other” (0.75) ... with the latter benefiting from significant discoveries of graphite, potash and lithium
- There are many factors associated with the recent decline in discovery performance. Some are structural and others are cyclical.

These include the:

- Progressive move to targets under-cover
- Increased emphasis on brownfields exploration and feasibility-studies (which don't deliver big discoveries) at the expense of greenfield exploration
- Decline in drilling activity (if we don't drill, we won't find)
- Input costs for drilling and geologists increased in the boom years (and have come back since)

And don't forget the ongoing issue of the inherent delay in reporting discoveries !

Conclusions [4/4]

- The long term outlook for exploration is positive. We are now at the bottom of the business cycle and subject to an expected moderate improvement in commodity prices, global exploration expenditures are set to rise by 60% over the next 4 years

Its time to get back out in the field and start drilling !



Drilling for gold at Rimfire Pacific Mining's Sorpresa project in NSW

Contact details

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